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Indexing and Abstracting

The Journal is indexed and abstracted in IndMed, EMBASE/Excerpta Medica, INMED, SCOPUS, PUBMED (For Medline), Ulrich's Periodical Directory USA, Index Academicus (IA), Index Copernicus, EBSCO, Google Scholar and is listed World Web in University and College Databases. Bibliographic details of the Journal are available in ICMR_NIC Centre's IndMED database (<http://indmed.nic.in>). Full text of the articles being made available in IndMED Database (<http://indmed.nic.in>) (2002-2015 issues only) and at www.jkpractitioner.com (1994 till date)

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1. Release of JK-Practitioner (Volume 31, Number 3)



Prof. Parvaiz Shah, Ex. Principal, GMC Srinagar, released the issue of **JK-Practitioner** in the presence of Prof. GM Malik, Chief Editor, Prof. Qayoom, Vice Principal, Prof. Sheikh Ismail, Ex. Director Chitranjan Hospital, GMC Srinagar, Prof.



Principal GMC Handwara with Prof. Malik during conference release of JK-Practitioner

Masoodi, HOD, Medicine, GMC Handwara, during the national conference held at GMC, Handwara, attended by more than 400 delegates

2. Promotion of Dr. Malik Suhail

Executive Editor of JK-Practitioner has been promoted to Professor. **Prof (Dr) Malik Suhail** is currently the HOD of the Blood Bank at SKIMS Medical College, Bemina, Srinagar, Kashmir.



Prof. (Dr.) Malik Suhail

3. Book Launch of Prof. Upendra Kaul

A special book launch ceremony was held in Srinagar, where Chief Minister Omar Abdullah released the revised second edition of the memoir **When the Heart Speaks**, authored by the eminent cardiologist Prof. (Dr.) Upendra Kaul. The autobiography documents Dr. Kaul's life journey, tracing his roots in Srinagar, his prominent medical career in New Delhi, and his eventual return to Kashmir to establish accessible rural healthcare through the Gauri Kaul Foundation.



Prof. GM Malik with Mr. Ishtiaq Qadri and Prof. (Dr.) Upendra Kaul

4. Doctors Housing Cooperative Limited Srinagar, Kashmir



The General Body Meeting of the Doctors Housing Co-operative Limited (DHCL) was held on 04 September. 2026 at 2:30 PM in the Auditorium of IMA Kashmir House, GMC Boys Hostel Campus, Srinagar. The General Secretary **Prof. Sajjad Qazi** apprised the members regarding the present status of the Doctors Housing Colony with the Srinagar Development Authority (SDA). A future course of action was chartered by the General Body. The meeting was presided over by I/C President, **Prof. (Dr.) G. M. Malik**.



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Aims and Scope

JK-Practitioner is a multidisciplinary Medical Journal Published Quarterly from Srinagar. Emphasis is placed on matters related to medicine in the country in particular, while articles from anywhere in the world are given due importance. Besides original articles and case reports the journal includes clinical reviews guest articles on current topics in medicine and therapeutics.

Information for Subscribers

The **JK-Practitioner: Frequency** Quarterly, one volume per year beginning January. Other issues in April, July and October. **Correspondence Regarding Editorial matters** should be addressed to the Chief Editor Prof.GM Malik, Srinagar Kashmir. **Annual Subscription rates: Personal** Rs.2000/-**Institutional Rs.1500/-**. Institutional rates apply to Libraries, Schools, Hospitals, Clinics, Commercial and Private Institutions and organisations. **Reduce rates** is available for medical students as well. **Rates outside India:** US \$ 100.Gulf Countries SR 100.All other countries US \$ 100 or equivalent. **Concessional rate for personal subscription** is available for three-year term at Rs.5000/-Outside India US \$ 300 /-, Gulf Countries SR 300 /-.Postal charges within the country is Rs.150/- extra for each issue. **Single Current issue** Rs.1000/-Old issues of the journal can be purchased at 20% discount subject to availability. **Prices are subject to change. Change of Address:** The publisher must be notified 30 days in advance. Volume Index appears in October issue. **Indexing/Abstracting Services:** The journal is currently indexed and abstracted **EMBASE/Excerpta Medica database, IndMED PubMed (Medline -Specific Articles)** and

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Opp SBI, Near Gol Chakkar, Dhillon Marg Tagore Theatre Road,
Model Town, Patiala-147001, India
(7009658583,7009004425). rajesh.bhal@gmail.com

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Multifaceted Prevention of Low Back Pain among sewing workers: A Review of Ergonomic, Physical and Psychosocial Interventions.

Rashmi Kaushal , Nitesh Malhotra .

Abstract

Sewing employees are more likely to endure occupational low back pain (LBP) because they have restricted biomechanics, do the same motions over and over , and stay in of static position over a prolonged period of time without micro brakes. The bio-psycho-social approach emphasizes the important significance of psychosocial stressors, while traditional prevention has concentrated on physical aspects. This literature review recapitulates the most recent research on the causes of lower back pain (LBP) in sewing workers and evaluates the effectiveness of precautionary measures that include ergonomics, physical activity, and psychosocial therapies. A comprehensive search was conducted utilizing a systematic combination of keywords throughout the primary academic databases (PubMed/MEDLINE, Scopus, Web of Science, and CINAHL). Research investigating low back pain risk factors or treatments, categorized as observational studies or clinical trials, and focused on sewing workers were included. This review reveals that the psychosocial pressures including inadequate management, high job demands and lack of social support make the physical risk factors of sitting for long periods of time and doing the same task over and over again worse. Studies indicate that most effective preventive strategy involves a holistic program that includes ergonomic adjustments like adjustable chairs and workstations and well planned exercise regimens that focuses at core strengthening and flexibility along with regular active breaks and psychosocial and organizational measures such as stress management training, job redesign and fostering a positive work environment. For low back pain in sewing workers to be effectively prevented, a thorough, bio-psycho-social strategy is required. The most promising way to lower the prevalence and severity of LBP and improve worker well-being and productivity is to combine ergonomic, physical, and psychosocial methods within a collaborative framework. Future initiatives have to concentrate on putting such integrated programs into practice and assessing their effectiveness in actual industrial contexts.

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Author Affiliations: **Author Affiliations:** Rashmi Kaushal , Research Scholar; Nitesh Malhotra , Professor : Department of Physiotherapy, School of Allied Health Sciences, Manav Rachna International Institute of Research and Studies. **Correspondence:** Dr.(Prof) Nitesh Malhotra Plot A , , Manav Rachna Campus Rd., Gadakhori Basti Village , Sector 43 , Faridbad , Haryana 121004.. mail. nitesh.sahs@mrii.edu.in .(m) 7503229661. **Indexed:** EMBASE, SCOPUS, IndMED , ESBCO, Google Scholar besides other national and international databases. **Cite this article as:** Kaushal R , Malhotra . Multifaceted Prevention of Low Back Pain among sewing workers: A Review of Ergonomic, Physical and Psychosocial Interventions. JK Pract2026;31(3):1-4. Full length article available at jkpractitioner.com one month after publication. **Keywords** Low back pain, sewing workers, ergonomics, exercise, psychosocial factors.

Introduction

Lower back pain is the most common problem in the world nowadays for working population. Due to prolonged static sitting there is increase of intradiscal pressure in the lumbar spine that leads to continuous stress on spinal ligaments, contributing to mechanical low back pain[1,2]. Forward head posture and slouched sitting are the poor postures that alters normal spinal alignment and causes uneven load distribution across spinal structures, increasing lumbar strain[3,4]. As there is reduced activation of core and trunk stabilizing muscles during prolonged sitting that decreases spinal stability and support, making the lumbar region more prone to pain[5,6]. Tight hip flexors and hamstrings are common muscle imbalances along with weak abdominal and gluteal muscles, that leads to altered pelvic alignment and increased lumbar stress[4]. Its prevalence is very common in industrial workers, who have a sitting job especially in the sewing industry. The sewing industry includes the garment industry, leather industry, and textile industry. Low back pain is the major cause of disability and chief contributor to reduced productivity and lost work time. The sewing workplace is characterized by prolonged sitting at the workstation, repetitive movement of hands, fine motor movements, and forward-bent back posture that leads to strain on the back and hence incidence of low back pain[3,4]. Beyond biomechanical exposures, psychosocial working conditions like work demands, poor social support, low job control, job improbability, and fear of job loss modify both risk and recovery, influencing absence, disability, and health-care seeking[5]. As the causes of low back pain are multifactorial, effective prevention and treatment must include ergonomic advice, on-site physiotherapy, and psychosocial treatment.

Epidemiology

According to many cross-sectional studies and workplace surveys, it has been found that the incidence of LBP is high in sewing workers of the garment and leather industry. It has been found that the prevalence is reported in the range of 40-88% annually depending on the sample and criteria, with the most commonly affected region being the back, mainly the lower region[6,7]. In many surveys it has been found that the prevalence of low back pain is higher in garment factory workers compared to other occupational groups. A large difference is expected because of differences in the definition of pain, the sampled population, and working settings[6].

Occupational Risk Factors

In sewing work there are many physical and biomechanical factors that are the main cause of low back pain.

Prolonged static sitting and trunk flexion: The workers have to sit for a prolonged period of time, mainly in a flexed posture that creates a sustained compressive and shear force on lumbar vertebrae along with the paraspinal muscles that creates muscle fatigue and impairs local blood circulation[8].

Asymmetric loading and awkward posture: Many factors, like frequent trunk rotation, lateral bending, and reaching for materials or tools (e.g., foot pedals and fabric pieces), increase torsional stresses and lumbar shear. **Repetition of fine motor demands:** Upper limb movements with high repetition increase cumulative load and produce static postures in the neck and trunk[3].

Psychosocial Factors:

Job control, job demand, job satisfaction, social support, job insecurity, and effort-reward imbalance are the psychosocial factors that contribute to both the onset and persistence of disabling LBP across occupations[5]. Mechanically, psychosocial stressors increase muscle tension and alter the motor patterns that lead to higher spinal loading during tasks. In garment and sewing settings, there are specific psychosocial issues like fear of job loss, high time pressure, and piecework payment systems that are most prevalent and interact with mechanical exposures to produce worse conditions[6,7].

Evidence for workplace design and ergonomics:

The aim of ergonomic interventions is to reduce hazardous exposures by changing the workstation design, tools, tasks, and environment. For sewing workers the most common ergonomic advice is adjustable sitting with appropriate lumbar support and height of seat so that feet rest comfortably and thighs are horizontal to reduce lumbar flexion[8]. The machine position should be like that: the tailor's elbows are around the waistline, shoulders relaxed, and the forearm supported to reduce forward trunk bend. The foot pedal should be designed to minimize the awkward lower limb postures and reduce ankle movements. There should be proper lighting at the workstation and task rotation and micro breaks to reduce the load on the back. Many systematic reviews of workplace intervention suggest that modification of the workstation and practical education are effective components of prevention strategies for LBP[9].

Exercise and physical approaches:

Physical exercises like strength training, targeting back and hip, and motor control exercises have shown benefit for low back pain. Many meta-analyses indicate the effect of targeted strengthening and stabilization on function and pain[10]. Some workplace exercise programs, like stretching and strengthening and in-between rest, show a reduction in pain and sickness absence[11]. Programs that incorporate both progressive strengthening and flexibility are ideal to reduce the severity of low back pain[10]. Exercise with education

about pain leads to fear-related avoidance and promotes return to function[11].

Practical prevention program for sewing workers:

The prevention program should be feasible, multilevel, low cost, and participatory. There should be workplace walk-throughs and quick ergonomic audits like chair dimension, table height, pedal placement, and lighting. There should be use of brief worker surveys like the Nordic questionnaire and psycho-social scales to score symptom distribution. There should be adjustment of seat height, lumbar support, repositioning of the table to allow neutral trunk posture that brings materials into comfortable reach, and repositioning of foot paddles[12]. Ensure adequate magnification and lighting to reduce forward bending. There should be micro-breaks of 1-2 minutes after every half an hour and task rotation where possible.

Incorporate supervised exercise sessions during shift starts or breaks that focus on hip flexor stretching, lumbar stabilization, gluteal strengthening, and thoracic agility training[13]. Construct easy poster instructions at each workstation that stress the right approaches and how to move forward in grades. Hold training on how to deal with and understand pain, addressing worries about job security and available help.

There should be implementation of worker participation of a worker committee that addresses workplace issues[14]. The main signs include keeping track of and evaluating the prevalence of self-reported low back pain, the number of sick days taken, the number of people who leave their jobs, and worker satisfaction. This combined method gives the best likelihood of a long-lasting and meaningful reduction in LBP that makes workers feel better[15].

Enactment Experiments and Obstacles

Even the best-designed programs have a lot of problems in sewing scenarios, such as:

Cost limits: The principal for adjustable equipment's may be limited by low production.

Production pressure: Short deadlines and piecework make it hard to take breaks and change behaviour without management support.

Literacy and cultural factors: Education intervention must be customized to language, literacy and local ideas about pain. Visual aids and group demonstrations are sometimes more effective than written material.

Adherence: To take part in exercise program the sewing worker need to do regular activities that have straightforward, brief rules and enough help from a supervisor.

Complexity of evaluation: Measuring outcomes require repeatable and simple metrics. Factories may be worried by reports of bad metrics, but developing programs that focus on quality and productivity can assist.

Methodology: The main goal of the search method was to find all relevant peer-reviewed literature that used databases, such as PubMed, Scopus, CINAHL, MEDLINE and Web of Science. A mix of vocabulary concepts and words such as "population" (sewing

workers, textile workers or garment workers), study design and specific tools like JBI Critical “condition” (LBP or musculoskeletal problems), Appraisal Checklist for Analytical Cross-Sectional “intervention” (stretching and strengthening exercise Studies, the Cochrane risk of bias tool for randomized and ergonomics), and “psychosocial” (job strain). control trials and AMSTAR2 for systematic reviews. Managing stress, job control and job demand. Boolean This elaborated methodology provides a rigorous and operators like OR and AND were used to put these ideas clear way how the literature review was conducted , together. The search was limited to the articles that were confirming the conclusions are based on a structured and published in English with no start date restriction and critical analysis of the available evidence. included literature up to the year 2025. This includes both recent and seminal studies.

Study selection and eligibility criteria: The records were initially evaluated by title and abstract, followed by a comprehensive text review.

Inclusion criteria encompasses observational research (cross sectional, cohort, case-control), randomized controlled trials, Quasi-experimental studies, Meta – analyses, and systematic reviews. Studies focusing on adult sewing machine operators or tailors in the textile and garment industry.

Studies outcomes that reported on the prevalence, risk factors, and effectiveness of intervention strategies for LBP.

Exclusion criteria:

Studies that were not published in English.

Studies where the full text was unavailable.

Studies were done on a population that

Data extraction and synthesis:

was not specifically sewing workers.

The data from the included studies was systematically extracted, including the information on study characteristics (author, publication year, country, and study design) and population details (sample size, specific occupation of subject, gender distribution), key findings (prevalence, rates of LBP, risk factors like our sitting and job strain, and details of intervention like type, frequency, and duration), and results (including as adjustable workstation are essential for reducing bio-measures of pain intensity, functional capacity, mechanical load, there effectiveness is augmented when disability, and work productivity).

Quality assessment:

The included studies were assessed using appropriate,

Thematic Synthesis of Reviewed Literature

Theme	Study/Author	Key Findings
Prevalence	Kumar et al. (2020)	68% of workers in South Asian leather units reported chronic LBP.
	Gupta et al. (2019)	High prevalence linked to prolonged static postures in small-scale units.
Ergonomic Risks	1. Dianat, I., & Salimi, A. (2014).	Poor chair/table design increased incidence of LBP.
	Tissot F, et al. (2019)	Lack of lumbar support and workstation customization cited as major concerns.
Socio-Economic Risks	Sharma et al. (2021)	15% decline in production linked to pain-related absenteeism.
	Singh et al. (2021)	Women reported greater severity and less access to care due to dual roles.
Psychosocial Factors	WHO (2022)	Mental stress amplifies LBP through lowered pain tolerance and fatigue.
	Hartvigsen J. et al. (2020)	Low job satisfaction correlates with higher incidence of chronic back

Conclusion and Discussion:

Low back pain is very common among sewing workers and has many causes. It can be prevented by doing changes to both the social and physical aspects of the workplace[3]. Organizational changes that includes ergonomic workstation improvements allow postural variations and breaks, brief targeted exercise program and participatory approach of the workers form the backbone of an effective approach. As the sewing workers often work under production and financial constraints, participatory, low cost and management supported approaches that shows progress in both health and productivity are most likely to be sustained and implemented[15]. This review shows the evidence that low back pain among sewing workers is a bio-psycho-social problem. The findings confirm that the traditional approach of only physical ergonomics is inadequate for sustainable prevention. As ergonomic intervention such as adjustable workstation are essential for reducing bio-measures of pain intensity, functional capacity, mechanical load, there effectiveness is augmented when integrated with workers physical capacity with exercises and their psycho-social work atmosphere[16]. The strong suggestion between psycho-social factors like

high job demands with low control and low back pain prevalence underscores a critical point. The piece rate system in the garment industry creates a high strain work

which not only increases stress but also physiologically increases muscle tension and pain, hence increasing the pathway from acute to chronic pain, so an intervention that includes an ergonomic chair but fails to address the production pressure is treating a symptom while ignoring the root cause[17]. Programs that combine education, supervise physical exercises, organizational changes and ergonomic modifications for stress reduction leads to supportive eco-system for musculoskeletal health.

Future Research Directions

To bridge the gap between research and practice future studies should focus on the following directions: Future research should be practical, high quality trials of integrated interventions like core strengthening and stretching exercise programs in sewing factory workers, combined with cost effectiveness and implementation studies.

There is a necessity for the deployment of science that transcends efficacy studies conducted in controlled environments within operational factories. This includes the most cost effective models for delivering exercises and ergonomic programs.

Future research may investigate the role of technology, including mobile health applications for delivering guided exercises routines and stress management techniques directly to sewing workers, as well as wearable sensors that offer real-time feedback on posture and movement breaks at predetermined intervals.

Implications of the study

This review has direct effects on a number of people who are interested. The occupational health protocol has to be improved. The examination should include psychosocial screening, and the therapies should be broad, including ergonomic recommendations, exercises, and stress management. Management and policy makers ought to consider integrated programs as an investment that lowers absenteeism and raises turnover.

They are encouraged to enhance safety rules to use a bio-psycho-social approach. This approach recognizes workers' experiences and gives them a way to promote overall health and well-being, not simply ergonomic tools but also a better workplace.

References

1. Adams MA, Dolan P. Spine biomechanics. *J Biomech.* 2005;38(10):1972-83.
2. Wilke HJ, Neef P, Caimi M, Hoogland T, Claes LE. New in vivo measurements of pressures in the intervertebral disc. *Spine.* 1999;24(8):755-62.
3. Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence. *J Electromyogr Kinesiol.* 2004;14(1):13-23.
4. Karasek R, Theorell T. Healthy work: stress, productivity, and the reconstruction of working life. New York: Basic Books; 1990.
5. McGill SM. Low back stability: from formal description to issues for performance and rehabilitation. *Exerc Sport Sci Rev.* 2001;29(1):26-31.
6. Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health.* 1993;19(5):297-312.
7. Pheasant S, Haslegrave CM. *Bodyspace: anthropometry, ergonomics and the design of work.* 3rd ed. Boca Raton: CRC Press; 2006.
8. Bridger RS. Introduction to ergonomics. 3rd ed. Boca Raton (FL): CRC Press; 2008.
9. Kroemer KHE, Grandjean E. Fitting the task to the human: a textbook of occupational ergonomics. 5th ed. Boca Raton (FL): CRC Press; 1997. Hodges PW, Richardson CA. Inefficient muscular stabilization of the lumbar spine associated with low back pain. *Spine (Phila Pa 1976).* 1996;21(22):2640-2650.
10. Bernard BP, editor. Musculoskeletal disorders and workplace factors. Cincinnati (OH): National Institute for Occupational Safety and Health (NIOSH); 1997.
11. van den Heuvel SG, de Looze MP, Hildebrandt VH, Thé KH. Effects of ergonomic interventions in office work. *Scand J Work Environ Health.* 2003;29(5):335-344.
12. Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. *Cochrane Database Syst Rev.* 2005;(3):CD000335.
13. van Middelkoop M, Rubinstein SM, Kuijpers T, Verhagen AP, Ostelo RWJG, Koes BW, et al. Exercise therapy for chronic non-specific low back pain. *Eur Spine J.* 2011;20(1):19-39.
14. Abate AE. Ergonomic Evaluation of Workstation for Sewing Machine Operators in Ethiopia. *Clin Case Rep Int.* 2022;6:1437.
15. Tissot F, Messing K, Stock S. Studying the relationship between low back pain and working conditions among sewing machine operators. *Int J Occup Environ Health.* 2009;15(2):121-129.
16. Choobineh A, et al. A comparison of the effects of ergonomic, organization, and education interventions on reducing musculoskeletal disorders in office workers. *Health Scope.* 2018 Sep 9.
17. Mithy SA, Hossain S, Afroz S. Factors associated with low back pain in ready-made garments workers in Bangladesh. *Bull Fac Phys Ther.* 2024;29(1):1-10.

Review

A systematic review on the importance of protein supplementation and resistance training on performance determinants and inflammatory biomarkers in male football players.

Kingshuk Ghosh, Jasmine Kaur Chawla, Indranil Manna .

Abstract

Resistance training (RT) may improve performance determinants such as strength, power, and speed, also reducing the risk of injury, and it needs to be included in Football training regimens of intermittent sports like Football. In combination with RT, protein is crucial for muscle recovery in various ways, including promoting muscle protein synthesis (MSP), boosting muscle protein kinetics, activating signalling proteins in the cascade of protein synthesis, reducing undesirable inflammatory responses, and aiding strength recovery. This systematic review assesses the effects of supplementation of whey protein (WP) versus pea protein (PP), in combination with Resistance Training (RT). Following the guidelines of PRISMA-ScR, the initial database search yielded 452 records. After the deduplication and abstract screening exclusion, full-text analysis was performed on 53 articles. The major full-text articles were rejected because they either used non-structured RT or used multi-ingredient supplements. Finally, 17 studies were included in the systematic review. The evidence suggests that total daily protein intake (1.6–2.2 g/kg) remains the most critical factor for optimizing muscle hypertrophy and strength, often overriding the specific benefits of the protein source. Both WP and PP effectively support maximal strength gains with no significant differences in performance determinants when total protein requirements are met. Regarding recovery, PP significantly lowered creatine kinase (CK), alanine transaminase (ALT), and lactate dehydrogenase (LDH) levels post-game compared to WP. This systematic review concludes that WP may offer short-term advantages in attenuating muscle damage, and whether PP is a viable and comparable alternative for long-term muscle adaptation in football players.

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Author Affiliations: Kingshuk Ghosh, Research Scholar, Jasmine Kaur Chawla, Associate Professor, Department of Physiotherapy, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana; Indranil Manna, Associate Professor, Department of Physiology, Midnapore College (Autonomous), Midnapore, West Bengal, India. **Correspondence:** Indranil Manna, Associate Professor, Department of Physiology, Midnapore College (Autonomous), Midnapore, West Bengal, India. Email-dr.indranilmanna@gmail.com. **Indexed** EMBASE, SCOPUS, IndMED, ESBDO, Google Scholar besides other national and international databases. **Cite this article as:** KGhosh K, Chawla JK, Manna I. A systematic review on the importance of protein supplementation and resistance training on performance determinants and inflammatory biomarkers in male football players. JK Pract 2026;31(3):5-11. Full length article available at jkpractitioner.com one month after publication. **Keywords** Resistance training, Muscle Strength, Power, Speed, Whey Protein, Pea Protein, Inflammatory biomarkers.

Introduction

For optimum performance, football demands advanced physiological and metabolic capacities combined with superior physical fitness. Playing Football includes repeated high-intensity actions like sprinting, jumping, acceleration, and direction changes. In football, these essential actions heavily rely on anaerobic energy systems. Consequently, one of the most important objectives in getting football players ready for a high proportion of essential amino acids (EAAs) competition is the development of high levels of muscular strength. Resistance training (RT), which is known to improve performance-enhancing qualities like strength, power, speed, agility, and endurance while also reducing the risk of injury, must be included in the training regimens of Football. It has been demonstrated that prolonged periodized RT could be effective for increasing the size of skeletal muscles and, eventually, their ability to generate force [1].

Protein is crucial for muscle recovery in several ways, such as boosting muscle protein kinetics, promoting muscle protein synthesis (MPS), triggering signalling proteins in the cascade of protein synthesis, decreasing undesirable inflammatory reactions, and aiding in the recovery of strength [2]. It is very important to understand the specific benefits of different protein sources in physical fitness and recovery of the footballer

[3]. For endurance athletes of different team sports, the daily protein intake recommendations range from 1.2 to 2.0 g/kg body weight/day, with more recent recommendations for football (soccer) indicating potential benefits from higher amounts, specifically 1.6–2.2 g/kg body weight/day [4]. This is necessary for individuals to maintain a positive nitrogen balance. High-quality protein sources are crucial, as they contain necessary for MPS. Of these, leucine is a primary amino acid agonist for MPS, capable of stimulating MPS to the same degree as all nine EAAs, and even independently. Leucine can transform the net negative whole-body protein balance to a positive one when it is consumed after an intense exercise [3]. To maintain performance during a busy match schedule, the recovery of inflammatory biomarkers like CK, LDH, and C-Reactive protein (CRP) is crucial [5].

The athletes strongly depend on protein supplements to ensure the absolute protein intake, because of continuous damage and disruption of muscle fibres caused by rigorous RT. Among the available protein sources, whey protein (WP) and pea protein (PP) are the most popular ones. WP is thought to effectively stimulate MPS, due to its high leucine content, rich in branched-chain amino acids (BCAA), and quickly

digestible. Despite being plant-based, pea protein has been studied as a similar substitute for whey and also contains essential BCAAs [3,5].

Even though protein supplements are widely used among footballers, synthesis requires an extensive understanding of the particular impact of WP and PP combined with RT on key performance determinants like strength, power, speed, and inflammatory biomarkers. This systematic review aims to synthesize pre-existing evidence from the provided sources on the importance of whey and pea protein supplementation combined with resistance training, on these essential performance and recovery determinants in football players.

Materials and Methods

A. Study Design and Protocol Registration

This review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines [6]. While the synthesis was prepared as an expert-level report, the conceptual protocol aligns with the standards established by the PROSPERO database (International Prospective Register of Systematic Reviews). Registration no: PROSPERO 2026 CRD420261386369.

B. Search Terms and Search Strategy

Independently, three investigators searched for studies published in the four databases (PubMed, Scopus, Cochrane, and Web of Science). The search was restricted to humans and the English language, spanning January 2000 to December 2025. As the primary source of evidence, the double-blind, randomized, placebo-controlled clinical trials were prioritized in the systematic approach. Whether pea protein is non-inferior to whey protein in terms of promoting strength, power, speed, and recovery of inflammatory biomarkers in football players was the focused primary research question. For the search strategy, Boolean operators and keywords customized to each database were developed. The search strategy employed Boolean operators to combine terms related to the protein sources, the population, and the outcomes. A representative search string used for PubMed and adapted for other databases is provided below: ("protein supplementation" OR "whey protein" OR "pea protein" OR "Pisum sativum" OR "dairy protein") AND ("football" OR "soccer" OR "futsal" OR "athlete") AND ("resistance training" OR "strength" OR "power" OR "speed" OR "sprint") AND ("biomarker" OR "inflammation" OR "creatine kinase" OR "CK" OR "C-reactive protein" OR "CRP" OR "lactate dehydrogenase" OR "LDH"). Furthermore, manual searches of the reference lists of included studies (backward citation tracking) and of articles citing the included studies (forward citation tracking) were performed to ensure no relevant data were missed. In the initial search, a total of 452 records were selected. All records imported into EndNote (X9) were retrieved from the database searches. After removing the duplicates, a manual search for the reference lists of the selected publications in the database was performed. Using the inclusion and exclusion criteria and the search strategies

mentioned, the title and abstract of each article were independently screened for suitability by three investigators.

C. Eligibility Criteria

The selection of studies was governed by strict inclusion and exclusion criteria based on the PICOS (Population, Intervention, Comparator, Outcome, Study Design) framework. The study population was restricted to competitive football players (including soccer, futsal, and collegiate American football) or highly trained athletes engaged in high-intensity functional training (HIFT) representative of athletic conditioning. Supplementation with either isolated whey protein or pea protein isolate in conjunction with a resistance training regimen or soccer-specific match/training intervention. Studies must have directly compared whey protein to pea protein, or compared both to a non-energetic/carbohydrate placebo. Primary outcomes included measures of physical performance (1-RM strength, jump power, sprint speed) and biochemical markers of inflammation and muscle damage (Creatine Kinase, C-Reactive Protein, Lactate Dehydrogenase). Only randomized controlled trials (RCTs), randomized crossover trials, and controlled clinical trials published in peer-reviewed journals were included. The search was limited to the English language, spanning January 2000 to December 2025.

D. Study Selection Process

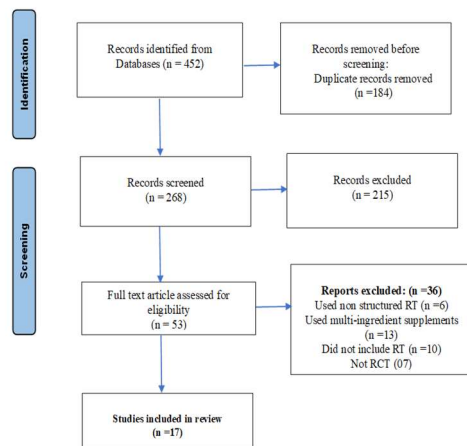
A multi-stage strategy was developed to select the studies. Using reference management software (Mendeley), the duplicate records were removed. The titles and abstracts of the remaining records, in contrast to the inclusion criteria screened by three independent reviewers. For all potentially relevant studies, full-text articles were acquired and independently assessed for eligibility in the second stage. The selection process highlighted the strong ecological relevance, such as the studies conducted during a football competitive season or a football training camp. The number of records at each stage (identification, screening, eligibility, and inclusion) was recorded to populate a PRISMA flow diagram.

E. Data Extraction

The data extraction process was done from the final set of included studies into a standardized and pilot-tested form. During data extraction, the Year of publication, Primary author, and Country of origin were considered. For participant characteristics, the total sample size (n), gender, age, sports type (soccer, futsal, etc.), and training status (elite, semi-pro, collegiate) were examined. Supplement type (whey isolate/concentrate vs. pea isolate), dosage (g/kg or absolute g), frequency of intake, and duration of the study (acute vs. chronic) were mulled over. The performance matrix includes mean change and standard deviation for strength (1-RM squat/press), power (CMJ height), and speed (10m/30m sprints). However, for biochemical data extraction, the pre and post-intervention concentrations of CRP, LDH, CK, ALT, and AST were considered.

F. Risk of Bias / Quality Assessment

The methodological quality of the included RCTs was **Figure 1 PRISMA Flow Diagram**



assessed using the Cochrane Risk of Bias (RoB 2) tool [7]. The tool evaluates five domains:

- 1) the randomization process bias
- 2) bias induced by deviations from intended interventions
- 3) missing outcome data bias
- 4) bias in measurement of the outcome, and
- 5) selection of the reported results bias.

For crossover studies or non-randomized studies, selection, exposure/outcome and comparability were assessed using the Newcastle-Ottawa Scale (NOS). Each study was characterised as low, medium or high risk of bias and this influenced the synthesis of the narrative and the force of the recommendations.

G. Data Synthesis

Due to the variability in protein dosages, participant training status, and the specific duration of the training interventions, a qualitative narrative synthesis was the primary method for analysing performance and inflammatory outcomes. However, where homogeneous data were available—specifically regarding 1-RM strength gains and CK attenuation—quantitative comparisons of effect sizes were performed. Statistical significance was defined as $p < 0.05$. Subgroup analyses were qualitatively conducted to determine if results differed by sport type (e.g., futsal vs. soccer) or by the duration of the supplementation (acute crossover vs. 8–12-week longitudinal training).

Results

The systematic search and rigorous screening process resulted in the selection of six core studies that provide direct empirical evidence for the comparison of whey and pea protein in the context of football-related training and performance.

A. PRISMA Flow Diagram Result

The initial search of the database selected 452 records. Then, the 184 duplicates were removed, and 268 records remained. Title and abstract screening excluded 215 articles. Full-text analysis was performed on 53 articles. The majority of excluded full-text articles were rejected because they either used non-structured RT, used multi-ingredient supplements, or did not include a pea protein arm. Finally, 17 studies were included in the systematic review (Fig 01)

B. Risk of Bias Results

The methodological quality across the included studies was generally high and used randomized, double-blind, placebo-controlled designs, which are the gold standard for nutritional intervention. Based on the results of ROB 2, studies received a low-risk quality assessment. Two studies raised some concerns because of data insufficiency (Table 01). Nieman et al. 2020 used a randomized, triple-blind design, although the inclusion of a water control group precluded total blinding for all participants [8]. A study implemented a randomized crossover design, which is highly effective for reducing inter-individual variability, particularly in small samples of elite athletes [5].

C. Findings

a. Body Composition and Strength

Body composition and strength outcomes of WP and PP supplementation in athletes are typically comparable, especially when the profiles of essential amino acids and total protein are matched. Whey protein supplementation in male college athletes achieved significantly greater increases in 1RM bench press (+16 kg) compared to leucine (+7.5 kg) and placebo (+5 kg) groups [9]. Whey protein and a novel plant-based protein matrix (mainly pea protein) had comparable effects on body composition, strength, and power over 8 weeks in a study of professional and semi-professional futsal players. This was seen in athletes who were already eating a high-protein diet (>1.6 g/kg/day), showing that the particular protein source could fail to provide any extra anabolic benefits once daily protein requirements have been fulfilled [10]. Both whey and pea protein supplementation (24 g twice daily) significantly increased 1RM back squat and deadlift strength over 8 weeks in a pilot study of participants in high-intensity functional training (HIFT). However, there were no significant differences in strength, body composition, or muscle thickness between the two protein groups [11]. There was no statistical difference between the two protein groups in another 12-week study that found that pea protein increased muscle thickness more than a placebo, while whey protein had an intermediate effect. This implies that pea protein is a good substitute for whey in terms of encouraging muscle growth [12].

A pivotal 8-week double-blind randomized trial involving trained HIFT athletes who consumed 48 g of protein daily (split pre- and post-exercise) demonstrated this functional parity. Both the 1-Repetition Maximum (1RM) back squat ($p = 0.006$) and the 1RM deadlift ($p = 0.008$) significantly increased in both the Whey (WP) and Pea protein (PP) group. But there were no significant differences found in the magnitude of these strength gains between groups [4]. The Pea Protein dosage used (approximately 48 g/day) provided sufficient Leucine to repeatedly reach the necessary anabolic threshold (Leucine content of approx. 2.0 g per 25 serving), thereby maximizing the signalling cascade

for MPS and subsequent strength accumulation over game, 24-hour, and 48-hour time points, the pea protein time. This conclusion is further supported by evidence group showed significantly lower levels of creatine

Table 01: Risk of bias results using the Revised Cochrane Risk of Bias tool.

Study	D1: Randomization	D2: Deviations	D3: Missing Data	D4: Measurement	D5: Selection	Overall
Babault et al. (2015)	L	L	L	L	L	L
Banaszek et al. (2019)	L	L	L	L	L	L
Hoffman et al. (2007)	SC	L	L	L	L	SC
Joy et al. (2013)	L	L	L	L	L	L
Kritikos et al. (2021)	L	L	L	L	L	L
Lollo et al. (2014)	L	L	L	L	L	L
Loureiro et al. (2023)	L	L	L	L	L	L
Mor & Ipekoglu (2018)	SC	SC	SC	L	L	SC
Nieman et al. (2020)	L	L	L	L	L	L
Obradović et al. (2020)	L	L	L	L	L	L
Park et al. (2019)	L	L	L	L	L	L
Singh et al. (2024)	L	L	L	L	L	L
Teixeira et al. (2022)	L	L	L	L	L	L

(The table presents the Risk of Bias assessment for the included studies utilizing the Cochrane RoB 2 (Revised Cochrane risk-of-bias tool for randomized trials) framework. The domains are assessed as Low (L), Some Concerns (SC), or High (H) risk.)

showing similar increases in muscle thickness following RT for twelve weeks when individuals consumed 50 g/day of either PP or WP [8].

b. Power and Speed development

The impact of whey versus pea protein on power and speed in football players is limited to direct evidence from sources. In contrast, there is evidence available that indicates the benefits are frequently marginal, especially when overall protein intake is sufficient. There was no significant effect of either plant-derived protein or whey protein on the power or aerobic performance of futsal players when daily protein intake was high [10]. In a comparable manner, a study evaluating the effect of whey and soy protein in football players revealed that although supplementation helped sustain high-intensity running capacity, it had little to no effect on indirect indicators of explosive power, like countermovement jump (CMJ) or 30-meter sprint time [13]. Different studies found no significant differences in CMJ when comparing PP and WP in under 20 soccer players [5]. Neither whey nor pea protein supplementation led to significant improvements in performance determinants, such as speed and power components in HIFT participants [11].

c. Inflammatory Biomarkers and Muscle Damage

The most important distinguishable outcome of pea and whey protein supplementation is monitoring their impact on recovery biomarkers. Recovery after a simulated match among U-20 male soccer players a randomized, double-blind, crossover trial that compared the effects of 10 days of pea versus whey protein supplementation (0.5 g/kg post-training) [5]. At post-

kinase (CK), a key marker of muscle damage, compared to the whey protein group. The pea protein group also had lower lactate levels post-game and lower alanine transaminase (ALT) levels post-game and at 24 hours. These results highlight the viability of pea protein as an effective alternative for recovery in soccer athletes [5]. In a study investigating the acute effects of whey protein consumption immediately after exhaustive exercise in soccer players, researchers found that the single dose of whey protein did not produce any immediate positive effect on measured muscle damage values, including total protein, ALT, AST, LDH, and CK [14].

A study comparing whey protein (WPr) and pea protein (PPr) supplementation in combination with RT in sedentary adults found a greater C-reactive protein (CRP) levels in the PPr group at days 28 and 84 compared to the WPr group. However, these changes were classified as not clinically relevant by the medical director [15]. Neither WP nor PP demonstrated a significant advantage over a water-only control in mitigating Delayed Onset Muscle Soreness (DOMS) or improving general physical fitness tests following severe Exercise-Induced Muscle Damage (EIMD) [8]. Several specialized plant proteins exhibit unique results after supplementation. For instance, oat protein supplementation decreases DOMS, CK, CRP, and myoglobin following intense running. This indicates that bioactive peptides of plant proteins may resolve the systemic inflammatory phase of recovery. This characteristic can be compared between WP and PP supplementation [8].

Previous study on non-athletic males reported that whey

protein supplementation can decrease the rise of muscle than WP after 24 hours and 48 hours post-match.

Table 2: Summary of the key features of the studies included in this review.

Author (Year)	Population	Intervention	Duration	Primary Outcomes
Babault et al. (2015)	161 Men (Resistance-trained adults)	25g PP vs. 25g WP vs. Placebo	12 Weeks	Biceps thickness, Max strength
Banaszek et al. (2019)	15 HIFT Athletes	24g WP vs. 24g PP (Match Leucine)	8 Weeks	1RM Squat/Deadlift, IMTP, Body Comp
Nieman et al. (2020)	92 Trained Adults	0.9g/kg WP vs. 0.9g/kg PP vs. Water	5 Days	CK, Myoglobin, CRP, Muscle Soreness
Teixeira et al. (2022)	40 Futsal Players	25g PP Matrix vs. 25g WP	8 Weeks	1RM Back Squat/Bench, CMJ, VO2max
Loureiro et al. (2023)	12 U-20 Soccer Players	0.5g/kg WP vs. 0.5g/kg PP	10 Days	CK, ALT, Lactate, NMR Metabolomics
Saracino et al. (2022)	40 Futsal Players	Plant Matrix vs. Whey	8 Weeks	Strength, Power, Aerobic Performance
Hoffman et al. (2007)	21 (11 PR, 10 PL)	Whey (dose not specified)	10 weeks	Muscular performance/hormones
Obradović et al. (2020)	30 males	Whey or Leucine (dose not specified)	8 weeks	Strength (1RM)
Park et al. (2019)	18 men	40 g of blended protein, including hydrolysed whey protein	12 weeks	Muscle adaptation
Joy et al. (2013)	28 adults	Whey vs. Rice (48g/day)	8 weeks	Body composition
Lollo et al. (2014)	24 soccer players	Hydrolysed Whey (dose not specified)	12 weeks	Muscle damage markers
Mor & Ipekoglu (2018)	22 soccer players	Whey (single dose)	Acute	Muscle damage markers
Kritikos et al. (2021)	10 males	Whey vs. Soy (dose not specified)	Not specified	Explosive power/Recovery
Singh et al. (2024)	19 adults	Pea vs. Whey (dose not specified)	84 days	Strength/Inflammation

damage biomarkers (CK and myoglobin) compared to water after intense extrinsic exercise. But pea protein did not show a significant effect. The authors explained that lower leucine content in pea protein might be the reason for such a lower effect [8].

Research involving Maltodextrin (MALTO), Hydrolysed Whey Protein (HWP), and whey protein (WP) supplementation has provided new insights [16]. In HWP, a significant decrease in muscle damage indicators (CK and LDH) was found. This elaborates that the application of HWP can preserve normal muscle function during the intense training regime of a recovery [5].

championship game. But no such change was observed after only WP supplementation when compared to the MALTO group. The authors hypothesised that HWP may suppress ROS production. However, in all groups, uric acid was high throughout the 12 weeks of training. This indicates the protein supplementation did not alter uric acid production.

A smaller randomized pilot study has compared WP and PP supplementation on the post-match rise in serum CK in under-20 soccer players, 72 hours after a competitive game. The PP group had lower serum CK concentration

Additionally, the WP-supplemented group showed an elevation in metabolites (Glutamate, Lactate, Arginine, and Taurine) between pre- and post-game. This was not seen in the PP-supplemented group. The observed results defined that Pea protein contains higher natural Arginine content and slower digestive release. So, it can improve the metabolic recovery combined with mechanical and high-glycolytic stress of the players. Pea protein's higher Arginine levels and sustained delivery may promote improved nitric oxide signalling and metabolic elimination, and it could promote systemic

Discussion

Football players must take protein supplements to boost muscle repair, adaptation, and recovery from strenuous exercise. To stimulate muscle mass formation, a daily intake of approximately 1.6 to 2.2 g/kg body mass/day is needed [2]. Moreover, leucine is necessary in promoting the synthesis of muscle protein. Whey protein contains ~11% leucine, but pea protein contains ~8.5-9% leucine. Due to this, pea protein sometimes becomes less applicable to footballers. However, a previous study demonstrated that high doses of pea

protein or pea protein combined with leucine supplements can exhibit the same anabolic response as whey [3,17].

There are very few studies which compares effect of whey vs pea protein supplementation on strength parameters. Whey protein increases strength (e.g., 1RM bench press, 1RM squat) more than placebo and only in leucine-supplemented subjects [9]. Conversely, when whey and pea protein supplementation was compared on the strength variables of HIFT athletes, both increased strength with no statistically significant difference [11,18].

Regarding power and speed, studies on soccer players indicate that both whey and soy protein supplementation (a plant-based alternative to pea) may facilitate the maintenance of high-intensity running and high-speed running performance during congested training schedules. However, they show little to no significant impact on indirect markers of explosive power like CMJ or short sprint times.¹³ Further supplementation with either whey or plant-based protein (yeast) in futsal players did not further affect power or aerobic performance when overall protein intake is already adequate [10].

Pea protein has an intermediate, non-significant effect in non-athletic populations, while whey protein may be more effective than water alone at reducing post-exercise muscle damage biomarkers (such as creatine kinase and myoglobin) in terms of inflammatory biomarkers [8]. A previous study also showed lower post-game CK and ALT in soccer players after pea protein supplementation.⁵ This lower elevation of CK level suggests that plant-based protein supplementation provides a protective effect on muscular damage by slow delivery of amino acids.

Limitations

Most of the research papers are based on athletes under twenty years old. There is a lack of research on elite or senior football players. Studies with different methods, doses, and durations complicate the process of meta-analysis. Different sources, amino acid profiles, and dosages of protein also cause difficulty in comparing research papers. Different studies focus on different performance assessments. Moreover, most of the studies emphasize biochemical markers rather than monitoring performance outcomes.

Conclusion

Current research about the effect of protein supplements on football players undergoing resistance training is incomplete and inconsistent. Moreover, there is a lack of comparison between animal-based and plant-based protein supplementation effects on strength, power, speed, and inflammatory biomarkers of footballers. Currently available studies show better performance outcomes for whey protein supplements over pea protein supplements, but sufficient dietary intake of pea protein may provide better results. Conversely, whey protein can provide short-term benefit by lowering muscle damage biomarkers. High dosage of pea protein or optimizations of the amino acid content of pea protein

have shown better muscular adaptation than whey protein.

References

1. **Tabassum Y, Amjad S, ud Din BM.** Investigating the Effects of High Intensity Resistance Training on Physical Fitness of University Male Football Players. *THE SKY-International Journal of Physical Education and Sports Sciences (IJPESS)*. 2023 Dec 29;7:27-34.
2. **Morton RW, Murphy KT, McKellar SR, Schoenfeld BJ, Henselmans M, Helms E, Aragon AA, Devries MC, Banfield L, Krieger JW, Phillips SM.** A systematic review, meta-analysis and meta-regression of the effect of protein supplementation on resistance training-induced gains in muscle mass and strength in healthy adults. *British journal of sports medicine*. 2018 Mar 1;52(6):376-84.
3. **Joy JM, Lowery RP, Wilson JM, Purpura M, De Souza EO, Wilson SM, Kalman DS, Dudeck JE, Jäger R.** The effects of 8 weeks of whey or rice protein supplementation on body composition and exercise performance. *Nutrition journal*. 2013 Jun 20;12(1):86.
4. **Kerksick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, Collins R, Cooke M, Davis JN, Galvan E, Greenwood M.** ISSN exercise & sports nutrition review update: research & recommendations. *Journal of the international society of sports nutrition*. 2018 Aug 1;15(1):38.
5. **Loureiro LL, Ferreira TJ, Cahuê FL, Bittencourt VZ, Valente AP, Pierucci AP.** Comparison of the effects of pea protein and whey protein on the metabolic profile of soccer athletes: a randomized, double-blind, crossover trial. *Frontiers in Nutrition*. 2023 Sep 22;10:1210215.
6. **Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, Shamseer L, Tetzlaff JM, Akl EA, Brennan SE, Chou R.** The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *bmj*. 2021 Mar 29;372.
7. **Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, Savović J, Schulz KF, Weeks L, Sterne JA.** The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *bmj*. 2011 Oct 18;343.
8. **Nieman DC, Zwetsloot KA, Simonson AJ, Hoyle AT, Wang X, Nelson HK, Lefranc-Millot C, Guérin-Deremaux L.** Effects of whey and pea protein supplementation on post-eccentric exercise muscle damage: a randomized trial. *Nutrients*. 2020 Aug 9;12(8):2382.
9. **Obradović J, Vukadinović Jurišić M, Rakonjac D.** The effects of leucine and whey protein supplementation with eight weeks of resistance training on strength and body composition. *J Sports Med Phys Fitness*. 2020 Jun 1;60(6):864-9.
10. **Teixeira FJ, Matias CN, Faleiro J, Giro R, Pires J, Figueiredo H, Carvalhinho R, Monteiro CP, Reis JF, Valamatos MJ, Teixeira VH.** A novel plant-based protein has similar effects compared to whey protein on body composition, strength, power, and aerobic performance in professional and semi-professional futsal players. *Frontiers in Nutrition*. 2022 Jul 19;9:934438.
11. **Banaszek A, Townsend JR, Bender D, Vantrease WC, Marshall AC, Johnson KD.** The effects of whey vs. pea protein on physical adaptations following 8-weeks of high-intensity functional training (HIFT): A pilot study. *Sports*. 2019 Jan 4;7(1):12.
12. **Babault N, Paizis C, Deley G, Guérin-Deremaux L, Saniez MH, Lefranc-Millot C, Allaert FA.** Pea proteins oral supplementation promotes muscle thickness gains during

- resistance training: a double-blind, randomized, Placebo-controlled clinical trial vs. Whey protein. *Journal of the International Society of Sports Nutrition*. 2015 Jan 21;12(1):3.
- Georgakouli K, Tsimeas P, Tzatzakis T, Batsilas D, Batrakoulis A, Deli CK, Chatzinikolaou A.** Effect of whey vs. soy protein supplementation on recovery kinetics following speed endurance training in competitive male soccer players: a randomized controlled trial. *Journal of the International Society of Sports Nutrition*. 2021 Mar 16;18(1):23.
- 14.Mor A, Ipekoglu G.** The effect of whey protein supplementation on exercise-induced muscle damage. *Int J Med Sci Public Health*. 2018 Jan 1;7(7):132-7.
- 15.Singh RG, Guérin-Deremaux L, Lefranc-Millot C, Perreau C, Crowley DC, Lewis ED, Evans M, Moulin M.** Efficacy of pea protein supplementation in combination with a resistance training program on muscle performance in a sedentary adult population: a randomized, comparator-controlled, Parallel Clinical Trial. *Nutrients*. 2024 Jun 26;16(13):2017.
- 16.Lollo PC, Amaya-Farfan J, Faria IC, Salgado JV, Chacon-Mikahil MP, Cruz AG, Oliveira CA, Montagner PC, Arruda M.** International Society of Sports Nutrition. 2015 Jan 21;12(1):3.
- 13.Kritikos S, Papanikolaou K, Draganidis D, Poullos A,** Hydrolysed whey protein reduces muscle damage markers in Brazilian elite soccer players compared with whey protein and maltodextrin. A twelve-week in-championship intervention. *International dairy journal*. 2014 Jan 1;34(1):19-24.
- 17.Park Y, Park HY, Kim J, Hwang H, Jung Y, Kreider R, Lim K.** Effects of whey protein supplementation prior to, and following, resistance exercise on body composition and training responses: A randomized double-blind placebo-controlled study. *Journal of exercise nutrition & biochemistry*. 2019 Jun 1;23(2):34-44.
- 18.Hoffman JR, Ratamess NA, Tranchina CP, Rashti SL, Kang J, Faigenbaum AD.** Effect of protein-supplement timing on strength, power, and body-composition changes in resistance-trained men. *International journal of sport nutrition and exercise metabolism*. 2009 Apr 1;19(2):172-85.

Upper Gastrointestinal Endoscopy Findings in Patients with Chronic Small Bowel Diarrhea: A Cross-Sectional Observational Study at a Tertiary Care Hospital.

Shallu Kumar, Aftab Ahmed, Asma Bashir, Vijyant Chandel, Aamir Shafi

Original Article

Abstract

Background

Chronic small bowel diarrhea is a clinically challenging condition that has a wide etiologic range including malabsorption syndromes, inflammatory diseases and infections. Endoscopy with histopathological examination of duodenal biopsies is a crucial step in clarifying the underlying pathology, particularly when investigations of the same with standard laboratory and stool tests are inconclusive.

Objectives

To determine the diagnostic productivity of UGI endoscopy, determine the range of underlying etiologies, and to match the endoscopic findings with histopathological findings in patients with chronic small bowel diarrhea.

Methods

The study was a cross-sectional observational one carried out at the Department of General Medicine, GMC Jammu, between May 2024 and March 2025. Fifty patients (18 years and above) were enrolled, who came with chronic cases of small bowel diarrhea (duration more than 4 weeks, non-inflammatory, high-output). Endoscopy (UGI) was also done with the help of Olympus video-endoscope, duodenal biopsies (2nd part) were examined histopathological laboratory. Serological testing (anti-TTG IgA ELISA) for Celiac disease was also done. An analysis of data was performed with the help of SPSS 23.0; the level of significance was taken as $p < 0.05$.

Findings

The average age of the study participants was 34.15 ± 15.68 years and 54 percent were males. All patients reported gradual onset of diarrhea with an average of 4.67 ± 1.6 months; 52% said that it was 6-7 times/day. Endoscopic results were mostly normal and the antrum showed gastritis in 14% and second part of the duodenum (D2) showed pathological changes in 50% (grooving 28%, decreased folds 12%, scalloping 6%, mucosal erythema 4%). Normal villous architecture in 66%, mild villous atrophy in 16%, mild villous blunting in 8%, marked villous blunting in 6%, and complete villous atrophy in 4% was revealed by histopathological analysis. The intraepithelial lymphocyte (IEL) count was raised ($\geq 25/100$ enterocytes) in 14 percent cases. Anti-TTG IgA serology was positive in 8% patients and celiac disease was the final diagnosis in 8% of patients.

Conclusion

UGI endoscopy and duodenal biopsy are useful in the diagnosis of chronic small bowel diarrhea. In 8% of cases celiac disease was found. The duodenum second part and the antrum form the most valuable areas in terms of yielding pathologic results. Large percentage of normal results supports the idea that more diagnostic modalities are necessary in non-celiac cases.

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Author Affiliations

Shallu Kumar, Junior Resident;
Aftab Ahmed, Aamir Shafi, Assistants
Professors; **Asma Bashir**, Senior Resident;
Vijyant Chandel, Professor; Department of
General Medicine, Government Medical
College (GMC), Jammu.

Correspondence

Asma Bashir

Senior Resident, Department of General
Medicine, Government Medical College
(GMC), Jammu
asmagatoo1@gmail.com

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Introduction

The term chronic diarrhea is used to describe the loss of loose or watery stools in a period of longer than four weeks. It is a major diagnostic problem because it is multifactorial etiological with disabling effects on the quality of life. It is estimated that 1-5 percent of adults are affected and some of the possible causes are irritable bowel syndrome (IBS), inflammatory bowel disease (IBD), celiac disease, and microscopic colitis [1]. Its etiology is associated with a complex interaction of reduced luminal solute-absorption, augmented secretion, or impaired intestinal-barrier-function; different infectious, inflammatory, malabsorptive, and motility illnesses trigger these variations [2,3]. Although most cases of acute diarrhea are infectious, chronic manifestations are often caused by secretory, osmotic, and functional pathogenesis [1,2].

The diagnosis of chronic small bowel diarrhea through gastrointestinal

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Keywords

Upper gastrointestinal endoscopy, chronic
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endoscopy is less well established, and the etiologies of gastrointestinal infections and celiac disease or IBD also vary significantly between the Western and the Asian populations [4]. Recent recommendations provided by the Japan Gastroenterological Association and the British Society of Gastroenterology propose a progressive method of diagnosis, which incorporates endoscopic testing, and accentuate the necessity of differentiating between secondary chronic diarrhea (drug-induced, infection-associated) and idiopathic forms [5,6].

The most common cause of watery diarrhea includes functional disorders like IBS, and excess gas and steatorrhea due to malabsorptive syndromes can be evidence of such pathologies as giardiasis [7]. Another cause is idiopathic secretory diarrhea that is diagnosed in about 20 percent of the specially-centered cases or post-surgery complications [8]. The uncommon infiltrative conditions, like gastrointestinal amyloidosis, and iatrogenic diseases like systemic drugs and herbal medications should also be discussed [9,10,11].

Primary care is accompanied by the first clinical examination which is aimed at objective complications like dehydration and anemia [8]. In the case of continuous watery diarrhea and malabsorption and weight loss, initial tests such as hemograms, albumin, and stool parasite analysis should be carried out before more invasive procedures [12]. Clinicians should also be able to distinguish between organic and functional disease, the latter of which can be characterized by the high frequency of stool despite the normal consistency of feces (pseudodiarrhea) [13]. Anti-tissue transglutaminase antibodies screening of celiac disease must also be implemented early together with thyroid function examination and C-reactive protein [14]. IBD is screened with fecal calprotectin, neuroendocrine tumors with serum chromogranin A, and nutritional deficiencies with vitamin B12, folate, and ferritin [8,15,16].

Breath testing of small intestinal bacterial overgrowth (SIBO), quantification of fecal fat, empirical cholestyramine trial in bile acid diarrhea, and fecal elastase in pancreatic exocrine insufficiency should be used in refractory cases or cases with diagnostic uncertainty [8,17,18,19]. To suspect secretory neuroendocrine tumors, plasma vasoactive hormones should be assessed (gastrin, glucagon, vasoactive intestinal peptide), and localization is done by octreotide scintigraphy or PET-CT [8,20]. Flexible sigmoidoscopy with biopsy is recommended in patients younger than 40 years with suspected functional disorders, who have normal fecal calprotectin, to rule out microscopic colitis; and in patients older than 45 with new symptoms of the condition, full gastrointestinal endoscopy is strongly recommended despite the absence of typical alarm features [19,21].

The Rome IV criteria recommends the deferral of endoscopy in the absence of laboratory abnormalities that indicate that the patient has anemia, hypoalbuminemia, or an elevated fecal calprotectin, as

these are highly likely to yield a positive result of organic disease such as IBD and microscopic colitis [22,23,24]. However, upper gastrointestinal endoscopy is especially useful in chronic small bowel diarrhea, where it makes it possible to observe and biopsy the duodenum directly, which is necessary to diagnose giardiasis, Whipple's disease, tropical sprue, and celiac disease that can have malabsorptive features and normal colonoscopic appearance [3,25]. Villous atrophy, which is a macroscopic finding, e.g., duodenal folds scalloped or fissured, can lead to a definite diagnosis when serology is inconclusive [23]. In spite of this utility, not all patients with diarrhea have duodenal biopsy despite being suggested by major guidelines up to 9% [26]. Clinically important lesions such as ulcers and atrophy of the villus were found in 54.5 percent of the patients in the refractory IBS-like cases, often necessitating the new diagnosis of either Crohn's disease or celiac disease [25]. There are also non-colon cancer disorders, including celiac disease and idiopathic bile acid diarrhea, which contribute to the causes of chronic diarrhea, respectively, about the 4-percent and 25-percent, which underscore the importance of excluding a diagnosis of small bowel pathology with a systematic diagnostic approach [27]. The current research was done to assess the diagnostic utility of upper gastrointestinal endoscopy and compare the endoscopic observations with the histopathological findings in patients with chronic small bowel diarrhea.

Materials and Methods

Study Design

This is a cross-sectional observational study conducted at the Department of General Medicine, Government Medical College (GMC), Jammu. The study was approved by the Institutional Ethics Committee and written informed consent was obtained from all participants prior to enrollment. Patient recruitment, data collection, and result interpretation were carried out from 1st May 2024 to 31st March 2025. A total of 50 patients presenting to the outpatient and inpatient departments (OPD/IPD) of GMC Jammu with chronic small bowel diarrhea who fulfilled the eligibility criteria were enrolled over a 12-month period.

Inclusion criteria were the following: (a) Patients aged 18 years and above presenting with chronic small bowel diarrhea (duration more than 4 weeks, non-inflammatory and high-output in character); (b) patients who underwent upper gastrointestinal endoscopy as part of their diagnostic evaluation; (c) and patients willing to provide written informed consent. Exclusion criteria were the following: (a) Patients who declined to provide consent; (b) patients with a history of recent gastrointestinal surgery or significant comorbidities likely to confound interpretation of endoscopic findings; and (c) cases with inadequate or autolyzed biopsy specimens.

Data Collection

Baseline demographic data (age and gender), detailed clinical history and relevant personal or family history were recorded in a standardized proforma. Systemic

physical examination, including abdominal and digital impact on quality of life (Table 1).

rectal examination, was performed for all participants. Laboratory investigations including stool microscopy and culture, complete blood count (CBC), C-reactive protein (CRP), and anti-tissue transglutaminase IgA (anti-TTG IgA) ELISA were performed as indicated.

Endoscopic and Histopathological Examination

Upper gastrointestinal endoscopy was performed using Olympus Video-Endoscope. Patients fasted from solid food for 8 hours and from liquids for 4 hours before the procedure. Detailed documentation of endoscopic findings including morphological changes in the esophagus, cardia, fundus, body, antrum, first part of the duodenum (D1), and second part of the duodenum (D2) was recorded.

Histopathology of Biopsy samples which were taken in the second part of the duodenum (D2) of all the subjects and any other areas that were suspicious and inflamed. All the biopsy specimens assessed microscopically were evaluated in terms of villous architecture (normal, mild atrophy, mild blunting, marked blunting, complete atrophy), the number of intraepithelial lymphocytes (IEL) per 100 enterocytes, villous/crypt ratio, and other specific histological findings that indicate any celiac disease, Crohn's disease, or other forms of inflammatory/infectious pathology.

Statistical Analysis

The data have been analyzed with SPSS (version 23.0) and the quantitative variables were represented as the mean $\pm$ standard deviation (SD). Frequency and percentage were used to represent categorical variables with a p-value <0.05 was considered statistically significant

Results

The data obtained from the patients was evaluated to identify the underlying etiology of chronic small bowel diarrhea. The following tables and descriptive analyses explain the demographic characteristics, clinical symptoms, and diagnostic outcomes observed within this study population.

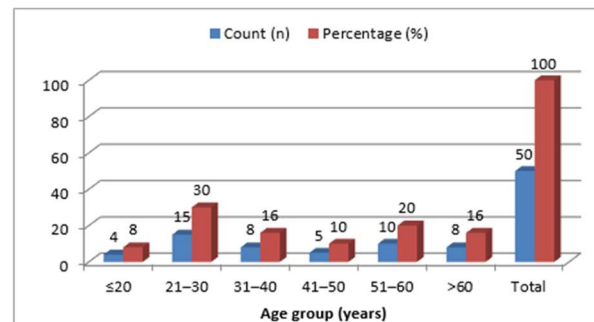
The majority of the participants were in the 21–30 age group (30%), followed by 51–60 (20%), >60 (16%), 31–40 (16%), ≤ 20 (8%), and 41–50 (10%). The mean age of the participants was 34.15 ± 15.68 years, indicating relatively younger but demographically diverse cohort (Figure 1).

Among the study participants males comprised 54% and females 46% which indicates comparatively a balanced gender distribution without significant predominance of either sex.

The most prevalent duration of diarrhea among study participants was 4–5 months (50%), followed by 6–8 months (26%) and 2–3 months (24%). The mean duration of diarrhea was 4.67 ± 1.6 months, which is the conformation of chronicity across all participants.

The majority of participants (52%) reported 6 to 7 episodes of diarrhea per day, followed by 26% having more than 7 episodes/day and 4 to 5 episodes/day in 22%, Signifying a disease burden and considerable

Figure 1: Age distribution of study participants



Frequency (episodes/day)	Count (n)	Percentage (%)
4–5	11	22.00
6–7	26	52.00
>7	13	26.00
Total	50	100.0

Table 1: Frequency of diarrhea episodes per day

Endoscopic results showed majorly normal results in the most parts of the upper gastrointestinal tract. The esophagus (100%), gastric fundus (100%), body (100%), and first part of the duodenum (100%), were normal everywhere. Small hiatus hernia was present in 6% in the cardia region. Antral gastritis was present in 14% of the participants in the antrum. Highest pathology was shown in the second part of the duodenum: only half ($n=25$) of them were normal, with 28% showing grooving, 12% revealed decreased folds, 6% displaying scalloping, and 4% manifesting mucosal erythema (Table 2).

Histopathological evaluation of duodenal biopsies found that normal villous architecture was apparent in 66% of the participants. Mild villous atrophy was found in 16%, mild villous blunting in 8%, marked villous blunting in 6%, and complete villous atrophy in 4%. Thus, a total of 34% of participants showed some level of villous abnormality, with severe changes (marked or complete atrophy) being present in 10% (Table 3).

Inflammatory activity was normal or not elevated as IEL count was below 25 per 100 enterocytes in 86% of the participants. Higher numbers of IEL of 25 to 50 were seen in 6%, and counts above 50 were seen in 8% indicating moderate mucosal inflammation in a few cases (Table 4).

The villous to crypt ratio was within normal limits in 90% ($n=45$) of participants. An increased ratio was observed in 10% ($n=5$), indicating an early histopathological alteration in a subgroup of patients even when overall villous morphology seemed conserved (Table 5).

In 92% anti-tissue transglutaminase IgA (anti-TTG IgA) serology was and positive in 8% of participants.

Confirmatory histopathological features of celiac disease on duodenal biopsy were also found in all four seropositive cases (Table 6).

Region	Finding	Count (n)	Percentage (%)
Esophagus	Normal	50	100.0
Cardia	Normal	47	94.00
	Small hiatus hernia	3	6.00
Fundus	Normal	50	100.0
Body	Normal	50	100.0
Antrum	Normal	43	86.00
	Antral gastritis	7	14.00
Duodenum 1st Part	Normal	50	100.0
Duodenum 2nd Part	Normal	25	50.00
	Grooving	14	28.00
	Decreased folds	6	12.00
	Scalloping	3	6.00
	Mucosal erythema	2	4.00

Table 2: Endoscopic findings by region

Villi Histopathology	Count (n)	Percentage (%)
Normal	33	66.00
Mild villous atrophy	8	16.00
Mild villous blunting	4	8.00
Marked villous blunting	3	6.00
Complete villous atrophy	2	4.00
Total	50	100.0

Table 3: Villous histopathology

IEL Count (per 100 enterocytes)	Count (n)	Percentage (%)
<25	43	86.00
25–50	3	6.00
>50	4	8.00
Total	50	100.0

Table 4: Intraepithelial Lymphocyte (IEL) count

Villous to Crypt Ratio	Count (n)	Percentage (%)
Normal	45	90.00
Increased	5	10.00
Total	50	100.0

Table 5: Villous to crypt ratio

Table 6: Serological testing — Anti-TTG IgA ELISA

Anti-TTG IgA ELISA	Count (n)	Percentage (%)
Negative	46	92.00
Positive	4	8.00
Total	50	100.0

In 92% of the participants the final diagnosis was normal (no identifiable organic pathology). In 8% it was determined that celiac disease was the definitive diagnosis and was confirmed by a combination of positive anti-TTG IgA serology and consistent histopathological abnormalities, such as villous atrophy and high IEL counts (Table 7).

Table 7: Final diagnosis

Final Diagnosis	Count (n)	Percentage (%)
Normal (No pathology detected)	46	92.00
Celiac Disease	4	8.00
Total	50	100.0

Discussion

This cross-sectional observational study assessed the upper gastrointestinal endoscopic findings, histopathological features, and final diagnoses in 50 patients with chronic small bowel diarrhea at a tertiary care facility. The results offer a detailed characterization of the demographic, clinical, endoscopic, and histopathological attributes within this patient population, revealing celiac disease as the sole identifiable organic diagnosis (8%), alongside a prevalence of normal findings throughout the cohort.

The average age of the participants was 34.15 ± 15.68 years, with the majority of the participants (30%) being 21–30 years old. This is in line with what has been said about chronic diarrhea affecting younger adults. This aligns with the findings of Shah et al. [28], which indicated a mean age of 36.2 years among patients with chronic diarrhea undergoing UGI endoscopy. However, our cohort was younger than those in the studies by Radhakrishna and Boda [29], with a mean age of 43.8 years, and Rauta et al. [30], with a mean age of 52.25 years; these differences are likely due to the specific focus on small bowel diarrhea rather than general dyspepsia. The gender distribution in this study was fairly even, with 54% males and 46% females. This is in line with earlier studies that found no strong gender preference for chronic diarrhea. Fine et al. [31] likewise reported a composition of 52% male and 48% female in their cohort. Limsrivilai et al. [4], in a substantial multicenter Thai study, reported 46.3% males, which aligns with our findings. The nearly equal gender distribution likely indicates the heterogeneous, multifactorial etiology of chronic small bowel diarrhea rather than a sex-linked pathology.

All participants reported a gradual onset of diarrhea, indicating an insidious instead of an acute or infectious

etiology. The typical period of diarrhea was 4.67 ± 1.6 months, and in half of the participants it lasted 4 to 5 months. This chronicity is similar to what Patel et al. [32] found in a similar endoscopy cohort, where the average length of time was 5.2 months, in addition to what May et al. [33] found in capsule endoscopy patients, where the average length of time was 4.8 months. These numbers confirm that the chronicity threshold used to define the study population is correct. Fifty-two percent of patients reported six to seven daily episodes, and twenty-six percent reported more than seven episodes. This high frequency of diarrhea in our cohort indicates a significant disease burden. This is different from May et al. [33], which found that the most common frequency was 4 to 6 episodes per day. The increased frequency of episodes in our study may indicate regional variations in disease severity or delays in seeking treatment, leading to a more advanced presentation.

The overall endoscopic results in upper gastrointestinal tract were normal. This is in line with the known pattern that these areas don't often have macroscopic pathology in people with chronic watery diarrhea. The antrum exhibited the initial significant pathology, with 14% indicating antral gastritis. This percentage is similar to the 12% that Giardiello et al. [34] found in patients with chronic diarrhea and the broader finding in Chinese national data [35] that gastritis is often found by chance in patients who are having UGI endoscopy for gastrointestinal symptoms. The second part of the duodenum (D2) yielded the highest endoscopic diversity and pathological load. Half of the participants had a completely normal D2, while the other half showed grooving (28%), fewer folds (12%), scalloping (6%), and mucosal erythema (4%). The prevalence of D2 abnormalities in our study (50%) significantly exceeds the 25% reported by Bouhnik et al. [36] and the 15% erythema rate documented by Yusoff et al. [37]. The elevated incidence of grooving (28%) requires scrutiny, as this indicator, alongside scalloping and reduced folds, is regarded as a proxy endoscopic marker for villous atrophy and has been linked to celiac disease and other malabsorption syndromes. The higher rate in our study may be due to differences in the disease patterns in the area, the fact that we only included symptomatic patients, or the fact that the endoscopists had different levels of experience and reporting standards.

Villi architecture was normal in 66% of participants on duodenal biopsy, resembling the 70% normal rate reported by Stotzer et al. [38] and the 60% reported by Thomas et al. [39]. Mild villous alterations (atrophy or blunting) constituted 24% of cases, while severe alterations (known as blunting or total atrophy) were observed in 10%. These results suggest that significant structural mucosal damage is not the primary histological characteristic in chronic small bowel diarrhea at this tertiary center, and that functional or non-mucosal mechanisms may be responsible for symptoms in a considerable number of patients. In 14%

of cases, the IEL count was high ($\geq 25/100$ enterocytes). Bini et al. [40] identified increased IEL counts in 15% of chronic diarrhea patients, corroborating our findings. Increased IEL counts, even without full villous atrophy, are acknowledged as an early or potential manifestation of celiac disease (Marsh I lesion) and may also signify lymphocytic enteritis due to alternative etiologies. The villous to crypt ratio increased in 10% of participants, indicating early histopathological remodeling, a subtle finding that could be overlooked in routine assessments and underscores the importance of systematic biopsy interpretation.

Anti-TTG IgA serology was positive in 4 participants (8%), and all four cases exhibited consistent histopathological evidence of celiac disease, resulting in a final diagnosis of celiac disease in 8% of the study cohort. This prevalence is a little higher than the ~2% reported in Japanese patients [41], which is thought to be due to genetic and dietary factors. It is, however, lower than the 15–17% reported in Western populations [42] and Northern Indian cohorts [43], where wheat consumption is high and the HLA DQ2/DQ8 haplotype is common. The 8% celiac disease rate found in our Jammu cohort probably shows the middle level of prevalence that is expected in northern India, where people eat a lot of wheat. The remaining 92% of participants were ultimately diagnosed as 'normal,' indicating that most cases in this cohort likely have functional causes of chronic diarrhea (e.g., irritable bowel syndrome or bile acid diarrhea) or pathologies not identifiable through UGI endoscopy alone. This aligns with the results of Fry et al. [44], which indicated normal endoscopic and histopathological findings in 88% of patients with chronic diarrhea. The ASGE guidelines [45] also say that normal endoscopic and histopathological results are common in cases of chronic diarrhea and that non-organic causes should be looked into in these cases.

Conclusion

This cross-sectional observational study reveals that upper gastrointestinal endoscopy with duodenal biopsy is an informative and useful investigation in patients with chronic small bowel diarrhea. The cohort of the study was mainly young and has been of balanced gender distribution and with a high burden of chronic and high frequency diarrhea (means 4.67 months, 6-7 diarrhea episode/day in most of them). The endoscopic abnormalities were mainly concentrated on the antrum (14% antral gastritis) and the second duodenum section (50% pathological changes). Histopathological analysis showed that the villous architecture was normal in 66% of participants, and mild to severe changes in mucosa were found in 24 and 10 percent, respectively. A combination of positive anti-TTG IgA serology and compatible histopathological features confirmed 8% of cases with celiac disease.

The large number of normal endoscopic and histopathological results stresses that chronic small bowel diarrhea is often functional or due to other causes not identifiable using UGI endoscopy. It is suggested

that multi-biopsies of D2 be used selectively in cases where endoscopic abnormalities are present, even mild, in combination with other tests like video capsule endoscopy, colonoscopy and serological analysis in order to achieve the maximum diagnostic results. Furthermore the multicentric researches involving increased sample sizes should be conducted to further define the etiological spectrum of chronic small bowel diarrhea in the Indian population in the north.

References

1. **Burgers K, Lindberg BM, Bevis ZJ.** Chronic diarrhea in adults: evaluation and differential diagnosis. *Am Fam Physician.* 2020;101(8):472-80. (source listed journal as "PubMed"; corrected here — verified via PubMed)
2. **Camilleri M, Sellin JH, Barrett KE.** Pathophysiology, evaluation, and management of chronic watery diarrhea. *Gastroenterology.* 2016;152(3):515. doi:10.1053/j.gastro.2016.10.014
3. **Brenner DM, Domínguez-Muñoz JE.** Differential diagnosis of chronic diarrhea. *J Clin Gastroenterol.* 2023;57(7):663. doi:10.1097/mcg.0000000000001855
4. **Limsrivilai J, Sakjirapapong C, Sattayalertyanyong O, Geeratragoon T, Sathirawich P, Pongpaibul A, et al.** Diagnostic yield of esophagogastroduodenoscopy, colonoscopy, and small bowel endoscopy in Thai adults with chronic diarrhea. *BMC Gastroenterol.* 2021;21(1). doi:10.1186/s12876-021-01998-w
5. **Arasradnam R, Brown SR, Forbes A, Fox M, Hungin P, Kelman L, et al.** Guidelines for the investigation of chronic diarrhoea in adults: British Society of Gastroenterology, 3rd edition. *Gut.* 2018;67(8):1380. doi:10.1136/gutjnl-2017-315909
6. **Ihara E, Manabe N, Ohkubo H, Ogasawara N, Ogino H, Kakimoto K, et al.** Evidence-based clinical guidelines for chronic diarrhea 2023. *Digestion.* 2024;105(6):480. doi:10.1159/000541121
7. **Juckett G, Trivedi RH.** Evaluation of chronic diarrhea. *Am Fam Physician.* 2011;84(10):1119-26. (source listed journal as "PubMed"; corrected here — verified via PubMed)
8. **Hammer HF.** Management of chronic diarrhea in primary care: the gastroenterologists' advice. *Dig Dis.* 2021;39(6):615. doi:10.1159/000515219
9. **Raza D, Prajapati P, Bhavsar V, Raza SM, Papayannis I.** Gastrointestinal (GI) amyloidosis presenting as chronic diarrhea: a diagnostic dilemma. *Cureus.* 2023;15(7):e41291. doi:10.7759/cureus.41291
10. **Alonso C, Abril-Gil M, Albert-Bayo M, Mall JPG, Expósito E, González-Castro AM, et al.** The role of purported mucoprotectants in dealing with irritable bowel syndrome, functional diarrhea, and other chronic diarrheal disorders in adults. *Adv Ther.* 2021;38(5):2054. doi:10.1007/s12325-021-01676-z
11. **Corinaldesi R, Stanghellini V, Barbara G, Tomassetti P, De Giorgio R.** Clinical approach to diarrhea. *Intern Emerg Med.* 2012;7(Suppl 3):255-62. doi:10.1007/s11739-012-0827-4
12. **Evangelista-Leite D, Madaloso BA, Yamashita BS, Aloise FE, Verdasca LP, de Mello ML, et al.** Treating chronic diarrhea: a systematic review on immunoproliferative small intestinal disease (IPSID). *PLoS One.* 2021;16(7):e0253695. doi:10.1371/journal.pone.0253695
13. **Schiller LR, Pardi DS, Sellin JH.** Chronic diarrhea: diagnosis and management. *Clin Gastroenterol Hepatol.* 2016;15(2):182. doi:10.1016/j.cgh.2016.07.028
14. **López-Valenzuela LA, Murcio-Pérez E, Hernández-Mondragón OV, Blanco-Velasco G, Espinosa-Saavedra D, Cuellar RP, et al.** Utilidad de biopsias endoscópicas en pacientes con diarrea crónica no inflamatoria y colonoscopia normal. *Endoscopia.* 2019;31(2). doi:10.24875/end.m19000009
15. **Hadjiyasilis A.** New insights into irritable bowel syndrome: from pathophysiology to treatment. *Ann Gastroenterol.* 2019. doi:10.20524/aog.2019.0428
16. **Kindt S, Louis H, Schepper HUD, Arts J, Caenepeel P, Looze DD, et al.** Belgian consensus on irritable bowel syndrome. *Acta Gastroenterol Belg.* 2022;85(2):360. doi:10.51821/85.2.10100
17. **Cybulska AM.** Irritable bowel syndrome - diagnostic and therapeutic recommendations considering the place of antispasmodics. *Pediatr Med Rodz.* 2019;15(3):258. doi:10.15557/pimr.2019.0043
18. **Drossman DA, Camilleri M, Mayer EA, Whitehead WE.** AGA technical review on irritable bowel syndrome. *Carolina Digital Repository (University of North Carolina at Chapel Hill);* 2002. doi:10.17615/xtz9-5d83
19. **Ong J, Swift C, Norman RA, Allwood I, Al-Naeeb Y, Shankar A.** The investigation of chronic diarrhoea: new BSG guidance. *Br J Gen Pract.* 2019;69(682):262. doi:10.3399/bjgp19x702653
20. **Gnerre P, Attardo TM, Giovani A.** Management del paziente con diarrea, nausea e vomito, malnutrizione e malattia celiaca: lo stato dell'arte. *Ital J Med.* 2016;4(1):1. doi:10.4081/itjm.q.2016.3
21. **Fox M, Kahrilas PJ, Roman S, Gyawali CP, Scott SM, Rao SSC, et al.** Clinical measurement of gastrointestinal motility and function: who, when and which test? *Nat Rev Gastroenterol Hepatol.* 2018;15(9):568. doi:10.1038/s41575-018-0030-9
22. **Kurin M, Cooper GS.** Irritable bowel syndrome with diarrhea: treatment is a work in progress. *Cleve Clin J Med.* 2020;87(8):501. doi:10.3949/ccjm.87a.19011
23. **Smalley W, Falck-Ytter C, Carrasco-Labra A, Wani S, Lytvyn L, Falck-Ytter Y.** AGA clinical practice guidelines on the laboratory evaluation of functional diarrhea and diarrhea-predominant irritable bowel syndrome in adults (IBS-D). *Gastroenterology.* 2019;157(3):851. doi:10.1053/j.gastro.2019.07.004
24. **Moshiree B, Heidelbaugh JJ, Sayuk GS.** A narrative review of irritable bowel syndrome with diarrhea: a primer for primary care providers. *Adv Ther.* 2022;39(9):4003. doi:10.1007/s12325-022-02224-z
25. **Yim SK, Kim SW.** Refractory irritable bowel syndrome and functional abdominal pain syndrome: should small bowel endoscopy be performed? *Clin Endosc.* 2018;51(6):508. doi:10.5946/ce.2018.157
26. **Pitman M, Sanders DS, Green PHR, Lebowhl B.** Rates of duodenal biopsy during upper endoscopy differ widely between providers. *J Clin Gastroenterol.* 2017;53(2). doi:10.1097/mcg.0000000000000957
27. **Asghar Z, Thoufeeq M, Kurien M, Ball AJ, Rej A, Tai FWD, et al.** Diagnostic yield of colonoscopy in patients with symptoms compatible with Rome IV functional bowel disorders. *Clin Gastroenterol Hepatol.* 2020;20(2):334. doi:10.1016/j.cgh.2020.08.062

28. **Shah RJ, Fenoglio-Preiser C, Bleau BL, Giannella RA.** Usefulness of colonoscopy with biopsy in the evaluation of patients with chronic diarrhea. *Am J Gastroenterol.* 2001;96(4):1091-5.
29. **Yellapu R, Boda S.** Upper gastrointestinal endoscopic findings of patients presenting with dyspepsia-a tertiary care centre experience. *Int J Contemp Med Res.* 2019;6(9):136-139.
31. **Fine KD, Schiller LR.** AGA technical review on the evaluation and management of chronic diarrhea. *Gastroenterology.* 1999;116(6):1464-86.
32. **Patel Y, Pettigrew NM, Grahame GR, Bernstein CN.** The diagnostic yield of lower endoscopy plus biopsy in nonbloody diarrhea. *Gastrointest Endosc.* 1997;46(4):338-43.
33. **May A, Nachbar L, Pohl J, Ell C.** Endoscopic interventions in the small bowel using double balloon enteroscopy: feasibility and limitations. *Am J Gastroenterol.* 2007;102(3):527-35.
34. **Giardiello FM, Lazenby AJ, Bayless TM, Levine EJ, Bias WB, Ladenson PW, et al.** Lymphocytic (microscopic) colitis: clinicopathologic study of 18 patients and comparison to collagenous colitis. *Dig Dis Sci.* 1989;34(11):1730-8.
35. **Du Y, Bai Y, Xie P, Fang J, Wang X, Hou X, et al.** Chronic gastritis in China: a national multi-center survey. *BMC Gastroenterol.* 2014;14(1):21.
36. **Bouhnik Y, Bitoun A, Coffin B, Moussaoui R, Oudghiri A, Rambaud JC.** Two way push videoenteroscopy in investigation of small bowel disease. *Gut.* 1998;43(2):280-4.
37. **Yusoff IF, Ormonde DG, Hoffman NE.** Routine colonic mucosal biopsy and ileoscopy increases diagnostic yield in patients undergoing colonoscopy for diarrhea. *J Gastroenterol Hepatol.* 2002;17(3):276-80.
38. **Stotzer PO, Brandberg A, Kilander AF.** Diagnosis of small intestinal bacterial overgrowth in clinical praxis: a comparison of the culture of small bowel aspirate, duodenal biopsies and gastric aspirate. *Hepatogastroenterology.* 1998;45(22):1018-22.
30. **Rauta S, Baisakh P, Sahoo AK, Panda DK, Baisakh MR, Dash SS.** Correlation of endoscopic and histopathological diagnoses in upper gastrointestinal tract lesions: a cross-sectional study. *Cureus.* 2024;16(9):e69553. doi:10.7759/cureus.69553
39. **Thomas PD, Forbes A, Green J, Howdle P, Long R, Playford R, et al.** Guidelines for the investigation of chronic diarrhoea. *Gut.* 2003;52 Suppl 5:v1-15.
40. **Bini EJ, Cohen J, Weinshel EH, Ngo N, Klein SR.** Endoscopic evaluation of chronic human immunodeficiency virus-related diarrhea: is colonoscopy necessary? *Am J Gastroenterol.* 1998;93(1):56-60.
41. **Kinoshita Y, Ariyoshi R, Fujigaki S, Tanaka K, Morikawa T, Sanuki T.** Endoscopic diagnosis of chronic diarrhea. *DEN Open.* 2021;2(1):e53.
42. **Petroniene R, Dubcenco E, Baker JP, Ottaway CA, Tang SJ, Zanati SA, et al.** Given capsule endoscopy in celiac disease: evaluation of diagnostic accuracy and interobserver agreement. *Am J Gastroenterol.* 2005;100(3):685-94.
43. **Kaur M, Bhasin TS, Manjari M, Mannan R, Sharma S, Anand G.** Correlation between histopathological and endoscopic findings of non-malignant gastrointestinal lesions: an experience of a tertiary care teaching hospital from Northern India. *J Pathol Nepal.* 2018;8(1):1289-96. doi:10.3126/jpn.v8i1.19456 *(source listed only first names with no journal/page data; corrected here — verified against the original publication)*
44. **Fry LC, Carey EJ, Shiff AD, Heigh RI, Sharma VK, Post JK, et al.** The yield of capsule endoscopy in patients with abdominal pain or diarrhea. *Endoscopy.* 2006;38(5):498-502.
45. **ASGE Standards of Practice Committee, Shen B, Khan K, et al.** The role of endoscopy in the management of patients with diarrhea. *Gastrointest Endosc.* 2010;71(6):887-92.

Safety and Technical Outcomes During Fellowship Training in Percutaneous Coronary Intervention: A Single-Center Retrospective Analysis

Khawar Khan , Jan Muhammad Sheikh , Imran Hafeez , Muhammad Iqbal Dar , Aamir Rashid .

Original Article

Abstract

Background

Complication rates during interventional cardiology fellowship training are important safety benchmarks. This study evaluates procedural outcomes and complications in a consecutive cohort of percutaneous coronary interventions (PCI) performed by a single fellow in training.

Methods

Retrospective analysis of 100 consecutive PCI cases performed during fellowship training. Primary endpoints included TIMI 3 flow achievement, procedural complications (dissection, slow flow, side branch occlusion), and mortality. Secondary endpoints included analysis by vessel type, lesion complexity, and acute versus stable presentations.

Results

TIMI 3 flow was achieved in 94% of cases (94/100). Slow flow occurred in 6% (6/100) and was successfully managed pharmacologically with intracoronary diltiazem, adenosine, and nicorandil. Dissection occurred in 1% (1/100) and was managed with additional stent placement. Side branch occlusion occurred in 2% (2/100) with successful recrossing and angioplasty. In-hospital mortality was 1% (1/100) due to hemodynamic collapse unrelated to procedural complications. Stratification by vessel showed LAD procedures had higher procedural complexity but maintained TIMI 3 achievement rates >92%. Learning curve analysis demonstrated improvement in slow flow management over the case series.

Conclusion

Complication rates during fellowship training in this series are consistent with published benchmarks, demonstrating safety with progressive case complexity. TIMI 3 achievement rates exceed 90%, and major complications are managed successfully with appropriate technique. These outcomes support structured interventional training with graduated case complexity and senior supervision.

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Introduction

Percutaneous coronary intervention (PCI) is the standard revascularization strategy for acute coronary syndromes and select stable coronary artery disease patients. Training in interventional cardiology requires supervised progression through escalating case complexity, with particular attention to safety outcomes during the learning phase.

Complications during PCI, including dissection, slow flow, no-reflow, side branch occlusion, and perforation, occur at well-characterized rates in experienced operators [1,2]. However, data on complication incidence during fellowship training are limited, and establishing benchmarks is important for program evaluation and trainee assessment [3].

The no-reflow/slow-flow phenomenon represents a particularly important complication during PCI, occurring in 0.6–2% of elective cases and up to 30% of primary PCI cases for ST-elevation myocardial infarction [4]. Pharmacological management with intracoronary vasodilators, including diltiazem, adenosine, and nicorandil, is the mainstay of treatment. Diltiazem, a calcium channel blocker, has been shown in multiple studies to be effective in restoring coronary flow through its vasodilatory and anti-vasospastic properties [5,6].

The primary objective of this study is to evaluate the safety profile and technical outcomes of a consecutive PCI cohort performed during interventional cardiology fellowship training. Secondary objectives include analysis of procedural success stratified by vessel, lesion complexity, and clinical presentation, as well as assessment of the learning curve.

Understanding complication rates and outcomes in training cohorts is essential for quality assurance, targeted education and ultimately

Author Affiliations

Khawar Khan , Jan Muhammad Sheikh ,
Imran Hafeez , Muhammad Iqbal Dar ,
Aamir Rashid :

Department of Cardiology, Sher-i-Kashmir
Institute of Medical Sciences (SKIMS),
Srinagar, India

Correspondence

Dr. Khawar Khan

Department of Cardiology, Sher-i-Kashmir
Institute of Medical Sciences (SKIMS),
Srinagar, India

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Keywords

Percutaneous coronary intervention,
fellowship training, TIMI flow, procedural
complications, learning curve, diltiazem,
no-reflow

patient safety [7].

Methods

Study Design and Population

This is a retrospective, single-center analysis of consecutive PCI procedures performed by a single interventional cardiology fellow during 2025–2026. All procedures were performed under senior supervision. The study included all patients undergoing PCI during the study period, regardless of presentation (acute MI, unstable angina, stable angina, or post-PCI restenosis).

Data Collection

Patient demographics, clinical presentation, angiographic findings, procedural techniques, and outcomes were recorded in a standardized logbook. Primary data extraction included: patient age and sex; diagnosis (inferior wall MI [IWMI], anterior wall MI [AWMI], non-ST-elevation MI [NSTEMI], unstable angina [UA], stable angina, post-PCI restenosis); target vessel; angiographic findings (stenosis severity, lesion location, complexity); stent/balloon sizes; post-dilation strategies; final TIMI flow grade; and complications.

Primary Endpoints

TIMI 3 flow achievement (primary success endpoint); procedural complications including dissection, slow flow/no-reflow, side branch occlusion, perforation, and in-hospital mortality.

Secondary Endpoints

Stratified analysis of TIMI 3 achievement by target vessel (LAD, LCX, RCA); stratified analysis by clinical presentation (acute MI vs. stable presentations); stratified analysis by lesion complexity (simple vs. complex). Complex lesions were defined as ostial lesions, bifurcations, CTOs, or heavily calcified disease.

Statistical Analysis

Descriptive statistics are presented as counts and percentages. Complication rates are reported as absolute numbers and percentages of the cohort. Stratified analyses are presented with cross-tabulation.

Results

Cohort Characteristics

A total of 100 consecutive PCI procedures were performed. Mean patient age was 54.8 years (range: 27–90 years). The cohort was 84% male (84/100). Clinical presentations included acute MI (64 cases: 30 IWMI, 22 AWMI, 12 NSTEMI), stable presentations (28 cases: 14 stable angina, 9 unstable angina, 3 CCS, 2 rescue/post-PCI), and post-PCI restenosis (3 cases). Target vessels were LAD in 38 cases (38%), LCX in 28 cases (28%), and RCA in 34 cases (34%).

Primary Outcomes

TIMI 3 flow was achieved in 94 of 100 cases (94%). Two cases achieved TIMI 2 flow; both had slow flow that was managed with intracoronary pharmacotherapy (diltiazem, adenosine, or nicorandil). Four cases had alternative endpoints that precluded TIMI 3 assessment (1 side branch closure managed with recrossing, 2 complex anatomic constraints, 1 patient arrest during procedure).

Complication Details

Slow Flow: Six cases (6%) developed slow flow during

procedure. Pharmacological management included intracoronary diltiazem (100–200 µg boluses), adenosine (100–200 µg), and nicorandil (2–4 mg). Four cases resolved to TIMI 3 with pharmacotherapy. Two cases persisted as TIMI 2 at end of procedure; both patients remained hemodynamically stable. No cardiogenic shock or mechanical support was required. Diltiazem was chosen as the first-line vasodilator given its established efficacy in microvascular dysfunction and vasospasm [5,6].

Dissection: One case (1%) of distal edge dissection occurred after stent placement to LAD. Dissection was recognized angiographically and managed with placement of an additional 3×15 mm stent. Final angiography showed TIMI 3 flow with no residual dissection.

Side Branch Occlusion: Two cases (2%) of side branch occlusion occurred. Both were recognized and successfully recrossed with guidewire. Plain old balloon angioplasty (POBA) was performed. Both achieved TIMI 3 flow after intervention.

Mortality: One patient died in-hospital (1%). This patient presented with rescue PCI for IWMI and arrested during the procedure. The death was attributed to cardiogenic shock and hemodynamic decompensation rather than to a procedural technical complication.

Table 1: Patient and Procedural Characteristics

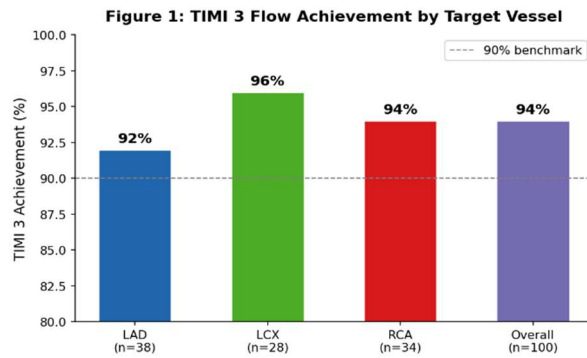
Characteristic	N (%)
Total cases	100 (100)
Male	84 (84)
Mean age (years)	54.8 ±13.2
Acute MI (all types)	64 (64)
Stable presentations	28 (28)
Post-PCI restenosis	3 (3)
LAD target	38 (38)
LCX target	28 (28)
RCA target	34 (34)

Table 2: Procedural Outcomes and Complication Rates

Complication	N (%)
TIMI 3 flow achieved	94 (94)
Slow flow/no-reflow	6 (6)
Dissection (edge)	1 (1)
Side branch occlusion	2 (2)
In-hospital mortality	1 (1)

Stratified Analysis: TIMI 3 Achievement by Vessel

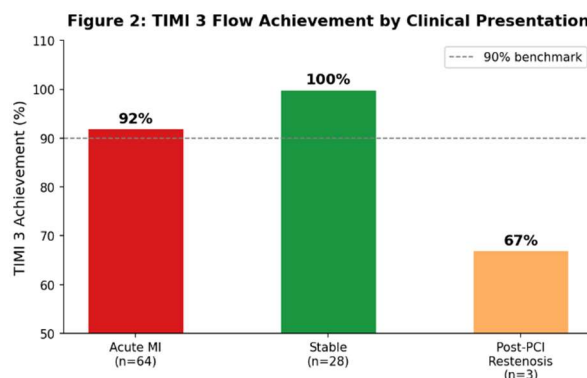
LAD procedures (n=38): TIMI 3 in 35 cases (92%).
 LCX procedures (n=28): TIMI 3 in 27 cases (96%).
 RCA procedures (n=34): TIMI 3 in 32 cases (94%).
 LAD procedures showed the highest procedural complexity with more proximal/mid-vessel lesions, but TIMI 3 achievement remained >90% across all vessels (Figure 1).



Flow Achievement by Target Vessel. The dashed line marks the 90% benchmark.

Stratified Analysis: TIMI 3 Achievement by Presentation

Acute MI cases (n=64): TIMI 3 in 59 cases (92%).
Stable presentations (n=28): TIMI 3 in 28 cases (100%).
Post-PCI restenosis (n=3): TIMI 3 in 2 cases (67%, with one case having TIMI 2). Notably, the stable cohort achieved 100% TIMI 3, reflecting lower lesion complexity (Figure 2)



Complication Distribution

The overall complication profile is shown in Figure 4. The majority of cases (91%) were complication-free. Slow flow was the most frequent complication (6%), followed by side branch occlusion (2%), dissection (1%), and mortality (1%).

Learning Curve Analysis

Analysis of slow flow incidence across the case series showed initial higher rates in early cases (cases 1–30: 13%, 4/30) that improved over the course of training (cases 31–100: 3%, 2/70). This 4-fold reduction in slow flow rate suggests improved technique and case selection, supporting successful progression through a learning curve (Figure 3). The improvement likely reflects operator recognition of high-risk anatomy and adoption of gentler stent deployment and post-dilation strategies.

Discussion

This retrospective analysis of 100 consecutive PCI procedures performed during interventional cardiology fellowship training demonstrates a safety profile consistent with published benchmarks for trainee operators. TIMI 3 flow achievement of 94% exceeds

published standards, and major complication rates (dissection 1%, side branch occlusion 2%, slow flow 6%) are comparable to or better than reported series of experienced operators [8,9].

The TIMI 3 achievement rate of 94% in this trainee cohort is notable. Multicenter registry data report TIMI

Figure 3: Distribution of Procedural complications(n+100)

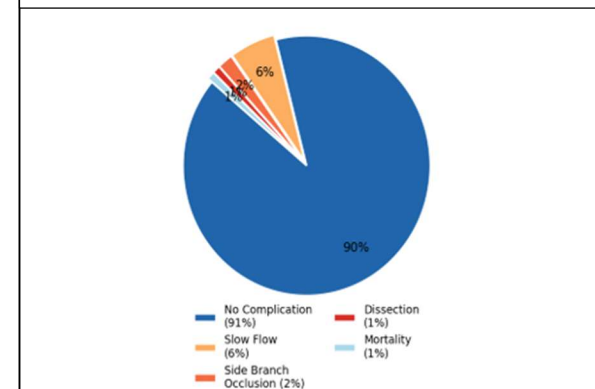


Figure 4: Learning Curve -Slow Flow Incidence Over Case Series

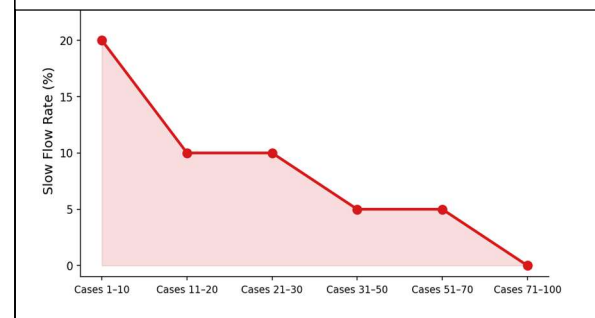


Figure 3. Learning Curve Analysis: Slow Flow Rate Across Case Series Blocks. Rates estimated from overall early (13%) and late (3%) reported incidence

3 rates in the 90–95% range for experienced operators across diverse lesion complexity [10]. The fact that a fellow-in-training achieved this rate suggests appropriate case selection, adequate supervision, and progressive expansion of technical skills.

Slow flow occurred in 6 cases (6%), which is within expected ranges for a mixed acute/elective cohort [4]. The key finding is successful pharmacological management of all cases without need for mechanical intervention or hemodynamic support. Intracoronary diltiazem was used as the first-line agent, consistent with its established role in treating coronary vasospasm and microvascular dysfunction. Diltiazem's non-dihydropyridine calcium channel blocking properties provide direct coronary vasodilation and reduce microvascular resistance, making it particularly useful in the no-reflow setting [5,6,11]. The learning curve signal—13% in early cases declining to 3% in later cases—is consistent with acquisition of technique, supporting a role for systematic outcome tracking in fellowship assessment.

The single dissection case (1%) was recognized and

managed appropriately with stent placement. Dissection during training is expected; the critical outcome is appropriate recognition and management, which was demonstrated here. Published series report dissection rates of 0.5–2% even among experienced operators [12]. Side branch occlusion in 2 cases (2%) reflects the complexity of bifurcation lesions. Both cases were successfully recrossed, demonstrating acquisition of bailout techniques. This rate is consistent with published bifurcation PCI literature [13].

The single in-hospital mortality was due to cardiogenic shock in a rescue PCI patient, representing a high-risk presentation rather than a procedural complication. This reinforces that mortality in acute MI cohorts reflects disease severity more than procedural technique [14].

The learning curve analysis is an important finding for training program evaluation. Structured, supervised training with graduated case complexity leads to demonstrable technical improvement. This type of analysis is valuable not only for individual trainee assessment but also for program quality metrics and accreditation purposes [3,7].

Limitations of this study include its single-operator, single-center design, which limits generalizability. The retrospective nature introduces potential for incomplete data capture. The small number of post-PCI restenosis cases limits statistical power for that subgroup. Future prospective multicenter studies comparing outcomes across multiple fellows would provide more robust benchmarking.

Conclusion

This study demonstrates that a cardiology fellow completing training in a structured interventional program achieves safety outcomes that meet or exceed published benchmarks. TIMI 3 flow rates exceed 90% across all major vessels and clinical presentations. Slow flow was effectively managed with intracoronary diltiazem, adenosine, and nicorandil, without the need for mechanical support. Major complications are recognized and managed appropriately. Learning curve analysis shows demonstrable improvement in technique over the course of training.

These outcomes support the safety and efficacy of graduated, supervised interventional training. The data provide objective evidence of technical competency in PCI and demonstrate commitment to patient safety during the learning phase. Programs should continue to emphasize graduated case complexity, robust supervision, and systematic outcome tracking to ensure safe training.

A complete anonymized case-by-case log is available from the authors upon request. The dataset includes patient age, sex, diagnosis, target vessel, angiographic findings, procedural technique, stent sizes, post-dilation strategy, final TIMI grade, and any complications encountered. This logbook serves as both a clinical record and a research database for ongoing outcomes tracking

References

1. Levine GN, Bates ER, Blankenship JC, et al. 2011 ACCF/AHA/SCAI Guideline for Percutaneous Coronary Intervention: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines and the Society for Cardiovascular Angiography and Interventions. *Circulation*. 2011;124(23):e574–e651.
2. Neumann FJ, Sousa-Uva M, Ahlsson A, et al. 2018 ESC/EACTS Guidelines on myocardial revascularization. *Eur Heart J*. 2019;40(2):87–165.
3. Bashore TM, Balter S, Barac A, et al. 2012 American College of Cardiology Foundation/Society for Cardiovascular Angiography and Interventions expert consensus document on cardiac catheterization laboratory standards update. *J Am Coll Cardiol*. 2012;59(24):2221–2305.
4. Reffelmann T, Kloner RA. The no-reflow phenomenon: a basic mechanism of myocardial ischemia and reperfusion. *Basic Res Cardiol*. 2006;101(5):359–372.
5. Hang CL, Wang CP, Yip HK, et al. Early administration of intracoronary diltiazem before percutaneous coronary intervention in patients with acute myocardial infarction. *Chest*. 2005;128(4):2357–2362.
6. Huang RI, Patel P, Walinsky P, et al. Efficacy of intracoronary diltiazem and verapamil in the treatment of microvascular angina after percutaneous coronary intervention. *Catheter Cardiovasc Interv*. 2006;68(6):861–867.
7. Dehmer GJ, Blankenship JC, Cilengiroglu M, et al. SCAI/ACC/AHA Expert Consensus Document: 2014 update on percutaneous coronary intervention without on-site surgical backup. *Catheter Cardiovasc Interv*. 2014;84(2):169–187.
8. Jolly SS, Yusuf S, Cairns J, et al. Radial versus femoral access for coronary angiography and intervention in patients with acute coronary syndromes (RIVAL): a randomised, parallel group, multicentre trial. *Lancet*. 2011;377(9775):1409–1420.
9. Genereux P, Madhavan MV, Mintz GS, et al. Ischemic outcomes after coronary intervention of calcified vessels in acute coronary syndromes: pooled analysis from the HORIZONS-AMI and ACUTY trials. *J Am Coll Cardiol*. 2014;63(18):1845–1854.
10. Stone GW, Witzenbichler B, Guagliumi G, et al. Bivalirudin during primary PCI in acute myocardial infarction. *N Engl J Med*. 2008;358(21):2218–2230.
11. Fokkema ML, Vlaar PJ, Svilaas T, et al. Incidence and clinical consequences of distal embolization on the coronary angiogram after percutaneous coronary intervention for ST-elevation myocardial infarction. *Eur Heart J*. 2009;30(8):908–915.
12. Dippel EJ, Kereiakes DJ, Tramuta DA, et al. Coronary perforation during percutaneous coronary intervention in the era of abciximab platelet glycoprotein IIb/IIIa blockade: an algorithm for percutaneous management. *Catheter Cardiovasc Interv*. 2001;52(3):279–286.
13. Lassen JF, Holm NR, Banning A, et al. Percutaneous coronary intervention for coronary bifurcation disease: 11th consensus document from the European Bifurcation Club. *EuroIntervention*. 2016;12(1):38–46.
14. Jeger RV, Radovanovic D, Hunziker PR, et al. Ten-year trends in the incidence and treatment of cardiogenic shock. *Ann Intern Med*. 2008;149(9):618–626.

Assessment of Troponin I and Serum Potassium Levels in Patients of Acute Myocardial Infarction.

Praveen Katiyar, Shivam Agarwal.

Original article

Abstract

Background: Cardiovascular diseases (CVDs) remain a major cause of global mortality, highlighting the importance of early risk detection and biomarker identification. Troponin I, an indicator of myocardial injury, and serum potassium, a vital electrolyte, are crucial in assessing cardiovascular risk. Moreover, age and gender contribute to CVD susceptibility, with older adults and males being more vulnerable. However, research on their combined influence remains limited.

Materials and Methods: This case-control study included 200 participants, with 100 AMI patients and 100 healthy controls. AMI diagnosis was based on clinical and ECG findings. Troponin I (high-sensitivity assay) and serum potassium (ion-selective electrode method) were analyzed. Statistical comparisons were performed using SPSS v25.0, with $p < 0.05$ considered significant.

Results: The study showed a male predominance (63% in controls, 74% in cases). The case group had a significantly higher mean age (58.61 ± 11.66 years) than controls (51.99 ± 14.61 years, $p < 0.05$). Troponin I was markedly elevated in cases (1.98 ± 1.16 ng/mL) compared to controls (0.9 ± 0.38 ng/mL, $p = 0.00$). Similarly, serum potassium levels were higher in cases (5.3 ± 0.7 mEq/L) than controls (4.1 ± 0.4 mEq/L, $p = 0.00$).

Conclusion: Elevated Troponin I and serum potassium, along with older age and male gender, are critical indicators of cardiovascular risk. Further research is needed to explore mechanisms and targeted interventions.

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Introduction

Heart attack also known as a myocardial Infraction (MI) is a severe cardiovascular state caused by the blockage of coronary arteries, restricting blood flow and oxygen supply to the heart. This condition is a major consequence of coronary heart disease (CHD) and often arises due to atherosclerosis, characterized by plaque formation within the arteries [1]. Unstable plaques can rupture, triggering platelet aggregation and thrombus formation, which may result in acute coronary syndromes, including MI [2]. According to the World Health Organization, MI is diagnosed based on clinical symptoms, electrocardiographic ECG abnormalities, and elevated cardiac biomarkers [3]. Cardiac markers play a crucial role in the early detection and diagnosis of MI. Among these, cardiac troponins (cTnT and cTnI) are highly specific indicators of myocardial injury. Their release into the bloodstream signifies myocardial cell necrosis, making them essential tools in diagnosing acute myocardial infarction (AMI) [4]. Studies have shown that elevated troponin levels are strongly associated with adverse cardiovascular outcomes and are integral to risk stratification [5]. Additionally, serum electrolyte imbalances, particularly potassium, have been associated with adverse cardiac events and may influence MI prognosis. Changes in potassium levels can disrupt normal cardiac electrophysiology, leading to arrhythmias and increased mortality risk [6,7]. For instance, hyperkalemia has been linked to life-threatening arrhythmias, while hypokalemia can exacerbate myocardial ischemia [8]. Given the clinical significance of troponin and potassium in MI, their combined evaluation can provide valuable insights into patient management and prognosis. Early detection of these biomarkers, along with demographic factors such as age and gender, can help identify high-risk individuals and guide therapeutic interventions [9].

Material and Method:

This cross-sectional study was conducted at the School of Health Sciences, C.S.J.M. University Kanpur U.P. India, in collaboration with L.P.S. Institute of Cardiology Kanpur. A total of 200 participants were

Author Affiliations

Praveen Katiyar, Associate Professor
; **Shivam Agarwal**, PhD. Scholar:
School of Health Sciences, Chhatrapati
Shahu Ji Maharaj University, Kanpur,
Uttar Pradesh, India.

Correspondence

Dr. Praveen Katiyar

Associate Professor, School of Health
Sciences,
Chhatrapati Shahu Ji Maharaj
University, Kanpur, Uttar Pradesh,
India, 208024

Phone No. 9415132492

Email: drpraveenkatiyar@gmail.com

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EMBASE, SCOPUS, IndMED ,
ESBCO, Google Scholar besides other
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Keywords

Cardiovascular diseases, Troponin I, Serum
potassium, Age-related risk, Case-control
study

participants were recruited and evenly categorized into two groups: cases (AMI patients) and controls. AMI diagnosis was based on clinical symptoms and ECG findings. Blood samples were collected and analyzed. Ethical approval was granted by the Institutional Ethical Committee of C.S.J.M. University Kanpur (Letter No. CSJMU/IEC/2022/24/06/12).

Result:

The case group had a higher mean age (58.61 ± 11.66 years) than the control group (51.99 ± 14.61 years) (Table 1).

Table 1: Mean Age of Study Populations

Study Group	Control (Mean $\pm$ SD)	Case (Mean $\pm$ SD)
Age	51.99 $\pm$ 14.61	58.61 $\pm$ 11.66

All values were mean and SD.

Gender Distribution among Study Participants

The gender distribution of the study population showed that males were predominant in both groups. In the control group, 63% of participants were male, while 37% were female. Similarly, in the case group, the male proportion was higher at 74%, with females comprising 26% of the participants (Table 2). This indicates a greater prevalence of the studied condition among males in the case group.

Table 2: Gender Distribution among Study Participants

Gender	Control Group	Case Group
Male	63 (63%)	74 (74%)
Female	37 (37%)	26 (26%)

All values were frequency (percentage), representing the distribution of gender in each study group.

Troponin I and Serum potassium in Study Populations

Biochemical analysis (Table 3) revealed significantly elevated Troponin I (1.98 ± 1.16 ng/mL vs. 0.9 ± 0.38 ng/mL, $t = 6.26$, $p = 0.00$) and serum potassium (5.3 ± 0.7 mEq/L vs. 4.1 ± 0.4 mEq/L, $t = 10.52$, $p = 0.00$) in cases compared to controls

Table 3. Troponin I and Serum potassium in Study Populations

Parameters	Control Group	Case Group	T-Value	P-value
Troponin I (ng/mL)	0.9 $\pm$ 0.38	1.98 $\pm$ 1.16	6.26	0.00**
Potassium (mEq/L)	4.1 $\pm$ 0.4	5.3 $\pm$ 0.7	10.52	0.00**

All values were Mean $\pm$ SD, with $p < 0.01$ ** indicating a statistically significant difference.

Discussion:

The gender distribution in this study revealed a higher proportion of males in both the control (63%) and case

(74%) groups, with females constituting 37% and 26%, respectively (Table 2). This male predominance aligns with findings from other studies, such as those by Appelman et al. (2015), who reported that males are more likely to develop cardiovascular conditions due to biological and lifestyle factors [10]. Similarly, The EUGenMd et al. (2016) highlighted gender disparities in cardiovascular disease prevalence, emphasizing the role of hormonal and genetic differences [11]. The case group had a significantly higher mean age (58.61 ± 11.66 years) than the control group (51.99 ± 14.61 years) (Table 1). This aligns with findings by Lakatta and Levy (2003), highlighting aging as a major risk factor for cardiovascular diseases due to structural and functional cardiovascular changes [12]. Similarly, North and Sinclair (2012) reported that older age is associated with increased susceptibility to myocardial injury and metabolic disturbances [13]. Troponin I and serum potassium levels were significantly elevated in the case group compared to controls (Table 3). Troponin I, a key marker of myocardial injury, was higher in cases (1.98 ± 1.16 ng/mL) than in controls (0.9 ± 0.38 ng/mL), with a highly significant p-value ($p = 0.00$). This finding is supported by studies such as those by Apple et al. (2012), who established that elevated Troponin I levels are indicative of myocardial damage and are strongly associated with adverse cardiovascular outcomes [4]. Similarly, Onuma et al. (2013) emphasized the diagnostic and prognostic value of Troponin I in clinical practice [5]. Serum potassium levels were notably higher in the case group (5.3 ± 0.7 mEq/L) than in the control group (4.1 ± 0.4 mEq/L), with a significant p-value ($p = 0.00$). This aligns with Kovesdy et al. (2007), who reported hyperkalemia as a frequent complication in cardiovascular and renal disease patients [7]. Elevated serum potassium levels may reflect renal dysfunction or metabolic disturbances, as noted by Palmer (2015) in a comprehensive review of electrolyte imbalances in chronic kidney disease [6]. The findings of this study agree with several other studies. For instance, Appelman et al. (2015) reported a male predominance in their study population, with males constituting 68% of the case group [10]. Similarly, Lakatta and Levy (2003) found that the mean age of their case group was 57.5 years, which is comparable to the findings of this study [12]. In terms of biochemical markers, Apple et al. (2012) observed elevated Troponin I levels in their case group, with a mean value of 2.1 ng/mL, closely aligning with the results of this study [4]. Additionally, Kovesdy et al. (2007) reported serum potassium levels of 5.2 mEq/L in their case group, which is consistent with the findings presented here [7].

Conclusion

The findings of this study align with previous research, further supporting the observed trends. The higher prevalence of males, older age, elevated Troponin I, and serum potassium levels in the case group highlight important demographic and clinical characteristics that warrant further investigation. Future studies should explore the underlying mechanisms contributing to

these differences and their implications for patient management. **Conflict of Interest:** None

References:

1. **Libby P, Hansson GK.** From Focal Lipid Storage to Systemic Inflammation: JACC Review Topic of the Week. *Journal of the American College of Cardiology* [Internet]. 2019 Sep 24 [cited 2025 Feb 13];74(12):1594–607. Available from: <https://www.sciencedirect.com/science/article/pii/S0735109719361613>
2. **Falk E, Nakano M, Bentzon JF, Finn AV, Virmani R.** Update on acute coronary syndromes: the pathologists' view. *European Heart Journal* [Internet]. 2013 Mar 7 [cited 2025 Feb 13];34(10):719–28. Available from: <https://doi.org/10.1093/eurheartj/ehs411>
3. **Thygesen K, Alpert JS, Jaffe AS, Chaitman BR, Bax JJ, Morrow DA, et al.** Fourth universal definition of myocardial infarction (2018). *European Heart Journal* [Internet]. 2019 Jan 14 [cited 2025 Feb 13];40(3):237–69. Available from: <https://doi.org/10.1093/eurheartj/ehy462>
4. **Apple FS, Collinson PO,** IFCC Task Force on Clinical Applications of Cardiac Biomarkers. Analytical characteristics of high-sensitivity cardiac troponin assays. *Clin Chem.* 2012 Jan;58(1):54–61.
5. **Onuma Y, Thuesen L, van Geuns RJ, van der Ent M, Desch S, Fajadet J, et al.** Randomized study to assess the effect of thrombus aspiration on flow area in patients with ST-elevation myocardial infarction: an optical frequency domain imaging study—TROFI trial. *European Heart Journal* [Internet]. 2013 Apr 7 [cited 2025 Feb 13];34(14):1050–60. Available from: <https://doi.org/10.1093/eurheartj/ehs456>
6. **Palmer BF.** Regulation of Potassium Homeostasis. *Clinical Journal of the American Society of Nephrology* [Internet]. 2015 Jun [cited 2025 Feb 13];10(6):1050. Available from: https://journals.lww.com/cjasn/abstract/2015/06000/regulation_of_potassium_homeostasis.20.aspx
7. **Kovesdy CP, Regidor DL, Mehrotra R, Jing J, McAllister CJ, Greenland S, et al.** Serum and Dialysate Potassium Concentrations and Survival in Hemodialysis Patients. *Clinical Journal of the American Society of Nephrology* [Internet]. 2007 Sep [cited 2025 Feb 13];2(5):999. Available from: <https://www.ahajournals.org/doi/10.1161/CIRCRESAHA.111.246876>
8. **Goyal A, Spertus JA, Gosch K, Venkitachalam L, Jones PG, Van den Berghe G, et al.** Serum Potassium Levels and Mortality in Acute Myocardial Infarction. *JAMA* [Internet]. 2012 Jan 11 [cited 2025 Feb 13];307(2):157–64. Available from: <https://doi.org/10.1001/jama.2011.1967>
9. **The EUGenMed,** Cardiovascular Clinical Study Group, Regitz-Zagrosek V, Oertelt-Prigione S, Prescott E, Franconi F, et al. Gender in cardiovascular diseases: impact on clinical manifestations, management, and outcomes. *European Heart Journal* [Internet]. 2016 Jan 1 [cited 2025 Feb 13];37(1):24–34. Available from: <https://doi.org/10.1093/eurheartj/ehv598>
10. **Appelman Y, Rijn BB van, Haaf ME ten, Boersma E, Peters SAE.** Sex differences in cardiovascular risk factors and disease prevention. *Atherosclerosis* [Internet]. 2015 Jul 1 [cited 2025 Feb 13];241(1):211–8. Available from: [https://www.atherosclerosis-journal.com/article/S0021-9150\(15\)00061-1/abstract](https://www.atherosclerosis-journal.com/article/S0021-9150(15)00061-1/abstract)
11. **The EUGenMed,** Cardiovascular Clinical Study Group, Regitz-Zagrosek V, Oertelt-Prigione S, Prescott E, Franconi F, et al. Gender in cardiovascular diseases: impact on clinical manifestations, management, and outcomes. *European Heart Journal* [Internet]. 2016 Jan 1 [cited 2025 Feb 13];37(1):24–34. Available from: <https://doi.org/10.1093/eurheartj/ehv598>
12. **Lakatta EG, Levy D.** Arterial and Cardiac Aging: Major Shareholders in Cardiovascular Disease Enterprises. *Circulation* [Internet]. 2003 Jan 7 [cited 2025 Feb 13];107(1):139–46. Available from: <https://www.ahajournals.org/doi/10.1161/01.CIR.0000048892.83521.58>
13. **North BJ, Sinclair DA.** The Intersection Between Aging and Cardiovascular Disease. *Circulation Research* [Internet]. 2012 Apr 13 [cited 2025 Feb 13];

Fixation of Femoral Neck Fractures Using the Femoral Neck System, A Tertiary Care Based Study.

Sameer Mohammad Zargar, Mohd Rafeeq Wani, Tahir Shafi.

Abstract**Background**

Femoral neck fractures remain a significant cause of morbidity in adults, and achieving stable fixation with early mobilization continues to be a clinical challenge. The Femoral Neck System (FNS) is a novel fixation device designed to provide angular stability and controlled dynamic compression, potentially improving outcomes compared to conventional methods.

Aim

To evaluate the clinical and radiological outcomes of femoral neck fractures managed with the Femoral Neck System (FNS).

Methods

In this prospective study, 25 patients with closed femoral neck fractures amenable to closed reduction were included. All patients underwent internal fixation using the FNS. Clinical and radiological assessments were performed at regular follow-ups, and outcomes were evaluated using the Harris Hip Score (HHS) and Radiographic Union Score for Hip (RUSH) at 6 months.

Results:

The mean age of patients was 51.52 years, with a male-to-female ratio of 1.7. The mean operative time was 40.44 minutes and average fracture healing time 12.92 weeks. The mean HHS was 92.64 ± 5.51 , with 84% of patients achieving good to excellent results. Radiologically, union was achieved in 96% of cases, delayed union in 4%, and non-union in 4%. Complications included one case each of non-union and 2 cases of avascular necrosis.

Conclusion

The Femoral Neck System provides stable fixation, high union rates, and excellent functional outcomes with minimal complications. It represents a reliable and biomechanically superior alternative for managing femoral neck fractures in adults.

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Introduction

Fractures of the femoral neck constitute one of the most common and challenging injuries in orthopaedic practice, particularly among the elderly population with osteoporotic bone and in younger adults following high-energy trauma [1,2]. These fractures account for nearly 48-54% of all hip fractures and are associated with considerable morbidity, mortality, and socioeconomic burden due to prolonged hospitalization, loss of mobility, and functional dependence [3,4]. The goals of treatment include achieving stable fixation, maintaining anatomical reduction, promoting early mobilization, and preventing complications such as avascular necrosis and non-union [5].

Despite advances in surgical techniques and implant design, the optimal fixation method for femoral neck fractures remains a topic of ongoing debate. Conventional fixation methods such as multiple cancellous screws and dynamic hip screw (DHS) have been widely used, but they are often associated with biomechanical limitations including inadequate rotational stability, risk of fixation failure, and collapse at the fracture site, especially in vertically oriented (Pauwels type III) and displaced fractures [6,7]. These challenges have driven the development of new fixation systems aimed at improving biomechanical stability and reducing postoperative complications.

The Femoral Neck System (FNS), introduced by the AO Foundation, represents a novel, minimally invasive implant designed to combine the angular stability of a fixed-angle construct with controlled dynamic compression at the fracture site. The system consists of a locking plate, a bolt, and an antirotation screw that together provide enhanced resistance to shear and torsional forces while allowing limited axial sliding for fracture impaction and healing [8]. Biomechanical studies have demonstrated that FNS offers compared to traditional screw, fixation,

Original Article**Author Affiliations**

Sameer Mohammad Zargar, Senior Resident, SKIMS; **Mohd Rafeeq Wani**, Assistant Professor, Kashmir Medical College, Sempora; **Tahir Shafi**, Senior Resident Sher-i-Kashmir Institute of Medical Sciences. Department of orthopedics, Government Medical College Srinagar.

Correspondence**Tahir Shafi**

Senior Resident, Sher-i-Kashmir institute of medical sciences Soura. Jammu and Kashmir, 190001, Waniajazwani@gmail.com Contact no. 8825094137

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Keywords

Femoral neck fracture, Femoral Neck System, internal fixation, Harris Hip Score, fracture union.

particularly in unstable fracture configurations [9]. femoral neck fractures; extracapsular fractures; However, clinical data on its real-world effectiveness, pathological fractures; and refractures.

union rates, and functional recovery remain limited, particularly from developing countries and varied patient populations. While the femoral neck system (FNS) has mechanical superiority over the traditional implants in cadaveric experiments, it is crucial to evaluate the safety and report outcomes of this new implant. The aim of this study was to investigate the outcome of patients with femoral neck fractures managed with FNS and we wish to validate the safety of this implant.

Given these considerations, evaluating the clinical and radiological outcomes of femoral neck fracture fixation using the Femoral Neck System is essential to determine its efficacy, safety, and potential advantages over conventional techniques. The present study aims to assess union rates, time to union, functional outcomes, and postoperative complications in patients with femoral neck fractures managed with the Femoral Neck System at our tertiary care center.

Materials and Methods

This prospective observational study was conducted in tertiary care hospital in kashmir. A total of 25 patients with femoral neck fractures fulfilling the inclusion criteria were enrolled after obtaining informed consent. Inclusion criteria consisted of patients aged 18–70 years with femoral neck fractures, of both genders, with closed injuries amenable to closed reduction. Both displaced and undisplaced intracapsular femoral neck fractures were included. Exclusion criteria included associated Hip Score (HHS) for functional evaluation and the femoral, acetabular, or segmental injuries; expected Radiographic Union Score for Hip (RUSH) for radiological assessment; patient non-compliance; severe systemic disorders with immunodeficiency or poor overall prognosis; bilateral

Surgical technique

The procedure was performed under general or spinal anesthesia with the patient in the supine position on a traction table. After achieving satisfactory closed reduction under fluoroscopic guidance, a longitudinal incision of approximately 3.5–4 cm was made distal to the greater trochanter to expose the lateral femoral cortex. An anti-rotation Kirschner wire was first placed near the superior aspect of the femoral neck to maintain reduction. A central guide wire was then inserted at an angle of 130° under fluoroscopic control using the FNS guide system. The position and depth of the guide wire were confirmed on anteroposterior and lateral views. The channel was reamed along the central guide wire, and the Femoral Neck System (FNS) implant was inserted over the guide wire into the pre-reamed hole. The lateral plate was secured to the femur with one or two locking screws. Through the guide sleeve, an anti-rotation screw of appropriate length was inserted, and interfragmentary compression was applied by turning the insertion screw counterclockwise when required. The final implant position was verified using C-arm fluoroscopy in both planes.

Postoperatively the patients were mobilized on first post-op day and partial weight-bearing was allowed. Patients were followed up at regular intervals upto 6 months postoperatively. Functional and radiological outcomes were assessed at 6 months using the Harris Hip Score (HHS) for functional evaluation and the Radiographic Union Score for Hip (RUSH) for radiological assessment.

Statistical Analysis

All collected data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean $\pm$ standard deviation (SD), and categorical variables as frequencies and percentages. Comparisons between continuous variables were performed using the Student's t-test or Mann–Whitney U test as appropriate, while categorical variables were compared using the Chi-square test or Fisher's exact test. A p-value of less than 0.05 was considered statistically significant.

Results

The mean age of the patients was 51.20 years (range 29–70 years). The majority of patients (42.9%) were above 50 years of age. There were 16 males (64%) and 9 females (36%). The right side

Table 1: Demographic characters of the enrolled population (N=25)

Parameters	Variables	No. of patients	Percentage
Age (Years)	<30	1	4%
	30-40	3	12%
	41-50	9	36%
	>50	12	48%
Gender	Male	16	64%
	Female	9	36%
Laterality	Right	14	56%
	Left	11	44%
Mechanism of injury	Simple fall	14	56%
	Fall from height	7	28%
	Road traffic accidents	4	16%
Garden classification	I	1	4%
	II	9	36%
	III	4	12%
	IV	11	44%

was involved in 14 patients (56%), while the left side was involved in 11 patients (44%). The most common mechanism of injury was a simple fall 14(56%), followed by fall from height 7(28%) and road traffic accidents 4(16%). According to Garden's classification, 4% of patients were type I, 36% type II, 16% type III, and 44% type IV fractures (Table 1).

The mean operative time was 40.44

Table 4: Functional and Radiological Outcome

Scales	Grade	No. of Patients	Percentage
Harris hip score (HSS)	Excellent (90-100)	17	68%
	Good (80-89)	4	16%
	Fair (70-79)	1	4%
	Poor (<70)	3	12%
Radiological outcome	Union	24	96%
	Delayed Union	2	8%
	Non-union	1	4%

Table 2: Surgical and functional outcomes of the study population

Parameters	Mean $\pm$ SD	Range
Operative time (Minutes)	40.44 $\pm$ 10.89	30-75
Fracture healing time (weeks)	12.92 $\pm$ 3.17	10-20
Harris hip score	92.64 $\pm$ 5.51	68-100
RUSH Score	25.30 $\pm$ 4.76	10-30
Femoral neck shortening (mm)	2.8 $\pm$ 2.1	0-9

$\pm$ 10.89 minutes (range 30–75 minutes). The average fracture healing time was 12.92 $\pm$ 3.17 weeks (range 10–20 weeks). The mean Harris Hip Score (HHS) at the final follow-up was 92.64 $\pm$ 5.51 (range 68–100), indicating a predominantly good to excellent functional outcome. The mean Radiographic Union Score for Hip (RUSH) was 25.30 $\pm$ 4.76 (range 10–30), and the mean femoral neck shortening was 2.8 $\pm$ 2.1 mm (range 0–9 mm) (Table 2).

Postoperative complications were observed in a small proportion of patients. Non-union was noted in 1 patient (4%), and avascular necrosis in 2 patients (8%). Delayed union occurred in 1 patient (4%). There were no cases of hardware removal, implant cut-out, or re-operation (Table 3).

Table 3: Post-operative Complication

Complications	No. of patients	Percentage
Non-union	1	4%
Femoral necrosis	2	8%
Delayed union	1	4%

Functional and radiological outcomes were evaluated at the final follow-up. Based on the Harris Hip Score, 68% of patients had excellent results, 16% had good results, and three patients (12%) had a poor outcome. Radiologically, union was achieved in 96% of cases, delayed union in 8%, and non-union in 4% of patients (Table 4).

Discussion

The increase in high-energy trauma, such as traffic injuries and high falls, has significantly increased the incidence rate of femoral neck fractures in young and middle-aged adults. However, the majority of hip fracture patients are still the elderly, many of whom

already have other major complications. The outcomes of femoral neck fractures mainly depend on the physical status and age of the patient, type of fracture, quality of reduction, and stable internal fixation [10]. It is generally acknowledged that anatomical reduction, stable and strong fracture fixation early after injury are

important factors ensuring good treatment effects [11]. This prospective study evaluating the clinical and radiological outcomes of femoral neck fractures managed with the Femoral Neck System (FNS) demonstrated excellent functional recovery and high union rates in the majority of patients. The mean age of the study population was 51.52 years, reflecting a mixed cohort of middle-aged and older adults—an age group where femoral neck fractures are increasingly encountered due to both high-energy trauma in younger individuals and low-energy falls in those with osteopenic bone. The mean Harris Hip Score (HHS) achieved at final follow-up was 92.64 $\pm$ 5.51, with 84% of patients attaining good to excellent outcomes.

Radiologically, union was achieved in 96% of patients, while delayed union and nonunion occurred in 4% each. The mean femoral neck shortening was 2.98 mm, indicating satisfactory maintenance of limb length and biomechanics. Overall, complications such as avascular

necrosis and nonunion were infrequent, suggesting that FNS provides a stable construct conducive to early union and functional recovery.

The results of this study are comparable with findings from existing literature. Previous studies by He C et al (2021) [12], and Hernández-Naranjo J M et al (2024)[13], have reported mean Harris Hip Scores 90.42 and 90.9 respectively, following fixation with FNS, while in our study the score was slightly higher, possibly due to the inclusion of younger patients and early mobilization protocols. Similarly, the union rate of 96% in the present series aligns with studies such as that of Hu H et al (2021)[14], who reported union rates around

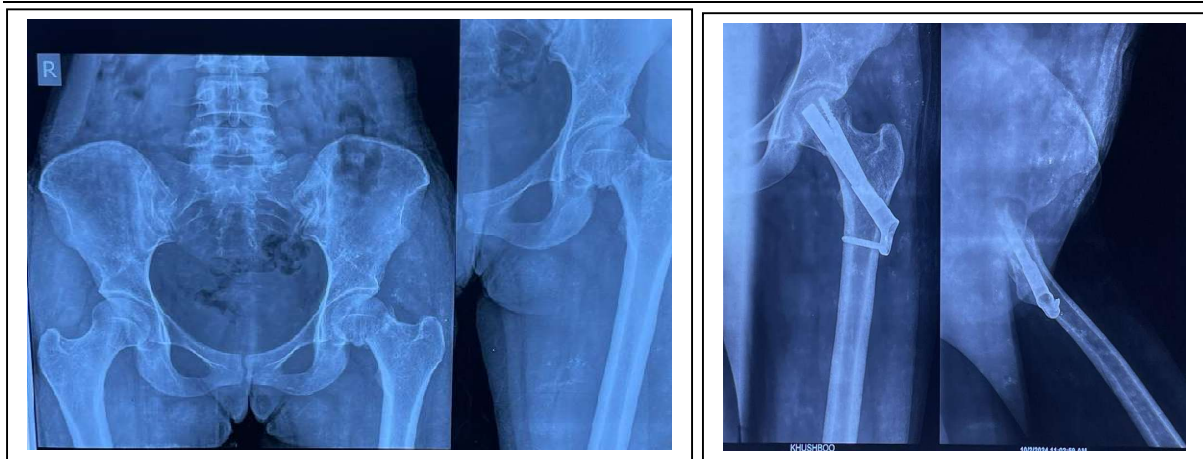


Figure 1: Pre-operative (left) and immediate post-operative (right) radiographs of one of the cases.

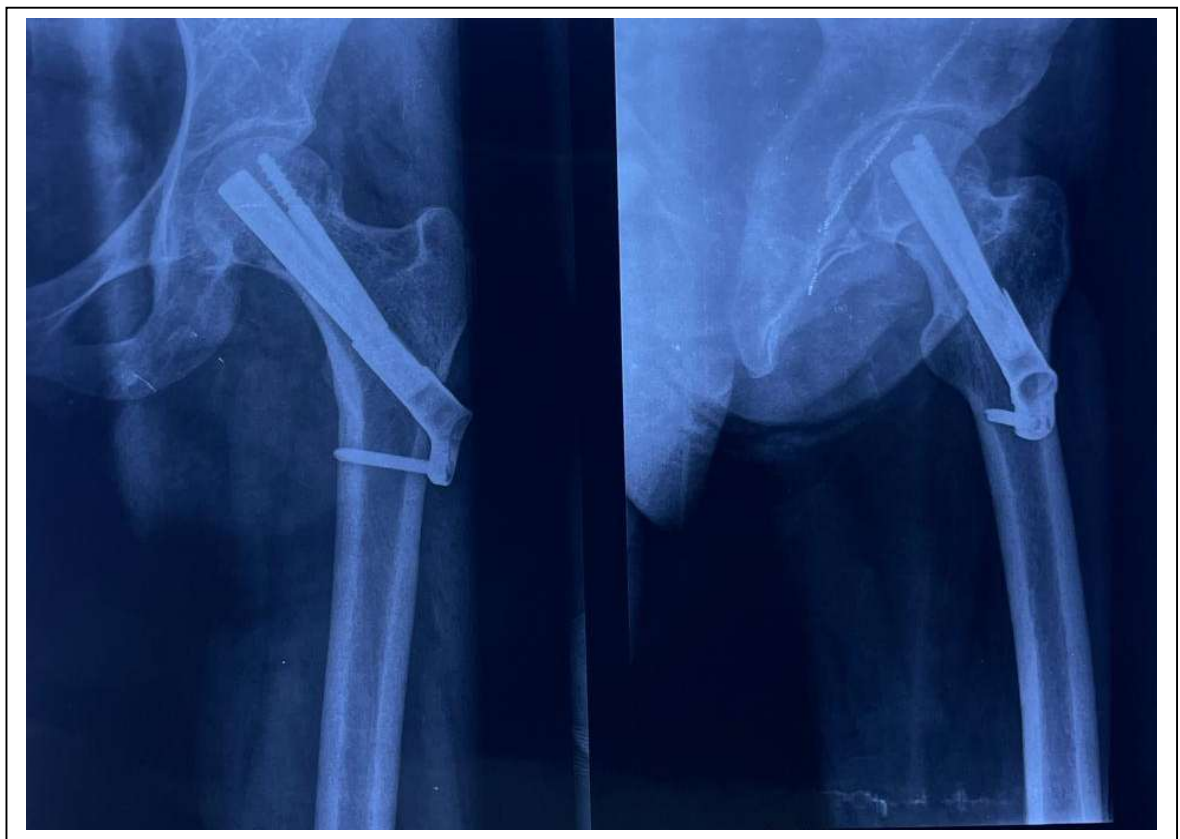


Fig 2: Radiograph of same patient at 6-month follow-up showing united fracture.

90% with minimal complications. The low rates of Pauwels type III fractures, thereby reducing the nonunion and avascular necrosis in our study are also likelihood of fixation failure and varus collapse [9]. consistent with those of Xu Z et al. (2024)[15] and Hu H et al (2021)[14], who observed that FNS provides FNS offers distinct biomechanical advantages. The improved rotational and angular stability, leading to design incorporates a central bolt for load-bearing, an fewer fixation failures compared to multiple cancellous antirotation screw for torsional stability, and a lateral screws (CCS) or dynamic hip screws (DHS). locking plate that provides angular stability while Furthermore, biomechanical studies have demonstrated allowing controlled compression at the fracture site. that the FNS construct exhibits higher stiffness and This hybrid mechanism ensures both rigidity and limited superior resistance to shear forces, particularly in dynamic sliding, optimizing conditions for fracture

healing. Studies by Stoffel et al. (2017)⁹ and Yang Y et al. (2021)[16], have shown that FNS fixation results in less femoral neck shortening and higher axial stability than multiple screw constructs. The mean shortening of 2.8 mm in our series is within acceptable limits and lower than that observed with traditional screw fixation, where shortening of 5–10 mm is commonly reported [17,18]. Reduced shortening contributes to better abductor mechanics, improved gait, and higher functional scores.

The low incidence of avascular necrosis (8%) observed in this study is noteworthy. Avascular necrosis remains one of the most feared complications following femoral neck fractures, with rates ranging from 10–30% in displaced fractures [19]. The lower incidence in our study may be attributed to careful reduction techniques, minimal soft tissue dissection, and prompt fixation, factors known to preserve the femoral head's vascularity. The mean operative time of 40 minutes indicating that the procedure is not technically demanding and can be performed efficiently with minimal surgical trauma. These features enhance the feasibility of the Femoral Neck System (FNS) even in resource-limited settings where advanced arthroplasty options may not be readily available. Comparable findings have been reported by other authors. He et al. (2021) [12], documented a mean operative duration of 49.94 minutes consistent with the present study's observations.

Despite these encouraging outcomes, certain limitations of the study should be acknowledged. The relatively small sample size limits the generalizability of the results and the ability to detect less frequent complications. Additionally, the follow-up period of up to 6 months, though sufficient to assess union and early functional outcomes, may not be long enough to evaluate late complications such as avascular necrosis or post-traumatic arthritis. The absence of a control group treated with conventional implants such as DHS or CCS precludes direct comparative analysis of relative efficacy. Furthermore, detailed assessment of reduction quality and fracture orientation (e.g., Pauwels angle) was not incorporated, though these parameters are known to influence the mechanical environment and healing potential.

Nevertheless, the findings from this study provide meaningful clinical insights. The FNS appears to combine the strengths of dynamic compression and fixed-angle stability, achieving predictable union and excellent function with minimal morbidity. These outcomes underscore its potential as a preferred implant for femoral neck fractures, particularly in young and middle-aged adults where preservation of the native hip joint is paramount. Early rehabilitation and weight-bearing, made possible by stable fixation, contribute to faster functional recovery and reduced postoperative complications.

Conclusion

Fixation of femoral neck fractures with the Femoral Neck System in our series yielded high rates of union,

excellent functional results, minimal complications, and negligible femoral neck shortening. These findings corroborate the growing evidence that FNS is a reliable and biomechanically superior alternative to traditional fixation methods for intracapsular fractures of the femoral neck. However, larger multicentric randomized trials with longer follow-up are warranted to confirm these results and further define the indications, cost-effectiveness, and long-term durability of this novel implant.

References

1. **Stevens JA, Rudd RA.** The impact of decreasing US hip fracture rates on future hip fracture estimates. *Osteoporosis International*. 2013 Oct;24(10):2725-8.
2. **Robinson CM, McQueen MM, Christie J.** Hip Fractures in Adults Younger Than 50 Years of Age Epidemiology and Results. *Clinical Orthopaedics and Related Research* (1976-2007). 1995 Mar 1;312:238-46.
3. **Enocson A, Lapidus LJ.** The vertical hip fracture—a treatment challenge. A cohort study with an up to 9 year follow-up of 137 consecutive hips treated with sliding hip screw and antirotation screw. *BMC musculoskeletal disorders*. 2012 Sep 13;13(1):171.
4. **Cooper C, Campion G, Melton III L.** Hip fractures in the elderly: a world-wide projection. *Osteoporosis international*. 1992 Nov;2(6):285-9.
5. **Song HK, Choi HJ, Yang KH.** Risk factors of avascular necrosis of the femoral head and fixation failure in patients with valgus angulated femoral neck fractures over the age of 50 years. *Injury*. 2016 Dec 1;47(12):2743-8.
6. **Zeng W, Liu Y, Hou X.** Biomechanical evaluation of internal fixation implants for femoral neck fractures: a comparative finite element analysis. *Computer Methods and Programs in Biomedicine*. 2020 Nov 1;196:105714.
7. **Ma JX, Kuang MJ, Xing F, Zhao YL, Chen HT, Zhang LK, Fan ZR, Han C, Ma XL.** Sliding hip screw versus cannulated cancellous screws for fixation of femoral neck fracture in adults: a systematic review. *International Journal of Surgery*. 2018 Apr 1;52:89-97.
8. **Ben Bouzid Y, Bassir RA, Boufettal M, Mekkaoui J, Kharmaz M, Lamrani MO, Berrada MS.** Minimally invasive technique in the management of tibial pilon fractures: new approach and promising results. *Advances in Orthopedics*. 2023;2023(1):1272490.
9. **Stoffel K, Zderic I, Gras F, Sommer C, Eberli U, Mueller D, Oswald M, Gueorguiev B.** Biomechanical evaluation of the femoral neck system in unstable Pauwels III femoral neck fractures: a comparison with the dynamic hip screw and cannulated screws. *Journal of orthopaedic trauma*. 2017 Mar 1;31(3):131-7.
10. **Smyth EH, Shah VM.** The significance of good reduction and fixation in displaced subcapital fractures of the femur. *Injury*. 1974 Jan 1;5(3):197-209.
11. **Chen MM, Lyu YX, Lin SL, Huang LP, Dong QR.** Pressure side and tension side comminution of femoral neck cortex are independent risk factors for aseptic necrosis after femoral neck fracture surgery. *Zhongguo gu Shang= China Journal of Orthopaedics and Traumatology*. 2021 Mar 1;34(3):203-8.
12. **He C, Lu Y, Wang Q, Ren C, Li M, Yang M, Xu Y, Li Z, Zhang K, Ma T.** Comparison of the clinical efficacy of a femoral neck system versus cannulated screws in the treatment of femoral neck fracture in young adults. *BMC musculoskeletal*

- disorders. 2021 Nov 29;22(1):994.
13. **Hernández-Naranjo JM, Campuzano-Bitterling B, Renau-Cerrillo M, Vives-Barquiel M, Camacho-Carrasco MP, Muñoz-Mahamud E.** Preliminary clinical and radiological evaluation of osteosynthesis using the Femoral Neck System (FNS) for subcapital fractures of the femur. *Scientific Reports*. 2024 Jun 24;14(1):14494.
 14. **Hu H, Cheng J, Feng M, Gao Z, Wu J, Lu S.** Clinical outcome of femoral neck system versus cannulated compression screws for fixation of femoral neck fracture in younger patients. *Journal of Orthopaedic Surgery and Research*. 2021 Jun 9;16(1):370.
 15. **Xu Z, Sun J, Li J, Huang F, Zhao J, Shao Y, Fang S, Wang Z, Gong Y, Zhou H, Tian S.** Comparative analysis of the femoral neck system (FNS) vs. cannulated cancellous screws (CCS) in the treatment of Middle-aged and elderly patients with femoral neck fractures: clinical outcomes and biomechanical insights. *BMC Musculoskeletal Disorders*. 2024 Sep 14;25(1):735.
 16. **Yang Y, Ma T, Zhang X, Luo X, Fan T, Wang Y.** Short-term effectiveness of femoral neck system in the treatment of femoral neck fracture. *Zhongguo xiu fu chong jian wai ke za zhi= Zhongguo xiufu chongjian waik zazhi= Chinese journal of reparative and reconstructive surgery*. 2021 May 1;35(5):539-43.
 17. **Zlowodzki M, Ayieni O, Petrisor BA, Bhandari M.** Femoral neck shortening after fracture fixation with multiple cancellous screws: incidence and effect on function. *Journal of Trauma and Acute Care Surgery*. 2008 Jan 1;64(1):163-9.
 18. **Zhao F, Guo L, Wang X, Zhang Y.** Analysis on risk factors for neck shortening after internal fixation for Pauwels II femoral neck fracture in young patients. *European journal of medical research*. 2021 Jun 24;26(1):59.
 19. **Konarski W, Poboży T, Śliwczyński A, Kotela I, Krakowiak J, Hordowicz M, Kotela A.** Avascular necrosis of femoral head—overview and current state of the art. *International Journal of Environmental Research and Public Health*. 2022 Jun 15;19(12):7348.

Therapeutic Role of Diphenylcyclopropenone (Diphencyprone) in Alopecia Areata: A Comprehensive Overview of 15 Cases in Kashmiri Population

Farah Sameem , Seerat Fatima , Adil Abdullah , Seema Qayoom .

Original Article

Abstract

Background

Alopecia areata (AA) is an autoimmune condition characterized by non-scarring hair loss. Diphencyprone (DPCP) is a topical immunomodulator commonly used in refractory cases, but data on its efficacy and safety in larger patient groups remain limited.

Aims and Objectives

This study aims to evaluate the clinical efficacy, safety, and tolerability of DPCP in patients with AA through a case series of 15 individuals.

Methodology

A prospective analysis of 15 patients diagnosed with severe AA who were treated with DPCP was conducted. The study included individuals aged 12 to 60 years with alopecia areata. Patients received 3 weekly applications, and responses were assessed using clinical photographs and hair regrowth scoring over 6 months. Adverse effects were recorded to evaluate tolerability.

Results

In our study it was seen that, 4 (26.7%) patients had grade 4 improvement i.e. complete hair growth in affected area and 3 (20%) had grade 3 improvement. Time to initial response was seen to be Avg. 3.48 ± 1.05 months and time to maximum response was Avg. 6.14 ± 1.48 months. It was also observed that 13.3% patients experienced relapse during follow-up. While adverse events like contact dermatitis, chemical leukoderma and urticarial lesions were observed in a few patients, they were generally well-tolerated by the patients and did not lead to treatment discontinuation.

Conclusion

DPCP showed promising results in inducing hair regrowth in a significant proportion of patients, with minimal adverse effects. It remains a valuable therapeutic option for AA, particularly in refractory cases.

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Author Affiliations

Farah Sameem , Associate Professor
Seerat Fatima , Senior Resident, Adil
Abdullah , Post-graduate Resident, Seema
Qayoom , Professor and Head :
Department of Dermatology, SKIMS MCH
Bemina.

Correspondence

Dr Seerat Fatima

Department of Dermatology,
SKIMS MC-H Bemina,
Srinagar, 190018
rizviseeratfatima@gmail.com

Indexed

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Google Scholar besides other national and
international databases.

Introduction

Alopecia areata (AA) is an autoimmune condition affecting hair follicles, resulting in unpredictable and often relapsing hair loss [1]. It is characterized by its heterogeneous presentation, ranging from small, well-demarcated patches of hair loss to complete loss of scalp (alopecia totalis) or even body hair (alopecia universalis) [2]. While the exact pathophysiology is not entirely understood, it is hypothesized that a breakdown of immune privilege at the hair follicle plays a central role. This breakdown triggers T-cell-mediated inflammation against anagen-phase hair follicles, halting their growth and leading to hair loss. Genetic predisposition, environmental factors, and psychological stress have also been implicated as potential triggers.

Management of AA remains challenging due to its unpredictable course and variability in patient response to treatments. Current therapeutic strategies aim to suppress immune-mediated damage or modulate the immune response. These include corticosteroids (topical, intralesional, or systemic), calcineurin inhibitors, Janus kinase (JAK) inhibitors, and topical immunotherapies. However, the lack of a definitive cure and the potential for relapses necessitate the exploration of alternative approaches.

Among the available options, diphencyprone (DPCP) has gained attention as a topical immunomodulator for refractory AA. It works by inducing a mild allergic contact dermatitis, thereby creating a diversion for the immune system and restoring the immune privilege of the hair follicle [3]. The therapy is typically reserved for patients who fail to respond to first-line treatments, given its time-intensive nature and requirement for close monitoring. Despite its increasing use, data regarding the efficacy, safety, and patient tolerability of DPCP are limited, particularly in diverse patient populations [4].

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This study presents a case series of 15 patients with AA treated with DPCP. The primary objective is to assess the clinical efficacy, safety, and tolerability of this treatment, with a secondary goal of identifying factors that may influence therapeutic outcomes. By doing so, the study aims to contribute to the growing body of evidence supporting the role of DPCP in managing this challenging condition.

Aims and Objectives:

To evaluate the safety, efficacy, and tolerability of DPCP (Diphenylcyclopropenone) treatment in patients with severe alopecia areata.

Methodology

This prospective study conducted in the post-graduate department of dermatology SKIMS MCH Bemina. It was conducted over a period of 2 years and included 15 patients in the age group of 12 to 60 years, who had severe disease and were recalcitrant to other conventional modalities of treatment. Written informed consent and ethical clearance was obtained from the Institutional ethical committee.

Inclusion criteria

1. Extensive Alopecia Areata: Participants must have experienced loss of more than 40% of their scalp hair.
2. Long-lasting Alopecia Areata: Participants must have had no hair regrowth for more than 12 months
3. Treatment-free Period: Participants must have had an interruption of any therapy for alopecia areata for the past 6 months

Exclusion criteria

1. Pregnant or breastfeeding individuals were excluded due to potential risks and unknown effects of the treatment.
2. Individuals with a history of any cardiovascular conditions were excluded to avoid potential safety risks.

Patients were clinically assessed for the severity grading of alopecia areata and baseline photographs and records were documented. Initial baseline investigations along with thyroid profile and ANA profile were assessed.

Diphenylcyclopropenone (DPCP) solutions were prepared in acetone at concentrations of 0.001%, 0.01%, 0.1% and 2%. Patients were first sensitized with a 2% DPCP solution applied to a 2cm x 2cm area of the scalp. Treatment was initiated on one half of the scalp, with the other half serving as a control. Subsequent treatments involved 3 weekly sessions, gradually increasing DPCP concentrations starting from 0.001%, adjusted to maintain erythema and itch on the scalp for 48 hours. Patients were advised to avoid direct sunlight or ultraviolet radiation exposure to the treated area for 48 hours after applying the Diphenylcyclopropenone (DPCP) treatment and to not wash or submerge the treated area in water for 48 hours following the application of the DPCP treatment. Treatment response was evaluated every 3 months for a period of 2 years. Patients who did not show any response within 6 months were considered non-responders. If a response was

observed on the treated half of the scalp within 3-6 months, DPCP application was extended to the entire scalp. The severity of alopecia areata (AA) was evaluated using the AA Investigational Assessment Guidelines, which provide a standardized method for assessing the extent and distribution of hair loss. Additionally, hair regrowth was graded according to the MacDonald, Hull, and Norris system, which categorizes the type and amount of hair regrowth on a scale from 1 to 4.

Statistical analysis

The recorded data was compiled and entered in a spreadsheet (Microsoft Excel) and then exported to data editor of SPSS Version 20.0 (SPSS Inc., Chicago, Illinois, USA). Continuous variables were expressed as Mean $\pm$ SD and categorical variables were summarized as frequencies and percentages. A P-value of less than 0.05 was considered statistically significant.

Results

At completion of therapy, it was seen that, 4 (26.7%) patients had grade 4 improvement i.e. complete hair growth in affected area, 3 (20%), 2 (13.3%), 3 (20%) and 3 (20%) had grade 3, grade 2, grade 1 and no response respectively. Time to initial response was seen to be Avg. 3.48 ± 1.05 months and time to maximum response was Avg. 6.14 ± 1.48 months. It was also observed that 13.3% patients experienced relapse during follow-up. While adverse events like contact dermatitis, chemical leukoderma and urticarial lesions were observed in a few patients, they were generally well-tolerated by the patients and did not lead to treatment discontinuation. The comparison of response rates (percentage of patients achieving a grade 3 or 4 response) between Kashmiri patients and other populations showed a lesser response (47%) as compared to previous studies in different populations showing 60% with grade 3 and 4 responses. The lower response rate could be attributed to several factors including genetic variability, environmental factors, patients with extensive or long-standing alopecia areata and the limited sample size of 15 patients in this study restricts the generalizability of the findings.

Discussion

The results of this case series affirm the utility of DPCP in promoting hair regrowth in patients with AA, particularly in those with patchy disease [5]. A majority of patients achieved cosmetically acceptable regrowth within six months, a finding consistent with previously published studies. This suggests that DPCP is an effective therapeutic option for patients with refractory or recalcitrant AA who have not responded to corticosteroids or other immunosuppressive therapies. DPCP's mechanism of action is thought to involve the induction of a type IV hypersensitivity reaction at the site of application [6]. This localized immune response may distract autoreactive T-cells away from the hair follicles, allowing them to resume their normal growth cycle. Additionally, the inflammatory milieu created by DPCP may recruit regulatory T-cells, which play a role in restoring immune privilege at the hair follicle. The

observed responses in this case series underscore the potential of this mechanism in achieving significant regrowth.

However, the variability in response among patients highlights the complex interplay of factors influencing treatment outcomes. For instance, patients with extensive AA, such as alopecia totalis or alopecia universalis, generally showed less favorable responses compared to those with localized patches of hair loss [7]. This aligns with the hypothesis that longstanding or severe disease may involve irreversible follicular damage or a more robust autoimmune response, limiting the efficacy of immunomodulatory therapies like DPCP. Adverse effects observed in this series were primarily mild and included erythema, pruritus, scaling, and transient hypopigmentation [8]. These side effects were generally well tolerated, and no patient required discontinuation of therapy due to adverse events. Importantly, no systemic side effects were reported, reaffirming the safety profile of DPCP when used appropriately. Patient adherence and satisfaction were also notable, despite the prolonged duration of treatment required to achieve visible results.

While the findings are encouraging, it is important to consider the limitations of DPCP therapy. The time-intensive nature of weekly applications and the need for regular follow-up may pose challenges for some patients. Additionally, the therapy's delayed onset of action requires careful counseling to manage patient expectations. Psychological support may also be necessary to address the emotional burden of AA, particularly for patients with extensive or relapsing disease.

Overall, this case series contributes to the growing evidence supporting the use of DPCP as a therapeutic option for AA. Future studies should aim to identify biomarkers or clinical predictors of response to optimize patient selection and outcomes. Furthermore, exploring combination therapies with DPCP may enhance efficacy, particularly in patients with severe or refractory disease [0].

In our study it was seen that the comparison of response rates (percentage of patients achieving a grade 3 or 4 response) between Kashmiri patients and other populations showed a lesser response (47%) as compared to previous studies in different populations showing 60% with grade 3 and 4 responses. The lower response rate could be attributed to several factors including genetic variability, environmental factors, patients with extensive or long-standing alopecia areata and the limited sample size of 15 patients in this study restricts the generalizability of the findings. The safety profile of diphenylcyclopropenone (DPCP) in our study of Kashmiri patients with alopecia areata was consistent with previous reports. The most common adverse events, including contact dermatitis, chemical leukoderma, occipital lymphadenopathy and urticarial lesions, were generally well-tolerated by the patients

Conclusion

This case series reinforces the efficacy and safety of

DPCP as a therapeutic option for alopecia areata, particularly in patients with patchy hair loss. DPCP demonstrated significant hair regrowth with minimal adverse effects, making it a valuable addition to the armamentarium for AA management. However, its variable efficacy in extensive cases and the time-intensive nature of treatment require careful patient selection and counseling.

Limitations

The findings of this study are limited by the small sample size and its retrospective nature, which may introduce selection and recall biases. The absence of a control group prevents direct comparison with other treatment modalities. Furthermore, the short duration of follow-up may not capture long-term efficacy and relapse rates. Larger, randomized controlled trials are needed to validate these findings and explore strategies to optimize treatment outcomes for AA patients.

References:

1. Gilhar, A., Etzioni, A., & Paus, R. (2012). Alopecia areata. *New England Journal of Medicine*, 366(16), 1515–1525.
2. Villasante Fricke, A. C., & Miteva, M. (2015). Epidemiology and burden of alopecia areata: A systematic review. *Clinical, Cosmetic and Investigational Dermatology*, 8, 397–403.
3. Higgins, E., & Shergill, B. (2017). Topical immunotherapy in alopecia areata. *Journal of Dermatological Treatment*, 28(8), 629–636.
4. Tosti, A., Bellavista, S., & Iorizzo, M. (2006). Alopecia areata: A long-term follow-up study of 191 patients. *Journal of the American Academy of Dermatology*, 55(3), 438–441.
5. Happle, R., & Röhl, L. (1983). Topical immunotherapy in alopecia areata with diphencyprone. *Journal of the American Academy of Dermatology*, 8(6), 749–753.
6. Norris, D. A. (1993). Mechanisms of action of topical therapies and the rationale for combination therapy. *Journal of Investigative Dermatology*, 100(1), 109S–115S.
7. Fenton, D. A., & Wilkinson, J. D. (1983). Topical immunotherapy in alopecia areata: A clinical evaluation of 48 cases. *British Journal of Dermatology*, 109(4), 439–447.
8. Van der Steen, P., van Baar, H. M., Happle, R., & Boezeman, J. B. (1991). Prognostic factors in alopecia areata: An evaluation of 103 patients. *Dermatology*, 183(3), 197–201.
9. Gupta, A. K., & Carviel, J. L. (2020). Meta-analysis of randomized placebo-controlled trials on the use of diphencyprone in alopecia areata. *Journal of Dermatological Treatment*, 31(6), 587–594.

Correlation of Serum Vitamin D Levels with Clinical Parameters of Dry Eye Disease: A Hospital-Based Study.

Haziqa Zahoor, Tufela Shafi, Shabana Khan .

Abstract

Background and Objectives

Dry eye disease (DED) is a multifactorial disorder characterized by tear film instability, ocular surface inflammation and visual disturbance. Vitamin D possesses anti-inflammatory and immunomodulatory properties and may play a role in maintaining ocular surface health. The present study evaluated serum vitamin D levels in patients with DED and assessed their association with clinical parameters of disease severity.

Methods

This hospital based observational study was conducted over a period of one year from January 2022 to December 2023. Eighty-two patients aged >18 years with clinically diagnosed DED were enrolled. Dry eye evaluation included Ocular Surface Disease Index (OSDI), Tear Break-Up Time (TBUT), Schirmer's test, and fluorescein staining. Serum 25-hydroxy vitamin D levels were measured and categorized as deficient (<20 ng/mL), insufficient (20–30 ng/mL), or sufficient (>30 ng/mL). Correlations between vitamin D levels and dry eye parameters were analyzed statistically.

Results:

The mean age of participants was 42.8±11.6 years; 63.4 per cent were females. Mean serum vitamin D level was 18.4±6.1 ng/mL, with deficiency observed in 68.3 per cent of patients. Mean OSDI score was 36.5±11.2, mean TBUT was 7.2±2.4 seconds, and mean Schirmer's test value was 8.5±3.2 mm/5 min. Serum vitamin D levels showed a significant negative correlation with OSDI scores ($p<0.001$) and significant positive correlations with TBUT ($r=0.44$, $p<0.001$) and Schirmer's test values ($r=0.40$, $p<0.01$). Greater ocular surface staining was observed among vitamin D-deficient patients.

Interpretation & conclusions:

Vitamin D deficiency was highly prevalent among patients with DED and was significantly associated with greater symptom severity, reduced tear film stability, decreased tear secretion, and increased ocular surface damage. Assessment and correction of vitamin D deficiency may be beneficial as an adjunct in the comprehensive management of DED.

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Introduction

Dry eye disease (DED) is a common multifactorial disorder of the tears and ocular surface characterized by ocular discomfort, tear film instability, and visual disturbance [1]. It significantly affects quality of life and daily activities such as reading, driving, and prolonged screen exposure [2]. The disease is more common among females, elderly individuals, and patients with systemic or autoimmune disorders [3]. Inflammation of the ocular surface and lacrimal functional unit plays a major role in the pathogenesis of dry eye disease [4]. Vitamin D, a fat-soluble vitamin with immunomodulatory and anti-inflammatory properties, has recently gained attention for its role in ocular surface health [5]. Vitamin D receptors are present in corneal epithelium, conjunctiva, and lacrimal glands, suggesting its importance in tear film maintenance and epithelial integrity [6].

Vitamin D deficiency may contribute to dry eye disease by increasing ocular surface inflammation, reducing tear secretion, and destabilizing the tear film [7]. Several studies have demonstrated lower serum vitamin D levels in patients with dry eye disease and significant associations with tear break-up time, Schirmer's test, and symptom severity [8-11].

Therefore, the present hospital-based observational study was conducted to evaluate serum vitamin D levels in patients with dry eye disease and to determine its association with the severity of dry eye parameters.

Aim

To evaluate serum vitamin D levels in patients with dry eye disease

Original Article

Author Affiliations

Haziqa Zahoor, Assistant Professor,
Shabana Khan, Associate Professor,
Department of Ophthalmology, GMC
Baramulla ;
Tufela Shafi, Associate Professor,
Department of Pediatric Ophthalmology,
GMC Srinagar.

Correspondence

Dr. Shabana Khan

Associate Professor, Department of
Pediatric Ophthalmology, GMC Baramulla

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Keywords

Dry eye disease; ocular surface disease
index; Schirmer's test; tear break-up time;
vitamin D deficiency; vitamin D.

and to determine the association between vitamin D deficiency and the severity of dry eye parameters.

Methods

Study Design and Setting

This hospital-based observational study was conducted in the Department of Ophthalmology GMC Srinagar over a period of one year from January 2022 to December 2022.

Study Population

A total of 82 patients clinically diagnosed with dry eye disease attending the ophthalmology outpatient department were included in the study.

Participant selection

A total of 82 patients aged >18 years with clinically diagnosed dry eye disease were enrolled after obtaining written informed consent.

Inclusion Criteria

- Patients aged more than 18 years
- Patients diagnosed with dry eye disease based on symptoms and clinical examination
- Patients willing to participate and provide informed consent

Exclusion Criteria

- Patients with active ocular infection or ocular allergy
- History of ocular trauma or ocular surgery within the previous 6 months
- Contact lens users
- Patients with autoimmune disorders such as Sjögren Syndrome
- Patients using topical ocular medications other than lubricants
- Patients already receiving vitamin D supplementation
- Pregnant and lactating women

Detailed history and ophthalmic examination were performed in all patients.

Dry eye assessment was done using:

- Ocular Surface Disease Index (OSDI)
- Tear Break-Up Time (TBUT)
- Schirmer's test
- Fluorescein staining

Serum 25-hydroxy vitamin D levels were measured in all participants and categorized as deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL).

Outcome variables

The primary outcome variable was serum 25-hydroxy vitamin D level. Secondary outcome variables included:

- Ocular Surface Disease Index (OSDI) score
- Tear Break-Up Time (TBUT)
- Schirmer's test value
- Fluorescein staining grade

Data collection and clinical assessment

A detailed history and comprehensive ophthalmic examination were performed in all participants. Dry eye evaluation included Ocular Surface Disease Index questionnaire, Tear Break-Up Time, Schirmer's test, and fluorescein staining. Serum 25-hydroxy vitamin D

levels were measured and categorized as deficient (<20 ng/mL), insufficient (20–30 ng/mL), and sufficient (>30 ng/mL).

Statistical analysis

Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences [SPSS] software. Continuous variables were expressed as mean $\pm$ standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Associations between categorical variables were assessed using the Chi-square test. Correlations between serum vitamin D levels and Ocular Surface Disease Index (OSDI) score, Tear Break-Up Time (TBUT), and Schirmer's test values were evaluated using Pearson's correlation coefficient. A p value <0.05 was considered statistically significant.

Results

A total of 82 patients diagnosed with dry eye disease attending the ophthalmology outpatient department were included in this hospital-based observational study. The demographic profile, serum vitamin D levels, and dry eye parameters were analyzed.

Demographic Characteristics

The age of the study participants ranged from 20 to 67 years, with a mean age of 42.8 ± 11.6 years. The majority of patients belonged to the 31–50 years age group.

Out of 82 patients:

- 52 (63.4%) were females
- 30 (36.6%) were males

Female predominance was observed among patients with moderate to severe dry eye symptoms.

Clinical Presentation

The most common presenting symptoms were:

- Foreign body sensation – 64 patients (78%)
- Burning sensation – 59 patients (72%)
- Ocular dryness – 56 patients (68.3%)
- Redness – 44 patients (53.7%)
- Excessive watering – 34 patients (41.5%)
- Blurring of vision – 30 patients (36.6%)

The mean duration of symptoms was 8.1 ± 3.4 months

The mean serum 25-hydroxy vitamin D level among study participants was 18.4 ± 6.1 ng/mL.

Vitamin D status among the patients was categorized as follows:

Vitamin D status	Serum level	Number of patients (n)	Percentage (%)
Deficient	<20 ng/ml	56	68.3%
Insufficient	20-30 ng/ml	18	22.0%
Sufficient	>30 ng/ml	8	9.7%

A high prevalence of vitamin D deficiency was observed among patients with dry eye disease.

Table 1. Serum vitamin D status and association with dry eye severity among study participants (n = 82)

Variable	Category	Number of patients (%)	Mean Vitamin D level (ng/mL)
Vitamin D Status	Deficient (<20 ng/mL)	56 (68.3)	—
	Insufficient (20-30 ng/ml)	18 (22.0)	
	Sufficient (>30ng/ml)	8 (9.7)	
Dry Eye Severity (OSDI)	Mild	20 (24.4)	25.1 ± 5.0
	Moderate	18.0 ± 4.6	18.0 ± 4.6
	Severe	12.7 ± 3.5	12.7 ± 3.5

A statistically significant negative correlation was found between vitamin D levels and OSDI score ($p < 0.001$).

Ocular Surface Disease Index (OSDI)

The mean OSDI score was 36.5 ± 11.2 .

Based on OSDI grading:

- Mild dry eye was seen in 20 patients (24.4%)
- Moderate dry eye in 38 patients (46.3%)
- Severe dry eye in 24 patients (29.3%)

Patients with lower serum vitamin D levels demonstrated higher OSDI scores, indicating greater symptom severity.

Tear Break-Up Time (TBUT) and Schirmer's Test**Table 2. Tear film and ocular surface parameters in patients with dry eye disease**

Parameter	Category	Number of patients (n)	Percentage
TBUT (seconds)	<5	22	26.8
	5-10	48	58.5
	>10	12	14.7
Schirmer's test (mm/5 min)	<5	18	22.0
	5-10	46	56.1
	>10	18	22.0

The mean TBUT among study participants was 7.2 ± 2.4 seconds. Patients with severe vitamin D deficiency had significantly lower TBUT values compared to patients with sufficient vitamin D levels.

A positive correlation was observed between serum vitamin D levels and TBUT values ($r = 0.44$, $p < 0.001$). The mean Schirmer's test value was 8.5 ± 3.2 mm/5 min. Lower Schirmer's test values were associated with lower serum vitamin D levels.

A significant positive correlation was noted between serum vitamin D levels and Schirmer's test scores ($r =$

0.40 , $p < 0.01$).

Fluorescein Staining

Fluorescein staining revealed varying degrees of ocular surface involvement

Table 3. Fluorescein staining grades among patients with dry eye disease

Staining Grade	Number of Patients
Grade 0	10
Grade 1	24
Grade 2	34
Grade 3	14

Moderate to severe staining grades were more commonly observed in patients with vitamin D deficiency.

Discussion

Dry eye disease is increasingly recognized as a chronic inflammatory disorder of the ocular surface associated with tear film instability and ocular discomfort.¹ The present hospital-based observational study demonstrated a high prevalence of vitamin D deficiency among patients with dry eye disease and showed significant correlations between lower serum vitamin D levels and severity of dry eye parameters.

In the present study, female predominance was observed among dry eye patients. Similar findings have been reported in previous epidemiological studies where dry eye disease was more common among women, especially in middle-aged and postmenopausal females [3,12]. Hormonal influences affecting lacrimal gland

function and tear film stability may explain this increased prevalence in females [13].

The mean serum vitamin D level in the study population was low, with a large proportion of patients showing vitamin D deficiency. Similar observations have been reported by Kurtul et al., Yildirim et al., and Meng et al., who found significantly lower serum vitamin D levels in patients with dry eye disease [8,9,10]. Vitamin D deficiency has been associated with increased inflammatory cytokine activity and impaired immunomodulatory function, which may contribute to ocular surface inflammation [14].

The present study demonstrated a significant negative correlation between serum vitamin D levels and Ocular Surface Disease Index (OSDI) scores. Patients with lower vitamin D levels had more severe symptoms, indicating a possible role of vitamin D in maintaining ocular surface comfort and tear film stability. Similar findings were reported in previous studies evaluating symptom severity in vitamin D-deficient dry eye patients [10,11].

Tear film stability assessed by Tear Break-Up Time (TBUT) was significantly reduced in patients with lower serum vitamin D levels. Similar findings were observed by Kurtul et al., who reported significantly decreased TBUT values among vitamin D-deficient individuals [8]. Vitamin D is believed to improve epithelial barrier function and reduce ocular surface inflammation, thereby contributing to improved tear film stability [6,15].

Schirmer's test values were also lower in patients with vitamin D deficiency, suggesting reduced aqueous tear secretion. Similar results have been documented in previous studies assessing lacrimal gland function in vitamin D-deficient individuals [8,9]. Vitamin D receptors present in lacrimal gland tissue may influence tear secretion and ocular surface lubrication [6].

Fluorescein staining findings in the present study demonstrated greater ocular surface damage in patients with severe vitamin D deficiency. Increased staining indicates epithelial surface disruption secondary to chronic inflammation and tear film abnormalities. Comparable findings have been reported by Watters et al. and Demirci et al., who demonstrated increased ocular surface staining in vitamin D-deficient patients [11,16].

The anti-inflammatory and immunomodulatory properties of vitamin D may explain its beneficial role in ocular surface health. Vitamin D suppresses inflammatory cytokines, promotes epithelial healing, and enhances barrier function of the corneal epithelium [14,15]. Bae et al. demonstrated improvement in dry eye symptoms following vitamin D supplementation in patients refractory to conventional treatment, suggesting a potential therapeutic role of vitamin D supplementation in dry eye disease [17].

An additional finding of the present study was the association between reduced sunlight exposure and severity of dry eye disease. This observation may be particularly relevant in our region where lifestyle,

clothing practices, prolonged indoor activity among women especially those belonging to far peripheral areas, and climatic conditions predispose individuals to vitamin D deficiency despite adequate daylight availability. The finding highlights the importance of environmental and behavioral factors in the pathogenesis of dry eye disease.

The findings of the present study support the hypothesis that vitamin D deficiency may contribute to the pathogenesis and severity of dry eye disease. Evaluation of serum vitamin D levels in patients with persistent or severe dry eye symptoms may therefore be beneficial. Early correction of vitamin D deficiency may provide additional improvement when combined with standard dry eye treatment modalities.

However, the present study had certain limitations. It was a hospital-based observational study with a relatively limited sample size. Lack of follow-up after vitamin D supplementation limited assessment of therapeutic response. Further prospective and interventional studies with larger sample sizes are required to establish causality and evaluate the effectiveness of vitamin D supplementation in dry eye management.

Conclusion

The present hospital-based observational study demonstrated a high prevalence of vitamin D deficiency among patients with dry eye disease. Lower serum vitamin D levels were significantly associated with increased severity of dry eye symptoms, reduced tear film stability, decreased tear secretion, and greater ocular surface involvement.

These findings suggest that vitamin D deficiency may play an important role in the pathogenesis and severity of dry eye disease. Assessment of serum vitamin D levels in patients with chronic or severe dry eye may aid in comprehensive management and may provide additional benefit when corrected alongside conventional dry eye treatment.

References

1. **The definition and classification of dry eye disease:** report of the Definition and Classification Subcommittee of the International Dry Eye WorkShop (2007). *Ocul Surf.* 2007;5(2):75–92.
2. **Miljanović B, Dana R, Sullivan DA, Schaumberg DA.** Impact of dry eye syndrome on vision-related quality of life. *Am J Ophthalmol.* 2007;143(3):409–415.
3. **Schaumberg DA, Sullivan DA, Buring JE, Dana MR.** Prevalence of dry eye syndrome among US women. *Am J Ophthalmol.* 2003;136(2):318–326.
4. **Bron AJ, de Paiva CS, Chauhan SK, et al.** TFOS DEWS II pathophysiology report. *Ocul Surf.* 2017;15(3):438–510.
5. **Holick MF.** Vitamin D deficiency. *N Engl J Med.* 2007;357(3):266–281.
6. **Reins RY, McDermott AM.** Vitamin D: implications for ocular disease and therapeutic potential. *Exp Eye Res.* 2015;134:101–110.
7. **Yin Z, Pintea V, Lin Y, Hammock BD, Watsky MA.** Vitamin D enhances corneal epithelial barrier function. *Invest Ophthalmol Vis Sci.* 2011;52(10):7359–7364.

8. **Kurtul BE, Özer PA, Aydinli MS.** The association of vitamin D deficiency with tear break-up time and Schirmer testing in non-Sjögren dry eye. *Eye (Lond)*. 2015;29(8):1081–1084.
9. **Yildirim P, Garip Y, Karci AA, Guler T.** Dry eye in vitamin D deficiency: more than an incidental association. *Int J Rheum Dis*. 2016;19(1):49–54.
10. **Meng YF, Lu J, Xing Q, Tao JJ, Xiao P.** Lower serum vitamin D level was associated with risk of dry eye syndrome. *Med Sci Monit*. 2017;23:2211–2216.
11. **Watters GA, Turnbull PRK, Swift S, Petty A, Craig JP.** Ocular surface disease in patients with vitamin D deficiency. *Cont Lens Anterior Eye*. 2019;42(6):597–602.
12. **Smith JA, Albenz J, Begley C, et al.** The epidemiology of dry eye disease. *Ocul Surf*. 2007;5(2):93–107.
13. **Sullivan DA, Rocha EM, Aragona P, et al.** TFOS DEWS II sex, gender, and hormones report. *Ocul Surf*. 2017;15(3):284–333.
14. **Gupta A, Monroy D, Ji Z, Pflugfelder SC.** T helper cytokines in dry eye disease. *Exp Eye Res*. 1997;65(5):661–668.
15. **Shetty R, Deshpande K, Deshmukh R, et al.** Bowman's layer transplantation in ocular surface disorders. *Indian J Ophthalmol*. 2018;66(2):283–290.
16. **Demirci G, Ozsutcu M, Karadag R, et al.** Dry eye assessment in patients with vitamin D deficiency. *Eye Contact Lens*. 2018;44:S62–S65.
17. **Bae SH, Shin YJ, Kim HK, Hyon JY, Wee WR, Park SG.** Vitamin D supplementation for patients with dry eye syndrome refractory to conventional treatment. *Sci Rep*. 2016;6:33083.

Impact of Different Radiotherapy Planning Techniques on OAR Sparing in Thymoma.

Rajdip Mitra , Avik Kundu , Anjan Bera , Doli Mridha .

Abstract**Background**

Thymomas, located in the anterior mediastinum, often require adjuvant radiotherapy after surgery or as the primary treatment. Because they are close to critical organs-at-risk (OARs) such as the lungs, heart, esophagus, thyroid, and spinal cord, reducing damage to normal tissues is essential.

Objective

The objective of this study was to evaluate and compare the dosimetric outcomes of three radiotherapy planning techniques—3D Conformal Radiotherapy (3DCRT), Intensity-Modulated Radiotherapy (IMRT), and Volumetric Modulated Arc Therapy (VMAT)—focusing on target coverage and OAR sparing.

Material and Methods

Eleven(11) patients with pathologically confirmed thymoma were planned using all three techniques. Planning Target Volume (PTV) coverage and doses to OARs were analysed and compared.

Results

IMRT and VMAT significantly improved PTV conformity and homogeneity compared to 3DCRT. OAR doses (lung V20, heart mean dose, spinal cord Dmax) have no significant differences. Only the mean oesophagus dose was less for IMRT and VMAT.

Conclusion

IMRT and VMAT techniques are superior to 3DCRT in terms of conformity and homogeneity. However, there is no statistically significant OAR dose sparing for these three techniques. The treatment time for VMAT is significantly less compared to IMRT because the total MU for VMAT is much lower. Therefore, to improve patient comfort during radiation, reduce intrafractional lung motion, and ensure a faster workflow, VMAT is considered superior to IMRT.

JK-Practitioner2026;31(3):40-45**Original Article****Author Affiliations**

Rajdip Mitra , Avik Kundu , Medical Physicist cum RSO ; **Anjan Bera ,** Associate Professor; **Doli Mridha ;** Senior Resident: Department of Radiotherapy, NRS Medical College and Hospital, Kolkata, West Bengal, India

Correspondence

Dr. Anjan Bera, Associate Professor, Department of Radiotherapy, NRS Medical College and Hospital, Kolkata-14, West Bengal, India.
Phone no- 8336855482
Email id- anjanbera78@gmail.com

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Introduction

Thymomas are rare tumours of the mediastinum that develop from the epithelial cells of the thymus. About 0.15 cases per one lakh of the Indian population are diagnosed with thymoma.

[1] Surgery remains the primary treatment, with complete thymectomy, i.e. complete en bloc surgical resection bis the preferred procedure. [2] The extent of resection, meaning the complete removal of the tumour mass, and the disease stage are two key prognostic factors for invasive thymoma that influence survival and local disease control. [1,2] The results from SEER data suggest that in patients with Masaoka stage II, & III, there is a possible overall survival (OS) benefit of the addition of postoperative radiotherapy (PORT). [3,4,5] The PORT had no advantage for patients with surgically resected localized disease (Masaoka stage I). Given the anatomical proximity of the thymus to vital thoracic organs, radiotherapy planning must focus on sparing OARs to minimize the risk of late toxicities. Similarly, analysis of the ITMIG database of 1263 cases who had received PORT after complete resection of stage II or III thymoma, found a seven percent improvement in ten years' Overall survival (79 % to 86%, p=0.002).[4,6]

In today's environment, using a CT-based treatment planning system is crucial to deliver a tumoricidal dose to the tumour accurately while sparing the organ at risk. Advances in radiotherapy planning, like IMRT and VMAT, enable highly conformal dose distributions. This study aims to compare these advanced techniques with traditional 3DCRT to evaluate their effects on PTV coverage and OAR dose exposure.

Materials and Methods**Patient selection**

A total of 11 patients with histologically confirmed postoperative

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Keywords

Thymoma, 3DCRT, IMRT, and VMAT

cases of Masaoka stage II and III thymoma, treated with PORT in our department between 2023 and 2024, were selected. Patients' age ranges from 20-57 years, and the male-to-female ratio was 1:1.2. All patients underwent CT simulation (Somatom Definition AS Open RT) in the head-first supine position (HFS) with 3 mm slice thickness. These CT images were transferred to TPS for contouring and planning.

Contouring

Target Volumes: GTV, CTV, and PTV were delineated based on both Preoperative and postoperative imaging, as well as RTOG guidelines. A 0.5 cm margin was added to the CTV to create the PTV. Lungs (right and left), heart, esophagus, and spinal cord were contoured for each case as OAR. The total dose delivered ranges from 54 to 60 Gy in 30 fractions (#) over six weeks, with the dose per fraction ranging from 1.8 to 2 Gy. According to Quantec, the heart dose constraint V25 is listed as 10%. However, since thymoma lies anterior to the heart and pericardium, it is often challenging, if not nearly impossible, to achieve this dose constraint. Therefore, we use a different institutional dose constraint protocol that is consistent with published literature, which is $V25 \leq 25\%$.

Treatment Planning

Three radiotherapy plans were generated for each patient: 3DCRT, IMRT, and VMAT. In the 3DCRT plan, three coplanar beams with gantry angles of 0° (anterior), and two anterior oblique beams- RAO between (300°-330°) and LAO between 30°-60°-were used. An enhanced dynamic wedge with a wedge angle of 45° was applied to the RLO and LLO beams. The MLC was fitted to the PTV structure using a 0.5 cm block margin and optimized collimator jaws. For oblique beams, the spinal cord was blocked by the MLC. Similarly, seven beam angles were used for the IMRT technique: gantry angles of 30°, 75°, 120°, 180°, 240°, 285° and 330°. For the VMAT plan, two full arcs with dose modulation optimization were employed- one from 179° to 181° counter-clockwise and the other from 181° to 179° clockwise, with a collimator angle of 30°. The normal tissue objective parameters and dose constraints (upper objective, lower objective, and the mean value with the same priority during optimization) were the same for both VMAT and IMRT. For optimal movement of MLC during dose delivery, the Varian leaf motion calculator (version 15.5.12) was used. All the Plans are done with 6MV photon with Eclipse (Varian_Siemens) version-15.1 planning system, with calculation grid size-0.25cm, photon volume dose calculation model-AAA (Anisotropic Analytic Algorithm), and VMAT calculation model-PO (Photon Optimizer) algorithm was used with inhomogeneity correction, and all plans are normalized at -Target Mean. A total dose of 54 Gy/30 # over five and a half weeks was prescribed for the above-mentioned treatment plan.

Dosimetric Comparison:

The Key metrics evaluated included the following: PTV Coverage and OAR sparing. To evaluate PTV coverage, the D95%, Dmean, Conformity Index (CI), and

Homogeneity Index (HI) were used. The HI is defined as $(D2\% - D98\%) / D50\%$ and the RTOG Conformity Index is defined as $CIRTOG = VRI / TV$. Similarly, to evaluate OAR Sparing, V5, V20, Mean Lung Dose (MLD) for lung, V25, Mean Heart Dose (MHD) for the heart, Dmean for the esophagus, and Maximum Dose (Dmax) for the spinal Cord were recorded. The dose received by 2% of the PTV represents the near-maximum dose(D2%), the Dose received by 98% of the

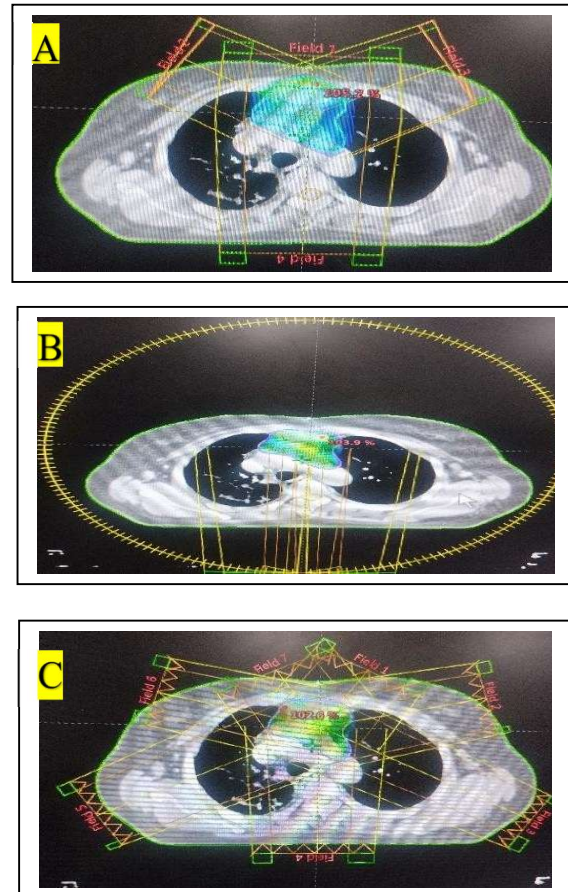


Figure illustrates the three different Radiotherapy Techniques (A) 3DCRT (B) VMAT AND (C)IMRT

PTV represents a near-minimum dose(D98%), and the Median dose to the PTV represents D50%. The volume of tissue receiving the Reference Isodose (e.g., 95% of the prescribed dose) is VRI. HI value defines the dose uniformity in PTV and CI defines the degree of dose conformity to the PTV. In an ideal scenario, the value of $HI=0$, and $CI=1$. The Paddick Conformity Index (CIPaddick) is defined as $(TVRI)^2 / (TV * VRI)$, and TVRI is defined as the Target volume or Volume of PTV covered by the Reference Isodose(e.g., 95% of the prescribed dose). In the Ideal scenario, $CIPaddick=1$, but in clinical practice, its value ranges from 0.7 to 1.

Statistical Analysis

Due to the different PTV volumes for different patients, the fluctuation of OAR doses is greater, and the data are not normally distributed and the number of patients we have taken for calculation is eleven ($n=11$), so we have

to choose a non-parametric test (Friedman test). P-value was compared across the three techniques (3DCRT, IMR, and VMAT) for the same

Results: 11 patients using the Friedman test (a non-parametric test), an alternative to repeated measures ANOVA

PTV Dosimetric Comparison: (illustrated in Table 3). The Friedman test reports the chi-square value and p-value. The p-value ≤ 0.05 signifies the result predicts statistically significant, i.e., we reject the null hypothesis (There is no significant difference of 3DCRT, IMRT, and VMAT). The doses to all OAR are comparable across three different techniques, i.e., 3DCRT, IMRT, and VMAT. No statistically significant differences were observed except for the mean OAR dose of the esophagus ($p < 0.05$), as illustrated in Figure (A)-(H). Considering

IMRT and VMAT provided significantly better conformity and homogeneity than 3DCRT ($p < 0.05$). Regarding the Conformity Index (CI) and Homogeneity Index (HI), there is no statistically significant difference between IMRT and VMAT, but the total Monitor Unit (MU) for VMAT is much lower than that for IMRT. As a result, the treatment time is approximately 50% shorter for VMAT compared to IMRT (illustrated in table -1). The comparison of OAR using three different techniques is shown in Table -2.

Table -1: PTV Dosimetric Comparison

Technique	PTVD95%	CIRTOG	CIPaddick	HI	Total MU
3DCRT	93.88±0.919	1.376±0.181	0.601±0.083	0.159±0.023	242.8±15.2
IMRT	96.24±2.312	1.065±0.076	0.830±0.033	0.089±0.033	860±93.2
VMAT	95.08±1.17	1.014±0.063	0.831±0.026	0.097±0.027	437±88.23

Table -2: OAR Dose Comparison

Volume	Parameter	3DCRT	IMRT	VMAT
Lung (Left)	V20Gy(%)	20.1±5.9	20.38±5.7	18.52±5.5
	V5Gy(%)	57.16±10.2	55.82±8.62	55.64±8.57
	MLD(Gy)	12.05±2.5	11.434±2.2	11.366±2.2
Lung (Right)	V20Gy(%)	16.42±9.1	15.46±6.7	18.04±5.5
	V5Gy(%)	59.96±16.3	58.94±15.7	57.18±13
	MLD(Gy)	11.16±2.8	10.35±2.4	11.73±1.9
Heart	V25(%)	15.64±9.6	10.34±6.92	10.32±8.01
	MHD(Gy)	9.8±5.5	7.63±3.83	7.4±1.41
Spinal Cord	Dmax	26.78±5.97	25.15±2.42	24.66±0.80
Oesophagus	Mean dose (Gy)	19.31±3.4	12.27±0.86	12.17±0.20
Thyroid	Mean dose (Gy)	3.31±1.09	2.88±0.87	3.03±0.73

Statistical Analysis Summary:

CI, HI, Dose constraints to the OAR (left lung, right lung, heart, esophagus, and thyroid) and the total MU

PTV coverage, D95%, no statistically significant differences were observed between the three techniques as illustrated in Figure 7. But CI and HI were much

better for IMRT and VMAT compared to 3DCRT. The VMAT and IMRT showed comparable target coverage with comparable CI and HI. The Only total MU of VMAT was much lower than the IMRT, which leads to better treatment efficacy.

Discussion:

As the thymoma is a rare malignancy, the knowledge regarding the treatment of thymoma is based on evidence gathered from small case series and retrospective analysis. [7]

Although surgical excision of

Of the tumour is the mainstay of treatment,

radiotherapy is commonly used as an adjuvant setting or sole modality in case of inoperability.[1]The anterior mediastinal location of thymomas places multiple

intrathoracic OARs at risk during radiotherapy[4].

The normal tissue toxicity (NTT) depends on the volume of the organ irradiated during the course of

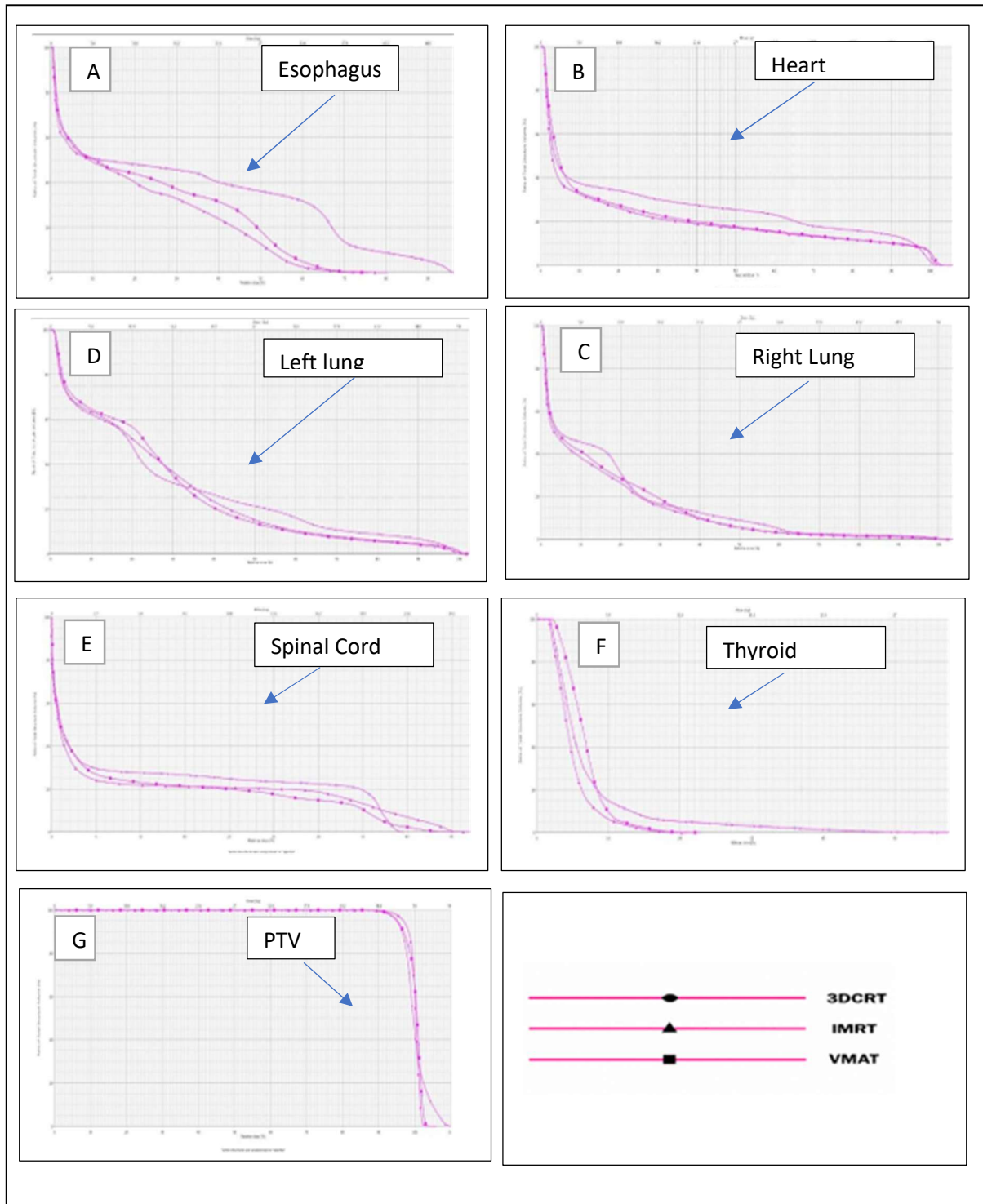
radiotherapy, and includes acute esophagitis, acute pneumonitis, and pericarditis. [5]This study aims to compare these

advanced techniques with traditional 3DCRT to evaluate their effects on PTV coverage and OAR dose exposure. Postoperative radiotherapy to the tumour bed in the thymic epithelial malignancy is usually delivered by using either 3DCRT or IMRT technique, and the clinical

Table3: Statistical Analysis Summary

Parameter	X ² value		Df(=K-1)	P value
Target Volume (PTV)				
D95%	3.6		2	0.1653
CI-RTOG	9.1			0.01057
CI-Paddick	8.4			0.015
HI	8.4			0.015
Organ at Risk (OAR)				
Spinal cord	1.2			0.54881
Heart Mean dose	4.8			0.09072
Heart V25(%)	5.2			0.07427
Left LungV20Gy(%)	1.6			0.44933
Left LungV5Gy(%)	0.4			0.81873
Left LungMLD(Gy)	0.4			0.81873
Right LungV20Gy(%)	0.4			0.81873
Right LungV5Gy(%)	1.2			0.54881
Right LungMLD(Gy)	2.8			0.2466
Esophagus(Mean dose)	8.4			0.015
Thyroid(Mean dose)	0.7			0.70469
Total MU	10			0.00674

target volume includes the whole thymic space, the tumour, its extensions, and the anterior, superior, and middle mediastinum. [8] Although the optimal PORT dose, fractionation is still to be defined, a total dose of 45-50 Gy after R0 resection, 50-54 Gy after R1 resection, with a boost to areas of likely residual disease, is recommended. [8] The conventional fractionation with a daily dose of 1.8 -2 Gy per fraction over 4- 6 weeks is recommended.



Figures illustrate dose volume histograms (DVH) for Organ at Risk (OAR) and Planning Target Volume (PTV) – [fig-A to F] in 3DCRT, IMRT and VMAT Techniques

A comparative study between IMRT vs VMAT for adjuvant radiotherapy treatment in postoperative thymoma, He DC, et al., showed that VMAT (fan-shaped) dosimetrically protects the lung and breast (in females) better than IMRT. The fan-shaped field performed better than the average and full arc field in PORT thymoma.

In another study by Haefner MF et al., comparing particle therapy vs photon therapy showed that charged particle therapy is superior to photon in reducing dose to lungs, heart, esophagus, spinal cord, and breast while providing optimal target coverage. [9] In our study, IMRT and VMAT provide superior PTV coverage and better sparing of the lungs, heart,

esophagus, and spinal cord compared with found between VMAT IMRT. While VMAT and IMRT 3DCRT.VMAT, in particular, shows advantages in provided similar dosimetric outcomes, i.e., PTV delivery efficiency, reduced treatment time, and coverage with CI and HI, VMAT significantly reduced marginally improved dosimetry. However, both treatment delivery time compared to IMRT. This advanced techniques should be considered depending on suggests that VMAT may be the more efficient modality institutional resources and clinician preference. for thymoma treatment, offering comparable dose conformity and OAR sparing with improved clinical workflow efficiency.

Limitations:

Apart from retrospective design and small sample size, the limitations of our study is the inclusion of only Financial support and sponsorship-Nil adjuvant RT (PORT) cases, and the definitive RT or salvage RT cases were not included.

Conclusions

In this dosimetric analysis of thymoma radiotherapy, all organs-at-risk (OARs) demonstrated comparable dose distributions across 3DCRT, IMRT, and VMAT techniques, except for the oesophagus dose, where a mean dose variation was observed. However, no statistically significant differences in OAR dose were

Conflict of interest- There are no conflicts of interest.

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References

- Rathod S, Munshi A, Paul S, Ganesh B, Prabhaskar K, Agarwal JP.** Thymoma: first large Indian experience. *Indian J Cancer.* 2014 Apr-Jun;51(2):109-12. doi: 10.4103/0019-509X.138144. PMID: 25104189. PMC5257334.
- Zhu G, He S, Fu X, Jiang G, Liu T.** Radiotherapy and prognostic factors for thymoma: a retrospective study of 175 patients. *Int J Radiat Oncol Biol Phys.* 2004 Nov 15;60(4):1113-9. doi: 10.1016/j.ijrobp.2004.05.013. PMID: 15519782.
- Forquer JA, Rong N, Fakiris AJ, Loehrer PJ Sr, Johnstone PA.** Postoperative radiotherapy after surgical resection of thymoma: differing roles in localized and regional disease. *Int J Radiat Oncol Biol Phys.* 2010 Feb 1;76(2):440-5. doi: 10.1016/j.ijrobp.2009.02.016. Epub 2009 May 8. PMID: 19427738.
- Shirvani SM, Gomez DR, Fuller CD, and Thomas CR Jr.** Mediastinum and Trachea. In: Halperin EC, Wazer DE, Perez CA, and Brady LW, editors. *Principles and Practice of Radiation Oncology.* Philadelphia, PA: Lippincott Williams & Wilkins; 2019. p. 3666-3779.
- Bogart JA.** Thoracic neoplasms. In: Tepper JE, Foote RL, Michalaski JM, editors. *Gunderson & Tepper's clinical radiation oncology.* Philadelphia, PA: Elsevier; 2021. P. 817-824.
- Rimner A, Yao X, Huang J, Antonicelli A, Ahmad U, Korst RJ, et al.** Postoperative Radiation Therapy Is Associated with Longer Overall Survival in Completely Resected Stage II and III Thymoma-An Analysis of the International Thymic Malignancies Interest Group Retrospective Database. *J Thorac Oncol.* 2016 Oct;11(10):1785-92. doi: 10.1016/j.jtho.2016.06.011. Epub 2016 Jun 23. PMID: 27346413; PMCID: PMC5257334.
- Kumar N, Kumar R, Bera A, Ghoshal S, Kapoor R, Radotra BD, Sharma SC.** Thymoma: clinical experience from a tertiary care institute from North India. *J Cancer Res Ther.* 2013 Apr-Jun;9(2):235-9. doi: 10.4103/0973-1482.113364. PMID: 23771365.
- Girard N, Ruffini E, Marx A, Faivre-Finn C, Peters S; ESMO Guidelines Committee.** Thymic epithelial tumours: ESMO Clinical Practice Guidelines for diagnosis, treatment and follow-up. *Ann Oncol.* 2015 Sep;26 Suppl5:v40-55. doi: 10.1093/annonc/mdv277. PMID: 26314779.
- He DC, Zhu ZJ, Zhang XY, Zhang Y, Hong J, Shi TT, et. al.** Dosimetric analysis of postoperative radiotherapy for thymoma. *Cancer Radiother.* 2022 Jun;26(4):537-541. doi: 10.1016/j.canrad.2021.07.037. Epub 2021 Oct 30. PMID: 34728117.
- Haefner MF, Verma V, Bougattf N, Mielke T, Tonndorf-Martini E, König L, et. al.** Dosimetric comparison of advanced radiotherapy approaches using photon techniques and particle therapy in the postoperative management of thymoma. *Acta Oncol.* 2018 Dec;57(12):1713-1720. doi: 10.1080/0284186X.2018.1502467. Epub 2018 Sep 28. PMID: 30264630.

Effect of Parental Education on Outcome of Pediatric Bronchial Asthma

Suhail Saifullah, Asif Ahmed, Reyaz Ahmad Malik .

Original Article

Abstract

Background

Asthma is an important non communicable disease, which affected an estimated 363 million people in 2023 and caused 442 000 deaths globally. Numerous epidemiological studies have found higher rates of mortality and morbidity among groups with a lower socioeconomic status. Parental education is a significant factor in the compliance of the child's illness with treatment. As with many chronic conditions, disparities in asthma outcomes exist according to race and socioeconomic status.

Methods

The sample consisted of 66 asthmatic children aged between 5-15 years attending the Out Patient Department of Pediatrics in a tertiary care teaching hospital. A modified International Study of asthma and allergies in Children (ISAAC) questionnaire for assessment of objectives of this investigation was administered to the parents.

Results

More educated fathers & mothers had asthma education ($p < 0.05$). Dust & viral colds were presumed to be most common triggers of Bronchial Asthma ($p < 0.05$). Parents with lesser education prevented their asthmatic children from participating in sports activities, while as more educated parents allowed their children to participate in sports activities ($p < 0.05$). Most of the lesser educated parents practiced ill and poor adherence to the important medicines for asthma as compared to more educated parents (P value < 0.05). The data revealed that less literate parents either didn't take their child for a regular check-up to their doctor or just visited 1-3 times a year. In contrast to this, better educated parents visited the doctor 4-6 or more than 6 times a year (P value < 0.05). Less educated parents reported a higher use of SABA in preceeding week, thus indicating a poorly managed & poorly controlled bronchial asthma ($p < 0.05$). they also reported a higher number of Emergency Room visits in preceeding year as compared to better educated parents ($p < 0.05$).

Conclusions

Higher education of parents was associated with a better understanding of Bronchial Asthma in their children, its management & outcome of the treatment.

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Author Affiliations

Suhail Saifullah MD ; **Asif Ahmed** MD , Associate Professor; **Reyaz Ahmad Malik** MD, Professor:
Department of Pediatrics SKIMS Medical College Srinagar J&K

Correspondence

Dr. Asif Ahmed, Associate Professor, Department of Pediatrics SKIMS Medical College Srinagar J&K. email ID- drasifskims@gmail.com

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Introduction

Asthma is an important non communicable disease, which affected an estimated 363 million people in 2023 and caused 442 000 deaths globally (1). It is a chronic, inflammatory, reversible respiratory condition (2). In 2013, asthma was the primary diagnosis for 2.0 million emergency room visits (3). Children with asthma missed 13.8 million school days in total in 2013 (4). These absences have been shown to have many adverse effects on children, including a decrease in academic performance as well as mental and social hindrances (5). In the last 30 years, there has been a steady, relentless increase in the prevalence of childhood bronchial asthma throughout the world. The common characteristics of bronchial asthma include bronchospasm, variable airway narrowing, bronchial hyper-responsiveness, and airway inflammation.

Inequalities in health between socio-economic groups are a major public health concern. Numerous epidemiological studies have found higher rates of mortality and morbidity among groups with a lower socioeconomic status (SES) defined by education, income or occupation within countries and across countries [1–8]. Social inequalities in health are not confined to poor health among the most deprived. Marmot and coworkers [9, 10] reported increasing mortality and morbidity with decreasing socioeconomic status for British civil servants, not considered to be poor by any usual standard. Allergies seem to be one of the exceptions with regard to their association with socioeconomic status.

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Keywords

Bronchial asthma, children, parental education, outcome .

A number of studies performed in industrialized Western countries reported decreased prevalence of eczema [11, 12], hay fever [11, 13], and atopy determined by skin-prick testing and measurements of specific immunoglobulin E [11, 14–16] among children and adults with low SES. Heinrich *et al.* [17] and Kramer *et al.* [18] reported an increased prevalence of eczema, allergic rhinitis and allergy for children from highly educated parents living in the former East Germany, where differences between social groups with regard to income were relatively small. Asthma which is at least partly attributable to allergy [19] does not follow the same pattern as eczema, hay fever and allergic sensitization. Mielck *et al.* [20] reviewed 24 studies on the association between childhood asthma and socioeconomic status and found that the studies did not reveal a clear picture; positive associations were as frequent as negative ones, and most studies showed no association at all. The International Study on Asthma and Allergies in Childhood [21] reported higher prevalence of asthma for urbanised, more “Westernised” countries compared with less developed countries. Differences in susceptibility and differences in exposure were proposed to influence, and to be influenced by, SES and each other [22]. Both exposure and susceptibility may lead to unequal health outcomes, which can then cycle back to affect socioeconomic status [22].

It is well known that parent education helps to reduce the burden of asthma in children. Parental education is a significant factor in the compliance of the child's illness with treatment. As with many chronic conditions, disparities in asthma outcomes exist according to race and socioeconomic status. Black children are at greater risk for hospitalization, even after controlling for socioeconomic status (11). Children of lower socioeconomic status have higher rates of hospitalization independent of their race (12) and report worse health status on self-report measures (13). The reasons for these disparities are not well understood and may be related to severity of illness, environmental exposures, quality of care, and literacy level of their parents. Low literacy is associated with several markers of vulnerability including non-white race and low socioeconomic status (SES) (14). Many researchers have hypothesized that low literacy may be a contributing factor in disparities according to race or socioeconomic status (15, 16 and 17). Parents with low literacy have less knowledge about asthma management (18). Specifically, such parents scored lower on a knowledge test, and also performed worse on metered-dose inhaler technique (18). Parents with low literacy also have higher rates of emergency department visits and lower asthma-related quality of their children's life (19).

Health literacy of parents is another key factor influencing asthma management outcomes of children. Increasing evidence emphasizes the role of health literacy among parents of [children in asthma](#) care quality and control (20) and has revealed that disease education

of parents provide suitable information that not only increases knowledge related to the health of their children but also helps them to take a more active role in the care management of them (21). Asthma education therefore assist the parent to manage the disease in terms of improving asthma patients' knowledge, controlling episodes of asthma, preventing acute and chronic complications, and maintaining or improving health behaviors (23).

Materials and methods

The sample consisted of 66 asthmatic children aged between 5-15 years attending the Out Patient Department of Pediatrics in a tertiary care teaching hospital.

A questionnaire for assessment of objectives of this investigation was administered to the parents. Questionnaire developed by International Study of asthma and allergies in Children (ISAAC) is the most widely accepted. Relevant modifications were made to this questionnaire and used. Each parent's literacy level, occupation and monthly family income were assessed along with other questions related to the disease of their child.

Every patient was included in the study after obtaining informed consent from the parent. Strict confidentiality of data was maintained throughout.

Inclusion Criteria: -

1. Children aged between 5-15 years with symptoms of intermittent dry coughing, wheezing or shortness of breath (but not cough alone) OR recurrent chest tightness OR non focal chest pain (symptoms being worse at night) AND often associated with worsening by physical exertion, or exposure to cold/dry air and airway irritants who were diagnosed to have Bronchial Asthma.
2. Presence of risk factors such as allergic rhinitis, allergic conjunctivitis, atopic dermatitis, food allergies or parental asthma & presence of physician detected wheeze &/or a prolonged exhalation phase, rales, reduced air entry, suprasternal and intercostal retractions.
3. Quick resolution (within 10 mins) or convincing improvement in symptoms and signs with administration of a SABA (e.g levosalbutamol)
4. Fully informed proxy consent and assent wherever appropriate.

Exclusion criteria: -

1. Viral episodic wheeze/ Multiple trigger wheeze/ Acute Bronchiolitis.
2. Chronic aspiration syndromes/ GERD/ Laryngopharyngeal reflux/ Posterior nasal drip/ Rhinosinusitis.
3. Bronchopulmonary dysplasia/Tracheobronchomlacia/Bronchiolitis Obliterans/ Laryngeal webs or stenoses/ Vocal cord dysfunction.
4. Nasal foreign body/ Foreign body aspiration.

5. Congestive heart failure.
6. Pneumonia/ Tuberculosis/ Cystic fibrosis presenting as a wheezy chest.
7. Allergic bronchopulmonary aspergillosis/ Immunodeficiencies/ Immobile Cilia Syndromes/ Interstitial lung diseases.
8. Use of medications causing chronic cough e.g beta blockers, ACE inhibitors.

Definition of explanatory variables:

In the current study, variables that might explain potential associations between parental education and parental knowledge and beliefs about the disease have been termed “explanatory variables”. Potential explanatory variables, such as asthma education, asthma being contagious, asthma being curable, asthma mechanism, triggers of asthma and food avoidance were identified.

Statistical and biometrical analysis:

Statistical and biometrical analysis includes bivariate analysis of the relationship between parental literacy and pediatric asthma outcomes, using chi-squared tests for categorical data. The information obtained was transferred to excel spreadsheet and entered in SPSS version. Data was checked and cleaned. The frequency analysis was done to assess the prevalence of asthma and various factors affecting it. Chi-square test was done for certain factors. P value of <0.05 was considered significant.

Results

This study was conducted on 66 asthmatic children aged between 5-15 years attending the OPD of the Department of Paediatrics at a tertiary care teaching hospital whose parents were invited to participate and complete the questionnaire. All the parents completed the questionnaire after detailed history and clinical examination of their children.

1. Description of the study population:

The following frequency variables were assessed: Mother's Age, Father's Age, Mother's Education, Father's Education, Mother's Job, Father's Job, Family Income, Habitation, Parental Smoking, Main attack symptom, Dr Visits/ year, ER (Emergency Room) visits last year, number of days SABA used last week, Controller medication use, Child taught spacer use.

Frequency distributions of mother's age ranged from 6.1% to 33% for the age group of 20-25 and >35yrs respectively. Frequency distributions of father's age ranged from 39.4% to 66% for the age group of 26-35 and >35yrs respectively. Frequency of parental education differed considerably. The percentage of low parental education, as defined here as illiterate was 16.7% in case of mothers and 1.5% in father's case. The highest percentage (22.7%) was of the matriculate mothers and highest percentage (33.3%) of the graduate fathers respectively. The lowest percentage was of doctorate mothers (1.5%) and of illiterate father group (1.5%).

When it came to the employment distribution, it was observed that mothers were usually home makers (72.7% of total study population) and there was only 1

father as a homemaker. The lowest percentage was that of Govt. employee mother (3%) and the frequency distribution was equally highest for labourer and business class in case of father's job (27.3%). 4.5% of the Families had lowest income of <10k and those with income of >50k were 36.4%. (Table 1)

Table 1: Frequency Distribution/Demographic Data:

Serial Number	Variable	Frequency	Percentage
1.	Mother's Age		
	20-25yrs	4	6.1
	26-35yrs	40	60.6
	>35yrs	22	33.3
	Total	66	100.0
2.	Father's Age		
	26-35yrs	26	39.4
	>35yrs	40	60.6
	Total	66	100.0
3.	Mother's Education		
	Illiterate	11	16.7
	Primary	14	21.2
	Matriculate	15	22.7
	Graduate	15	22.1
	PG	10	15.2
	Doctorate	1	1.5
	Total	66	100.0
4.	Father's Education		
	Illiterate	1	1.5
	Primary	2	3.0
	Matriculate	16	24.2
	Graduate	22	33.3
	PG	20	30.3
	Doctorate	5	7.6
	Total	66	100.0
5.	Mother's Job		
	Home maker	48	72.7
	Skilled	3	4.5
	Business	5	7.6
	Professional	8	12.1
	Govt. emp	2	3.0
	Total	66	100.0

Out of 66 asthmatic children, 39.4% had either a smoking father or smoking mother and 60.6% children had non-smoker parents. The main attack symptom as cough was highest having a frequency distribution of 51.5% followed by fast breathing (30.3%) and wheeze (18.2%). 47% of children were taken to a doctor 1-3 times a year and 16.7% were taken 4-6 times a year. Emergency visits for last year was highest as 1-3 times with 42.4% distribution and lowest percentage (1.5%) was for >6 visits last year. For management of the symptoms, inhaled corticosteroids (ICS) were used in majority of the children (63.6%) and the lowest

percentage was for Montelukast and oral steroids used alone (1.5%). 38 children were taught to use spacers out of 66.

2. Parental education, beliefs and explanatory variables:

Out of 66 children in our study, no illiterate and matriculate mother had asthma education, 1 primary educated mother, 4 graduates, 6 P.G and 1 doctorate Mother had knowledge about asthma. This difference is statistically significant (P value ≤ 0.0001).

Out of 66 children in our study, highest number of Fathers was graduates. It was observed that no illiterate and primary educated father had asthma education, 1 matriculate, 1 graduate, 4 P.G and 6 doctorate Fathers had knowledge about asthma. This difference is statistically significant (P value ≤ 0.05).

Out of all mothers, the ones who believed asthma is contagious were either illiterate or primary pass outs. Though this difference is statistically insignificant (P value > 0.05).

Similarly, out of all fathers, the ones who believed asthma is contagious were matriculate and graduate. Though this difference is statistically insignificant (P value > 0.05).

The belief that asthma is curable was independent of the fact that whether a mother is less or more educated. Almost all of them believed the same with some exceptions. This difference is statistically insignificant (P value > 0.05).

The belief that asthma is curable was more seen among matriculate, graduate and PG fathers as 10, 18 and 19 fathers respectively. This difference is statistically insignificant (P value > 0.05).

Various asthma mechanisms are Constriction of wind pipe, Allergic reactions, Chest muscle tightness and swollen airways. Out of these mechanisms, less educated as well as highly educated mothers believed that the two most common mechanisms for asthma were constriction of wind pipe and allergic reactions. This difference is statistically insignificant (P value > 0.05). Similarly, in case of fathers, less educated as well as highly educated fathers believed that the two most common mechanisms for asthma were constriction of

wind pipe and allergic reactions, also 3 matriculates, 3 Post graduates and 2 scholars believed that chest muscle tightness was also a mechanism to induce asthma attack. This difference is statistically insignificant (P value > 0.05).

Triggers of asthma which were taken into consideration in our investigation were Dust, Exercise, Scents, Viral colds and Pollen/ grass. Amongst these triggers, Dust and viral colds were considered the major trigger by mothers followed by scents and exercise. This difference is statistically insignificant (P value > 0.05).

Amongst these triggers, Dust and viral colds were considered the major trigger by fathers followed by scents and exercise. This difference is statistically significant (P value < 0.05).

Foods which were believed to cause an asthma attack and thus to be avoided by asthmatic children were

banana, ice creams, curd and citrus fruits. Almost all mothers believed that ice creams and curd are to be avoided as well as citrus fruit intake. This difference is statistically insignificant (P value > 0.05) thus the level of education of mothers didn't affect the belief of avoiding certain kind of food by their asthmatic children.

In the same way, ice creams, curd and citrus fruits were believed to be avoided by fathers in our investigation. This difference is statistically insignificant (P value > 0.05). Thus the level of education of fathers didn't affect the belief of avoiding certain kind of food by their asthmatic children.

The data revealed that illiterate, primary pass outs and high school pass outs usually believed sports to trigger asthma hence didn't permit their children with asthma to play sports. While as, graduate, post graduate and doctorate mothers allowed their children to enjoy sports activities. This difference is statistically significant (P value < 0.05).

The data revealed that primary pass outs, high school pass outs and few graduate fathers believed sports to trigger asthma hence didn't permit their children with asthma to play sports. While as, most of the graduates and post graduates and all doctorate fathers allowed their children to enjoy sports activities. This difference is statistically significant (P value < 0.05).

Tablets, nebulizers and inhaler devices were the prescriptions used by parents for their sick children. Out of these, mothers believed nebulizers to be the most effective and quick first-hand treatment for pediatric asthma followed by inhalers as believed by primary and matric pass out Mothers. This difference is statistically insignificant (P value > 0.05).

Fathers believed nebulizers and inhalers to be the most effective and quick first-hand treatment for pediatric asthma followed. This difference is statistically insignificant (P value > 0.05).

Out of 66 mothers, 46 mothers from different education backgrounds believed that inhaled corticosteroids (ICS) reduced the height of children to some extent. This difference is statistically insignificant (P value > 0.05).

Similarly, Out of 66 fathers, 46 Fathers from different education backgrounds believed that inhaled corticosteroids (ICS) reduced the height of children to some extent. This difference is statistically insignificant (P value > 0.05).

3. Practices to manage asthma:

Parents used many practices to manage asthma and keep it under check. Asthma was mainly managed by using ICS (inhaled corticosteroids), nebulizers, adhering to prescribed medicines, use of controller medicines, visiting the doctor, use of SABA (Short-Acting Beta Agonists) and finally ER (emergency room) visits.

ICS was used twice a day by 45 mothers, among which 7 were illiterate, 9 primaries, 14 matriculate, 9 graduate, 5 post graduate and 1 doctorate. Hence the lesser educated ones used it more frequently although, this difference is statistically insignificant (P value > 0.05).

A similar trend was observed in case of Father where ICS was used twice a day by 45 fathers out of 66, among which 1 was primary pass out, 11 matriculate, 19 graduate, 10 post graduate and 4 doctorate. This difference is statistically insignificant (P value >0.05). 3 illiterate, 4 primary pass outs, 8 matriculate, 14 graduate, 9 post graduate and 1 doctorate mother used nebulizer at home. This difference is statistically significant (P value <0.05).

1 primary pass outs, 3 matriculate, 13 graduate, 18 post graduate and 4 doctorate Fathers used nebulizer at home. This difference is statistically significant (P value <0.05).

11 illiterate, 13 primary pass outs, 10 matriculate, 7 graduate, 3 post graduate and zero doctorate mothers practiced ill and poor adherence to the important medicines for asthma. This difference is statistically significant (P value <0.05).

1 illiterate, 2 primary pass outs, 14 matriculate, 18 graduate, 8 post graduate and 1 doctorate father used nebulizer at home. This difference is statistically significant (P value <0.05).

The data revealed that illiterate mothers, primaries and matriculates either didn't take their child for a regular check-up to their doctor or just visited 1-3 times a year. In contrast to this, graduates and above graduates visited the doctor 4-6 or more than 6 times a year. This difference is statistically significant (P value <0.05).

The data revealed that illiterate fathers, primaries and matriculates either didn't take their child for a regular check-up to their doctor or just visited 1-3 times a year. In contrast to this, graduates and above graduates visited the doctor 4-6 or more than 6 times a year. This difference is statistically significant (P value <0.05).

The controller medicine used at home in case of a sudden asthma attack were either none, or ICS, or montelukast, or ICS + montelukast or oral steroids. In majority of cases, ICS or ICS + montelukast was used by mothers to deal with it. Below matric and matric pass mothers used both ICS as well as montelukast simultaneously where as graduates and above graduates used only ICS. Further, oral steroids were used by only uneducated mothers. This difference is statistically significant (P value <0.05).

ICS (42) or ICS + montelukast (14) was used by fathers as a controller medicine. This difference is statistically significant (P value <0.05).

6 graduate mothers and 6 post graduate mothers didn't use SABA last week. 1 illiterate, 2 primary pass outs, 10 matriculate, 8 graduate and 2 post graduate mothers used SABA 1-3 times last week. This difference is statistically significant (P value <0.05).

2 graduate mothers, 9 post graduate and 3 doctorate fathers didn't use SABA last week. 1 primary pass outs, 2 matriculate, 10 graduate and 8 post graduate fathers used SABA 1-3 times last week. 1 illiterate, 1 primary pass outs, 14 matriculate, 10 graduate and 3 post graduate fathers used SABA 4-7 times last week. This difference is statistically significant (P value <0.05).

4 illiterate, 7 primary pass outs, 9 matriculate, 6

graduate, 2 post graduate and zero doctorate mothers needed 1-3 Emergency room visit for their child last year. 5 illiterate and 7 primary educated mothers required ER visits 4-6 times last year and only 1 mother who was uneducated needed to visit >6 times to ER last year. This difference is statistically significant (P value <0.05).

1 primary pass out, 6 matriculate, 11 graduate, 9 post graduate and 1 doctorate fathers needed 1-3 Emergency room visit for their child last year. 8 matriculate, 5 graduate, 1 post graduate Fathers required ER visits 4-6 times last year and only 1 father who was primary pass out needed to visit >6 times to ER last year. This difference is statistically significant (P value <0.05)

Discussion

Several studies have been conducted illustrating the effectiveness of asthma education programs (21,22). One systematic literature review concluded that educating the patient and/or the caregivers about the proper management of asthma shows statistically significant reductions in missed school days and Emergency room visits. This study provides evidence that parents of children with asthma harbor considerable misconceptions about the disease. More than half of the surveyed parents expressed a lack of understanding or confusion about asthma etiology. In recent decades, very few studies have been found in our databases highlighting the parental perceptions and practices towards asthma management. To understand the present lacuna in asthma control and management, the health care system and parental education are the key component, which needs to be improved in order to achieve better asthma control.

This study provides valuable insight and critical cognizance about perceptions and various practices adopted by Kashmiri parents in asthma management. In our society the diagnosis of asthma is viewed as a stigma. Fifty per cent of those interviewed in this study confessed that they hesitated to disclose to others that their child suffered from asthma. Parents used terms like allergy, chronic cough, chest congestion, etc. to refer to their child's illness.

Our results revealed that only 18.2% of the parents had a good amount of knowledge about asthma while the majority of parents (81.8%) lacked such knowledge. One-third of the parents believed asthma to be contagious, which was more common amongst parents with poor education background, although it is difficult to postulate the basis of this belief, the consequences, as far as the child is concerned, are probably serious. In many families the affected child was not allowed to share food with the other siblings. It is reasonable to presume that such actions on the part of the mother make the asthmatic child feel different or inferior to other children by repeatedly reminding him of the fact that he has asthma. It remains to be studied whether this contributes to behavioral disturbances in asthmatic children. Parents who were graduates or more than that educated believed it to be a non-contagious disease. Hence, the differences were statistically significant

which shows that there was an association between the idea of asthma being contagious and the level of education a parent had. The belief that asthma is curable was independent of the fact that whether a mother is less or more educated. Almost all of them believed the same with some exceptions. This difference is statistically insignificant, however in case of fathers, educated ones believed it to be curable as compared to uneducated ones. Educated parents had a clearer concept of the mechanism behind an asthma attack. However, less educated as well as highly educated mothers and fathers believed that the two most common mechanisms for asthma were constriction of wind pipe and allergic reactions. So, there was no significant correlation observed between parental education and knowledge of asthma mechanism.

Triggers of asthma which were taken into consideration in our investigation were Dust, Exercise, Scents, Viral colds and Pollen/ grass. There was no significant correlation between trigger of asthma and parental education. Amongst these triggers, dust and viral colds were considered a potent trigger factor by mothers as well as fathers, followed by scents and exercise. To have better treatment outcomes, it is important to explain to the parents that asthma is not solely hereditary, but environmental factors play a major role in susceptibility and triggering of attacks.

Parents described a variety of factors which could precipitate an attack of asthma in their child. These were foods, cold weather, change in season, exertion and others. Most parents were restricting certain foods in their child's diet because of these beliefs. These foods were banana, curd, ice creams and orange (which are considered to be cold). Such beliefs were not restricted to any particular education group & hence educated and uneducated parents did not differ significantly in this regard. Parents with higher education allowed their children to exert and play sports but the less educated and uneducated parents were usually found reluctant to permit their asthmatic child to participate in sports activities. Hence, there was a significant relation between parental education and the belief of sports to trigger asthma.

In order to enhance the level of perceptions among asthmatic patients and caregivers, education should include knowledge about asthma and its management, as there might be misperceptions about the use of inhalers and the safety of inhaled corticosteroids (ICS). Parents often express concern about the safety of asthma medications. Furthermore, parental concern regarding medication dependence was reported as a reason for weaning children off the drugs. In our study, the majority 46 (69.7%) of parents with asthmatic children were concerned about the side effects of ICS in reducing the height which may be related to lack of knowledge about asthma, lack of partnership in the management, inappropriate expectations, and cultural issues. It is widely known that improving adherence to inhaled corticosteroids (ICS) in children with asthma is probably the most effective method through which healthcare

providers can reduce the burden of uncontrolled asthma. However, unfortunately the majority of parents with asthmatic children from Asian countries view ICS administration to their children as a means of becoming addicted to or dependent on inhaler use, a misconception possibly related to modern day inhalational drug abuse and steroid abuse driven by extensive media campaigns. These concerns may likely prompt the children to miss the prescribed doses of inhaled steroids with increased problems of non-adherence to treatment as well as higher number of consequent hospitalizations.

Regarding parental practices toward asthma control, inhalers, nebulizers, SABA, controller medicines etc. were used. Nebulizers were mostly used by higher educated parents. 28.6% primary educated mothers, 53.3% matriculates, 93.3% graduates, 90% post graduates and 100% doctorates used nebulizers at home. Also, 18.8% matriculates, 59.1% graduates, 90% post graduates and 80% doctorate fathers used nebulizers. Thus, there was a correlation between using nebulizer at home and parental education.

It was also observed that educated parents adhere to the prescribed regimen as compared to less educated ones. 100% of illiterate mothers, 92.9% of primary pass outs, 66.7% of matriculates, 46.7% of graduates and 30% of post graduate mothers didn't adhere to medicine properly. 100% of illiterates, 100% of primary pass outs, 87.5% of matriculate, 81.8% of graduates, 40% of post graduates and 20% of doctorate fathers didn't adhere to medicine properly. Moreover, parents with lower family incomes and a higher number of children were concerned more about medication dependency and parents with lower education levels were more concerned about the side effects of inhaled steroids compared with more highly educated parents.

This finding can be considered as lack of awareness and under utilization of medical facilities in management and control of asthma, which might also explain increased asthma prevalence among lower socioeconomic groups with education also being a determinant of asthma risk. Parental education is crucial for successful treatment of this disease, and it is important that the treating physician emphasizes the role of effective medications in asthma control. It is necessary to inform parents/children about the long-term course of asthma and point out the safety of prolonged inhaled steroid use. The data revealed that illiterate fathers and mothers, primaries and matriculates either didn't take their child for a regular check-up to their doctor or just visited 1-3 times a year. 42.9% graduates, 28.6% post graduates and 14.3% doctorate mothers took their asthmatic child >6 times per year to the doctor and 28.6% graduates, 57.1% post graduates and 14.3% doctorate fathers took their asthmatic child >6 times per year to the doctor. This shows that less educated parents didn't take an asthmatic child serious enough to be shown to the doctor for a check-up.

34.5% illiterate mothers, 41.4% primaries and 13.8% matriculates used SABA the highest number of times last week (4-7). 42.9% graduates and 42.9% post

graduate mothers didn't use SABA at all. This survey showed that children of uneducated and less educated parents more often used inhaled β -agonists and inhaled steroids for asthma control, as was shown in other studies which also suggest their lack of efficiency in keeping the asthma of their child under check.

There was only 1 doctorate mother and she didn't require the need for ER for her child last year. Out of total 10 post graduate mothers, only 2 visited 1-3 times and 1 visited 4-6 times while as rest of the 7 mothers didn't visit ER at all. There were 15 graduates among whom 6 required 1-3 visits and rest of them didn't visit ER. Out of 11 uneducated mothers, 4 visited 1-3 times and 5 visited 4-6 times last year. 7 primary pass out mothers needed to take their asthmatic child 1-3 times to ER and 7 of such mothers visited 4-6 times to ER. Out of total 5 doctorate fathers, only 1 visited ER 1-3 times and rest of the 4 fathers didn't visit ER at all. There were 20 post graduates and only 9 required 1-3 ER visits for their child and the remaining ones didn't need the visit. 50% of matriculate fathers needed 4-6 ER visits last year. This suggests that there was a significant association between the two factors and educated parents didn't require emergency visits as frequent as the less educated ones.

Conclusions

Higher education of parents was associated with a better understanding of Bronchial Asthma in their children, its management & outcome of the treatment. These children were using ICS as advised. They had better follow up with doctors. Their bronchial asthma was better controlled & thus there was a lesser need for rescue SABA therapy in them & they had fewer Emergency Room visits.

References

1. **Global Burden of Disease Collaborative Network.** Global Burden of Disease Study 2023 (GBD 2023). Seattle, United States: Institute for Health Metrics and Evaluation (IHME), 2025. Center for Disease control and prevention <https://www.cdc.gov/asthma/triggers.html>.
2. **Douglas J.** Occupational asthma. *Practice Nurse* 40 (4): 19-20.
3. **Centers for Disease Control and Prevention.** 2015 National Health Interview Survey (NHIS) Data: Current Asthma Population Estimates – in thousands, <https://www.cdc.gov/asthma/nhis/2015/table3-1.htm>
4. **Centers for Disease Control and Prevention.** National Hospital Ambulatory Medical Care Survey: 2014 Emergency Department, https://www.cdc.gov/nchs/data/nhamcs/web_tables/2014_ed_web_tables.pdf
5. **United states Environmental Protection Agency.** Asthma Facts, <https://www.epa.gov/asthma/2017-asthma-fact-sheet>
6. Moonie S, Sterling DA, Figgs LW. The relationship between school absence, academic performance, and asthma status. *Journal of School Health* 78: 140–148.
7. **United States Center for Disease Control.** Asthma's Impact on Nation, https://www.cdc.gov/asthma/impacts_nation/asthmafactsheet.pdf
8. **Seans MR, Rea HH, Rothwell RPG.** Asthma mortality comparison between New Zealand and England. *British Medical Journal* 239:1342-1344.
9. **Evans RE, Mullally DI, Wilson RW.** National trends in morbidity and mortality of asthma in USA: Prevalence, hospitalization and death from asthma over last two decades: 1965- 1984. *Chest* 91: 655-745.
10. **Venables KM, Farrer N, Sharp L, Graneek BJ, Newman Taylor AJ.** Respiratory symptoms questionnaire Bronchial Asthma epidemiology: Validity and reproducibility. *Thorax* 48:214-9.
11. **Singh D, Sobti PC, Arora V, Soni RK.** Epidemiological study of Bronchial Asthma in rural children. *Indian Journal of Community Medicine* 27:167-70.
12. **Kelley E, Clancy C, Stryer D.** National Healthcare Quality Report. <http://www.qualitytools.ahrq.gov/qualityreport>.
13. **Amre DK, Infante-Rivard C, Gautrin D, Malo JL.** Socioeconomic status and utilization of health care services among asthmatic children *Journal of Asthma* 39(7):625–631.
14. **Olson LM, Lara M, Frintner MP.** Measuring health status and quality of life for US children: relationship to race, ethnicity, and income status. *Ambulatory Pediatrics* 4: 377–386.
15. **Kutner M, Greenberg E, Baer J. A** first look at the literacy of America's adults in the 21st century. Baltimore: U.S. Department of Education; 2005. NCES 2006–470.
16. **Saha S.** Improving Literacy as a Means to Reducing Health Disparities. *Journal of General Internal Medicine* 21(8):893–895.
17. **Sentell TL, Halpin HA.** Importance of Adult Literacy in Understanding Health Disparities. *Journal of General Internal Medicine* 21(8):862–866.
18. **Howard DH, Sentell T, Gazmararian JA.** Impact of Health Literacy on Socioeconomic and Racial Differences in Health in an Elderly Population. *Journal of General Internal Medicine.* 21(8):857–861.
19. **Williams MV, Baker DW, Honig EG, Lee TM, Nowlan A.** Inadequate literacy is a barrier to asthma knowledge and self-care. *Chest* 114(4):1008–1015.
20. **Mancuso CA, Rincon M.** Impact of Health Literacy on Longitudinal Asthma Outcomes. *Journal of General Internal Medicine.* 21(8):813–817.
21. **Wood MR, Price JH, Dake JA, Telljohann SK, Khuder SA.** African American parents'/guardians' health literacy and self-efficacy and their child's level of asthma control. *Journal of Pediatric Nursing* 25: 418-427.
22. **Hoover EL, Pierce CS, Spencer GA, Britten MX, Neff-Smith, James GD.** Relationships among functional health literacy, asthma knowledge and the ability to care for asthmatic children in rural dwelling parents. *Online Journal of Rural Nursing and Health Care* 12: 30-40.
23. **Adams CD, Joseph KE, MacLaren JE, DeMore M, Koven L.** Parent-youth teamwork in pediatric asthma management. *Journal of Allergy and Clinical Immunology* 113: 159-175.

Gestational Weight Gain as Per Pre-Pregnancy Nutritional Status: Comparison Across Different BMI Categories

Gazala Nisar, Nilofer Khan.

Original Article

Abstract

Background

Gestational weight gain (GWG) is a critical determinant of maternal and fetal outcomes. Pre-pregnancy BMI is the strongest predictor of GWG, but data from Kashmir Valley is limited.

Objectives:

To assess gestational weight gain across different pre-pregnancy BMI categories and compare it with Institute of Medicine (IOM) 2009 recommendations.

Methods

A hospital- based cross sectional study was conducted among 400 pregnant women attending the department of Obstetrics and Gynecology in Kashmir. Pre-pregnancy BMI was calculated and pregnant women were categorized as underweight, normal, overweight and obese as per WHO criteria. Total GWG was recorded on a scientifically designed questionnaire. Data was analyzed using ANOVA and chi-square test. $p < 0.05$ was considered significant.

Results

Overall, only 40.25% of pregnant women met the IOM 2009 recommendations for total gestational weight gain (TGWG), while 37.75% gained less and 22% gained more than recommended. Among underweight women, 82% had inadequate GWG and only 18% met recommendations, with none gaining excess weight. In normal BMI pregnant women, 51.5% gained within and 48.5% gained less than the recommended, with no excess gain. In contrast, 60.5% of overweight and 97.3% of obese pregnant women had excess GWG, while none gained less than recommended. The difference in GWG across BMI categories was statistically significant $9p < 0.001$.

Conclusion

The study reveals a dual burden of inadequate GWG among underweight and normal BMI pregnant women and excessive GWG among overweight and obese pregnant women. Poor adherence to IOM guidelines highlights the need for BMI-specific nutritional counseling during antenatal visits to optimize maternal and fetal outcomes in Kashmir.

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Author Affiliations

Gazala Nisar, Sr. Assistant Professor (Specialisation: Food Science and Nutrition) Institute of Home Science; **Nilofer Khan**, Professor (Specialisation: Extension and Communication), Vice Chancellor, University of Kashmir

Correspondence

Dr Gazala Nisar, Sr. Assistant Professor (Food Science and Nutrition), Institute of Home Science, University of Kashmir. Email: nisargazala@gmail.com. Contact no. 9906834330.

Indexed

EMBASE, SCOPUS, IndMED , EBSCO, Google Scholar besides other national and international databases.

Introduction

Weight gain during the course of gestation is an important determinant of fetal growth. Inadequate gestational weight gain is a significant risk factor for intrauterine growth retardation (IUGR) and low birth weight (LBW), birth weight of less than 2.5 kg. Inadequate maternal weight gain during the third trimester of gestation is associated with increased risk of preterm delivery. Gestational weight gain is not the same thing as “getting fat”. Gaining weight is a positive and healthy sign that a woman is giving her baby what it needs to develop in a healthy manner. Pregnant women need not to put on any weight in the first trimester but in order to have a healthy baby, it is necessary for them to gain the normal gestational weight, a total of 25-35 pounds over the course of nine months. Inadequate weight gain or dieting during gestation could have severe ramifications on the health of the growing baby within the womb.

Maternal pre-pregnancy weight, pattern of weight gain throughout the course of gestation and total pregnancy-related weight gain are important factors in determining birth weight of neonates. Birth weight has a major impact on neonatal morbidity, mortality and also appears to affect long-term health and early adult weight[1].

During the entire course of gestation, variable amount of weight gain is a constant phenomenon. In early weeks i.e. during the first trimester, pregnant women may lose weight because of vomiting. During subsequent months the weight gain is progressive until last one or two weeks during the third trimester of gestation, when the weight remains static. The total weight gain (TWG) during the course of a singleton

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Keywords

Gestational weight gain, Pre-pregnancy BMI, IOM guidelines, Nutritional status.

pregnancy averages 11kg (24 lb). This has been distributed to 1kg in first trimester and 5kg in second and third trimester each. Rapid gain in weight of more than 0.5kg (1lb) a week or more than 2kg (5lb) a month in later months of gestation may be the early manifestation of pre-eclampsia/toxemia. Stationary weight is one of the indicative feature of intrauterine growth retardation (IUGR) or intrauterine death of the fetus. Poor weight gain is too often associated with higher incidence of pre-eclampsia, prematurity and impairment of effective breastfeeding during the course of lactation[2].

Most women gain weight during gestation. However, there are exceptions that some mothers do not gain at all or rather lose weight, in such situations the fetal growth is presumed to be at the cost of the mother. There are fetal and maternal components of weight gain, the maternal components (being due to expansion of blood volume, growth of uterus, breast and fat storage) occurs in 2nd trimester and the fetal component (being due to growth of fetus, placenta and amniotic fluid) occurs in 3rd trimester[3].

In, India the dual burden of under nutrition and over nutrition makes GWG monitoring crucial. In Kashmir, specific dietary patterns, cold climate and limited physical activity during the course of gestation may influence GWG. However, data comparing GWG across BMI categories in this region is very scarce. Therefore, this study aimed to compare gestational weight gain across different pre-pregnancy BMI categories and assess adherence to IOM guidelines.

Materials and methods

Study Design: Cross sectional random study design.

Data Source and Collection: The present study was conducted in a hospital based setting. The sample was primarily collected from Maternity Hospital of Sher-e-Kashmir Institute of Medical Sciences (SKIMS) Soura Srinagar. A structured questionnaire and an interview schedule was devised and used for collecting the primary information from the pregnant women. The Questionnaire was prepared in accordance with the latest standards. A non stretchable measuring tape and a digital weighing scale were also used to collect information regarding the height and weight of the respondents. Weight of the pregnant women was assessed during the three trimesters of pregnancy by using standard weighing machine and recorded in scientifically designed questionnaire. Data collected from secondary sources represented the information obtained from books, published research papers, medical and public health journals and latest information from internet etc.

Sample Size: A minimum sample size of 350 pregnant women was required as study participants. An additional

sample size of 150 (30%) was added to take care of attrition (follow up loss), in order to get power of test 80% and as such the sample size including follow up loss was 500. Out of the total ten districts of Kashmir Valley, five districts were selected randomly keeping in view both urban and rural areas. The sample size was distributed among the selected districts on the basis of probability proportional to size (Table 1).

The sample size was calculated with the help of the following formula:

$$n = \frac{NZ_{\alpha/2}^2 p(1-p)}{d^2(N-1) + NZ_{\alpha/2}^2 p(1-p)}$$

Where,

n = minimum sample size required for the study

N = population size.

Z = 1.96 at level of significance 5%

α = level of significance (5%).

p = proportion of registered Pregnant women in Kashmir valley

d = margin of error at 5%.

The present study included a total no. of 400 pregnant women and their neonates. Out of them 211 were from urban area and 189 from rural area. Pregnant women were selected purposively from the hospital until the desired number of subjects was reached.

Table 1: Distribution of the Sample Subjects

S.No	Districts	Sample size	Follow - up loss (During the three trimester and post-delivery:	Overall Respondents Taken for analysis
1.	Srinagar	153	05	148
2.	Baramulla	127	41	86
3.	Budgam	99	14	85
4.	Ganderbal	55	11	44
5.	Kulgam	66	29	37
Overall		500	100	400

Sample Selection Procedure: Pregnant women attending the department of Obstetrics and Gynecology SKIMS hospital situated in Srinagar district were selected for data collection. From among all pregnant women attending the OPD, randomly every 3rd pregnancy was included as per the inclusion/exclusion criteria (purposive sampling method). The whole process of selection was completed within 8 to 12 weeks. The pregnant women selected were followed throughout their pregnancy till term.

A well formulated interview schedule was used to elicit the information pertaining to socio-demographic characteristics, maternal health prior to pregnancy, reproductive history, history of present conception, anthropometric assessment, weight gain pattern during current pregnancy, particulars of neonates at birth and dietary assessment of the selected pregnant women. All respondents were given an information sheet detailing the objective and nature of the study. Informal consent was obtained from the selected pregnant women prior to their participation. The following inclusion and exclusion criterion was used in the selection of the sample.

Selection Criteria

Inclusion Criterion

- Singleton Normal Pregnancy
- Pregnant women free from any medical illness or Obstetric complications.
- Pregnant women without pregnancy related complications like pre-eclampsia, eclampsia, gestational diabetes, hyperemesis gravidarum, metabolic or chronic disease and so on.

Tools Used

The tool used in the present study devised as per objectives of the study was essentially a questionnaire supplemented by an interview schedule. After a thorough and detailed study of the problem and the review of literature, a preliminary questionnaire was framed. This was pre-tested on 10% of the sample size to ensure the validity and feasibility and was then used in the study. The questionnaire was administered to the pregnant women through face-to-face interview during the morning hours.

Operational Definition and Calculation of Gestational Weight Gain

Total Gestational Weight Gain (TGWG) as defined by the **Institute of Medicine (IOM) 1990 and 2009** guidelines,⁴ is the amount of weight a pregnant women gains between the time of conception and the onset of labor. Total Gestational weight gain was recorded as the difference between the last recorded Maternal weight (Taken at the end of the last trimester during the 4th prenatal visit) and the Maternal pre-pregnancy weight, which was recorded at the first prenatal visit during the time of registration/enrollment of pregnant women in the hospital. The 1st prenatal visit was not later than the first month of pregnancy (20-25 days of conception). According to the Total Gestational Weight Gain, pregnant women were categorized as Ideal/within, poor/below and excess /above the IOM recommendations as per four Asian pacific BMI groups given by WHO.⁵ In 2009, the Institute of Medicine (IOM) recommended weight gain guidelines for singleton pregnancy based on pre-pregnancy body mass index (BMI) classes. That is for underweight mothers, a recommended GWG of 12.5-18 kg, 11.5-16kg for normal weight, 7-11.5 kg for overweight and 5-9kg for obese mothers.

TGWG

= Weight of the Pregnant Women at the last visit
(at around the nine month 37to 40 weeks)
of gestation

– Weight taken at the First Prenatal Visit
(20 – 25 days of conception)

Ethical considerations: Confidentiality was assured and anonymity was maintained, no participants were identified in any report or publication under this study. Informed consent was sought prior to the individual's participation in the study. Participants were assured that their participation is voluntary and they can withdraw at any point during the study. Data collected from participants was kept confidential and only researcher and supervisor had access to the data. Ethics committee approval was not required since no-human samples were taken from the respondents. Proper permission from the head of the concerned hospital was taken before the conduct of the study.

Data Analysis: For analysis of data in the present study, Microsoft Excel and statistical package SPSS version 22 was used. After collecting the data, coding of the responses of the questions was imperative for statistical analysis. Every item of the questionnaire was coded and was entered into Microsoft-Excel sheet. The data thus generated was tabulated and presented as per the objectives of the study. The data was analyzed using mean, standard deviation and subjected to various tests of significance like Pearson chi-square, ANOVA, t test. Tests were considered significant for p value <0.05. Further correlation coefficient (r) of various variables with gestational weight gain was also computed. Multivariate logistic regression analysis was also applied to identify most specific determinant influencing pregnancy weight gain and neonatal birth weight. Some of the observations are presented in graphic forms also.

Results 52.8% and 47.2% of the respondents were from urban and rural area respectively. Majorities i.e. 78.2% of the respondents were from nuclear family and only 21.8% were belonging to joint family. Majority i.e. 81% of the respondents were literate and only 19% were illiterate. Among literate respondents, 28% were graduate, followed by 14.50% and 14.20% were middle pass and 10+2 respectively. Only 13.50% were post graduates. Majorities i.e. 60.20% of the respondents were housewives and only 39.8% were working. Among working respondents, 17.50% and 14.50 were skilled and semi-skilled workers respectively. Only 2.8% were professional.

Table 2 reveals that majority i.e. 58% of the respondents who were underweight (BMI <18.5kg/m²) at the time of pregnancy gained 8-11kg of weight throughout the course of pregnancy and only 5% gained 14-17kg of weight. Whereas, half or more than half the number i.e. 50.7%, 52.3%, and 54.1% of respondents who were having healthy weight (BMI 18.5-22.9 kg/m²), overweight (BMI 23-24.9 kg/m²) and obese (BMI ≥ 25 kgs/m²) respectively gained 11-14kg of weight throughout the entire course of gestation. The

Table2: Mean Gestational Weight Gain of the respondents in relation to Pre-pregnancy Nutritional Status

Variable	Category	N	Mean GWG±SD	Min.	Max.	Range	F	df	P-value
BMI (Kg/m ²)	<18.5 (Under weight)	50	10.80±1.67	8.0	16.0	8	6.67	3,396	0.0001*
	18.5-22.9 (Normal Weight)	227	11.92±1.77	8.0	16.0	8			
	23-24.9 (Over weight)	86	12.12±1.79	8.0	16.0	8			
	≥25 (Obese)	37	11.95±1.73	9.0	16.0	8			
	Overall	400	11.82±1.80	8.0	16.0	8			

*significant at 5%. **Note:** Body Mass Index (BMI kg/m²) WHO 2004

Table 3 shows that while the overall weight gain among the studied mothers was 11.82±1.80kg, it was significantly low among under nourished mothers i.e. 10.80±1.67kg and in no way better or more among obese women i.e. 11.95±1.73 kg.

Table 3: Gestational Weight Gain in relation to Pre-pregnancy Nutritional Status (BMI Kg/m²)

BMI (Kg/m ²)	Gestational Weight Gain(kg)			X ²	Df	p-value
	8-11	11-14	14-17			
	N (%)	N (%)	N (%)			
<18.5 (Under weight)	29 (58.0)	16 (32.0)	5 (10.0)	22.13	6	0.001*
18.5-22.9 (Normal Weight)	60 (26.4)	115 (50.7)	52 (22.9)			
23-24.9 (Over Weight)	23 (26.7)	45 (52.3)	18 (20.9)			
≥25 (Obese)	8 (21.6)	20 (54.1)	9 (24.3)			
Overall	120(30.0)	196(49.0)	84(21.0)			

*Significant at 5% **Note:** Body Mass Index (BMI kg/m²)-WHO2004.

Table 4: Comparison of Weight Gain across different Body Mass Index Categories. (N=400)

Variable	Category	Recommended Total GWG ** (kg)	Total Gestational Weight Gain			X ²	df	p-value
			Ideal	Poor	Excess			
			N (%)	N (%)	N (%)			
BMI(kg/m ²)	<18.5 Under weight	12.5-18	9 (18.0)	41(82.0)	0.0	319.70	6	<0.0001*
	18.5-22.9 Normal weight	11.5-16	117(51.5)	110(48.5)	0.0			
	23-24.9 Overweight	7-11.5	34 (39.5)	0.0	52(60.5)			
	≥25 Obese	5-9	1 (2.7)	0.0	36(97.3)			
Overall			161(40.25)	151(37.75)	88(22.0)			

*Significant at 5%.

**Total Gestational Weight Gain(TGWG)Recommended Ranges as per Pre-pregnancy

BMI-Institute of Medicine & National Research Council (IOM &NRC) 2009.

difference between the groups with respect to weight gain was found to be statistically significant.

Overall majority i.e. 49% of the respondents gained 11-14kg of weight during the course of pregnancy.30% gained 8-11kg and only 21% gained 14-17kg of weight.

Table 3 shows comparison of Gestational weight gain (GWG) across different BMI in relation to Recommended Total Gestational Weight Gain (TGWG) given by IOM 2009.

Table 4 and shows comparison of Gestational weight gain (GWG) across different BMI in relation to Recommended Total Gestational Weight Gain (TGWG) given by IOM 2009.

It is quite clear that less than half i.e. 40.25% of the respondents met the recommendations for weight gain and 37.75% gained less than recommended during the course of pregnancy. Only 22% gained more weight. Further the table 4 reveals that none of the underweight and normal weight pregnant women gained more weight during the course of pregnancy.82%, which formed the majority of underweight respondents gained

less than recommended weight i.e. less than 12.5 -18kg recommended by IOM. Only a minor section i.e. 18% of underweight pregnant women gained TGW within (ideal weight gain) the recommendations. As far as health pregnant women are concerned, half of them i.e. 51.5% and 48.5% gained within and less than the recommended TGWG given by IOM 2009. None of the overweight and obese pregnant women gained less (poor weight gain) than the recommended weight. More than half i.e. 60.5% of overweight pregnant women gained excess (above the recommended TGW) weight and 39.5% gained within recommended weight during the entire course of pregnancy. Almost all i.e. 97.3% of obese pregnant women gained more weight during the course of pregnancy.

Discussion

Maternal weight gain and pattern of weight gain during pregnancy influence pregnancy outcome such as birth weight of the neonate. Pre-pregnancy body mass index (BMI), maternal nutrient intake during the course of gestation and age determine the weight gain during gestation.

40% of weight gain is due to the fetus and placenta. 60% of weight gain is associated with maternal changes during pregnancy. Women with a high pre-pregnancy BMI have infants with higher birth weights and heavier babies have a higher body fat mass. Except for the very overweight group, birth weight is strongly correlated to maternal weight gain during the entire course of gestation [6,7].

Higher energy intake during pregnancy is associated with increased maternal weight gain, increased risk of hypertension such as eclampsia, Gestational diabetes mellitus (GDM), Cesarean deliveries and macrosomia. Whereas insufficient energy intake during pregnancy is for gestational age (SGA) or low birth weight (LBW) [8]. Obesity has become very much common in pregnant women. Obesity in pregnancy is linked to severe maternal complications such as its effects on delivery as well as many complications affecting the developing fetus and newborn [9]. Obese pregnant women are at a elevated risk of gestational diabetes mellitus [10,11], higher incidences of preeclampsia/toxemia [12-14] and C section [15-16]. Complications related to too much gestational weight gain (GWG) also include foetal macrosomia, resulting in the delivery of a large for gestation age (LGA) neonates [17-19]. Likewise, too much weight gain during the entire course of gestation may raise the risk of weight retention and obesity after pregnancy [20,21] which may be further increased by early termination of breastfeeding among those who gain excess weight during gestation [22-23]. Maternal excessive weight gain during gestation is linked with an elevated risk of the children being overweight/obese [1,24-26].

Body Mass Index (BMI) and Gestational Weight Gain (GWG) are indicators of maternal nutritional status.

Total weight gain throughout the course of gestation among underweight respondents was 10.80 kg. Mean total weight gain was significantly better among healthy

and overweight respondents, with average weight gain of 11.92kg and 12.12kg respectively. However, obese respondents did not gain significantly more weight during pregnancy and remained at an average of 11.95kg, which is much better than the underweight pregnant mothers. The findings are in agreement with a study conducted by Koh *et al.* (2013) [27] who revealed that underweight pre-pregnancy body mass index (BMI kg/m^2) increased the risk of insufficient gestational weight gain. Whereas overweight pre-pregnancy body mass index decreased this risk and resulted in much better gestational weight gain in comparison with underweight pregnant mothers. Crane *et al.* (2009) [28] revealed in his study that pregnancy weight gains of 6.7-11.2kg in overweight women and less than 6.7kg in obese pregnant women are associated with a reduction in the risk of adverse pregnancy outcome.

In the present study less than half i.e. 40.25% of the respondents met the recommendations for weight gain and 37.75% gained less than recommended during the course of pregnancy. Only 22% gained more weight.

Further the study reveals that none of the underweight and normal weight pregnant women gained more weight during the course of pregnancy. 82%, which formed the majority of underweight respondents gained less than recommended weight i.e. less than 12.5 -18kg recommended by IOM. Only a minor section i.e. 18% of underweight pregnant women gained TGW within (ideal weight gain) the recommendations. As far as health pregnant women are concerned, half of them i.e. 51.5% and 48.5% gained within and less than the recommended TGWG given by IOM 2009. None of the overweight and obese pregnant women gained less (poor weight gain) than the recommended weight. More than half i.e. 60.5% of overweight pregnant women gained excess (above the recommended TGW) weight and 39.5% gained within recommended weight during the entire course of pregnancy. Almost all i.e. 97.3% of obese pregnant women gained more weight during the course of pregnancy. Asvanarunat (2014) [29] found in his study that 34.9% had weight gain within, 36.5% above and 28.7% below IOM guidelines. Results of the study conducted by Crane *et al.* (2009) [28] revealed that only 30.6% of women gained the recommended amount of weight during the entire course of pregnancy, 52.3% of women gained additional than recommended and 17.1% gained less than recommended. A study conducted by Nachvak *et al.* (2012) [30] revealed that 86.1% of underweight & 77.7% of normal weight pregnant women gained weight during pregnancy below the lower limits of recommended range, while weight gain in none of the underweight pregnant women was more than the new (2009) IOM recommendations. About 1.1% of normal weight, 17.8% of overweight & 36.4% of obese women gained weight more than the upper limits of the recent 2009 IOM recommendations.

Conclusion

The study concludes that adherence to IOM recommendations for GWG is suboptimal in Kashmir. There is a dual burden of inadequate GWG among

underweight and normal BMI women, and excess GWG among overweight and obese women. Pre-pregnancy BMI is significantly associated with total GWG [$p<0.001$]. These findings underscore the importance of addressing maternal nutritional status before and during pregnancy.

Recommendations

Measures recommended in Pre-pregnancy stage

Details of various pre-pregnancy measures remain beyond the scope of present recommendations yet following few important needs a mention.

- ✓ Pre-pregnancy weight of mother being an important variable affecting birth weight of neonate, the women of reproductive age group need to be counseled regarding its significance in this context.
- ✓ A complete and comprehensive care of girl child right from her childhood, through adolescence and adulthood to ensure that she becomes a healthy adult girl is of paramount importance.
- ✓ Effort to encourage, promote and ensure female literacy is highly advisable.
- ✓ Measures to Improve overall socio-economic status of women and ensuring women empowerment for right decision at right time will take care of women's health and nutrition in pregnancy.
- ✓ Ensuring utilization of services provided under Nutrition intervention program directed towards young females and at risk population as to improve pre-conceptual maternal nutritional status may be more beneficial than those during pregnancy.
- ✓ Sensitizing adult female through mass awareness and education on role and importance of pregnancy weight gain for mother and newborn.
- ✓ Popularizing concept of postponement of first pregnancy after marriage and spacing between the pregnancies appears to be a feasible and achievable goal to ensure better reproductive health in absence of increasing age at marriage as well repeated conceptions especially in rural areas.

Measures recommended in Pregnancy

- ✓ Nutritional care during the course of pregnancy contributes significantly to an adequate nutritional status preventing negative impacts on maternal and neonatal health resulting from low or excess gestational weight gain than the recommended.
- ✓ In order to ensure a thorough pregnancy monitoring, prenatal care should begin during the first trimester (before 13 weeks). It is equally very much important to emphasize that not only is early prenatal care imperative but regular care at the same time is just as fundamental. For low-risk pregnancy, women seeking all prenatal visits, provides better opportunity to keep an eye on

gestational weight gain and undertake nutrition education for them so that they will adopt healthy eating habits

- ✓ Ensure all pregnant mothers are registered early in the pregnancy and remain under regular medical supervision for better pregnancy care.
- ✓ Ensure all 'at risk' and 'high risk' mothers are identified to provide special care during pregnancy and at delivery.
- ✓ Ensure balanced dietary intake and nutrition supplementation throughout the pregnancy by regular counseling and awareness activities.
- ✓ Ensure institutional deliveries for better pregnancy outcome.
- ✓ Ensure to meet all the essential nutrient needs within calorie limits, choose a variety of nutrient-dense foods across and within all the major food groups in recommended amounts as specified by the ICMR.
- ✓ Pregnant women should be advised regarding recommended weight gain ranges during the antenatal visits.
- ✓ Ensure that a pregnant woman maintains ideal gestational weight gain throughout pregnancy.
- ✓ Ensure that pregnancy progresses normally during antenatal period and all deliveries are conducted in an institution for better intra natal and newborn outcome.

References

1. Mamun, A. A., O'Callaghan, M., Callaway, L., Williams, G., Najman, J., & Lawlor, D. A. (2009). Association of gestational weight gain with offspring body mass index and blood pressure at 21 years of age: Evidence from a birth cohort study. *Circulation*, 119, 1720-1727.
2. Dutta, D. C. (2000). *Textbook of obstetrics* (6th ed.). New Central Book Agency.
3. Robinson, C. H., Lawer, M. R., Chenoweth, W. L. & Garwich, A. L. (2000). *Normal and Therapeutic Nutrition*. New York: Macmillan publishing company.
4. Institute of Medicine. (2009). *Weight gain during pregnancy: Reexamining the guidelines*. The National Academies Press. <https://doi.org/10.17226/12584> Note: For IOM 1990: Institute of Medicine. (1990). *Nutrition during pregnancy*. National Academy Press. <https://doi.org/10.17226/1451>
5. World Health Organization. (2000). *The Asia-Pacific perspective: Redefining obesity and its treatment*. Health Communications Australia.
6. Kunz, L. H., & King, J. C. (2007). Impact of maternal nutrition and metabolism on health of the offspring. *Seminars in Fetal & Neonatal Medicine*, 12(2), 71–77. <https://doi.org/10.1016/j.siny.2007.01.005>
7. Abrams, B., & Laros, R. K., Jr. (1986). Prepregnancy weight, lactation, and pregnancy outcome. *American Journal of Obstetrics and Gynecology*, 154(3), 503–509. [https://doi.org/10.1016/0002-9378\(86\)90237-4](https://doi.org/10.1016/0002-9378(86)90237-4)
8. Hales, C. N., & Barker, D. J. P. (2001). The thrifty phenotype hypothesis. *British Medical Bulletin*, 60(1), 5–20. <https://doi.org/10.1093/bmb/60.1.5>
9. Arendas, K., Qiu, Q., & Gruslin, A. (2008). Obesity in pregnancy: Pre-conceptional to postpartum consequences. *Journal of Obstetrics and Gynaecology Canada*, 30(6), 477–

488. [https://doi.org/10.1016/S1701-2163\(16\)32863-8](https://doi.org/10.1016/S1701-2163(16)32863-8)
10. **Chu, S. Y., Callaghan, W. M., Kim, S. Y., Schmid, C. H., Lau, J., England, L., & Dietz, P. M.** (2007). Maternal obesity and risk of gestational diabetes mellitus. *Diabetes Care*, 30(8), 2070–2076. <https://doi.org/10.2337/dc06-2559a>
11. **Ogonowski, J., & Miazgowski, T.** (2009). The prevalence of gestational diabetes mellitus among obese pregnant women in Poland. *International Journal of Gynecology & Obstetrics*, 104(1), 38–41. <https://doi.org/10.1016/j.ijgo.2008.08.018>
12. **O'Brien, T. E., Ray, J. G., & Chan, W. S.** (2003). Maternal body mass index and the risk of preeclampsia: A systematic overview. *Epidemiology*, 14(3), 368–374. <https://doi.org/10.1097/01.EDE.0000055588.34858.99>
13. **Frederick, I. O., Williams, M. A., Sales, A. E., Martin, D. P., & Killien, M.** (2008). Pre-pregnancy body mass index, gestational weight gain, and other maternal characteristics in relation to infant birth weight. *Maternal and Child Health Journal*, 12(5), 557–567. <https://doi.org/10.1007/s10995-007-0278-0>
14. **Leddy, M. A., Power, M. L., & Schulkin, J.** (2008). The impact of maternal obesity on maternal and fetal health. *Reviews in Obstetrics & Gynecology*, 1(4), 170–178.
15. **Callaway, L. K., Prins, J. B., Chang, A. M., & McIntyre, H. D.** (2006). The prevalence and impact of overweight and obesity in an Australian obstetric population. *Medical Journal of Australia*, 184(2), 56–59. <https://doi.org/10.5694/j.1326-5377.2006.tb00106.x>
16. **Poobalan, A. S., Aucott, L. S., Gurung, T., Smith, W. C., & Bhattacharya, S.** (2009). Obesity in pregnancy and the risk of gestational diabetes mellitus: A systematic review and meta-analysis. *Obesity Reviews*, 10(2), 137–143. <https://doi.org/10.1111/j.1467-789X.2008.00533.x>
17. **Abrams, B., Altman, S. L., & Pickett, K. E.** (2000). Pregnancy weight gain: Still controversial. *The American Journal of Clinical Nutrition*, 71(5 Suppl), 1233S–1241S. <https://doi.org/10.1093/ajcn/71.5.1233s>
18. **Stotland, N. E., Hopkins, L. M., & Caughey, A. B.** (2004). Gestational weight gain, macrosomia, and risk of cesarean birth in nondiabetic nulliparas. *Obstetrics & Gynecology*, 104(4), 671–677. <https://doi.org/10.1097/01.AOG.0000139510.97797.40>
19. **Helms, E., Alperin, M., & Crowley-Nowick, P. A.** (2006). The effect of obesity on pregnancy outcome. *Journal of the National Medical Association*, 98(1), 46–50.
20. **Gunderson, E. P., Abrams, B., & Selvin, S.** (2000). The relative importance of gestational gain and maternal characteristics associated with the risk of becoming overweight after pregnancy. *International Journal of Obesity*, 24(12), 1660–1668. <https://doi.org/10.1038/sj.ijo.0801400>
21. **Rooney, B. L., & Schauburger, C. W.** (2002). Excess pregnancy weight gain and long-term obesity: One decade later. *Obstetrics & Gynecology*, 100(2), 245–252. [https://doi.org/10.1016/S0029-7844\(02\)02125-6](https://doi.org/10.1016/S0029-7844(02)02125-6)
22. **Hilson, J. A., Rasmussen, K. M., & Kjolhede, C. L.** (2006). Maternal obesity and breastfeeding success in a lactation clinic population. *Breastfeeding Medicine*, 1(4), 233–242. <https://doi.org/10.1089/bfm.2006.1.233>
23. **Rasmussen, K. M.** (2007). Association of maternal obesity before conception with poor lactation performance. *Annual Review of Nutrition*, 27, 103–121. <https://doi.org/10.1146/annurev.nutr.27.061406.093710>
24. **Moreira, P., Padez, C., Mourao, I., & Rosado, V.** (2007). Maternal weight gain during pregnancy and overweight in Portuguese children. *International Journal of Obesity*, 31(4), 608–614. <https://doi.org/10.1038/sj.ijo.0803457>
25. **Oken, E., Taveras, E. M., Kleinman, K. P., Rich-Edwards, J. W., & Gillman, M. W.** (2007). Gestational weight gain and child adiposity at age 3 years. *American Journal of Obstetrics and Gynecology*, 196(4), 322.e1–322.e8. <https://doi.org/10.1016/j.ajog.2006.11.027>
26. **Wrotniak, B. H., Shults, J., Butts, S., & Stettler, N.** (2008). Gestational weight gain and risk of overweight in the offspring at age 7 years in a multicenter, multiethnic cohort study. *The American Journal of Clinical Nutrition*, 87(6), 1818–1824. <https://doi.org/10.1093/ajcn/87.6.1818>
27. **Koh, S., Egeland, G. M., & Czoli, C.** (2013). Pre-pregnancy body mass index and gestational weight gain in relation to birth outcomes in a multi-ethnic Asian cohort. *Maternal & Child Nutrition*, 9(1), 58–67. <https://doi.org/10.1111/j.1740-8709.2011.00342.x>
28. **Crane, J. M., White, J., Murphy, P., Burrage, L., & Hutchens, D.** (2009). The effect of gestational weight gain by body mass index on maternal and neonatal outcomes. *Journal of Obstetrics and Gynaecology Canada*, 31(1), 28–35. [https://doi.org/10.1016/S1701-2163\(16\)34059-5](https://doi.org/10.1016/S1701-2163(16)34059-5)
29. **Asvanarunat, E.** (2014). Gestational weight gain and pregnancy outcomes in Thai women. *Journal of the Medical Association of Thailand*, 97(10), 1019–1026.
30. **Nachvak, S. M., Abdollahzadeh, S. M., Mostafai, R., Moradi, S., & Khosravi, S.** (2012). Relationship between pre-pregnancy body mass index and gestational weight gain with pregnancy outcome. *Journal of Family & Reproductive Health*, 6(4), 157–162.

Influence of Maternal Dental Anxiety and Attendance Pattern on Dental Caries Experience Among Preschool Children of Mysore City, India—A Cross-Sectional Study

Pranjan Mitra, Thippeswamy H M, Chandrashekhara B R, Sunitha S, Maurya M, Sushma R.

Abstract

Background

Maternal dental anxiety and dental attendance patterns are suggested as indicators of preschool child dental health and for taking the child to dental care. The relationship is still unclear and there is scarcity of literature in the Indian context which needs to be explored.

Aim

To assess the influence of maternal dental anxiety and attendance patterns on dental caries experience among 2-5 year old preschool children in Mysore city, India.

Design

An analytical cross sectional study was conducted on a stratified random sample of 635 mother child dyads. A pre tested proforma collected information on maternal dental anxiety using Modified Dental Anxiety Scale (MDAS), dental attendance pattern (regular, occasional, emergency, never) and dental caries using dmft and dmfs indices . Descriptive analysis, Chi-square test, Kruskal-Wallis test, Spearman correlation test and a binary logistic regression model was used.

Results

The dental caries prevalence among preschool children was 40.6%. Mothers who exhibited low, moderate and high dental anxiety were 50.2%, 39.1%, 10.7% respectively. Majority (34.5%) of the mothers were found to have never visited a dentist. A statistical significant difference was found between maternal dental attendance and dental caries ($p < 0.05$). Mean dental caries score was found to increase with increase in maternal dental anxiety levels but was not statistically significant ($p = 0.537$). In the binary regression model, maternal dental attendance was significantly associated with dental caries ($p < 0.05$)

Conclusion

In the present study, an indirect association between maternal dental anxiety and dental caries experience may be inferred through maternal dental attendance pattern.

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Author Affiliations

Pranjan Mitra, Professor & HOD ,
Department of Public Health Dentistry,
Luxmi Bai Institute of Dental Sciences &
Hospital, Patiala, Punjab: **Thippeswamy H M, Chandrashekhara B R, Sunitha S,**
Professors; **Maurya M, Sushma R,**
Readers:
Department of Public Health Dentistry, JSS
Dental College & Hospital, JSS University,
Mysore, Karnataka, India.

Correspondence

Dr. Pranjan Mitra ,
Staff Quarters, Room No. 3, Luxmi Bai
Institute of Dental Sciences & Hospital ,
Sirhind Road , 8 KM Milestone , Patiala,
Punjab – 147001
Email id- drpranjanmitra@gmail.com

Indexed

EMBASE, SCOPUS, IndMED , ESBCO,
Google Scholar besides other national and
international databases.

Introduction

Dental caries is still a major oral health problem in most industrialized countries, affecting 60–90% of school children and the vast majority of adults. It is also a most prevalent oral disease in several Asian and Latin-American countries, while it appears to be less common and less severe in most African countries[1].

Dental caries has detrimental consequences on children's quality of life by inflicting pain, premature tooth loss, malnutrition and finally influences overall growth and development. The children suffering from poor oral health are 12 times more likely to have restricted activity days as compared to those who did not[2].

The prevalence of dental caries among pre-school children of developed nations has been declining over the past few decades. However, current evidence shows that this decline has ceased in certain developed countries, and the prevalence is still high among preschoolers of developing nations.² In India, findings from three studies among preschool children showed prevalence of dental caries to be 48%, 54.1%, 63.4% respectively[1,3,4]. As for local statistics, a study reported a caries prevalence in 3-6 year old preschool children to be 56.6% with a mean dmft and dmfs of 2.20 and 2.97 respectively[5].

Oral health in preschool children is to a large extent determined by behavioural factors[6]. Children are dependent on their environment to establish favourable health behaviours[7]. The mother and the family are part of the child's environment influencing child development and the establishment of oral health behaviours[8]. Young children's dental health

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relies on the parents' involvement and support from the dental services[7]. It has been reported that parent's behaviours and attitudes towards oral health are associated with child's dental health[7,9]. Moreover, mother's attitudes and beliefs about dental care are major determinants of whether she takes her child to dentist[10].

Dental anxiety has been defined as an 'Abnormal fear or dread of visiting the dentist for preventive care or therapy and unwarranted anxiety over dental procedures'[11]. In adults, dental anxiety has proven to restrict prophylactic measures and is associated with impaired oral health status[12]. It is possible that children learn these unfavourable behaviours from their parents. As parents bear the responsibility for their preschool children's oral health, anxiety may influence parental attitudes and habits regarding the child's oral health care[13].

Maternal dental anxiety is the fear of the mother to receive dental care. It has been suggested as an indicator of child's oral health and dental use service[14]. Maternal dental anxiety is likely to be associated with dental treatment avoidance; similar to what occurs in adults, so this situation could prevent children from receiving appropriate dental care. Thus, the presence of untreated dental caries in preschool children of dentally anxious mothers reflects their negative beliefs and attitudes towards dental care[13].

Moreover, a mother's dental attendance has also been reported to influence her child's dental attendance. Regular maternal dental attendance is indicated as a positive dental health attitude which would reflect in the child's dental health and attendance[15].

Thus, maternal dental anxiety and dental attendance patterns are suggested as indicators of preschool child dental health and for taking the child to dental care, but the relationship is still unclear and need to be further explored[10].

Owing to the scarcity of literature in the Indian context, the present study aimed to assess the influence of maternal dental anxiety and attendance patterns on dental caries experience of preschool children in Mysore city, India. The hypothesis to be tested was that maternal dental anxiety and attendance pattern was associated with dental caries experience among 2-5 year old preschool children of Mysore city, India.

Materials and Methods

This analytical cross-sectional study was conducted among 2-5 year old children in preschools of Mysore city, India between July 2013 and March 2014.

Ethical considerations and approval from authorities

Prior to the commencement of the study, the research proposal was submitted to JSS University for approval. The Ethical clearance was obtained from the Institutional Ethical Committee of JSS Dental College & Hospital, Mysore. The permission to conduct the study was obtained from the Head Masters/Principals of the respective preschools

Designing the Assessment Proforma

The information on maternal dental anxiety, dental

attendance pattern and caries experience amongst the preschool children was collected using a pre-designed structured proforma. The proforma consisted of general information, assessment of maternal dental anxiety and dental attendance pattern.

General information included questions reading demographics of mothers and children, socio-economic status, oral hygiene practices and type of diet of children.

Maternal dental anxiety was assessed using Modified Dental Anxiety Scale (MDAS)[16]. MDAS is a five item questionnaire with each item having five responses. The responses are scored using a Likert scale ranging from 1 (not anxious) to 5 (extremely anxious). The total score for the scale ranged from 5 to 25[17]. Scores from 5-10 were classified as low dental anxiety, 11- 18 as moderate dental anxiety and 19 – 25 as high dental anxiety[18].

In the present study, the English version and a local Indian language (Kannada) version of MDAS was used. The Indian version of MDAS has shown good reliability and validity[17]. Its performance also proved the stability of its constructs in a clinical setting and also its applicability among the Indian populations[19]. Linguistic validation of MDAS was done as described by Acquadro *et al*[20]. The translated version was corrected with the help of the translators to eliminate any difference in the meaning between the original version and the back-translated version.

Mothers were asked about their frequency of dental visits. Maternal dental attendance pattern was assessed by four responses (1) Regular (<1year), (2) Occasional (1-5 years), (3) Emergency (only during dental problem), (4) Never.

Training and Calibration of the Investigator

The clinical examination to assess dental caries was carried out by a single examiner. The intra – examiner agreement was tested on a group of 25 preschool children twice using diagnostic criteria on successive days. The kappa statistic score (κ) obtained was 0.87 which suggested almost perfect agreement[21].

Pilot Study

A pilot study was conducted with a convenience sample of 50 mothers of preschool children to estimate the study sample and check the reliability and validity of the questionnaire. The intra class correlation coefficient was 0.89 indicating almost perfect agreement[21]. Face and content validity was assured by consultation with subject experts from the Department of Public Health Dentistry, JSS Dental College & Hospital.

Sample size estimation

Based on pilot study results, prevalence of maternal dental anxiety (p) = 44%, 95% confidence interval $Z = 1.96$, Absolute error (d) = 5%, the initial sample size was calculated as 379. Using design effect[22] (D) of 1.4 and compensating for non-respondents, the final sample size was calculated as 584.

Sample selection and recruitment of study participants

The mother child dyads were selected using stratified cluster random sampling technique. The list of aided and

unaided preschools in Mysore city was obtained from the Child Development Program Office, Mysore. According to CDPO, Mysore city was stratified into two zones – North, South. A list containing names and addresses of 80 preschools were obtained from both zones. From each zone, five preschools, two aided and three unaided were randomly selected to obtain the desired sample size, such that there was an equal representation from each of the two zones. A total of ten preschools were selected. Each preschool was considered as one cluster. All preschool children and their mothers who fulfilled the eligibility criteria and present on the day of examination were considered in this cluster.

Inclusion and Exclusion criteria

The study included all preschool children and their mothers who accompanied them on the day of examination and were willing to participate. Preschool children with neurological or systemic diseases, physical or mental disability, cleft lip and palate and using oral appliance were excluded from the study.

Informed consent

A bilingual written informed consent (English / Kannada) was obtained from the mothers after briefing them about the nature and purpose of the study.

Data Collection

In consultation with head master / principals, a prior appointment was scheduled for the study. On the appointed day, data was collected by administering questionnaire to mothers and subsequent oral examination of their preschool children. The questionnaire and clinical examination sheet were coded before administration.

Administration of questionnaire

The examiner administered the questionnaires to the mothers and any ambiguity regarding the questions was clarified by him. Kannada versions were distributed to mothers who were not well versed with English language. On an average, it took 5 minutes for a mother to answer the questionnaire. The answered questionnaires were kept separately to keep the examiner blinded.

Clinical Examination

The clinical examination of the preschool children was performed in a separate class room. All examinations were carried out by the trained and calibrated investigator and were entered into the clinical recording sheet. Dental caries was assessed using decayed, missing, filled tooth [dmf(t)] and decayed, missing, filled surface [dmf(s)] index [23]. WHO (1997) criteria was used for diagnosing dental caries [24].

After the clinical examination, the questionnaires and clinical recording sheet were attached together using the codes.

Data Analysis

Data were analysed using SPSS version 17.0. The significance level was set at $P < 0.05$. Descriptive statistics - frequencies, mean and standard deviation was used. For analysis, dmf(t) score of 0 was termed as 'caries free'. dmf(t) score > 0 was termed as 'caries

affected'. The Kolmogorov-Smirnov test was used to check the normality distribution of data. As the data was not normally distributed, non-parametric test were applied. Chi-square test was used to test the association dental caries prevalence and other variables in the study. Kruskal Wallis test was performed to compare mean dental caries score, maternal dental anxiety and maternal dental attendance. Spearman correlation test was used to study the relationship between maternal dental anxiety, maternal dental attendance and dental caries score. A binary logistic regression model was used to predict the relationship between dental caries and other variables used in the study.

Results

The final sample included 635 mother child dyads. Among 635 preschool children, 380 (59.8%) were males and 255 (40.2%) were females. Dental caries prevalence was 40.6%. Majority of the mothers felt "not anxious" in visiting dentist for treatment (56.5%), sitting in the waiting room (54.0%), having a tooth drilled (46.5%), and getting teeth cleaned and polished (40.6%). However most of the mothers felt "extremely anxious" to the use of a local anaesthetic injection (41.3%) (Table 1). 50.2% of mothers exhibited low, 39.1% of mothers exhibited moderate and 10.7% of mothers exhibited high dental anxiety. Majority (34.5%) of the mothers never visited a dentist in the present study.

The caries prevalence among preschool children in relation to age, gender, maternal dental anxiety and dental attendance is presented in (Table 2). Dental Caries was significantly associated with age and maternal dental attendance ($p < 0.001$). However, no statistical significance difference was found between maternal dental anxiety and dental caries prevalence. Maternal education level was also to be found to be significantly related to occurrence of dental caries in preschool children.

Mothers who visited dentist regularly had preschool children with lower dmf(t) score as compared to mothers who never visited dentist. This was found to be statistically significant ($p < 0.001$) (Table 4).

A negative correlation (-0.043) was found between maternal dental anxiety and maternal dental attendance score. A positive correlation was also found between maternal dental attendance score and dmf(t) score (0.064). The correlations suggested that an increase in maternal dental anxiety resulted in a decrease in maternal dental attendance score and increase in dmf(t) score.

A binary regression model was used to predict the relationship between dental caries and other variables used in the study. Dental caries was the dependent variable. The independent variables were child's age, gender, mother's age, maternal education, diet, socio-economic class, maternal dental attendance and maternal dental anxiety. The table shows that mothers with lower literacy levels were more likely to caries affected preschool children. (odds ratio = 1.068). Older preschool children were almost twice more likely to

Table 1:- Distribution of Modified Dental Anxiety Scale (MDAS) responses.

Questions	Responses					Total N (%)
	Not anxious N (%)	Slightly anxious N (%)	Fairly anxious N (%)	Very anxious N (%)	Extremely anxious N (%)	
Q1. If you were to go to your Dentist for TREATMENT TOMORROW, how would you feel?	359 (56.5)	168 (26.5)	38 (6.0)	23 (3.6)	47 (7.4)	635 (100)
Q2. If you were sitting in the WAITING ROOM (waiting for treatment), how would you feel?	343 (54.0)	173 (27.2)	39 (6.1)	32 (5.0)	48 (7.6)	635 (100)
Q3. If you were about to have a TOOTH DRILLED, how would you feel?	295 (46.5)	175 (27.6)	23 (3.6)	76 (12.0)	66 (10.4)	635 (100)
Q4. If you were about to have your TEETH CLEANED AND POLISHED, how would you feel?	258 (40.6)	191 (30.1)	47 (7.4)	85 (13.4)	54 (8.5)	635 (100)
Q5. If you were about to have a LOCAL ANAESTHETIC INJECTION in your gum, above an upper back tooth, how would you feel?	153 (24.1)	105 (16.5)	22 (3.5)	93 (14.6)	262 (41.3)	635 (100)

Table 2: Caries prevalence among preschool children in relation to age, gender, maternal dental anxiety and dental attendance

	Caries free	Caries affected	P value
Age			
2yrs	35 (9.3)	12 (4.7)	<0.001*
3yrs	89 (23.6)	26 (10.1)	
4yrs	97 (25.7)	64 (24.8)	
5yrs	156 (41.4)	156 (60.5)	
Gender			
Male	233 (61.3)	147 (38.7)	0.223
Female	144 (56.5)	111 (43.5)	
Maternal dental anxiety			
Low	196 (52.0)	123 (47.7)	0.488
Moderate	144 (38.2)	104 (40.3)	
High	37 (9.8)	31 (12.0)	
Maternal dental attendance			
Regularly	42 (11.1)	17 (6.6)	<0.001*
Occasionally	74 (19.6)	20 (7.8)	
Emergency	127 (33.7)	136 (52.7)	
Never	134 (35.5)	85 (32.9)	

*Highly significant (HS) , Chi- Square test

Table 3: Mean Dental Caries Score in relation to Maternal Dental Anxiety

Maternal Dental Anxiety	Caries score			
	d(t) (Mean±S.D.)	m(t) (Mean±S.D.)	f(t) (Mean±S.D.)	dmf(t) (Mean±S.D.)
Low	1.46±2.57	0.03±0.22	0.01±0.09	1.50±2.63
Moderate	1.73±3.21	0.03±0.22	0.03±0.30	1.80±3.29
High	2.47±4.38	0.10±0.62	0.00±0.00	2.57±4.56
Total	1.70±3.14	0.04±0.29	0.02±0.23	1.76±3.23

have dental caries than younger ones which was found to be statistically significant ($p<0.001$). Mothers from lower middle socio-economic status were thrice more likely to have caries affected children but this was not statistically significant. Mothers who never visited dentist were significantly more likely to have caries affected preschool children (odds ratio =1.69), ($p=0.008$). (Table 6).

Discussion

The present study assessed the impact of maternal dental anxiety and dental attendance pattern on caries status of their preschool children aged 2- 5 years. To our knowledge, this is the first study in the Indian context to explore the association between dental anxiety and attendance pattern of mothers and dental caries of their preschool children.

The present study reported a dental caries prevalence of 40.6% among preschool children. Similar results were obtained by Singh *et al.*[25](40%), Saravanan *et al.*[26] (44.4%) (India). A higher prevalence was found by Sarumathi *et al.*[4] (63.4%), Agarwal *et al.*[5] (56.6%) and Mahajabeen *et al.*[3](54.1%) (India). A lower prevalence was reported by Narang *et al.*[27](33.1%) (India). Caries prevalence among preschool children worldwide was reported to be 38% by Perera *et al.*[28] in Sri Lanka, 51% by Dawani *et al.*[2]in Pakistan, 69.2 % by Khan *et al.*[29]in Bangladesh, 26% by Kramer *et al.*[30]in Brazil and 11% by Wigen *et al.*[31]in Norway. The regional variations in caries prevalence may be due to differences in the socio-demographic, cultural, dietary and oral hygiene behaviour patterns of the study population.

Table 4:- Mean Dental Caries Score in relation to Maternal Dental Attendance

Maternal Dental Attendance	Caries score			
	d(t) (Mean±S.D.)	m(t) (Mean±S.D.)	f(t) (Mean±S.D.)	dmf(t) (Mean±S.D.)
Regularly	0.91±1.68	0.02±0.13	0.03±0.26	0.96±1.77
Occasionally	0.80±1.85	0.00±0.00	0.00±0.00	0.80±1.85
Emergency	2.32±3.67	0.05±0.28	0.04±3.12	2.41±3.78
Never	1.56±3.04	0.04±0.39	0.01±0.07	1.61±3.12
Total	1.70±3.14	0.04±0.29	0.02±0.23	1.76±3.23

P value - <0.001 (HS) using Kruskal Wallis test

Our study found a significant association between age of preschool children and their caries status. It was observed that dental caries prevalence among preschool children increased with increasing age. Similar results were found in Indian studies conducted by Sarumathi *et al.*[4]., Mahajabeen *et al.*[3]. An increase in caries prevalence among preschool children with increasing age may have attributed to higher caries prevalence reported by Agarwal *et al.* [5], as compared to our study. In the present study, maternal education level was found to be significantly related to occurrence of dental caries in preschool children. Dental caries prevalence was higher in preschool children whose mothers had lower literacy levels. This is in accordance to findings reported by Sarumathi *et al.*[4], Narang *et al.*[27]. This may be due to the fact that mothers with a better attitude and more knowledge will probably build up better oral health habits in their children and look after their children's oral health[4].

The main aim of the study was to determine the relationship between dental anxiety of mothers and child's caries status. So, maternal dental anxiety was assessed by Modified Dental Anxiety Scale (MDAS). The advantage of using the MDAS over Corah's scale is the translation of the response categories. The MDAS requires translating into the native language under various levels of anxiety which represents an ordinal scale, while CDAS requires a greater variety of words such as tense, anxious, relaxed and uneasy to match Corah's original categorization. The comparison between different translations also are conducted with greater confidence using the MDAS[32]. Moreover, the inclusion of local anaesthetic injection question in MDAS which is not included in CDAS, makes assessment of dental anxiety more relevant as most dental patients are fearful of injections.

maternal dental anxiety.

In the present study, mothers self-reported to experience high and moderate dental anxiety in their first visit to dentists. However, their dental anxiety decreased in subsequent dental visits.

Maternal dental anxiety was found to be significantly related to socio-economic status in our study. Mothers from low socio economic status were found to have higher prevalence of dental anxiety. Armfield *et al.*[34] also reported that adults from lower socioeconomic status are generally more fearful of dental treatment. This may be due to the fact that people from lower socio-economic backgrounds experience poorer physical health, more psychological problems and have reduced access to resources [34]. Furthermore, cultural barriers remain a strong deterrent for accessing the health care. Different cultures bring with them, a host of taboos, mores and beliefs that may hinder utilization of dental care and may lead to dental anxiety[19].

Literature reveals conflicting results about the relationship between maternal dental anxiety and dental caries experience in preschool children. In the present study, as maternal dental anxiety increased, dental caries experience of preschool children increased. However, this was not statistically significant. This may be attributed to the fact that maternal dental anxiety is associated with children's dental attendance[15]. Maternal dental anxiety blocks the provision of children's dental care which leads to their dental neglect. [33]. This ultimately results in poor dental health of the children. The results obtained were similar to study conducted by Wigen *et al.*[10] in Norway where no association was found between caries in 5 year old children and parental dental anxiety. This was in contrast to a study conducted by Goettems *et al.* [13] in

A study conducted in Brazil by Goettems *et al.*[33] using CDAS reported a higher prevalence of maternal dental anxiety compared to our study. The differences can be attributed to the dental anxiety scale used, different education level and socio-economic status of mothers who were involved in the study. No other relevant study was found in the Indian scenario to assess the prevalence of

Brazil, where a significant association was found between maternal dental anxiety and dental caries prevalence in preschool children. In the present study, the prevalence of maternal dental anxiety was low compared to Goettems *et al.* [33] which may have contributed to the variation in results. Moreover, differences in dietary factors and socio-economic backgrounds may have affected the strength of association between maternal dental anxiety and dental caries among preschool children.

Maternal dental attendance was found to be significantly related to socio-economic status in our study. The maternal dental attendance was less frequent or nonexistent amongst most of the mothers from lower socio-economic classes. Kulkarni *et al.* [35] reported that adults from lower socioeconomic status visit dentist irregularly similar to our results. This finding was similar to studies conducted by Goettems *et al.* [33] and Moimaz *et al.* [36] where 60.2% and 45.2% mothers did not visit dentist regularly.

In the present study, dental caries prevalence in preschool children was higher among mothers who had lower frequency of dental visits and was found to be statistically significant. This may be due to the fact that maternal dental attendance pattern is a predictor of children's dental attendance and dental health [15,33]. Mothers who do not prioritize their own dental attendance will not take their child for dental visits. This results in missed dental appointments and increased caries prevalence among the preschool children [10]. This is similar to a study conducted by Grembowski *et al.* [37] who found mothers with regular source of dental care to be associated with preschool children receiving more preventive services and subsequently to have lower caries prevalence. A negative correlation was found in the present study between dental caries in preschool children and maternal dental attendance. Moimaz *et al.* [36] also reported strong association between caries history of preschool children and low frequency of mothers' visits to dentists. Our study found that as maternal dental anxiety increased, the frequency of mothers' visiting dentists decreased and this was found to be statistically significant. This is in accordance with Cinar *et al.* [38] who reported that dental visit frequency was associated with dental anxiety among Turkish and Finnish mothers. A study conducted by Goettems *et al.* [39] among Brazilian women found that an increased severity of dental anxiety was associated with decreased frequency of dental visits. Eitner *et al.* [40] also found a negative association among young adult male soldiers between dental anxiety and use of dental services in adults. Various reasons can be attributed for this association. Psychological variables such as embarrassment with dental anxiety leads to avoidance of dental care. A deterioration in dental health occurs and feelings of shame and embarrassment is experienced which culminates into reinforced avoidance. Furthermore, anxiety plays a crucial role in avoidance behaviour by causing a deterioration in oral health. This

leads to an increase in the perceived likelihood of pain and restorative treatments resulting in further negative dental visiting experiences. Dental anxiety may be a component in a cycle of dental disadvantage, with dentally anxious individuals avoiding dental care and thereby worsening their problems. This increases the likelihood that subsequent dental visits will be for emergency reasons [41].

The present study showed that as maternal dental anxiety levels increased, there was an increase in mean dmft(t) score. It was also observed that mothers with high and moderate dental anxiety had visited dentists less frequently and their preschool children had higher caries prevalence as compared to mothers with low dental anxiety. This can be attributed to irregular dental visits by dentally anxious mothers as maternal dental anxiety has been strongly associated with irregular maternal dental attendance [39]. Studies [15,42] have found an association between a child's dental visits and parental visits to dentist for preventive reasons and also their caregiver's recent dental visits. It is also reported that parents who did not obtain dental care for themselves were less likely to seek dental care for their children [43]. Therefore, it is likely that a mother's negative perception or previous negative experience of dental treatment influences not only the mother's dental care use but also dental care use by the child which ultimately affects child's caries status [33].

The study is unique in the context that a first attempt has been made to throw light on the influence of maternal characteristics such as anxiety and dental attendance on caries status of their preschool children in the Indian context. Maternal dental anxiety was assessed using Modified Dental Anxiety Scale (MDAS) which has shown good reliability, validity and acceptability among Indian population. The association between maternal dental anxiety and dental attendance was assessed in the study which is novice to the existing literature. Very few studies including our study have demonstrated the effect of maternal dental anxiety, as a psychological variable on children's dental health.

However, the present study was based on cross sectional study design, so a causal relationship cannot be established. Mothers were not enquired about their first dental visit in the present study. This may have resulted in low prevalence of maternal dental anxiety as mothers self-reported to feel highly anxious on their first dental visit.

Paternal and child dental anxiety are also associated with children's dental health which were not taken into account in this study.

Conclusion

An indirect association between maternal dental anxiety and dental caries experience among preschool children may be inferred through maternal dental attendance pattern.

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References

1. **Shrutha SP, Vinit GB, Giri KY, Alam S.** Feeding Practices and Early Childhood Caries: A Cross-Sectional Study of Preschool Children in Kanpur District, India. *ISRN Dent* 2013;http://dx.doi.org/10.1155/2013/275193. (accessed 20 September 2014)
2. **Dawani N, Nisar N, Khan N, Syed S, Tanweer N.** Prevalence and factors related to dental caries among pre-school children of Saddar town, Karachi, Pakistan: a cross-sectional study. *BMC Oral Health* 2012 12:59.
3. **Mahejabeen R, Sudha P, Kulkarni SS, Anegundi R.** Dental caries prevalence among preschool children of Hubli: Dharwad city. *J Indian Soc Pedod Prev Dent* 2006; 24:19–22.
4. **Sarumathi T, Saravana B, Manjula D, Hemalatha V.T., Aarthi V.** Prevalence, Severity and Associated Factors of Dental Caries in 3-6 Year Old Children. *J Clin Diagn Res* 2013; 7(8): 1789-1792.
5. **Agarwal D, Sunitha S, Reddy C V K, Machale P.** Early Childhood Caries Prevalence, Severity and Pattern in 3-6 Year Old Preschool Children. *Brazilian Research in Pediatric Dentistry and Integrated Clinic* 2012; 12(4):561-65.
6. **Branden SV, Broucke SV, Leroy R, Declerck D, Hoppenbrouwers K et al .** Measuring determinants of oral health behaviour in parents of preschool children. *Community Dent Health* 2013; 30 (1): 19-25.
7. **Wigen TI, Wang NJ.** Caries and background factors in Norwegian and immigrant 5-year-old children. *Community Dent Oral Epidemiol* 2010; 38: 19–28.
8. **Wigen TI, Wang NJ.** Parental influences on dental caries development in preschool children. An overview with emphasis on recent Norwegian research. *Norsk Epidemiologi* 2012; 22 (1): 13-19.
9. **Skeie MS, Espelid I, Riordan PJ, Klock KS.** Caries increment in children aged 3–5 years in relation to parents' dental attitudes: Oslo, Norway 2002 to 2004. *Community Dent Oral Epidemiol* 2008; 36: 441–450.
10. **Wigen TI, Skaret E, Wang NJ.** Dental avoidance behaviour in parent and child as risk indicators for caries in 5 year old children. *Int J Paediatric Dent* 2009; 19:431-43
11. **Kritsidima M, Newton T, Asimakopoulou K.:** The effects of lavender scent on dental anxiety levels: a cluster randomized –controlled trial. *Community Dent Oral Epidemiol* 2010; 38(1):83-87.
12. **Mehrsedt M, Tonnies S, Eisentraut I:** Dental fears, health status and quality of life. *Anesth Prog* 2004; 51:90-94.
13. **Goettems ML, Ardenghi TM, Romano AR, Demarco FF, Torriani DD.** Influence of maternal dental anxiety on the child's dental caries experience. *Caries Res* 2012; 46: 3-8.
14. **Goettems ML, Ardenghi TM, Romano AR, Demarco FF, Torriani DD.** Influence of Maternal Dental Anxiety on Oral Health Quality of Life of preschool children.; *Qual Life Res* 2011;20:951-959.
15. **Kinirons M, McCabe M.** Familial and maternal factors affecting the dental health and dental attendance of preschool children. *Community Dent Health* 1995; 12: 226-9.
16. **Humphris G M, Morrison T, Lindsay S J E.** The Modified Dental Anxiety Scale: UK norms and evidence for validity. *Community Dent Health* 1995 12: 143-150.
17. **Appukuttan D, Datchnamurthy M, Deborah SP, Hirudayaraj GJ, Tadeipalli A, Victor DJ.** Reliability and validity of the Tamil version of Modified Dental Anxiety Scale. *J Oral Sci* 2012; 54(4): 313-320.
18. **Acharya S, Sangam D K ,** Dental anxiety and its relationship with Self- Perceived Health Locus of Control Among Indian Dental Students. *Oral Health Prevent Dent* 2010 8:9-14.
19. **Acharya S.** Factors affecting dental anxiety and beliefs in an Indian population. *J Oral Rehabil* 2008; 35:259–267.
20. **Acquadro C, Conway K, Giroudet C, Mear I.** Linguistic validation manual for patient-reported outcomes (PRO) instruments. Lyon: Mapi Research Institute, 2004.
21. **Landis JR , Koch GC.** The measurement of observer agreement for categorical data. *Biometrics* 1977; 33:159-174.
22. **Gene Shackman.** Sample size and design effect. Presented at Albany Chapter of American Statistical Association. March 24, 2001.
23. **Klein H, Palmer CE, Knutson JW.** Dental status and dental needs of elementary school children. *Public health report* 1938; 53(19):751–765.
24. **World Health Organization:** Oral health surveys: basic methods. 4th edition. Geneva: WHO; 1997.
25. **Singh S, Vijayakumar N, Priyadarshini H R, Shobha M.** Prevalence of early childhood caries among 3-5 year old pre-schoolers in schools of Marathahalli, Bangalore. *Dent Res J (Isfahan).* 2012; 9(6): 710–714.
26. **Saravanan S, Madivanan I, Subashini B, Felix JW.** Prevalence pattern of dental caries in the primary dentition among school children. *Indian J Dent Res* 2005; 16:140-6.
27. **Narang R, Saha S, Jagannath GV, Kumari M, Mohd S, Sonali S.** Maternal socioeconomic status and the caries experience among 2-6 years old preschool children of Lucknow city, India. *J Clin Diagn Res.* 2013; 7(7): 1511-1513.
28. **Perera P J, Abeyweera NT, Fernando MP, Warnakulasuriya T D, Ranathunga N .** Prevalence of dental caries among a cohort of preschool children living in Gampaha district, Sri Lanka: A descriptive cross sectional study. *BMC Oral Health* 2012; 12:49.
29. **Khan I, Raihan M, Hossain M, Shahin A .** Dental Caries and associated factors among 2-5 years children attending OPD of a selected Dental Hospital in Bangladesh. *Update Dent. Coll. j* 2011; 1(1): 02-05
30. **Kramer PF, Feldens CA, Ferreira SH, Bervian J, Rodrigues PH, Peres MA.** Exploring the impact of oral diseases and disorders on quality of life of preschool children. *Community Dent Oral Epidemiol.* 2013; 41(4):327-35.
31. **Wigen TI, Espelid I, Skaare AB, Wang NJ.** Family characteristics and caries experience in preschool children. A longitudinal study from pregnancy to 5 years of age. *Community Dent Oral Epidemiol* 2011; 39: 311–317.
32. **Humphris GM, Freeman R, Campbell J, Tuutti H, D'Souza V.** Further evidence for the reliability and validity of the Modified Dental Anxiety Scale. *Int Dent J* 2000; 50(6):367-70.
33. **Goettems ML, Ardenghi TM, Demarco FF, Romano AR, Torriani DD.** Children's use of dental services: Influence of maternal dental anxiety, attendance pattern, and perception of children's quality of life. *Community Dent Oral Epidemiol* 2012; 40: 451–458.
34. **Armfield JM, Spencer AJ, Stewart JF.** Dental fear in Australia: who's afraid of the dentist? *Aust Dent J* 2006; 51(1):78-85.
35. **Kulkarni S, Jain M, Mathur A, Mehta P, Gupta R, Goutham B.** A relation between dental anxiety, the parental family and regularity of dental attendance in India. *J Oral Health Comm Dent* 2009; 3(2):29-33
36. **Moimaz SAS, Fadel CB, Lolli LF, Garbin CAS, Garbin AJÍ, Saliba NA.** Social aspects of dental caries in the context of mother-child pairs. *J Appl Oral Sci* 2014; 22(1):73-8

37. **Grembowski D, Spiekerman C, Milgrom P.** Linking mother -an epidemiological study on its clinical correlation and access to dental care and child oral health. *Community Dent Oral Epidemiol* 2009; 37(5):381-90.
38. **Cinar AB, Murtomaa H.** A comparison of psychosocial factors related to dental anxiety among Turkish and Finnish pre-adolescents. *Oral Health Prev Dent* 2007; 5(3):173-9.
39. **Goettems ML, Schuch H S, Demarco FF, Ardenghi TM, Torriani DD.** Impact of dental anxiety and fear on dental care use in Brazilian women. *J Public Health Dent* 2014. doi: 10.1111/jphd.12060.
40. **Eitner S, Wichmann M, Paulsen A, Holst S.** Dental anxiety- an epidemiological study on its clinical correlation and effects on oral health. *J Oral Rehabil.* 2006; 33(8):588-93.
41. **Armfield JM, Stewart JF, Spencer AJ.** The vicious cycle of dental fear: exploring the interplay between oral health, service utilization and dental fear. *BMC Oral Health* 2007, 7:1
42. **Sohn W, Ismail A, Amaya A, Lepkowski J.** Determinants of dental care visits among low-income African- American children. *J Am Dent Assoc* 2007; 138:309–18.
43. **Isong IA, Zuckerman KE, Rao SR, Kuhlthau KA, Winickoff JP, Perrin JM.** Association between parents' and children's use of oral health services. *Pediatrics* 2010; 125:502–8.

Formulation, Standardization and Nutritional Evaluation of Gluten-Free Plant-Based Protein Powder.

Aamena Zaidi, Saurabh Tripathi, Arvind Chauhan, Siddharth Singh, Anamika Dixit, Neha Shukla, Swasti Srivastava.

Abstract

Background

The demand for plant-based protein supplements has increased due to growing interest in functional foods, plant-based diets, and dietary restrictions such as gluten intolerance. However, many commercially available protein supplements are expensive and rely on highly processed protein isolates. Development of affordable protein supplements using commonly available plant ingredients remains an area of interest.

Objective

The present study aimed to formulate and standardize a plant-based protein powder prepared from naturally gluten-free ingredients and evaluate its sensory acceptability and proximate nutritional composition.

Materials and Methods

Three formulations of protein powder (PP₁, PP₂ and PP₃) were prepared using nuts, pulses, and seeds. Organoleptic evaluation of the formulations was carried out using a 9-point hedonic scale by 10 untrained panellists. The most acceptable formulation was subjected to proximate composition analysis following AOAC (2019) methods.

Results

Among the developed formulations, PP₃ received the highest mean sensory scores for taste, flavour, and overall acceptability. Proximate analysis of PP₃ showed 517.55 KCal energy, 21.22 g protein, 33.04 g carbohydrates, and 36.9 g fat per 100 g.

Conclusion:

The study demonstrates the feasibility of developing a plant-based protein powder using commonly available ingredients. However, further studies involving larger sensory panels, microbiological safety testing, functional property analysis, and protein quality evaluation are necessary to validate the formulation for wider nutritional applications

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Original Article

Author Affiliations

Aamena Zaidi , Anamika Dixit, Neha Shukla ,Assistant Professors; School of Health Sciences;**Saurabh Tripathi, Arvind Chauhan,Siddharth Singh**, Assistant Professors,School of Hotel Management; **Swasti Srivastava**, Assistant Professor, School of Life Sciences and Biotechnology; Chhatrapati Shahu Ji Maharaj University, Kanpur, U.P.

Correspondence

Anamika Dixit

Assistant Professor, School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur, U.P.
Email- anamikadixit014@gmail.com

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Introduction

A necessary macronutrient for the development, maintenance, and repair of bodily structures is protein. It is essential for the synthesis of muscle proteins, hormones and enzymes, immunological control, and general metabolic processes. Because protein promotes tissue repair, muscle regeneration, and adaptation to physical exercise, it is especially crucial for athletes, physically active persons, developing children, and those recuperating from sickness or injury to consume an adequate amount of protein in their diet [1]. The market for protein supplements and functional food items has grown globally in recent years due to a major rise in understanding of sports nutrition, fitness, and healthy living habits.

Due to their comprehensive amino acid profile and outstanding biological value, animal-based protein supplements like whey and casein proteins have historically dominated the market. However, consumers are moving toward plant-based protein substitutes because of growing concerns about lactose intolerance, nutritional choices, sustainability, environmental effect, and ethical issues [2]. The nutritional, functional, and health-promoting qualities of plant-based proteins are becoming more widely acknowledged, which makes them appropriate components for the creation of sustainable functional meals.

In recent decades, there has been a significant rise in knowledge of wheat allergies, non-celiac gluten sensitivity, celiac disease, and gluten intolerance. In genetically predisposed people, gluten consumption can cause celiac disease, an autoimmune condition that causes intestinal inflammation, mal absorption, and other gastrointestinal issues [3]. As a result, there is a growing market for gluten-free food items made using naturally gluten-free components. Due to lifestyle choices and

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perceived health benefits, consumers without a diagnosis of gluten problems are also increasingly following gluten-free diets.

As naturally gluten-free, nutrient-dense dietary items that may be used to develop protein-rich supplements, millets, pulses, nuts, and seeds have drawn a lot of interest. Proteins, healthy fats, dietary fiber, vitamins, minerals, and bioactive substances with antioxidant qualities are all abundant in these plant-based diets [4]. In contrast to animal protein sources, they are also affordable, readily available regionally, and ecologically sustainable. Using entire food sources instead of separated protein concentrates can save production costs and processing needs while improving nutritional quality.

There are a number of commercially available plant-based protein powders; however, many formulations need considerable industrial processing and heavily rely on isolated soy, pea, or rice proteins. In addition to being somewhat pricey, these products could not have enough micronutrient diversity or be palatable to consumers in terms of taste and texture. As a result, there is increasing interest in developing inexpensive, minimally processed, plant-based protein supplements using whole food ingredients that are tasty, functionally useful, and nutritionally balanced.

For the development of gluten-free protein formulations, ingredients with substantial nutritional potential include almonds, peanuts, Bengal gram, pumpkin seeds, sunflower seeds, melon seeds, oats, and makhana. Protein, monounsaturated fatty acids, vitamin E, magnesium, and antioxidants that promote metabolic and cardiovascular health are all abundant in almonds [5]. High-quality plant protein, niacin, folate, healthy fats, and bioactive phytochemicals with antioxidant activity are all found in peanuts [6]. Bengal gram (*Cicer arietinum*) helps increase satiety and glycemic management and is a great source of protein, dietary fiber, iron, and complex carbs.

Nutrient-dense foods that are high in protein, essential fatty acids, zinc, iron, magnesium, and antioxidant components include pumpkin, sunflower, and melon seeds. Sunflower seeds include vitamin E and selenium, which help minimize oxidative stress, while pumpkin seeds are particularly valued for their high protein content and healthy unsaturated fats. [7]. Melon seeds are beneficial ingredients for nutritional enrichment since they provide significant levels of protein and minerals.

Oats are well known for their β -glucan soluble fiber, protein, and antioxidant content, all of which may enhance digestive health and lipid metabolism [8]. Despite being inherently gluten-free, oats are frequently treated properly to prevent gluten contamination.

Another important component that is high in protein, carbs, calcium, and antioxidant components is makhana (*Euryale ferox*), sometimes referred to as fox nuts. Makhana has grown in popularity as a functional food component and healthy snack because of its low fat content and ease of digestion.

The total amino acid balance and nutritional quality of the protein supplement may be enhanced by combining cereals, pulses, nuts, and seeds in a single formulation. While pulses and legumes are rather abundant in lysine but low in sulfur-containing amino acids, cereals often lack lysine. As a result, mixing different plant components can enhance protein quality and produce complimentary protein benefits [9]. Additionally, adding a variety of plant based ingredients may improve the final product's texture, taste, sensory acceptability, and functional qualities.

Therefore, developing a gluten-free plant-based protein powder with whole food components might offer an affordable, wholesome, and sustainable substitute for protein supplements that are sold in stores. While encouraging the use of locally accessible nutrient-rich foods, such formulations may assist meet the dietary needs of athletes, health-conscious customers, and those with gluten sensitivity.

Thus, the present study aimed to develop and standardize a plant-based protein powder using commonly available ingredients and evaluate its sensory acceptability and basic nutritional composition. The focus of the investigation was formulation feasibility rather than advanced nutritional validation.

Objectives of the study

1. To formulate and standardize different variations of plant-based protein powder.
2. To evaluate the sensory acceptability of the developed formulations.
3. To determine the proximate composition of the most acceptable formulation.

Materials and Methods

Procurement of Raw Materials

The raw materials required for the preparation of the formulated protein powder were procured from local departmental stores and retail markets located in the Kanpur district, Uttar Pradesh, India. In order to guarantee the formulation's accessibility, affordability, and usefulness for preparation at the home and community levels, procurement from local marketplaces was favoured. Every item was carefully chosen based on its physical appearance, freshness, lack of bug infestation, and general quality attributes.

Almonds, peanuts, Bengal gram, pumpkin seeds, sunflower seeds, melon seeds, oats, and makhana were the main raw materials purchased for the study. To reduce the amount of synthetic flavours, additives, and preservatives that are frequently included in commercially processed goods, these materials were bought fresh and unprocessed. Before being processed and formulated further, the materials were brought to the lab in a sanitary manner and kept at room temperature in sealed containers.

All raw materials were cleaned to get rid of dust, broken grains, stones, foreign objects, and other contaminants prior to formulation. To preserve the resulting product's safety and sanitary quality, proper washing and sorting were done. After that, the materials underwent

additional processing techniques such as roasting, grinding, and mixing in accordance with the specifications of the formulation.

Ingredient Selection

Numerous significant factors, including as nutritional composition, protein content, availability, affordability, functional qualities, sensory appeal, and complimentary nutrient profiles, were taken into consideration while choosing the formulation's constituents. Finding naturally nutrient-dense plant-based components that may improve the formulation's overall nutritional value and protein quality was a primary objective of the selection procedure.

Complementary Nutritional Profile

In contrast to single-source protein products, the combination of nuts, oilseeds, pulses, grains, and makhana was intended for a more balanced nutritional composition. Combining different ingredients may enhance the formulation's overall amino acid balance and protein quality because individual plant proteins frequently lack one or more necessary amino acids. By adding healthy fats, dietary fiber, vitamins, minerals, and bioactive components, the chosen ingredients further improve the protein powder's functional and nutritional qualities.

Gluten-Free Consideration

The formulation's components can be used in gluten-free dietary preparations since they are inherently gluten-free. The selection of ingredients that are generally regarded as suitable substitutes for wheat-based goods for those with celiac disease and gluten sensitivity was given particular attention. However, the current study did not include certified gluten-free testing or laboratory analysis for gluten contamination. As a result, even though the components are inherently gluten-free, cross-contamination during processing, packing, shipping, or retail handling cannot be totally ruled out. This restriction should be taken into account when determining whether the developed formulation is suitable for gluten-free diets.

Formulation of Protein Powder- Three variations of protein powder (PP₁, PP₂ and PP₃) were developed using different proportions of ingredients as presented in Table 1. All ingredients were dry roasted at low temperature, cooled, ground into fine powder, sieved, and stored in airtight containers.

Sensory Evaluation-Organoleptic evaluation was conducted using a 9-point hedonic scale ranging from “dislike extremely” to “like extremely” [10]. The sensory panel consisted of 10 untrained panellists including postgraduate students and staff members. Samples were coded and presented in identical

Table 1: Formulations of different variations of Protein powder

Ingredients	Protein powder (PP ₁)	Protein powder (PP ₂)	Protein powder (PP ₃)
Almonds	10	10	10
Makhana	20	20	30
Cashewnuts	15	15	10
Peanuts	15	15	15
Chana	20	20	15
Oats	20	10	5
Pumpkin seeds	0	10	5
Melon seeds	0	0	5
Sunflower seeds	0	0	5
Total amount	100 gm	100 gm	100 gm

containers under similar serving conditions. The parameters evaluated included colour, texture, taste, flavour, and overall acceptability.

Flow chart for development of protein powder

Dry roast all the ingredients on a low flame and then cool it down
↓
Grind them into a fine powder
↓
Sieve well and transfer into airtight container

Proximate Composition Analysis

Proximate composition analysis was used to assess the nutritional content of the most acceptable formulation, as determined by sensory evaluation. The Association of Official Analytical Chemists' standard procedure protocols were used to conduct the analysis [11]. Determining the protein powder's moisture, crude protein, crude fat, carbohydrate, and energy content was part of its proximate composition. To guarantee the precision and dependability of the findings, every analysis was carried out in triplicate.

Determination of Moisture Content

The hot air oven drying technique, as recommended by AOAC (2019), was used to evaluate the moisture content of the protein powder. Because it affects food items' texture, microbiological stability, shelf life, and storage quality, moisture estimate is crucial. A clean, dry, and previously weighed porcelain dish was used to precisely weight 2-5 gm of the powdered material. After that, the sample was kept in a hot air oven set at 105°C for 4-6 hours, or until the weight remained constant. The sample's moisture evaporated during the heating process, leaving behind dry materials. The sample was taken out of the oven after drying and placed right away in a desiccator for cooling and stop it from absorbing moisture from the surrounding air. An analytical balance was used to reweigh the cooled sample.

The percentage moisture content was calculated using

the following formula:

$$\text{Moisture (\%)} = \frac{W_1 - W_2}{W_1} \times 100$$

Where:

$W_1 - W_2$ = Initial weight of sample before drying

W_2 = Final weight of sample after drying

The moisture content provides an estimate of water present in the formulation and helps predict storage stability and susceptibility to microbial spoilage.

Determination of Crude Protein

The AOAC-recommended Kjeldahl technique was used to determine the crude protein content (2019). This technique calculates the sample's total nitrogen content, which is subsequently transformed into protein content using a conventional conversion factor.

The material was precisely weighed into a Kjeldahl digestion flask, weighing between 0.5 and 1 g. The flask was filled with concentrated sulfuric acid (H_2SO_4) and a digestive catalyst combination that included copper and potassium sulfate. The sample was boiled until the solution turned clear, signifying that all organic materials had been completely digested and that nitrogen had been transformed into ammonium sulfate. Following digestion, the mixture was cooled before being diluted with distilled water. Ammonia gas was released from the digested sample by adding sodium hydroxide solution in a distillation unit. A receiving flask holding a boric acid solution with a mixed indicator was filled with the distilled ammonia that was emitted. The endpoint was then attained by titrating the trapped ammonia against a standard hydrochloric acid (HCl) solution.

The nitrogen content was calculated, and crude protein was estimated using the standard protein conversion factor of 6.25.

$$\text{Protein (\%)} = \{\text{Nitrogen (\%)}\} \times 6.25$$

The Kjeldahl method is widely used because of its reliability and accuracy in estimating total protein content in food samples.

Determination of Crude Fat

According to AOAC (2019), the Soxhlet extraction technique was used to calculate the crude fat content. This technique calculates the food sample's total amount of ether-extractable fat.

A dry sample weighing between 2-5 gm was precisely weighed and put into a filter paper thimble. The Soxhlet extraction apparatus, which was attached to a pre-weighed extraction flask with petroleum ether as the solvent, was filled with the thimble. Continuous heating of the system allowed the solvent to condense, evaporate, and repeatedly wash the sample. Fats and lipid-soluble materials were collected in the extraction flask after dissolving in the solvent during the extraction process.

To ensure full fat extraction, the extraction procedure was carried out for around 6-8 hours. Following extraction, the extracted fat was dried, cooled in a desiccator, and weighed after the solvent had evaporated.

The percentage crude fat was calculated using the

following formula:

$$\text{Fat (\%)} = \frac{\text{Weight of extracted fat}}{\text{Weight of sample}} \times 100$$

Fat estimation is important because lipids contribute to energy density, texture, flavor, and nutritional quality of the developed formulation.

Determination of Carbohydrate Content

As recommended by proximate analysis procedures, the difference method was used to determine the total carbohydrate content. By deducting the percentages of moisture, protein, fat, ash, and crude fiber from 100, the carbohydrate content is determined indirectly.

$$\text{Carbohydrate (\%)} = 100 - (\text{Moisture \%}) + \text{Protein \%} + \text{Fat \%} + \text{Ash \%} + \text{Crude Fiber \%}$$

This method provided an estimate of total available carbohydrates present in the formulated protein powder. Carbohydrates serve as a major source of energy and also influence texture, flavor, and acceptability of food products.

Estimation of Energy Content

Aberoumand's (2009) method [12] was used to assess the protein powder's total energy value. The Atwater universal conversion factors for macronutrients were used to compute the calorific value.

using a factor of 4 KCal/g, while fat contribution was calculated using a factor of 9 KCal/g.

$$\text{K. Cal/100 g: Energy [K. Cal]} = [\text{Protein} \times 4] + [\text{Fat} \times 9] + [\text{Carbohydrates} \times 4]$$

The calculated energy value represents the total calorific contribution of macronutrients present in the developed formulation and is useful for evaluating its suitability as a nutrient-dense protein supplement.

Statistical Analysis- For accurate result interpretation, the data collected from the formulated protein powder's proximate composition analysis and sensory evaluation was summarized, tabulated, and statistically analysed. The degree of variance between various formulations and the statistical significance of the observed variations in sensory qualities were ascertained by statistical analysis.

The mean $\pm$ standard deviation (SD) was used to express each sensory assessment score. The standard deviation shows the degree of variability or dispersion of data around the mean, whereas the mean value shows the average score achieved for each sensory characteristic. The dependability and consistency of panel responses are better understood when data are presented as mean $\pm$ SD.

The Statistical Package for Social Sciences (SPSS) software version 22.0 was used to analyse the sensory assessment data for factors such as appearance, colour, flavour, texture, taste, and overall acceptability. For managing data, descriptive statistics, and inferential statistical analysis in food science and nutrition research, SPSS is a commonly used statistical tool.

Descriptive Statistics

The sensory evaluation results were first compiled using descriptive statistical analysis. For every formulation, the mean and standard deviation for every sensory characteristic were computed independently.

Comparing the acceptance levels of various formulations and determining the most preferred product among the developed samples were made easier with the use of descriptive statistics.

One-way analysis of variance (ANOVA) was used to determine if the developed formulations differed significantly from one another. An inferential statistical test called one-way ANOVA was used to compare the means of many groups simultaneously.

The sensory ratings of several formulations for distinct sensory qualities were compared in this study using ANOVA. The alternative hypothesis (H_1) asserted that at least one formulation varied significantly from the others, whereas the null hypothesis (H_0) assumed there was no significant difference between the mean sensory scores of the formulations.

A statistical significance of $p < 0.05$ was set. The observed changes between formulations were statistically significant and unlikely to have occurred by random chance if the p-value was less than 0.05. On the other hand, differences between formulations were not statistically significant if the p-value was more than 0.05.

The statistical analysis facilitated an objective comparison of the formulated protein powder samples and assisted in determining the most appropriate formulation based on sensory qualities.

Interpretation of Statistical Results

The most acceptable product was determined to be the formulation with the highest mean overall acceptability score and statistically significant differences when compared to other formulations. As a result, statistical analysis enhanced the sensory evaluation results' dependability and scientific validity.

When choosing the best gluten-free protein powder composition, the application of ANOVA and descriptive statistical techniques reduced subjective bias and guaranteed a methodical interpretation of sensory data.

Results

The mean sensory scores of the three developed protein powder formulations were compared for colour, texture, taste, flavour, and overall acceptability. Among the three formulations, PP₃ obtained the highest mean scores for taste, flavour, and overall acceptability as shown in Table 2. However, slight variations were observed in colour and texture attributes among the formulations. Based on the sensory evaluation results, PP₃ was selected as the most acceptable formulation and

was further subjected to proximate composition analysis. According to this method, energy contribution from protein and carbohydrates was calculated. The proximate composition of PP₁, PP₂ and PP₃ formulations of protein powder per 100 g indicated that the moisture content of all formulations remained below 10%, indicating good storage stability and reduced chances of microbial spoilage. PP₂ contained highest protein content due to the addition of pumpkin seeds. PP₁ had the highest carbohydrate content because of higher oats and chana proportion, PP₂ and PP₃ contained higher fat and energy values owing to the inclusion of seeds and nuts as depicted in Table 3. However, PP₃ provided a more balanced nutrient profile with diversified seed incorporation.

Table 2: Mean scores of organoleptic parameters of different variations of protein powder

Parameters	Protein powder (PP ₁)	Protein powder (PP ₂)	Protein powder (PP ₃)	Significance (p-value)
Colour	7.5+0.52	7.8+0.42	7.1+0.56	S
Texture	7.2+0.78	6.7+0.67	6.9+0.31	S
Taste	6.2+0.63	7.15+0.74	7.7+0.48	NS
Flavour	6.6+0.51	7.25+0.42	7.9+0.31	NS
Overall acceptability	6.5+0.52	7.2+0.63	8.2+0.63	NS

Data presented as mean $\pm$ SD

p-value <0.05=NS Not significant, >0.05=S Significant

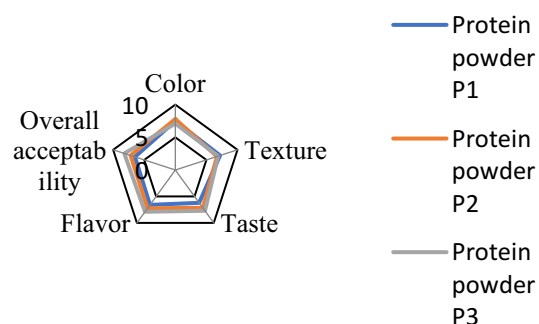


Fig 1: Organoleptic parameters of different variations of protein powder

Table 3: Proximate composition of different variations of protein powder per 100 gm

Nutrients	PP ₁	PP ₂	PP ₃
Moisture (%)	3.1	2.8	3.6
Energy (KCal)	508.62	536.90	517.55
Protein (g)	19.20	23.23	21.22
Fat (g)	31.2	36.4	36.9
Carbohydrate (g)	35.88	31.32	33.04

Discussion

In order to improve nutritional quality, protein

balance, functional qualities, and overall well-being advantages, the current formulation was developed by carefully combining nuts, seeds, grains, and pulses. Proteins, healthy fats, dietary fiber, vitamins, minerals, and bioactive compounds all of which are known to enhance metabolic health and nutritional adequacy were all given by those selected constituents. Amino acid balance, antioxidant potential, and nutrient bioavailability may all be enhanced by these components' synergistic interactions, making the composition nutritionally more effective.

The primary ingredient, almonds, provides an abundance of mono-unsaturated and polyunsaturated fats, protein, dietary fiber, vitamin E, and various trace minerals [13].

Almonds greatly improved the nutritional profile and were an important ingredient of the formulation. Monounsaturated and polyunsaturated fats, dietary fiber, vitamin E, calcium, magnesium, and phenolic antioxidants are all abundant in almonds. Strong antioxidant activity and cardio-protective benefits are attributed to the presence of tocopherols and poly phenolic substances. Almond intake supports cardiovascular and metabolic health by lowering LDL cholesterol, improving lipid profiles, and increasing satiety, according to studies [14, 15 & 16]. Almonds also provide necessary minerals and plant-based protein, both of which are vital to the immune system and tissue repair [17].

Makhana (*Euryale ferox*) was included because to its excellent nutritional content and gluten-free qualities [18]. It is frequently incorporated into gluten-free cookies and starchy flour. Cashew nuts contribute high-quality protein and beneficial fats, offering a comprehensive amino acid profile [19]. Makhana is known for being naturally low in fat and rich in carbohydrates, proteins, phosphate, potassium, and bioactive substances. Because of its digestibility and health-promoting qualities, it is frequently utilized in gluten-free and functional food compositions. Because makhana contains flavonoids and phenolic components, research has shown that it has anti-inflammatory, anti-aging, and antioxidant properties [20, 21, & 22]. Its addition most likely enhanced the product's sensory qualities and nutritional value.

Healthy fats, good quality proteins, and vital minerals including iron, zinc, magnesium, and phosphorus were all provided by cashew nuts. Unsaturated fatty acids and bioactive substances found in cashews have positive impacts on oxidative stability and cardiovascular health. Their amino acid makeup enhances the total protein quality by complementing the protein profile of cereals and legumes. Regular nut consumption has been linked to a lower risk of coronary heart disease and better metabolic health, according to earlier studies [23, 24 & 25].

In the formulation, peanuts were an affordable and nutrient-rich component. Protein, good fats, niacin, folate, and antioxidants including resveratrol, phenolic acids, flavonoids, and phytosterols are all abundant in

peanuts. These substances may lessen oxidative stress and prevent the absorption of cholesterol. They also supply Co-enzyme Q10 and all 20 amino acids, with arginine being found in large amounts [18]. According to earlier research, eating peanuts improves satiety, cardiovascular health, and lowers the chance of developing chronic illnesses [26, 27 & 28].

Due to their abundance of proteins, slowly digesting starch, dietary fiber, vitamins, minerals, and phytochemicals, pulses constitute significant nutritional components. Consuming Bengal gram has been associated with better gastrointestinal health, lower blood cholesterol, and an enhanced glycaemic response. Bengal gram has proteins, carbohydrates, fibers, vitamins, and minerals, contributing to the prevention of various health conditions [29]. Bengal gram's lysine-rich protein improves the amino acid balance in composite food items by complementing plant proteins lacking methionine [30, 31]. Additionally, chickpea proteins have useful qualities that make them excellent for dietary fortification and good digestion [32].

Because of their improved fiber content and functional carbohydrate profile, oats were included. Oats are particularly high in β -glucan, a soluble fiber that has been shown to reduce cholesterol and regulate blood sugar. The formulation's carbohydrate quality and satiety were probably enhanced by the addition of oats. Additionally, oats improve sensory acceptance, flavor, and texture. According to scientific research, oat β -glucan lowers blood cholesterol and improves digestive and cardiovascular health [33 & 34]. Oats also include antioxidants including avenanthramides, which may lessen oxidative damage and inflammation [35].

Pumpkin seeds offer substantial protein, fats rich in PUFAs, and various macro and micro minerals [36]. These seeds are rich in nutrients and have been shown to have cardioprotective and anti-inflammatory qualities. Additionally, phytosterols and tocopherols contained in pumpkin seeds enhance lipid metabolism and promote immunological function. Their incorporation improved the formulation's micronutrient density and protein quality. Additionally, it has been observed that pumpkin seed proteins have high emulsifying and functional qualities in food systems [37].

Melon seeds are notable for their high content of proteins, fats, energy, and minerals, particularly potassium, calcium, magnesium, and iodine, while containing minimal anti-nutritional components [38].

Melon seeds were incorporated because of their high mineral content and nutritional value. They contain barely any anti-nutritional components and supply proteins, vital fatty acids, calcium, magnesium, potassium, and phosphorus. Proteins from melon seeds enhance the total nutritional value and composition of amino acids. Melon seeds are an inexpensive source of minerals and edible oils that can be used in functional food applications, according to earlier research [39].

Sunflower seeds provide vitamins B₁, B₅, vitamin E, and folate, along with essential minerals such as copper,

magnesium, selenium, and phosphorus [40].

Because sunflower seeds contain vitamin E, B-complex vitamins, selenium, copper, magnesium, and phosphorus, the product's nutritional value was further enhanced. Antioxidant properties of sunflower seeds are due to tocopherols and phenolic compounds, which aid in preventing oxidative stress. Additionally, sunflower seeds provide beneficial amino acids and unsaturated fats that enhance the nutritional and functional qualities of food compositions [41].

Protein complementation among plant sources is a well-recognized approach for improving amino acid balance, particularly through the pairing of lysine-rich pulses with methionine-containing cereals. Previous researchers have reported that such combinations significantly enhance overall protein quality and biological value [42 & 43].

Rationale behind High Fat and Carbohydrate content in Plant based Protein Powder

Based on formulation objectives, ingredient selections, and physiological advantages, higher fat and carbohydrate content of formulated plant based protein powder can be scientifically justified as:

1. Gluten, which often affects texture, mouth feel, and structural integrity was absent in this formulation. In order to make up for this, fats from different sources were added to the powder to increase its creaminess, palatability, satiety, and functional stability.
2. High fat content of the formulated plant based protein powder also offered a number of health benefits, such as the presence of essential fatty acids (omega-3 and omega-6) that support brain and cardiovascular health, improved absorption of fat-soluble vitamins (A, D, E, and K) in the presence of dietary fat, and sustained energy release that aids in nutrition for endurance and recovery. It was formulated for bodybuilders and athletes who require extra calories, as well as for people who are malnourished or have higher energy needs. Increased fat content is advantageous rather than harmful for such groups.
3. Fat improves satiety and lowers postprandial glucose increases by slowing stomach emptying and digestion. Because of this, these formulations have applications in metabolic health also.

The results of the present study support this concept, suggesting that the selected ingredient proportions successfully achieved nutritional synergy. This aspect is especially critical in gluten-free product development, where dependence on single plant sources may otherwise result in amino acid limitations.

The satisfactory functional behaviour of the standardized product may be attributed to appropriate pre-processing operations such as cleaning, controlled roasting or drying, and fine milling. Processing treatments are known to alter protein structure, hydration properties, and particle size distribution, thereby influencing reconstitution performance [35 & 44]. The present findings are consistent with these

reports and indicate that well-managed processing can substantially improve the functional quality of gluten-free plant proteins.

Sensory acceptability remains one of the most challenging aspects in the development of plant-based protein supplements, primarily due to issues such as beany flavour, bitterness, and coarse mouth feel. Encouragingly, the developed formulation achieved favourable sensory scores, suggesting that careful ingredient selection and proportion optimization were effective in minimizing undesirable sensory attributes. The sensory evaluation results indicated that variation in ingredient proportions influences the overall acceptability of the formulation. The PP₃ formulation achieved the highest sensory scores, suggesting that the selected proportion of ingredients produced a more acceptable taste and flavour profile.

Similar observations have been documented in other studies where consumer acceptance of plant proteins improves markedly when flavour masking, proper thermal treatment, and balanced formulations are applied [45 & 46]. The acceptable sensory profile obtained in the present study enhances the practical feasibility of the product for routine dietary use.

Another critical concern in gluten-free product development is the possibility of nutritional inadequacy. Earlier studies have indicated that poorly planned gluten-free diets may be deficient in protein, dietary fiber, iron, and certain B vitamins [47 & 48]. The present formulation incorporates a diverse range of plant ingredients, which likely contributed not only to higher protein content but also to improved micronutrient and fiber levels. This broader nutritional contribution strengthens the value of the developed powder as a functional food ingredient rather than merely a protein supplement.

Protein digestibility and amino acid bioavailability are also key determinants of nutritional effectiveness. Plant proteins may sometimes exhibit slightly reduced digestibility due to the presence of ant nutritional factors such as phytates and tannins. However, appropriate processing techniques including soaking, roasting, and fine grinding are known to reduce these compounds and enhance protein utilization [49]. Although direct digestibility measurements were not conducted in the present study, the satisfactory functional and sensory performance suggests improved protein accessibility.

This formulation exemplifies the idea of protein complementation, which is crucial to plant-based diets. Amino acid balance and biological value can be greatly enhanced by mixing cereals, legumes, nuts, and seeds. Individual plant proteins frequently lack one or more important amino acids. Pulses high in lysine enhance the quality and digestibility of protein by complementing cereals and seeds that contain methionine. Mixed plant proteins successfully improve nutritional sufficiency and enable balanced vegetarian diets, according to earlier study [50]. Therefore, these components work together to develop a functional food product that is high in protein, nutritionally balanced and able to improve

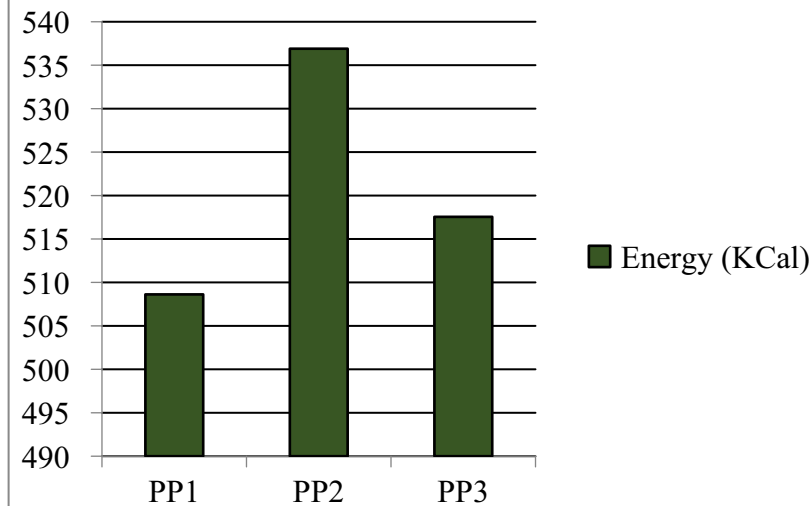


Fig 2: Energy value of different variations of protein powder per 100 gm

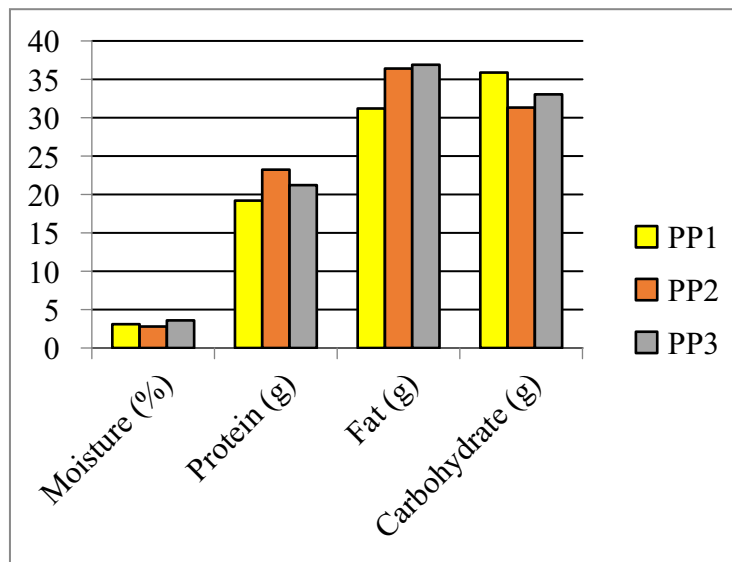


Fig 3: Proximate composition of different variations of protein powder per 100 gm

health outcomes.

The present findings demonstrate the feasibility of developing a plant-based protein powder using simple processing techniques and locally available ingredients. However, further comprehensive studies are required to validate the nutritional quality, safety, and functional performance of the developed formulation.

Limitations

The present study has several limitations.

1. The sensory evaluation was conducted with a small sample size (n=10) of untrained panellists, which limits the reliability and generalizability of the results.
2. Functional properties such as solubility, dispensability, and bulk density were not experimentally evaluated.
3. Microbiological analysis and formal shelf-life studies were also not conducted.
4. Furthermore, detailed protein quality

assessment including amino acid profiling and digestibility evaluation was beyond the scope of the study. Future research should address these aspects to provide stronger scientific validation of the developed formulation.

Conclusion

The current study effectively illustrated the viability and efficacy to develop a plant-based, gluten-free protein powder utilizing affordable, easily accessible ingredients such as nuts, oilseeds, pulses, and makhana. This study's formulation method demonstrated how conventional plant dietary products might be combined to develop a nutritionally enhanced product with acceptable sensory qualities and possible functional health advantages. The results show that effectively chosen ingredients from plants may be used to develop a protein-rich supplement that can meet contemporary dietary requirements, especially for people seeking plant-based and gluten-free nutritional options.

Based on sensory evaluation factors such as colour, appearance, flavour, taste, texture, and overall

acceptability, PP3 was found to be the most acceptable formulation out of the three that were developed. According to PP3's high sensory score, balanced addition of nuts, seeds, and pulse-based ingredients can greatly enhance palatability and consumer acceptability, which are key factors for the successful acceptance of functional food items. Product sustainability in the market is largely determined by sensory acceptance, and PP3's positive evaluations indicate its promising potential for widespread use.

The nutritional significance of formulated protein powder was further demonstrated by the proximate composition analysis. The product had a balanced macronutrient profile since it contained significant amounts of protein, healthy fats, carbohydrates, and dietary fiber. The formulation's moderate to high protein content which derived from plant sources including pulses, nuts, and seeds, making it appropriate for a variety of demographic groups as an additional source

of protein. Furthermore, the product's energy density was significantly enhanced by the presence of healthy fats from nuts and oilseeds, which makes it especially advantageous for people with higher protein and calorie needs, such as athletes, physically active people, undernourished populations, and recovering patients. The new formulation's nutritional value is further enhanced by its dietary fiber content, which supports gut health, improves bowel regularity, and supports digestive health. Numerous health advantages, such as increased satiety, better glycaemic control, and a lower risk of gastrointestinal problems, have been linked to diets high in fiber. Thus, the formulated protein powder's functional and therapeutic potential is increased by the addition of fiber-containing ingredients.

The final product's low moisture content, which maintained an below 4%, was another significant finding of the investigation. Maintaining product stability, reducing microbiological growth and development, and prolonging shelf life all depend on low moisture levels. Under suitable storage situations, the proposed formulation showed a shelf life of around 60 days, demonstrating good storage stability and practical usefulness. This feature increases the product's commercial viability even further.

Additionally, the study highlights the increasing importance of plant-based nutrition in relation to sustainable food systems and public health. There is a growing need for reasonably priced, wholesome, plant-based protein substitutes due to the rising incidence of lactose intolerance, celiac disease, gluten sensitivity, and consumer preferences for vegan or vegetarian diets.

By offering a natural and affordable alternative to the pricey commercial protein supplements now on the market, the recently developed gluten-free protein powder alleviates these dietary concerns. The current recipe makes use of natural food sources with great nutritional potential, in contrast to many commercially available protein powders that could contain artificial additives, preservatives, or highly processed components.

Additionally, this formulation is particularly important for low- and middle-income groups where access to high-quality protein supplements may be restricted due to the price and accessibility of the ingredients utilized in it. In order to combat protein-energy malnutrition and improve nutritional status, the product has a great deal of potential for use in community nutrition programs, sports nutrition interventions, and dietary supplementation approaches.

Despite the study's favourable outcomes, there are still certain issues requiring for more research. Further research is required to thoroughly assess the product's functional and nutritional efficacy because the current study mainly concentrated on sensory evaluation and proximate composition analysis. Larger and more varied sensory panels should be used in future research to increase the generalizability of consumer acceptance results. Thorough amino acid profile, protein

digestibility assessments, biological value assessment, and protein quality evaluation are also advised to ascertain how effectively the plant protein combination satisfies human nutritional needs,

Furthermore, to guarantee product safety and shelf stability during long-term storage, microbiological analysis and safety evaluation are required. The formulation's scientific basis would be further strengthened by evaluating functional characteristics such water absorption capacity, dispersibility, solubility, emulsification, and antioxidant activity. The health advantages and useful uses of the proposed protein powder may potentially be confirmed by clinical and intervention-based research including athletes, malnourished people, or patients in need of nutritional supplements.

The current study concludes that employing simple and readily available ingredients in a carefully developed plant-based gluten-free protein powder may effectively achieve desired nutritional composition, acceptable sensory quality, and functional health benefits. The new formulation, especially PP3, showed encouraging promise as a dietary supplement that is affordable, consumer-friendly, and nutrient-dense. This product could be a sustainable substitute for commercially available protein supplements and make a substantial contribution to plant-based nutrition, gluten-free dietary management, sports nutrition, and public health nutrition initiatives with additional refinement, quality standardization, and clinical validation.

Conflict of Interest

Declared none

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References

1. **Phillips, S. M., & Van Loon, L. J.** (2011). Dietary protein for athletes: from requirements to optimum adaptation. *Journal of sports sciences*, 29 Suppl 1, S29–S38. <https://doi.org/10.1080/02640414.2011.619204>
2. **Amanda Gomes Almeida Sá, Yara Maria Franco Moreno, Bruno Augusto Mattar Carciofi**, Plant proteins as high-quality nutritional source for human diet, *Trends in Food Science & Technology*, Volume 97, 2020, Pages 170-184, <https://doi.org/10.1016/j.tifs.2020.01.011>.
3. **Lebwohl, B., Sanders, D. S., & Green, P. H. R.** (2018). Coeliac disease. *Lancet* (London, England), 391(10115), 70–81. [https://doi.org/10.1016/S0140-6736\(17\)31796-8](https://doi.org/10.1016/S0140-6736(17)31796-8)
4. **Taylor, J. R. N., & Emmambux, M. N.** (2008). Gluten-free foods and beverages from millets. In E. Gallagher (Ed.), *Gluten-free food science and technology* (pp. 119–148). Oxford, UK: Blackwell Publishing. <https://doi.org/10.1016/B978-012373739-7.50008-3>
5. **Berryman CE, West SG, Fleming JA, Bordi PL, Kris-Etherton PM.** Effects of daily almond consumption on cardiometabolic risk and abdominal adiposity in healthy adults with elevated LDL-cholesterol: a randomized controlled trial. *J Am Heart Assoc.* 2015 Jan 5;4,(1), 437-449:e000993. <https://doi.org/10.1161/JAHA.114.000993>. PMID: 25559009; PMCID: PMC4330049.

6. **Arya, S. S., Salve, A. R., & Chauhan, S.** (2016). Peanuts as functional food: a review. *Journal of food science and technology*, 53(1), 31–41. <https://doi.org/10.1007/s13197-015-2007-9>
7. **Arunima Singh, Vivek Kumar,** Pumpkin seeds as nutraceutical and functional food ingredient for future: A review, *Grain & Oil Science and Technology*, Volume 7, Issue 1, 2024, Pages 12-29, <https://doi.org/10.1016/j.gaost.2023.12.002>.
8. **Singh, R., De, S., & Belkheir, A.** (2013). *Avena sativa* (Oat), a potential nutraceutical and therapeutic agent: an overview. *Critical reviews in food science and nutrition*, 53(2), 126–144. <https://doi.org/10.1080/10408398.2010.526725>
9. **Food and Agriculture Organization (FAO).** (2013). Dietary protein quality evaluation in human nutrition: Report of an FAO expert consultation. Rome: FAO.
10. **Roland P. Carpenter, David H. Lyon.** Guidelines for Sensory Analysis in Food Product Development and Quality Control. 2000; 35-58.
11. **AOAC Official Methods of Analysis**, 18th edition. Association of Official Analytical Chemist. Washington DC. 2019.
12. **Ali Aberoumand & S.S. Deokule.** Studies on the Nutritional values of Some Wild Edible Plants from Iran and India. *Pak J of Nutr* 2009; 8(1):26-31 <https://doi.org/10.3923/pjn.2009.26.31>.
13. **Richardson David, Astrup Arne, Cocaul Arnaud, et al.** Peter. The nutritional and health benefits of almonds: a healthy food choice. *Food Science & Technology Bulletin: Functional Foods* 2009; 6. 41-50. <https://doi.org/10.1616/1476-2137.15765>
14. **Chen, C. Y., & Blumberg, J. B.** (2008). Phytochemical composition of nuts. *Asia Pacific journal of clinical nutrition*, 17 Suppl 1, 329–332.
15. **Jenkins, D. J., Kendall, C. W., Marchie, A., Parker, T. L., Connelly, P. W., Qian, W., Haight, J. S., Faulkner, D., Vidgen, E., Lapsley, K. G., & Spiller, G. A.** (2002). Dose response of almonds on coronary heart disease risk factors: blood lipids, oxidized low-density lipoproteins, lipoprotein(a), homocysteine, and pulmonary nitric oxide: a randomized, controlled, crossover trial. *Circulation*, 106(11), 1327–1332. <https://doi.org/10.1161/01.cir.0000028421.91733.20>
16. **Berryman, C. E., Preston, A. G., Karmally, W., Deckelbaum, R. J., & Kris-Etherton, P. M.** (2011). Effects of almond consumption on the reduction of LDL-cholesterol: a discussion of potential mechanisms and future research directions. *Nutrition reviews*, 69(4), 171–185. <https://doi.org/10.1111/j.1753-4887.2011.00383.x>
17. **Mandalari G, Tomaino A, Arcoraci T, Martorana M, Turco VL, Cacciola F, et al.** Characterization of polyphenols, lipids and dietary fibre from almond skins. *Journal of Food Composition and Analysis* (2010) 23(2):166-17, <https://doi.org/10.1016/j.jfca.2009.08.015>
18. **Chen N, Wang Q, Wang MX, Li NY, Briones AV, Cassani L, Prieto MA, Carandang MB, Liu C, Gu CM, Sun JY.** Characterization of the physicochemical, thermal and rheological properties of cashew kernel starch. *Food Chem X*. 2022 Aug 17; 15:100432. doi: 10.1016/j.fochx.2022.100432. PMID: 36211743; PMCID: PMC9532777.
19. **Begum N, Khan QU, Liu LG, Li W, Liu D, Haq IU.** Nutritional composition, health benefits and bio-active compounds of chickpea (*Cicer arietinum* L.). *Front Nutr*. 2023 Sep 28;10:1218468. doi: 10.3389/fnut.2023.1218468. PMID: 37854353; PMCID: PMC10580981.
20. **Jha SN, Kumar M, Bunkar DS.** Physicochemical and functional properties of makhana. 2007 *Journal of Food Process Engineering* 21(4):301- 316; DOI: 10.1111/j.1745-4530.1998.tb00455.x
21. **Kapoor, S., Kaur, A., Kaur, R., Kumar, V., & Choudhary, M.** (2022). *Euryale ferox*, a prominent superfood: Nutritional, pharmaceutical, and its economical importance. *Journal of food biochemistry*, 46(12), e14435. <https://doi.org/10.1111/jfbc.14435>
22. **Rathod RV, Neve G, Jain A and Giri P,** A comprehensive review on health benefits and nutritional aspects of Foxnut (Makhana), *The Pharma Innovation Journal* 2023; 12(6): 4432-4438,
23. **Rico, R., Bulló, M., & Salas-Salvadó, J.** (2015). Nutritional composition of raw fresh cashew (*Anacardium occidentale* L.) kernels from different origin. *Food science & nutrition*, 4(2), 329–338. <https://doi.org/10.1002/fsn3.294>
24. **Ros E.** (2010). Health benefits of nut consumption. *Nutrients*, 2(7), 652–682. <https://doi.org/10.3390/nu2070652>
25. **Alasalvar C, Shahidi F.** Tree nuts: composition, phytochemicals, and health effects. Boca Raton: CRC Press; 2008.
26. **Arya, S. S., Salve, A. R., & Chauhan, S.** (2016). Peanuts as functional food: a review. *Journal of food science and technology*, 53(1), 31–41. <https://doi.org/10.1007/s13197-015-2007-9>
27. **Kris-Etherton, P. M., Hu, F. B., Ros, E., & Sabaté, J.** (2008). The role of tree nuts and peanuts in the prevention of coronary heart disease: multiple potential mechanisms. *The Journal of nutrition*, 138(9), 1746S–1751S. <https://doi.org/10.1093/jn/138.9.1746S>
28. **Toomer O. T.** (2018). Nutritional chemistry of the peanut (*Arachis hypogaea*). *Critical reviews in food science and nutrition*, 58(17), 3042–3053. <https://doi.org/10.1080/10408398.2017.1339015>
29. **Rebello, C. J., O'Neil, C. E., & Greenway, F. L.** (2016). Dietary fiber and satiety: the effects of oats on satiety. *Nutrition reviews*, 74(2), 131–147. <https://doi.org/10.1093/nutrit/nuv063>
30. **Jukanti, A. K., Gaur, P. M., Gowda, C. L., & Chibbar, R. N.** (2012). Nutritional quality and health benefits of chickpea (*Cicer arietinum* L.): a review. *The British journal of nutrition*, 108 Suppl 1, S11–S26. <https://doi.org/10.1017/S0007114512000797>
31. **Wallace TC, Murray R, Zelman KM.** The Nutritional Value and Health Benefits of Chickpeas and Hummus. *Nutrients*. 2016 Nov 29;8(12):766. doi: 10.3390/nu8120766. PMID: 27916819; PMCID: PMC5188421.
32. **Boye, J., Zare, F., & Pletch, A.** (2010). Pulse proteins: Processing, characterization, functional properties and applications in food and feed. *Food Research International*, 43(2), 414–431. <https://doi.org/10.1016/j.foodres.2009.09.003>
33. **Sadiq Butt, M., Tahir-Nadeem, M., Khan, M. K., Shabir, R., & Butt, M. S.** (2008). Oat: unique among the cereals. *European journal of nutrition*, 47(2), 68–79. <https://doi.org/10.1007/s00394-008-0698-7>
34. **Othman, R. A., Moghadasian, M. H., & Jones, P. J.** (2011). Cholesterol-lowering effects of oat β -glucan. *Nutrition reviews*, 69(6), 299–309. <https://doi.org/10.1111/j.1753->

- 4887.2011.00401.x
- 35.**David M. Peterson**, Oat Antioxidants, *Journal of Cereal Science*, Volume 33, Issue 2, 2001, Pages 115-129, <https://doi.org/10.1006/jcrs.2000.0349>.
- 36.**Haya Fatima, Ashiq Hussain, Ambreen, et al.** Pumpkin seeds; an alternate and sustainable source of bioactive compounds and nutritional food formulations. *J of Food Comp and Analysis*, 2025;137: Part B,2025,106954, <https://doi.org/10.1021/jf0706979>
- 37.**Stevenson, D. G., Eller, F. J., Wang, L., Jane, J. L., Wang, T., & Inglett, G. E.** (2007). Oil and tocopherol content and composition of pumpkin seed oil in 12 cultivars. *Journal of agricultural and food chemistry*, 55(10), 4005–4013. <https://doi.org/10.1021/jf0706979>
- 38.**Khalid Waseem, Ikram, Rehan Muhammad. et al.** Chemical Composition and Health Benefits of Melon Seed: A Review. *Pakistan Journal of Agricultural Research*. 2021; 34:309-317. <https://doi.org/10.17582/journal.pjar/2021/34.2.309.317>
- 39.**Mallek-Ayadi S, Bahloul N, Kechaou N.** Characterization of melon seed oil and proteins. *Food Chem*. 2018;247:196-203. <https://doi.org/10.3989/gya.0215181>
- 40.**Puraikalan, Yamunadevi & Scott Michelle.** Sunflower Seeds [*Helianthus Annuus*] and Health Benefits. A Review Recent Progress in Nutr. 2023; 03:1-5. 10.21926/rpn.2303010.
- 41.**Batool M, Ranjha MMAN, Roobab U, Manzoor MF, Farooq U, Nadeem HR, Nadeem M, Kanwal R, AbdElgawad H, Al Jaouni SK, Selim S, Ibrahim SA.** Nutritional Value, Phytochemical Potential, and Therapeutic Benefits of Pumpkin (*Cucurbita* sp.). *Plants* (Basel). 2022 May 24;11(11):1394. doi: 10.3390/plants11111394. PMID: 35684166; PMCID: PMC9182978.
- 42.**Gorissen, S. H. M., Crombag, J. J. R., Senden, J. M. G., Waterval, W. A. H., Bierau, J., Verdijk, L. B., & van Loon, L. J. C.** (2018). Protein content and amino acid composition of commercially available plant-based protein isolates. *Amino Acids*, 50(12), 1685–1695. <https://doi.org/10.1007/s00726-018-2640-5>
- 43.**Young, V. R., & Pellett, P. L.** (1994). Plant proteins in relation to human protein and amino acid nutrition. *The American Journal of Clinical Nutrition*, 59(5 Suppl), 1203S–1212S. <https://doi.org/10.1093/ajcn/59.5.1203S>
- 44.**Kinsella, J. E.** (1976). Functional properties of proteins in foods: A survey. *Critical Reviews in Food Science and Nutrition*, 7(3), 219–280. <https://doi.org/10.1080/10408397609527208>
- 45.**Aiking, H.** (2011). Future protein supply. *Trends in Food Science & Technology*, 22(2–3), 112–120. <https://doi.org/10.1016/j.tifs.2010.04.005>
- 46.**Kyriakopoulou, K., Dekkers, B., & van der Goot, A. J.** (2019). Plant-based meat analogues. In *Sustainable meat production and processing* (pp. 103–126). Academic Press.
- 47.**Saturni, L., Ferretti, G., & Bacchetti, T.** (2010). The gluten-free diet: safety and nutritional quality. *Nutrients*, 2(1), 16–34. <https://doi.org/10.3390/nu20100016>
- 48.**Melini, V., & Melini, F.** (2019). Gluten-free diet: Gaps and needs for a healthier diet. *Nutrients*, 11(1), 170. <https://doi.org/10.3390/nu11010170>
- 49.**Sarwar Gilani, G., Wu Xiao, C., & Cockell, K. A.** (2012). Impact of antinutritional factors in food proteins on the digestibility of protein and the bioavailability of amino acids and on protein quality. *The British journal of nutrition*, 108 Suppl 2, S315–S332. <https://doi.org/10.1017/S0007114512002371>
- 50.**Young, V. R., & Pellett, P. L.** (1994). Plant proteins in relation to human protein and amino acid nutrition. *The American journal of clinical nutrition*, 59(5 Suppl), 1203S–1212S. <https://doi.org/10.1093/ajcn/59.5.1203S>

Prevalence of Low Back Pain and Assess Fatigue Level in Athletes, Sedentary Population, and Computer Operators: A Cross-Sectional Study.

Umesh Kumar Maurya, Komal Kumari, Digvijay Sharma.

Abstract

Background:

Low back pain (LBP) is a common musculoskeletal condition that affects individuals across various populations, including athletes, sedentary individuals, and computer operators which leads to rising prevalence of LBP.

Aim:

The aim of this study was to evaluate the prevalence of low back pain in different population (Athletes, sedentary, computer operators) in both males and females and also to assess their fear-avoidance belief due to pain.

Materials and Methods:

A cross-sectional study of total 900 participants (male and female) consist of athletes mean age (20-40) included hockey(H), football(F), weightlifters(W), computer operator (C) and sedentary (S) population mean age (20-40) were recruited from the CSJM University and Green Park stadium, Kanpur, India. We included those who experienced LBP from past 2 years. An established validated questionnaires like Japanese Orthopaedic Association back pain evaluation questionnaire (JOABEQ), Oswestry Low Back Pain Disability Questionnaire (OSW), Fear-avoidance belief questionnaire (FABQ) and Checklist individual strength (CTS-20) were used in this study.

Results:

LBP was prevalent among athletes, computer operator, sedentary population from India. ANOVA test was used to analyses the data. In JOA prevalence of pain higher in sedentary population as compared to hockey players (p value <0.001). OSW and CIS showed more cases of LBP in Weightlifters among all (p value <0.001). Prevalence of high avoidance in physical and work-related activity showed higher in Weightlifters (p value <0.001) than rest of three population.

Conclusions: The findings showed that high prevalence of LBP in sedentary population and hockey players was due to their daily life activities and also their change in life style along with decrease in fitness level. This indicates that weightlifters, despite being physically active, might be at higher risk for LBP, possibly due to the high physical demands and strain from lifting heavy weights.

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Introduction

The World Health Organization (WHO) advises all nations to create national policies and physical activity goals that help people reach appropriate levels of physical activity [1]. The most prevalent orthopedic issue globally is low back pain (LBP), which can impact both younger and older persons [2]. Prevalence of Adolescent LBP in sports like football, gymnastics, wrestling, rowing, and diving, which strain the lumbar spine. In contrast, sports like swimming, which put less strain on the spine, are less likely to cause LBP[3]. LBP is commonly characterized by pain, muscle stiffness, or tension in the area below the ribs and above the buttocks, which may or may not include leg pain (sciatica) [4]. LBP is a common ailment among working adults, and its incidence tends to increase with age. A recent study indicated that the global prevalence of LBP at a specific point, which restricts daily activities, is 7.3%, positioning LBP as a primary cause of disability worldwide[5]. With a lifetime incidence of up to 80% and an estimated yearly prevalence of 15% to 20%, LBP has long been identified as an issue affecting nearly all adults [6]. Young elite athletes had a 3–5 times higher prevalence of LBP than the standard age-related population [7]. Lifetime prevalence of LBP can reach up to 1-58% [8]. Research shows Occupational factors like heavy lifting, frequent bending, twisting, and involvement in extreme sports are well-established risk factors for LBP [9-11]. Fatigue is an important issue in both the general population and among patients in primary healthcare, where it is a widely prevalent non-specific symptoms [12]. Fatigue is the decline in muscle force capacity during

Original Article

Author Affiliations

Umesh Kumar Maurya, Assistant Professor; **Komal Kumari**, Master of Physiotherapy ;**Digvijay Sharma**, Associate Professor:
School of Health Sciences, Chhatrapati Shahu ji Maharaj University, Kanpur.

Correspondence

Umesh Kumar Maurya

Assistant Professor, School of Health Sciences, Chhatrapati Shahu ji Maharaj University, Kanpur, India.
Email umesh@csjmu.ac.in
Contact No: +91-7985700676

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Low back pain, Fatigue, Disability, Fear-avoidance belief

prolonged exercise e, often due to depletion of liver and muscle glycogen. Endurance sports, athletes commonly refer to this experience as "bonking" or "hitting the wall." [13]. The present study was throwing light upon the relationship between and assess the level of fatigue and associated risk factors for an injury to occur in athletes & if there is any specific sport in which LBP is most common, it may also help to provide effective methods for prevention of associated Contributing factors of LBP.

Materials & Methods

Study Design: This cross-sectional study included 900 participants (300 each from athletes, computer operators, and sedentary populations). The JOABEQ, OSW, FABQ, and CTS-20 questionnaires were used to assess fatigue levels and LBP prevalence. Participants, aged 20-40, had LBP for 2 years, with an equal gender distribution (50% male, 50% female). Results were based on the analysis of 900 completed questionnaires.

Participants: The study included athletes (hockey, football, weightlifting), computer operators, and sedentary individuals aged 20-40 (athletes) and 20-40 (others) with LBP for at least 2 years. Excluded were those under 18, over 40 (for non-athletes), or with systemic illnesses. Consent from all participants was duly acquired.

Outcome variables: The JOA Back Pain Evaluation Questionnaire has 25 questions, calculating 5 functional scores (0-100), with higher scores indicating better condition [14]. The OSW has 10 items (scored 0-5), with a higher score showing more disability, multiplied by 2 for a percentage [15]. The FABQ, developed by Waddell, assesses fear-avoidance beliefs in LBP patients to identify those needing psychosocial support [16]. The CIS-20 measures fatigue with 20 statements rated on a 7-point scale, based on the past 2 weeks [17].

Statistical analysis: The data collected was analyzed using the IBM SPSS Statistics software, version 26. The analysis of variance (ANOVA) test was applied to compare the prevalence of LBP between males and females. Statistical significance was determined when the p-value was less than or equal to 0.05.

Results

The data shows that JOA1 prevalence of LBP is highest in the sedentary population and lowest in weight lifters. JOA2 lumbar function disability is highest in hockey players and lowest in football players. JOA3 walking ability is highest in the sedentary group, followed by hockey players. JOA4 social life function is highest in the sedentary population, followed by hockey players, football players, and computer operators. JOA5 mental health is ranked highest in hockey, followed by sedentary and football populations, with weight lifters having the lowest scores ($P < 0.001$) (Table 1).

The data shows that in CIS1, weight lifters report the highest fatigue levels, with hockey players having the least ($P < 0.001$). In CIS2, weight lifters have the most concentration issues, while football players have the least. CIS3 shows football players with the highest levels, and weight lifters with the least ($P < 0.001$). In

CIS4, weight lifters report the highest physical activity level, followed by football players with lower activity levels ($P > 0.275$) (Table 2).

An OSW shows prevalence of LBP in Weight lifters is highest among all followed by little difference of prevalence in Football players. Computer operators occupied prevalence of LBP at followed by Hockey players. Least value shows the prevalence of LBP for Sedentary population (P value < 0.001) (Table 3).

The data shows that FABP indicates the highest physical activity avoidance in weight lifters, followed by computer operators, football players, and sedentary individuals, with the least in hockey players. FABW reveals that work-related avoidance is highest in weight lifters, followed by football players and computer operators, with similar results for both groups. Hockey

Table 1: All the data of Japanese Orthopedic Association back pain evaluation questionnaire (JOABEQ).T

P Value	F test	Std. Deviation	Mean	ANOVA	
<0.001	6.25	25.678	35.16	H	JOA1
		22.717	30.48	W	
		29.621	34.11	F	
		31.807	43.23	S	
		26.093	33.95	C	
0.041	2.49	27.603	49.8	H	JOA2
		26.911	42.68	W	
		28.135	37.98	F	
		26.572	42.3	S	
		28.805	41.56	C	
<0.001	12.11	30.133	60.3	H	JOA3
		30.93	49.58	W	
		31.84	45.96	F	
		29.344	65.15	S	
		31.501	52.15	C	
		23.019	50.96	H	

Table 2: All the data of Checklist individual strength (CTS-20)

ANOVA	CIS 1					CIS 2					CIS3					CIS4				
	H	W	F	S	C	H	W	F	S	C	H	W	F	S	C	H	W	F	S	C
Mean	28.77	38.10	31.21	29.38	32.23	14.97	20.04	14.50	16.28	17.39	13.00	12.49	14.55	14.04	13.23	10.88	11.12	9.93	10.26	10.81
Std. Deviation	12.328	10.533	12.587	10.361	11.932	7.762	5.495	7.909	6.371	7.255	6.299	4.366	6.860	5.946	5.730	5.677	4.043	5.527	4.837	4.944
F test	12.727					10.888					2.510					1.283				
P Value	<0.001					<0.001					0.041					0.275				

Table 3: All the data of Oswestry Low Back Pain Disability Questionnaire (OSW).

ANOVA	H	W	F	S	C
Mean	34.24	40.57	39.33	27.23	36.74
Std. Deviation	16.293	13.538	18.062	14.626	16.464
F test	23.398				
P Value	<0.001				

Table 4: All the data of Fear-avoidance belief questionnaire (FABQ)

ANOVA	FABP					FABW				
	H	W	F	S	C	H	W	F	S	C
Mean	15.04	18.22	16.07	15.22	16.29	22.64	27.23	24.76	20.08	24.63
Std. Deviation	6.179	4.587	4.142	4.896	5.243	7.062	7.317	7.704	6.730	7.750
F test	7.753					25.515				
P Value	<0.001					<0.001				

CIS2, weight lifters have the most concentration issues, while football players have the least. CIS3 shows football players with the highest levels, and weight lifters with the least ($P < 0.001$). In CIS4, weight lifters report the highest physical activity level, followed by football players with lower activity levels ($P > 0.275$) (Table 2).

An OSW shows prevalence of LBP in Weight lifters is highest among all followed by little difference of prevalence in Football players. Computer operators occupied prevalence of LBP at followed by Hockey players. Least value shows the prevalence of LBP for Sedentary population (P value < 0.001) (Table 3).

The data shows that FABP indicates the highest physical activity avoidance in weight lifters, followed by computer operators, football players, and sedentary individuals, with the least in hockey players. FABW reveals that work-related avoidance is highest in weight lifters, followed by football players and computer operators, with similar results for both groups. Hockey players have the least prevalence, and sedentary individuals fall in between ($P < 0.001$) (Table 4).

Discussion

The key finding of this study is that the occurrence of LBP and assess the level of fatigue in athletes, sedentary population, computer operators and their associated risk factors. The current study showed the different level of prevalence of LBP, among the given population. This data is calculated on basis of different questionnaire filled by the total population and results were according to the sub-parts of the questionnaire. JOA scale shows that there is high prevalence of LBP in sedentary population followed by hockey players. Least value came out for the weight lifters but according to previous

study Sedentary individuals and computer operators scored significantly higher on the JOA ($p < 0.01$). The authors declare that they have no conflicts of interest. previous literature shows comparing the prevalence of LBP between male (83%) and female (67%) football and hockey players reports no significant difference but in others LBP in young elite athletes is observed to be 3 to 5 times more common than in the general population of the same age group. Risk factors for LBP related to sports were observed in field hockey and speed skating.[7].LBP causes more globally disability than other condition.[16] As considered to past study the postures associated with field hockey do not seem to significantly contribute to the increase in LBP incidence. [18].FABQ showed that there was high prevalence of avoidance in Physical activity and work-related avoidance in Weight lifters but in previous article shows that higher in work related avoidance and no differences in physical exercise. A p-value smaller than 0.05 was considered to indicate statistical significance.[19], People with elevated fear-avoidance had 2.27 times greater chances of experiencing prolonged pain duration. ($p = 0.0001$) [20], Oswestry ($p < 0.05$) questionnaires, indicating higher levels of disability due to LBP compared to athletes in behalf of recent study the prevalence of LBP is higher in weightlifters than others (P value < 0.001), The study revealed that ice hockey players have the highest prevalence of lower back pain (60.1%) compared to other groups[21]. Increased subjective fatigue was reported in Weight lifters and other groups. Higher scores reflect increased fatigue, greater difficulty with concentration, lower motivation, and reduced physical activity. Limitation of this study considered as larger sample size are needed to validate, categorized the demographic information like Stature, weight, and body mass index (BMI) in male and females according to their age.

Conclusion

This study concludes that high widespread nature of back pain in sedentary population, weightlifters existed due to their daily life activities and also their change in life style, despite being physically active, may face a higher risk of LBP due to the intense physical demands and strain associated with lifting heavy weights. All four-questionnaire showed that result is significant for all three populations. To overcome this problem of low back pain strengthening exercises at regular interval and for sedentary population mobility exercises and walking should be recommended, for others suggests that individuals engaged in sports may be susceptible to LBP if their training or activity places excessive stress on the back, underlining the importance of balanced exercise routines, proper technique, and sufficient recovery to minimize the risk of injury.

Abbreviations LBP: low back pain; WAD: walking ability dysfunction; SLD: Social life dysfunction; LFD: lumbar function disability; JOABEQ: Japanese Orthopedic Association back pain evaluation questionnaire; FABQ: Fear-avoidance belief questionnaire; CTS-20: Checklist individual strength

Conflict of interest

The authors declare that they have no conflicts of interest.

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References

1. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, Carty C, Chaput JP, Chastin S, Chou R, Dempsey PC. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *British journal of sports medicine*. 2020 Dec 1;54(24):1451-62.
2. Aggarwal N, Anand T, Kishore J, Ingle GK. Low back pain and associated risk factors among undergraduate students of a medical college in Delhi. *Educ Health*. 2013 May-Aug;26(2):103-8.
3. Skoffer B, Foldspang A. Physical activity and low-back pain in schoolchildren. *European Spine Journal*. 2008 Mar; 17:373-9.
4. Balagué F, Mannion AF, Pellisé F, Cedraschi C. Non-specific low back pain. *The lancet*. 2012 Feb 4;379(9814):482-91.
5. Uthman OA. Global, regional, national incidence, prevalence and years lived with disability for 310 acute and chronic diseases and injuries 1990-2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016 Oct 8;388(10053):1545-602.
6. Rubin DI. Epidemiology and risk factors for spine pain. *Neurologic clinics*. 2007 May 1;25(2):353-71.
7. Van Hilst J, Hilgersom NF, Kuilman MC, Kuijer PP, Frings-Dresen MH. Low back pain in young elite field hockey players, football players and speed skaters: prevalence and risk factors. *Journal of back and musculoskeletal rehabilitation*. 2015 Feb;28(1):67-73.
8. Hoy D, Brooks P, Blyth F, Buchbinder R. The epidemiology of low back pain. *Best practice & research Clinical rheumatology*. 2010 Dec 1;24(6):769-81.
9. Heneweer H, Staes F, Aufdemkampe G, van Rijn M, Vanhees L. Physical activity and low back pain: a systematic review of recent literature. *European Spine Journal*. 2011 Jun; 20:826-45.
10. Hoogendoorn WE, Bongers PM, De Vet HC, Douwes M, Koes BW, Miedema MC, Ariëns GA, Bouter LM. Flexion and rotation of the trunk and lifting at work are risk factors for low back pain: results of a prospective cohort study. *Spine*. 2000 Dec 1;25(23):3087-92.
11. Jensen C. Development of neck and hand-wrist symptoms in relation to duration of computer use at work. *Scandinavian journal of work, environment & health*. 2003 Jun 1:197-205.
12. Swaen GM, Van Amelsvoort LG, Bültmann U, Kant IJ. Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. *Occupational and environmental medicine*. 2003 Jun 1;60(suppl 1):i88-92.
13. Katch FI, Katch VL. Exercise physiology: nutrition, energy and human performance. Wolters Kluwer Health/Lippincott Williams & Wilkins; 2010.
14. Kasai Y, Fukui M, Takahashi K, Ohtori S, Takeuchi D, Hashizume H, Kanamori M, Hosono N, Kanchiku T, Wada E, Sekiguchi M. Verification of the sensitivity of functional

- scores for treatment results—Substantial clinical benefit back pain in ncaa division iii female field hockey players. thresholds for the Japanese Orthopaedic Association Back International journal of sports physical therapy. 2012 Pain Evaluation Questionnaire (JOABPEQ). Journal of Jun;7(3):296. Orthopaedic Science. 2017 Jul 1;22(4):665-9.
15. **Fairbank JC, Couper J, Davies JB, O'Brien JP.** The Oswestry beliefs as a predictor for long-term sick leave, disability and low back pain disability questionnaire. Physiotherapy. 1980 pain in patients with chronic low back pain. BMC musculoskeletal disorders. 2018 Dec; 19:1-8. Aug 1;66(8):271-3.
16. **Hoy D, March L, Brooks P, Blyth F, Woolf A, Bain C, Williams G, Smith E, Vos T, Barendregt J, Murray C.** Work-related fear-avoidance beliefs and risk of low-back pain: Prospective cohort study among healthcare workers. Journal of Burden of Disease 2010 study. Annals of the rheumatic Occupational Rehabilitation. 2024 Aug 5:1-9. diseases. 2014 Jun 1;73(6):968-74.
17. **Beurskens AJ, Bültmann U, Kant I, Vercoulen JH, Bleijenberg G, Swaen GM.** Fatigue among working people: Back Pain among Professional Football, Ice Hockey, and validity of a questionnaire measure. Occupational and Floorball Athletes. Medical Science Monitor: International environmental medicine. 2000 May 1;57(5):353-7. Medical Journal of Experimental and Clinical Research. 2023;29: e941
18. **Haydt R, Pheasant S, Lawrence K.** The incidence of low
19. **Trinderup JS, Fisker A, Juhl CB, Petersen T.** Fear avoidance
20. **Jakobsen MD, Vinstrup J, Andersen LL.** Work-related fear-
21. **Hagovská M, Buková A, Takáč P, Knap V, Ondová P, Oravcová K, Kubincová A.** Comparative Risk Analysis of Low

Correlation Between Quadriceps Angle and Balance Among Young Females.

Chandra Shekhar Kumar, Abhilasha Singh.

Original Article

Abstract

Background: Impaired balance and lower limb injuries may be linked to the variations in Q-angle, a significant anatomical variable that provides insight into lower limb alignment in the frontal plane. Females exhibit a considerably larger Q-angle than males. However, the relationship between balance and quadriceps angle has not been investigated in young females.

Aim: The study aimed to determine the correlation between Q-angle and balance among young females.

Material & method: A purposive sample of 100 females of means age 22.32 ± 2.50 years and mean BMI 21.15 ± 2.05 kg/m² were recruited based on selection criteria. The Q-angle was evaluated using a standard 30 cm goniometer while the participant lay supine, ensuring relaxed quadriceps and neutral lower limb rotation. The static balance was assessed by stork test. The dynamic balance was assessed Y balance test using ruler affixed on floor method. The leg dominance was determined by ball-kicking test.

Results: The Kolmogorov-Smirnov test was used to evaluate the normality ($n > 50$) and data was found to be normally distributed. Pearson's correlation coefficient (r) was used to estimate the correlation between Q-angle and static and dynamic balance respectively. Q-angle showed a weak positive correlation with static balance ($r = 0.105$, $p = 0.300$) and a moderate negative correlation ($r = -0.310$, $p = 0.002$) with dynamic balance. Statistical significance was established at a p-value of less than 0.05.

Conclusion: These results collectively imply that a higher Q-angle may contribute to impaired dynamic balance in young females due to altered lower limb biomechanics. However static balance is not significantly impacted by variation in Q-angle. Assessing Q-angle in young females can help identify risks of balance impairments, guiding targeted neuromuscular and biomechanical interventions.

JK-Practitioner2026;31(3):84-87

Introduction

The Quadriceps angle (QA) is an anatomical variable that gives insight into the alignment of the knee joint, femur and tibia in the frontal plane. Q-Angle broadly reflects lower limb biomechanics.[1] A higher Q-angle has been linked to greater femoral anteversion, increased anterior pelvic tilt, increased knee valgus, excessive external tibial rotation, and patellar and foot position.[2] The female individuals exhibited a considerably larger Q-angle on both sides compared to the male subjects.[3] A plausible explanation for why females have higher Q angle values than males that the anatomy of their pelvis is wider than that of men. This is implied by the fact that there is a greater distance between the pelvis and the patella compared to the patella's proximity to the tibial tuberosity. This causes an alteration in the positioning of the ASIS, which greatly affects Q-angle values. [3,4] According to a review of the literature; for men, it is between 10° to 15°, while for women, it is between 15° and 20°.[4]

The results of a study suggest that heavier individuals with greater BMI and Q-angle had a higher incidence of ankle sprains.[5] Studies indicate a higher risk of fall-related injuries among women.[6] Recent studies show that high Q-angle values in females are associated with increased cartilage thickness and grading in female osteoarthritis patients.[3] The alignment of lower extremity structures may have a significant impact on postural control strategies and stability, especially among females. Any changes in structural alignment may increase the risk of lower limb injuries. However, there are inconsistent results in the literature regarding this topic.

To the best of the information we have, no research has addressed the direct association of quadriceps angle with balance in young females.

Author Affiliations

Chandra Shekhar Kumar, Assistant Professor; **Abhilasha Singh** : School of Health Sciences, Department of Physiotherapy, Chhatrapati Shahu Ji Maharaj University, Kanpur , Uttar Pradesh, India.

Correspondence

Abhilasha Singh

MPT Student (Orthopaedics), School of Health Sciences, Chhatrapati Shahu Ji Maharaj University, Kanpur – 208024

Email: abhilashasingh0308@gmail.com

Contact no. 8271155040

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Keywords

Quadriceps angle, postural balance, biomechanics, stork test, Y balance test

Given that Q-angle deviations may influence balance mechanisms, this study seeks to examine the correlation of quadriceps-angle with static & dynamic balance respectively.

Materials And Methods

A purposive sample of 100 females was recruited based on selection criteria. The female participants were included if they were between the age of 18-30 yr, had a BMI of 18.5-24.9 kg/m², and additionally they were asymptomatic. The females were excluded if they had undergone any lower limb or spinal surgery in past 1 year, had a history of immobilization in last 3 years, a history of pain due to any underlying pathologies like patellar bursitis, OA of hip and knee, achilles tendinitis etc, any neuromuscular disorder, radiculopathy, vestibular and visual impairments, any neurological condition that could impair balance, pregnant woman, had any psychological illness, any documented use of medication 24-48 hours prior to the evaluation.

The trial, registered under CTRI with registration number CTRI/2024/10/074813, was reviewed and approved by the Human Ethical Committee at CSJMU (2024-Jul-003). The study was conducted in Physiotherapy OPD of School of Health Sciences, CSJMU (Kanpur) in accordance with the Declaration of Helsinki.

Selected females received in-depth information regarding the study and informed consent form was signed. After screening, the demographic data was collected. The ball kicking test was done to determine dominance because the study focused on the participant's dominant limb.[7] Participants completed the assessment barefoot, with sufficient rest between trials to prevent fatigue, and tests were stopped if discomfort occurred.

The Q-angle was evaluated using a standard 30 cm goniometer while the participant lay supine, ensuring relaxed quadriceps and neutral lower limb rotation. Three landmarks were identified namely ASIS, mid patellar point and tibial tuberosity. To mark the mid-patellar point, the patellar margins were palpated and outlined. The point where the patella's maximum vertical and transverse diameters intersect was designated as its midpoint. The tibial tuberosity was marked at the site of maximum prominence on the anterior upper end of tibia. To measure the Q-angle, the goniometer's fulcrum was positioned at the patellar center, with its moving arm extending toward the ASIS and the stationary arm toward the tibial tuberosity. The angle at their intersection was recorded.[8]

Outcome Measures: The Stork Test, a reliable and

Variables (Q angle)	r	Sig. (2 tailed)
Static Balance (stork score)	0.105	0.300
Dynamic Balance (YBT)	-0.310	0.002*

r = Pearson's correlation-coefficient, *correlation is significant at the 0.01 level (2-tailed)

valid ICC technique, was used to assess static balance.[9] The subject was instructed to stand on both feet, raise the non-dominant leg, position the other foot against the dominant leg's knee, and the hands across their chest or on their hips. Participants held the posture for two minutes, with time recorded across three trials. The stopwatch was stopped if the participant acquired a double-limb stance, the non-weight-bearing foot lost touch with the knee, or the other foot moved in any direction.

The Y-Balance Test, using a floor-affixed ruler, assessed dynamic balance and demonstrated strong interrater and test-retest reliability.[10] Each participant received both verbal instructions and a visual presentation of the test. The subject was asked to hold a single-leg stance while standing on the dominant foot at the center. The subject was instructed to reach with the other leg in three directions i.e., anterior, posteromedial, and posterolateral in relation to the stance foot as far as possible along the ruler affixed on floor. Participants were required to perform three consecutive trials for each reach direction.

Statistical Analysis

The normality of the data was assessed by using Kolmogorov Smirnov Test ($n > 50$) and data was found to be normally distributed. All statistical analysis was done on SPSS software (Statistical Package for Social Sciences IBM version 26). The Pearson's Correlation Coefficient was employed to determine the strength and direction of the correlation between Q-angle and balance measures. Statistical significance was established at a p-value of less than 0.05.

Results

Total 100 female participants of mean age 22.32 ± 2.50 years and mean BMI 21.15 ± 2.05 kg/m² performed all the tests completely and there were no dropouts. The demographic characteristics are presented in table 1 while table 2 illustrates the relation between QA and both static & dynamic balance.

Table.1 Demographic attributes of the participants

Demographic Details	Total N=100
Age (years)	22.32±2.50
Height (cm)	155.36±6.51
Weight (kg)	51.17±6.83
BMI (kg/m ²)	21.15±2.05
Q angle (degree)	16.84±2.20

Table 2. Relationship between Q angle and balance among females (n=100)

A weak positive correlation was found between Q-angle & static balance, as measured by the stork test ($r = 0.105$, $p = 0.300$). Nevertheless, the correlation did not reach statistical significance ($p > 0.05$). In contrast, a moderate negative correlation was found between the Q-angle and dynamic balance, assessed by Y-Balance Test ($r = -0.310$, $p = 0.002$).

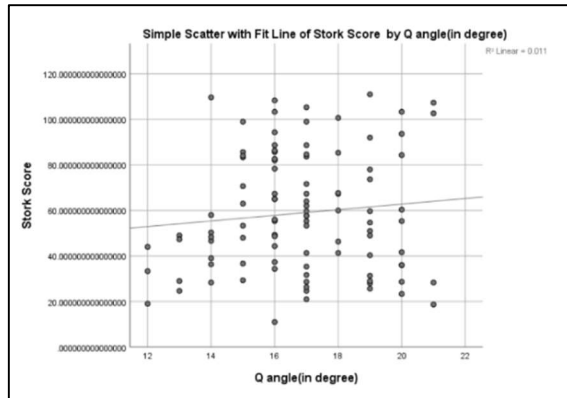


Fig.1 scatter plot for relation between QA and stork test

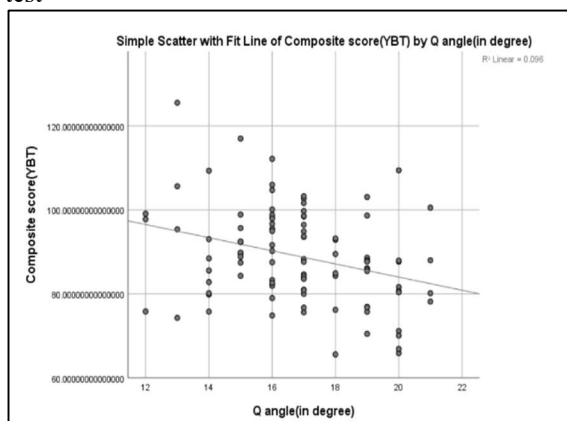


Fig 2. Scatter plot for relation between QA and YBT

Discussion

The current research explored the correlation between Q-angle and balance in young females emphasizing its role in lower limb biomechanics and stability, consistent with previous researches. A study by Denizoglu Kulli et al. (2019) noted that quadriceps angle and static balance, [as measured by the single-leg-stance test (SLST)], did not significantly correlate. Additionally, they noticed a significantly moderate correlation between Q-angle and dynamic balance.[11] In contrast, Skouras et al. (2022) highlighted the clinical relevance of the Q-angle, reporting that a higher dynamic Q-angle is linked to chronic patellofemoral instability.[4] This instability can adversely affect dynamic balance during activities such as walking or single-leg squats. Collectively, these studies indicate that while the Q-angle may not significantly influence static balance, it has a more pronounced effect on dynamic balance.

Sharma et al. (2023) concluded that a larger Q-angle is linked to altered lower extremity mechanics, potentially leading to decreased dynamic balance and increased injury risk.[12] The significant negative correlation observed in the current study underscores the importance of assessing Q-angle in this population to identify individuals at risk for balance impairments and to develop targeted interventions aimed at improving dynamic stability. A higher Q-angle has

been linked to changes in patellar tracking and increased lateral forces on the patella, potentially affecting knee stability during static postures.[12] However, static balance tasks, such as the Stork test, primarily assess the ability to maintain a stationary position with minimal joint movement. This minimal movement may not sufficiently challenge the knee's structural alignment during static balance performance. Neuromuscular Adaptations: Individuals with a higher Q-angle may develop neuromuscular adaptations, such as increased vastus medialis oblique activation, to counteract lateral patellar displacement and enhance knee stability during static tasks.

It is crucial to consider the constraints of our research. The sample size of 100 young females may restrict the applicability of the results to other demographics. Additionally, the use of the Stork test as the sole measure of static balance may not capture all aspects of postural control. Future studies should consider incorporating a variety of balance assessments and including participants of different ages and activity levels.

Conclusion

The clinical implications of these findings suggest that while Q-angle may not significantly affect static balance, it plays a crucial role in dynamic postural control. Therefore, assessing Q-angle in young females could be essential for identifying individuals at risk of dynamic balance impairments and lower extremity injuries. Interventions focusing on neuromuscular training and biomechanical correction may help improve dynamic stability in those with higher Q-angles. Future research should explore the combined effects of Q-angle with other factors, such as hip strength, core stability, and proprioceptive training, to develop comprehensive intervention strategies.

Conflict Of Interest

None

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References

1. Apley Graham, Solomon Louis. Apley's and Solomon's System of Orthopaedics and Trauma 10th edition. vol. 1. 10th ed. Boca Raton: CRC Press; 2018.
2. Kaya D, Doral MN. Is there any relationship between Q-angle and lower extremity malalignment? *Acta Orthop Traumatol Turc.* 2012;46(6):416-419. doi:10.3944/AOTT.2012.2883.
3. Khasawneh RR, Allouh MZ, Abu-El-rub E. Measurement of the quadriceps(Q)angle with respect to various body parameters in young Arab population. *PLoS One* 2019;14. <https://doi.org/10.1371/journal.pone.0218387>.
4. Skouras AZ, Kanellopoulos AK, Stasi S, Triantafyllou A, Koulouvaris P, Papagiannis G, et al. Clinical Significance of the Static and Dynamic Q-angle. *Cureus* 2022. <https://doi.org/10.7759/cureus.24911>.

5. **Zamani Moghadam H, Taha Hoseini S, Masoud Hashemian A, Davood Sharifi M.** The Relation of Q Angle and Anthropometric Measures with Ankle Sprain; a Case-control study. vol. 5. 2017.
6. **Srivastava S, Muhammad T.** Prevalence and risk factors of fall-related injury among older adults in India: evidence from a cross-sectional observational study. BMC Public Health 2022;22. <https://doi.org/10.1186/s12889-022-12975-7>.
7. **van Melick N, Meddeler BM, Hoogeboom TJ, Nijhuis-van der Sanden MWG, van Cingel REH.** How to determine leg dominance: The agreement between self-reported and observed performance in healthy adults. PLoS One 2017;12. <https://doi.org/10.1371/journal.pone.0189876>.
8. **Raveendranath V, Nachiket S, Sujatha N, Priya R, Rema D.** Bilateral Variability of the Quadriceps Angle (Q angle) in an Adult Indian Population. vol. 14. n.d.
9. **Kranti Panta by, Arulsingh WD, Oliver Raj J, Sinha M, Rahman M.** The Foot and Ankle Online Journal A study to associate the Flamingo Test and the Stork Test in measuring static balance on healthy adults 2015. <https://doi.org/10.3827/faoj.2015.0803.0004>.
10. **Foldager FN, Aslerin S, Baekdahl S, Tønning LU, Mechlenburg I.** Reliability of the Y Balance Test: A Reliability Study Including 51 Healthy Participants. vol. 16. 2023
11. **Denizoglu Kulli H, Yeldan I, Yildirim NU.** Influence of quadriceps angle on static and dynamic balance in young adults. Journal of Back and Musculoskeletal Rehabilitation. 2019;32(6):857-862. doi:10.3233/BMR-181332
12. **Sharma R, Vaibhav V, Meshram R, Singh B, Khorwal G. A** Systematic Review on Quadriceps Angle in Relation to Knee Abnormalities. Cureus 2023. <https://doi.org/10.7759/cureus.34355>.

sEMG-Neuromuscular Biofeedback-Led Telerehabilitation Post Robot-Assisted Total Knee Arthroplasty: A Randomised Trial.

Dheeraj Kumar, Jasmine Kaur Chawla

Original Article

Abstract

Background.

Arthrogenic muscle inhibition (AMI) of the quadriceps is a well-documented neuromuscular impairment after total knee arthroplasty (TKA) and is a key barrier to early functional recovery. Surface electromyographic (sEMG) biofeedback can target AMI by providing real-time, quantitative knowledge of voluntary motor output. We tested whether sEMG-led telerehabilitation, produces knee range of motion (ROM) and Knee Injury and Osteoarthritis Outcome Score (KOOS) outcomes comparable to conventional in-person physiotherapy following robot-assisted TKA (RA-TKA).

Methods.

Thirty patients were recruited at hospital discharge after RA-TKA and randomised 1:1 to sEMG-guided telerehabilitation (n = 15) or conventional in-person physiotherapy (n = 15). Both arms followed an identical two-week, daily structured exercise programme; the sEMG arm received real-time biofeedback via a wireless Trigno Discover sensor (Delsys) with synchronous video supervision. Outcomes were active knee flexion, extension deficit, and the five KOOS subscales, assessed at baseline (discharge) and at two weeks. Outcome assessors were blinded to allocation.

Results.

Both groups showed large within-group improvements across every outcome (all $p < 0.001$; Cohen's d_z 2.49–3.79). Active knee flexion improved from $88.27 \pm 2.96^\circ$ to $108.60 \pm 7.70^\circ$ in the sEMG arm ($\Delta +20.33^\circ$, 95% CI 17.23–23.44) and from $87.13 \pm 2.67^\circ$ to $107.40 \pm 6.58^\circ$ in the conventional arm ($\Delta +20.27^\circ$, 95% CI 16.85–23.68). KOOS-QoL improved by +57.93 points (sEMG) versus +54.17 points (conventional) ($p = 0.612$). Between-group analyses favoured sEMG on KOOS-Sport/Recreation ($\Delta +14.67$ points; $d = 1.12$) and KOOS-ADL (Mann-Whitney $p = 0.030$).

Conclusions.

sEMG-led telerehabilitation produced clinically equivalent ROM and KOOS outcomes to in-person physiotherapy in the early post-RA-TKA period, with a signal of advantage on higher-demand functional subscales. Findings support sEMG-led telerehabilitation as a viable neurorehabilitation modality where access to in-person specialist physiotherapy is constrained.

Trial registration.

Clinical Trial Registry, India: REF/2025/02/099521.

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Introduction

Knee osteoarthritis (OA) is the most prevalent degenerative joint disease worldwide, characterised by progressive articular cartilage degradation, subchondral bone remodelling, synovial inflammation and periarticular muscle weakness [1]. Its global burden is projected to increase by 74.9% by 2050 [2]. In India, the reported prevalence ranges from 22% to 39% of the adult population, with women and individuals aged over 65 years most affected [3]. Total knee arthroplasty (TKA) is the gold-standard surgical intervention for end-stage knee OA [4], and recent advances such as MAKO robotic-arm-assisted TKA (RA-TKA) offer pre-operative three-dimensional planning and intra-operative haptic guidance, improving implant alignment, soft-tissue balancing and short-term functional recovery [5-7].

Despite these surgical advances, recovery of quadriceps strength, joint ROM and patient-reported function depends critically on early post-operative rehabilitation [8]. A central neuromuscular impediment to this recovery is arthrogenic muscle inhibition (AMI) which is a reflex-mediated, ongoing failure of voluntary motor drive to the quadriceps that persists after the underlying joint pathology has been corrected [9,10]. AMI involves altered afferent input from the operated joint, attenuation

Author Affiliations

Dheeraj Kumar, PhD Scholar; **Jasmine Kaur Chawla**, Associate Professor: Department of Physiotherapy, School of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Faridabad, Haryana, India.

Correspondence

Jasmine Kaur Chawla

Department of Physiotherapy, School of Allied Health Sciences, Manav Rachna International Institute of Research and Studies, Faridabad-121003, Haryana, India.
Email : jasmine.k.chawla@gmail.com

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Keywords

surface electromyography; telerehabilitation; arthrogenic muscle inhibition; motor relearning; total knee arthroplasty

of cortical motor drive and impaired motor-unit recruitment, and can persist for weeks to months after TKA. Effective post-operative rehabilitation is therefore not only a problem of joint mobility but also a problem of motor relearning.

Surface electromyography (sEMG) biofeedback is well-suited to this motor-relearning problem. sEMG sensors placed over target muscles transduce motor-unit electrical activity into a real-time, quantitative signal of voluntary recruitment, allowing the patient to act as an augmented observer of their own motor output [11-13]. By converting an otherwise opaque neural process into immediate visual feedback, sEMG biofeedback can directly target AMI, drive cortical motor activation and reveal compensatory or asymmetric recruitment patterns that escape visual or palpatory observation.

Telerehabilitation is the remote delivery of rehabilitation services via digital platforms, video conferencing and wearable sensors that has emerged as a scalable alternative when access to in-person physiotherapy is constrained by cost, distance or caregiver availability [14,15]. Meta-analyses in the TKA population indicate that telerehabilitation produces ROM, pain and functional outcomes comparable to, and on some measures superior to, in-person care [16-18]. Preoperative telerehabilitation in TKA candidates has been shown to improve quadriceps strength and knee ROM [19], and wearable sensor-based platforms have demonstrated promise in knee OA more broadly [20]. However, the use of sEMG as the directing biofeedback modality within a post-operative RA-TKA telerehabilitation model has not, to our knowledge, been examined.

Anatomical recovery alone does not capture surgical success; Knee Injury and Osteoarthritis Outcome Score (KOOS) are now recognised as primary indicators of outcome [21]. The KOOS is a knee-specific instrument comprising five subscales Pain, Symptoms, Activities of Daily Living (ADL), Sport and Recreation, and Quality of Life with good reliability, validity and responsiveness to change after TKA [22-24].

The aim of this Research Note was to evaluate whether sEMG-led telerehabilitation, by targeting AMI through real-time neuromuscular biofeedback, produces ROM and KOOS outcomes comparable to those of conventional in-person physiotherapy in patients in the early post-RA-TKA period.

Materials & Methods

Study design

This was a two-arm parallel-group randomised controlled trial conducted in accordance with the Consolidated Standards of Reporting Trials (CONSORT) 2010 guidelines [25] and the principles of the Declaration of Helsinki [26]. The study was approved by the Institutional Ethics Committee of Manav Rachna International Institute of Research and Studies (EC/2024-25/060) and prospectively registered with the Clinical Trial Registry India (REF/2025/02/099521). Written informed consent was obtained from every participant. participant flow is

Participants

Thirty consecutive patients who had undergone RA-TKA were recruited from a single orthopaedic surgical unit at the time of hospital discharge. Inclusion criteria were: (i) age 50–80 years; (ii) no previous TKA; (iii) ability to read and write English; (iv) personal smartphone with the ability to use applications; and (v) willingness to participate and complete the intervention [27]. Exclusion criteria were rheumatoid arthritis or other systemic inflammatory diseases, current or past neurological or cognitive disorders, and unforeseen complications precluding adherence [27]. The trial was designed as a pilot study aimed at detecting a between-group effect size of $d \geq 0.8$ on the primary outcome (active knee flexion) at $\alpha = 0.05$ and 80% power; the resulting per-arm sample of $n = 15$ should be regarded as preliminary, with effect estimates intended to inform a larger confirmatory study.

Randomisation, allocation concealment and blinding

Participants were randomised 1:1 to sEMG telerehabilitation or conventional in-person physiotherapy using a computer-generated random number sequence prepared by an independent statistician [28]. Allocation was concealed in sequentially numbered, opaque, sealed envelopes opened by the recruiting physiotherapist at the point of enrolment [29]. Blinding of participants and treating therapists was not feasible given the nature of the interventions; however, outcome assessors performing goniometry and administering the KOOS were blinded to allocation throughout the two-week follow-up [30].

Interventions

Both groups commenced rehabilitation under inpatient physiotherapy supervision from postoperative day one and continued for two weeks after hospital discharge in their allocated mode (telerehabilitation or in-person). The exercise programme was fully standardised in content, progression criteria and session duration; the only differential was the mode of delivery and the presence of sEMG biofeedback.

sEMG telerehabilitation group. Participants performed home-based rehabilitation exercises guided by a wireless Trigno Discover sEMG system (Delsys, USA), which transmitted muscle-activation data in real time to a dedicated tablet application and provided continuous visual biofeedback on muscle recruitment during therapeutic exercises [31]. Physiotherapists supervised sessions synchronously via Zoom, delivering verbal coaching, and reviewed sEMG recordings asynchronously between sessions to adjust exercise parameters. Sessions were conducted daily for two weeks (45–60 minutes per session) and comprised warm-up, progressive therapeutic exercise (quadriceps strengthening, active ROM, closed-kinetic-chain loading, balance and proprioceptive training, gait re-education) and cool-down.

Conventional rehabilitation group. Participants received individual, in-person physiotherapy at home from the same qualified physiotherapists who supervised the sEMG arm, at the same frequency (daily, 45–60

minutes per session, for two weeks). The same structured exercise programme was followed without sEMG monitoring or biofeedback; therapists used conventional clinical observation, tactile facilitation and verbal instruction.

Outcome measures

Primary outcomes were active knee flexion ROM and active extension deficit (residual flexion contracture), measured in degrees with a digital goniometer by the same blinded assessor. Flexion was measured in supine with the knee actively flexed through its maximum comfortable range; extension deficit was measured in prone with gravity-assisted extension. Three measurements were obtained at each time point and averaged. Assessments were performed at baseline (discharge, before commencement of the rehabilitation programme) and two weeks post-discharge.

Secondary outcomes were the five KOOS subscales [22]: Pain (9 items), Symptoms (7 items), ADL (17 items), Sport and Recreation (5 items) and Quality of Life (4 items). Each subscale is transformed to a 0–100 scale, with higher scores indicating better outcomes. The KOOS was self-completed at baseline and at two weeks, and subscale scores were calculated using the published scoring algorithm. All 30 participants completed every item at both time points.

Statistical analysis

Normally distributed continuous variables are presented as mean $\pm$ standard deviation; non-normally distributed variables as median (interquartile range). Between-group comparisons at baseline used independent-samples t-tests (Welch's correction where variances were unequal) and the Mann–Whitney U test for non-normal data. Within-group changes used paired-samples t-tests (Wilcoxon signed-rank tests where appropriate). Between-group post-intervention scores and change scores were compared with independent-samples t-tests or Mann–Whitney U tests as indicated. Effect sizes are reported as Cohen's d_z (paired), Cohen's d (independent) and the rank-biserial correlation r (non-parametric), with thresholds of small (≥ 0.2), medium (≥ 0.5) and large (≥ 0.8). Within-group comparisons were Bonferroni-adjusted; between-group comparisons were further corrected using the Benjamini–Hochberg false discovery rate. The threshold for statistical significance was $p < 0.05$. There were no missing data ($n = 30$).

Results

Participant flow and baseline characteristics

All 30 randomised participants completed the two-week intervention and both assessment points. No intervention-related adverse events were reported. Baseline demographic and clinical characteristics were comparable between groups (Table 1). Mean age was 65.1 ± 4.4 years in the sEMG arm and 66.6 ± 6.8 years in the conventional arm, with an identical 5:10 male-to-female ratio in each group. Baseline ROM and KOOS subscale scores were statistically comparable between the two groups.

Primary outcomes: Knee range of motion Active knee flexion improved by approximately 20° in both the

groups (Table 2): from $88.27 \pm 2.96^\circ$ to $108.60 \pm 7.70^\circ$ in the sEMG arm ($\Delta +20.33^\circ$; 95% CI 17.23–23.44; $p < 0.001$; $d_z = 3.31$) and from $87.13 \pm 2.67^\circ$ to $107.40 \pm 6.58^\circ$ in the conventional arm ($\Delta +20.27^\circ$; 95% CI 16.85–23.68; $p < 0.001$; $d_z = 3.00$). The between-group difference in flexion change was negligible (mean difference 0.07° ; $p = 0.978$; $d = 0.01$). Extension deficit decreased substantially in both groups, with near-complete resolution: sEMG $7.20 \pm 5.67^\circ$ to $3.07 \pm 2.74^\circ$ ($\Delta -4.13^\circ$; $p < 0.001$) and conventional median 10.0° (IQR 5.0–10.0) to 0.0° (IQR 0.0–5.0) ($\Delta -5.87^\circ$; $p < 0.001$). The between-group difference in extension change was not statistically significant ($p = 0.138$).

Secondary outcomes: KOOS subscales

All five KOOS subscales improved significantly within both groups (all $p < 0.001$; d_z 2.49–3.79; Table 3), with mean changes of +35 to +58 points, substantially above the minimal clinically important difference of 8–10 points reported for TKA populations. Post-intervention scores in the sEMG arm reached 89.43 (Pain), 83.57 (Symptoms), 93.72 (ADL), 67.67 (Sport/Rec) and 82.11 (QoL); corresponding scores in the conventional arm were 85.93, 81.42, 87.75, 53.00 and 79.20.

Between-group analysis favoured sEMG telerehabilitation on the higher-demand functional subscales. The largest difference was on KOOS-Sport/Recreation (sEMG 67.67 ± 11.32 vs conventional 53.00 ± 14.74 ; mean difference +14.67 points; $p = 0.005$; Cohen's $d = 1.12$, a large effect; Bonferroni-adjusted $p = 0.102$). KOOS-ADL also favoured sEMG (Mann–Whitney $p = 0.030$; $r = -0.47$; change-score advantage +9.97 points; $d = 0.67$). No between-group difference reached significance on KOOS-Pain, KOOS-Symptoms or KOOS-QoL ($p > 0.20$).

Discussion

This study shows that sEMG-led telerehabilitation produces ROM and KOOS outcomes broadly equivalent to in-person physiotherapy in the early post-RA-TKA period, with a clear signal of advantage on the higher-demand functional KOOS subscales (Sport/Recreation and ADL). Both interventions delivered statistically significant and clinically meaningful improvements across every primary and secondary outcome over two weeks (within-group $p < 0.001$; d_z 2.49–3.79).

The convergence of ROM outcomes between arms ($\Delta +20.33^\circ$ vs $+20.27^\circ$; $p = 0.978$) is consistent with previous meta-analyses showing that telerehabilitation matches or exceeds in-person care for ROM, pain and function after TKA [16–18]. Our two-week post-intervention flexion values (108.6° sEMG; 107.4° conventional) fall just short of the $\sim 110^\circ$ required for stair-climbing and low-level kneeling but exceed the $\sim 90^\circ$ required for sitting and chair transfers, indicating functionally meaningful gains by both delivery modes.

The between-group advantage favouring sEMG on KOOS-Sport/Recreation ($d = 1.12$) and KOOS-ADL is plausibly mediated by the neuromuscular mechanism we hypothesised. AMI of the quadriceps is well documented after knee surgery and reflects altered afferent discharge from the operated joint, attenuating

Table 1. Baseline demographic and clinical characteristics of the two groups.

Characteristic	sEMG Telerehab (n = 15)	Conventional Rehab (n = 15)
Age (years), Mean $\pm$ SD	65.13 $\pm$ 4.37	66.60 $\pm$ 6.82
Gender (Male / Female)	5 / 10	5 / 10
Surgical technique	RA-TKA	RA-TKA
Baseline flexion ROM (°)	88.27 $\pm$ 2.96	87.13 $\pm$ 2.67
Baseline extension deficit (°)	7.20 $\pm$ 5.67	8.13 $\pm$ 3.58
Baseline KOOS-Pain	42.24 $\pm$ 11.89	39.81 $\pm$ 15.91
Baseline KOOS-Symptoms	48.11 $\pm$ 9.24	40.71 $\pm$ 10.95
Baseline KOOS-ADL	37.36 $\pm$ 10.78	41.37 $\pm$ 13.31
Baseline KOOS-Sport/Rec	17.00 $\pm$ 13.99	13.67 $\pm$ 10.93
Baseline KOOS-QoL	24.19 $\pm$ 13.95	25.03 $\pm$ 13.15

Note. RA-TKA = robot-assisted total knee arthroplasty; KOOS = Knee Injury and Osteoarthritis Outcome Score; ADL = Activities of Daily Living; QoL = Quality of Life. Values are mean $\pm$ SD unless otherwise stated.

Table 2. Knee range of motion (degrees): pre- and post-intervention by group.

ROM measure	sEMG Pre	sEMG Post	sEMG Δ (95% CI)	Conv Pre	Conv Post	Conv Δ (95% CI)
Knee flexion (°)	88.27 $\pm$ 2.96	108.60 $\pm$ 7.70	+20.33 [17.23, 23.44]; p < 0.001*	87.13 $\pm$ 2.67	107.40 $\pm$ 6.58	+20.27 [16.85, 23.68]; p < 0.001*
Extension deficit (°)	7.20 $\pm$ 5.67	3.07 $\pm$ 2.74	-4.13 [-5.96, -2.31]; p < 0.001*	10.0 (5.0–10.0)†	0.0 (0.0–5.0)†	-5.87 [-7.04, -4.69]; p < 0.001*

Note. Conv = Conventional Physiotherapy; sEMG = sEMG-guided Telerehabilitation; Δ = mean change score (Post – Pre) with 95% CI. *Within-group p < 0.001 (paired t-test; Wilcoxon signed-rank for Conv extension deficit). Extension-deficit values represent residual flexion contracture; a negative Δ indicates improvement. †Median (IQR) reported for non-normally distributed data.

Table 3. KOOS subscale scores (0–100): pre- and post-intervention by group.

KOOS subscale	sEMG Pre	sEMG Post	sEMG Δ (95% CI)	Conv Pre	Conv Post	Conv Δ (95% CI)
Pain	42.24 ± 11.89	89.43 ± 10.70	+47.19 [39.07, 55.32]; p < 0.001*	39.81 ± 15.91	85.93 ± 9.59	+46.11 [39.77, 52.46]; p < 0.001*
Symptoms	48.11 ± 9.24	83.57 ± 5.71	+35.46 [30.01, 40.91]; p < 0.001*	40.71 ± 10.95	81.42 ± 7.29	+40.71 [33.65, 47.76]; p < 0.001*
ADL	37.36 ± 10.78	93.72 ± 6.65	+56.36 [48.84, 63.88]; p < 0.001*	41.37 ± 13.31	87.75 ± 6.93	+46.39 [38.87, 53.90]; p < 0.001*
Sport/Rec	17.00 ± 13.99	67.67 ± 11.32	+50.67 [42.01, 59.32]; p < 0.001*	13.67 ± 10.93	53.00 ± 14.74	+39.33 [31.34, 47.33]; p < 0.001*
Quality of Life	24.19 ± 13.95	82.11 ± 11.77	+57.93 [47.96, 67.89]; p < 0.001*	25.03 ± 13.15	79.20 ± 13.28	+54.17 [43.84, 64.49]; p < 0.001*

Note. Higher scores indicate better outcome. ADL = Activities of Daily Living; Sport/Rec = Sport and Recreation; Conv = Conventional Physiotherapy; Δ = mean change score (Post – Pre) with 95% CI.

cortical motor drive and impairing voluntary discharge outpatient attendance is constrained by recruitment for weeks to months [9,10]. sEMG transport, cost and caregiver availability. The biofeedback directly targets AMI by providing the combination of widely available smartphones, 4G/5G patient with continuous, quantitative knowledge of connectivity and inexpensive wearable sensors makes voluntary motor output through increasing cortical sensor-enabled telerehabilitation a scalable model, motor drive, accelerating motor relearning and exposing consistent with prior evidence on videoconference-compensatory or asymmetric recruitment patterns that delivered biofeedback in musculoskeletal care [32].

escape visual observation [12,13]. Selective **Limitations** include the short two-week follow-up; biofeedback of vastus medialis and vastus lateralis may longer-term outcomes at 3–12 months were not be particularly important during eccentric weight-bearing tasks, which load the very subscales (Sport/Rec, arm, so the biofeedback signal cannot be isolated from ADL) on which we observed the largest between-group other effects of remote monitoring and digital advantage.

engagement. The sample (n = 30) was sized for a pilot, KOOS-Quality of Life improved substantially in both and the loss of statistical significance on KOOS-arms (from ~24 points to ~80 points), with a modest Sport/Recreation after Bonferroni correction (adjusted p non-significant numerical advantage for sEMG (+3.76 = 0.102) reflects this. Future multi-centre trials with points; p = 0.612). This pattern is consistent with prior longer follow-up, isokinetic dynamometry, gait analysis evidence that biofeedback-assisted telerehabilitation and quantitative sEMG outcomes (e.g., motor-unit improves patient-reported outcomes by increasing recruitment indices) are warranted.

engagement and self-monitoring [32,33]. The slightly **Conclusions**

greater within-group change in the Symptoms domain in the Symptoms domain in the sEMG-led telerehabilitation produced ROM and KOOS the conventional arm (+40.71 vs +35.46; p = 0.258) outcomes comparable to in-person physiotherapy at two reflects a baseline imbalance, not a treatment effect: weeks post-RA-TKA, with a signal of advantage on post-intervention scores were nearly identical between demanding functional subscales. By providing real-time arms (81.42 vs 83.57; p = 0.377), suggesting that early neuromuscular feedback that targets arthrogenic muscle joint healing in this domain proceeds on its own time inhibition and supports motor relearning, sEMG-led course irrespective of biofeedback [34]. telerehabilitation is a viable neurorehabilitation

From an implementation perspective, sEMG-led modality for the early post-arthroplasty period, telerehabilitation has direct relevance to the Indian particularly where access to in-person specialist healthcare context, where specialist orthopaedic physiotherapy is limited.

physiotherapy is concentrated in urban areas and post- **Acknowledgements**

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Ethical approval

This study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was granted by the Institutional Ethics Committee of Manav Rachna International Institute of Research and Studies (EC/2024-25/060). The trial was prospectively registered with the Clinical Trial Registry India (REF/2025/02/099521).

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Conflicts of interest

Delsys manufactures the Trigno Discover sEMG hardware used in this trial and provided partial equipment support, as described in the Funding statement. Beyond this equipment support, the authors declare no other conflicts of interest. Each author has completed the ICMJE conflict-of-interest disclosure form.

References

1. Mohd Yunus MH, Nordin A, Kamal H. Pathophysiological perspective of osteoarthritis. *Medicina (Kaunas)*. 2020;56(11):614. <https://doi.org/10.3390/medicina56110614>
2. GBD 2021 Osteoarthritis Collaborators. Global, regional, and national burden of osteoarthritis, 1990-2020 and projections to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet Rheumatol*. 2023;5(9):e508-e522. [https://doi.org/10.1016/S2665-9913\(23\)00163-7](https://doi.org/10.1016/S2665-9913(23)00163-7)
3. Yadav R, Verma AK, Uppal A, Chahar HS, Patel J, Pal CP. Prevalence of primary knee osteoarthritis in the urban and rural population in India. *Indian J Rheumatol*. 2022;17(3):239-43. https://doi.org/10.4103/injr.injr_337_20
4. Kamlay P, Bagewadi R, Khodnapur G, Bulagond A, Biradar BS, Nandi S. Clinical and functional outcomes following primary total knee arthroplasty in patients with knee osteoarthritis: a prospective study. *Cureus*. 2025;17(6):e86944. <https://doi.org/10.7759/cureus.86944>
5. Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, Haddad FS. Robotic-arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced time to hospital discharge compared with conventional jig-based total knee arthroplasty: a prospective cohort study. *Bone Joint J*. 2018;100-B(7):930-7. <https://doi.org/10.1302/0301-620X.100B7.BJJ-2017-1449.R1>
6. Roche M. The MAKO robotic-arm knee arthroplasty

- system. *Arch Orthop Trauma Surg*. 2021;141(12):2043-7. <https://doi.org/10.1007/s00402-021-04208-0>
7. Alrajeb R, Zarti M, Shuaib Z, Alzobi O, Ahmed G, Elmhiregh A. Robotic-assisted versus conventional total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *Eur J Orthop Surg Traumatol*. 2024;34(3):1333-43. <https://doi.org/10.1007/s00590-023-03798-2>
8. Mizner RL, Petterson SC, Stevens JE, Vandenborne K, Snyder-Mackler L. Early quadriceps strength loss after total knee arthroplasty: the contributions of muscle atrophy and failure of voluntary muscle activation. *J Bone Joint Surg Am*. 2005;87(5):1047-53. <https://doi.org/10.2106/JBJS.D.01992>
9. Sonnery-Cottet B, Hopper GP, Gousopoulos L, Vieira TD, Thaumat M, Fayard JM, Freychet B, Ouanezar H, Cavaignac E, Saithna A. Arthrogenic muscle inhibition following knee injury or surgery: pathophysiology, classification, and treatment. *Video J Sports Med*. 2022;2(3):26350254221086295. <https://doi.org/10.1177/26350254221086295>
10. Hart JM, Pietrosimone B, Hertel J, Ingersoll CD. Quadriceps activation following knee injuries: a systematic review. *J Athl Train*. 2010;45(1):87-97. <https://doi.org/10.4085/1062-6050-45.1.87>
11. Farina D, Enoka RM. Evolution of surface electromyography: from muscle electrophysiology towards neural recording and interfacing. *J Electromyogr Kinesiol*. 2023;71:102796. <https://doi.org/10.1016/j.jelekin.2023.102796>
12. Achens JT, Raj Victor VS, Joseph JK. Early activation of quadriceps with pressure biofeedback for the prevention of arthrogenic muscle inhibition following lower limb orthopedic surgeries: a proof of concept clinical trial. *J Chiropr Med*. 2022;21(4):296-304. <https://doi.org/10.1016/j.jcm.2022.05.005>
13. Sturma A, Hruby LA, Prahm C, Mayer JA, Aszmann OC. Rehabilitation of upper extremity nerve injuries using surface EMG biofeedback: protocols for clinical application. *Front Neurosci*. 2018;12:906. <https://doi.org/10.3389/fnins.2018.00906>
14. Agnihotri S, Gupta N, Sindwani P, Srivastava A, Ahmad A, Karki M. Telerehabilitation: exploring the untapped potential. *Cureus*. 2024;16(4):e57405. <https://doi.org/10.7759/cureus.57405>
15. Crawford T, Parsons J, Webber S, Fricke M, Thille P. Strategies to increase access to outpatient physiotherapy services: a scoping review. *Physiother Can*. 2022;74(2):197-207. <https://doi.org/10.3138/ptc-2020-0119>
16. Liu X, Yang G, Xie W, Lu W, Liu G, Xiao W, Li Y. Efficacy of telerehabilitation for total knee arthroplasty: a meta-analysis based on randomized controlled trials combined with a bibliometric study. *J Orthop Surg Res*. 2024;19(1):874. <https://doi.org/10.1186/s13018-024-05381-9>
17. Tsang MP, Man GCW, Xin H, Chong YC, Ong MT, Yung PS. The effectiveness of telerehabilitation in patients after total knee replacement: a systematic review and meta-analysis of randomized controlled trials. *J Telemed Telecare*. 2024;30(5):795-808. <https://doi.org/10.1177/1357633X221097469>
18. Wang Y, Liu X, Wu Q, Zhu Q, Zhang M. Impact of telerehabilitation on rehabilitation efficacy and patient satisfaction after knee surgery: systematic review and meta-analysis of randomized controlled trials. *J Med Internet Res*. 2025;27:e76844. <https://doi.org/10.2196/76844>

19. **An J, Ryu HK, Lyu SJ, Yi HJ, Lee BH.** Effects of preoperative telerehabilitation on muscle strength, range of motion, and functional outcomes in candidates for total knee arthroplasty: a single-blind randomized controlled trial. *Int J Environ Res Public Health*. 2021;18(11):6071. <https://doi.org/10.3390/ijerph18116071>
20. **Plavoukou T, Kasnesis P, Contiero Syropoulou A, Papagiannis G, Stasinopoulos D, Georgoudis G.** Wearable sensor-based telerehabilitation versus conventional physiotherapy in knee OA: insights from the KneE-PAD pilot study. *Appl Sci*. 2025;15(24):12988. <https://doi.org/10.3390/app152412988>
21. **Billig JJ, Sears ED, Travis BN, Waljee JF.** Patient-reported outcomes: understanding surgical efficacy and quality from the patient's perspective. *Ann Surg Oncol*. 2020;27(1):56-64. <https://doi.org/10.1245/s10434-019-07748-3>
22. **Roos EM, Lohmander LS.** The Knee injury and Osteoarthritis Outcome Score (KOOS): from joint injury to osteoarthritis. *Health Qual Life Outcomes*. 2003;1:64. <https://doi.org/10.1186/1477-7525-1-64>
23. **Peer MA, Lane J.** The Knee Injury and Osteoarthritis Outcome Score (KOOS): a review of its psychometric properties in people undergoing total knee arthroplasty. *J Orthop Sports Phys Ther*. 2013;43(1):20-8. <https://doi.org/10.2519/jospt.2013.4057>
24. **Kim GW.** Patient-reported outcome measure of knee function: Knee Injury and Osteoarthritis Outcome Score (KOOS). *Ann Rehabil Med*. 2023;47(6):441-3. <https://doi.org/10.5535/arm.230009>
25. **Moher D, Hopewell S, Schulz KF, Montori V, Gøtzsche PC, Devereaux PJ, Elbourne D, Egger M, Altman DG.** CONSORT 2010 explanation and elaboration: updated guidelines for reporting parallel group randomised trials. *BMJ*. 2010;340:c869. <https://doi.org/10.1136/bmj.c869>
26. **World Medical Association.** Declaration of Helsinki: ethical principles for medical research involving human subjects. *Jahrb Wiss Ethik*. 2009;14(1):233-8. <https://doi.org/10.1515/9783110208856.233>
27. **Farrokhi N, Sarzaeem MM, Feizi D.** Feasibility and acceptability of a telerehabilitation intervention on patients undergoing total knee arthroplasty in Iran: randomised controlled trial protocol. *BMJ Open*. 2024;14(6):e083784. <https://doi.org/10.1136/bmjopen-2023-083784>
28. **Schulz KF, Grimes DA.** Generation of allocation sequences in randomised trials: chance, not choice. *Lancet*. 2002;359(9305):515-9. [https://doi.org/10.1016/S0140-6736\(02\)07683-3](https://doi.org/10.1016/S0140-6736(02)07683-3)
29. **Doig GS, Simpson F.** Randomization and allocation concealment: a practical guide for researchers. *J Crit Care*. 2005;20(2):187-91. <https://doi.org/10.1016/j.jcrc.2005.04.005>
30. **Karanicolas PJ, Farrokhyar F, Bhandari M.** Practical tips for surgical research: blinding: who, what, when, why, how? *Can J Surg*. 2010;53(5):345-8.
31. **Bawa A, Banitsas K.** Design validation of a low-cost EMG sensor compared to a commercial-based system for measuring muscle activity and fatigue. *Sensors (Basel)*. 2022;22(15):5799. <https://doi.org/10.3390/s22155799>
32. **Janela D, Costa F, Weiss B, Areias AC, Molinos M, Scheer JK, Lains J, Bento V, Cohen SP, Correia FD, Yanamadala V.** Effectiveness of biofeedback-assisted asynchronous telerehabilitation in musculoskeletal care: a systematic review. *Digit Health*. 2023;9:20552076231176696. <https://doi.org/10.1177/20552076231176696>
33. **Seron P, Oliveros MJ, Gutierrez-Arias R, Fuentes-Aspe R, Torres-Castro RC, Merino-Osorio C, Nahuelhual P, Inostroza J, Jalil Y, Solano R, Marzuca-Nassr GN, Aguilera-Eguía R, Lavados-Romo P, Soto-Rodríguez FJ, Sabelle C, Villarroel-Silva G, Gomolán P, Huaiquilaf S, Sanchez P.** Effectiveness of telerehabilitation in physical therapy: a rapid overview. *Phys Ther*. 2021;101(6):pzab053. <https://doi.org/10.1093/ptj/pzab053>
34. **Sheen JR, Mabrouk A, Garla VV.** Fracture healing overview. In: *StatPearls*. Treasure Island (FL): StatPearls Publishing; 2025. Available from: <https://www.ncbi.nlm.nih.gov/books/NBK551678/>

A Rare Anatomical Variant: Congenital Absence of Right Coronary Artery with Super-dominant Left Circumflex Artery

Randy Dwirizaldi Hidayat, , Faras Hilmy, , Iyus Maolana Yusup, , Dian Komala Dewi.

Abstract

Background

Congenital absence of the right coronary artery (RCA) is an exceptionally rare Single Coronary Artery variant where right ostium development fails, making global myocardial perfusion single-trunk dependent. This study highlights the critical diagnostic role of Cardiac Computed Tomography Angiography (CCTA) in identifying this high-stakes anomaly.

Case Presentation

A 77-year-old male with hypertension presented with a two-year history of progressive exertional dyspnea. A 256-slice CCTA was performed due to persistent symptoms, revealing a complete absence of the right coronary ostium and an RCA calcium score of 0. The circulation exhibited complete left dominance via a markedly elongated, super-dominant left circumflex (LCx) artery supplying the entire posterior and inferior myocardial territories. A critical, heavily calcified stenosis was identified in the middle segment of the left anterior descending (LAD) artery, which was subsequently managed with a successful confirmatory invasive angiography and percutaneous coronary intervention (PCI).

Conclusion

Congenital RCA absence is a critical anomaly easily misdiagnosed as chronic total occlusion. CCTA serves as an invaluable non-invasive roadmap guiding targeted secondary prevention.

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Introduction

Congenital absence of the right coronary artery (RCA) is an extraordinarily rare cardiovascular malformation within the anatomical spectrum of a Single Coronary Artery (SCA) network [1,2]. While normal myocardial perfusion is sustained by independent dual-source arteries, an isolated left SCA network forces the entire myocardial architecture to rely exclusively on a single coronary ostium to maintain cardiac output^{3,4}. Large-scale retrospective studies estimate the overall prevalence of an isolated SCA to range between 0.024% and 0.066% among patients undergoing angiographic evaluation, with complete territorial agenesis of the RCA trunk standing out as one of the least frequently documented variants [1,2].

The embryological pathogenesis of this malformation stems from either a primary developmental failure during the budding phase of the right coronary cord or a premature involutational occlusion of the proximal right vascular plexus during the first trimester of intrauterine life [3]. Although many individuals remain asymptomatic for decades, this single-vessel dependent heart presents a severe pathophysiological liability due to the lack of alternative routes for collateral circulation [2,4]. Consequently, if atherosclerotic plaque progression develops within the lone functioning tree, patients become exceptionally vulnerable to extensive transmural ischemia, malignant arrhythmias, or sudden cardiac death [4].

Historically, complex coronary anomalies were discovered incidentally during conventional invasive coronary angiography (ICA), which often encounters high engagement failure rates when managing an absent ostium [2,5]. In the modern era, multi-slice Cardiac Computed Tomography Angiography (CCTA) has emerged as the premier non-invasive tool, providing superb spatial resolution and three-dimensional multiplanar reconstructions to meticulously delineate complex vascular trajectories and plaque morphology [5]. This case report highlights the critical diagnostic role of 256-slice CCTA in non-invasively identifying a congenital absence of the RCA with a super-dominant left circumflex (LCx) artery, providing a precise anatomical roadmap for a subsequent successful confirmatory intervention and percutaneous coronary intervention (PCI).

Author Affiliations: Randy Dwirizaldi Hidayat, , Faras Hilmy, , Iyus Maolana Yusup, , Dian Komala Dewi .Department of Radiology, Faculty of Medicine Padjadjaran University, Dr. Hasan Sadikin Hospital Bandung, **Correspondence:** : Randy Dwirizaldi Hidayat, Department of Radiology, Faculty of Medicine Padjadjaran University, Dr. Hasan Sadikin Hospital Bandung. +62-821-2475-3661, randy15001@mail.unpad.ac.id, Address ,Jl. Letjen H Mashudi Siluman RT/RW 004/002 Kelurahan Setiaratu Kecamatan Cibeureum Kota Tasikmalaya: **Indexed** EMBASE, SCOPUS, IndMED, ESBCO, Google Scholar besides other national and international databases.. **Cite this article as:**

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Case Presentation

A 77-year-old male with hypertension presented with a two-year history of progressive exertional dyspnea and easy fatigability. He described the dyspnea as a heavy pressing sensation on his chest during physical activity. He denied typical anginal pain, palpitations, or lower extremity edema. His medical history was significant only for well-controlled hypertension treated with amlodipine 5 mg once daily. Physical examination and laboratory profiles, including a lipid panel, were unremarkable. Baseline transthoracic echocardiography (TTE) demonstrated normal chamber sizes with no regional wall motion abnormalities. Given the distinct clinical mismatch between his unremarkable echocardiographic findings and debilitating symptoms, a 256-slice cardiac computed tomography angiography (CCTA) was performed to evaluate the coronary architecture. The coronary artery calcium scoring protocol yielded a total Agatston score of 219 (left circumflex [LCx]: 177, left main artery [LMA]: 38, left anterior descending [LAD]: 4). Notably, the calcium scores for both the right coronary artery (RCA) and posterior descending artery (PDA) were absolute 0.

Contrast-enhanced CCTA revealed a complete congenital absence of the RCA, characterized by the absolute non-visualization of the right coronary ostium and its proximal trunk at the right aortic sinus. Consequently, the coronary circulation exhibited complete left dominance. The LMA originated normally and bifurcated into the LAD and LCx. The LCx presented as a super-dominant, markedly elongated vessel that wrapped continuously around the atrioventricular groove, extending well past the cardiac crux to retrogradely supply the entire posterior and inferior myocardial territories.

Evaluation of the atherosclerotic burden across this single network revealed a critical, heavily calcified plaque in the middle segment of the LAD, resulting in severe luminal stenosis, alongside mild non-obstructive plaques in the LMA and proximal LCx. Extra coronary findings included a localized Grade 2 calcification at the non-coronary cusp (NCC) of the aortic valve with an Agatston score of 102.

Guided by the precise CCTA roadmap, the patient was referred for conventional invasive coronary angiography (ICA). The catheterization confirmed the complete absence of the right coronary origin, verifying the retrograde perfusion from the left network with 100% diagnostic accuracy. Given the critical nature of this single-vessel dependent network, a successful Percutaneous Coronary Intervention (PCI) was immediately performed with a drug-eluting stent deployed across the severe mid-LAD lesion. Post-procedure, the patient's exertional dyspnea completely resolved, and he was discharged on guideline-directed medical therapy.

Discussion

Non-visualization of the RCA on standard imaging presents a significant diagnostic challenge, requiring a

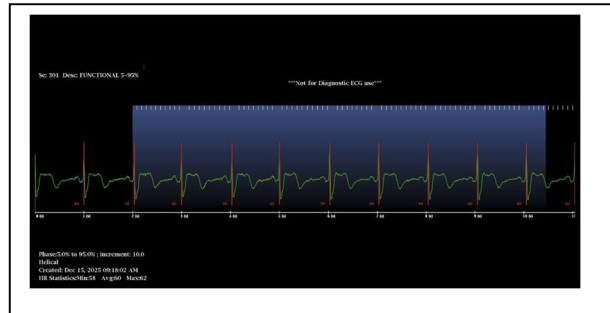


Figure 1. Graphical representation of the prospectively electrocardiographically triggered (ECG-gated) coronary computed tomography angiography (CCTA) protocol. The acquisition window is strategically targeted during the mid-to-end diastole phase to ensure optimal image resolution and eliminate cardiac motion artifacts.

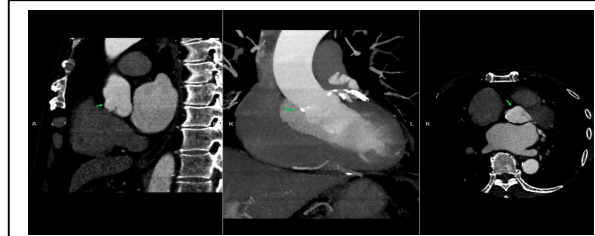


Figure 2. Axial contrast-enhanced cardiac computed tomography angiography (CCTA) reconstruction at the level of the aortic root. The image definitively demonstrates the true congenital absence of the right coronary artery (RCA), characterized by the absolute non-visualization of the right coronary ostium at the right aortic sinus (indicated by the area of interest). Concurrently, the left coronary network originates normally from the contralateral left aortic sinus.

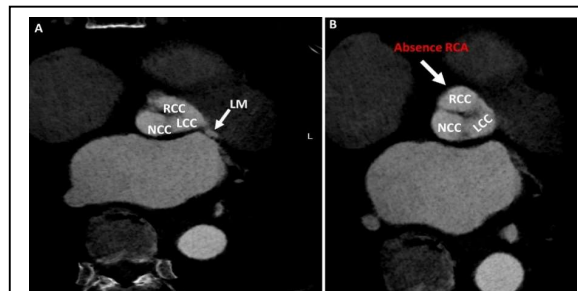


Figure 3. Axial cross-sectional CCTA image focusing on the aortic sinus morphology. The landmark labeled "LM" confirms the normal structural origin of the left main coronary artery arising from the left aortic sinus. Conversely, the contralateral right aortic sinus displays complete structural agenesis, with no identifiable right coronary ostium or proximal arterial trunk, confirming a single left coronary network.

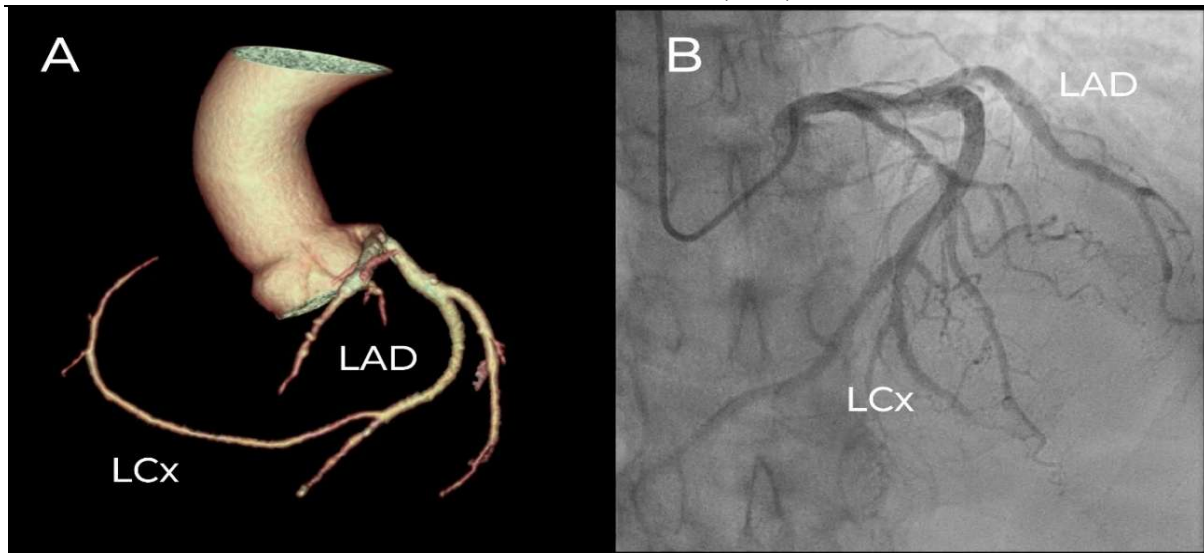


Figure 4. Dual-modality anatomical correlation of the single left coronary artery (SCA). (A) Invasive coronary angiography (ICA) confirms the absence of the right coronary artery (RCA) ostium, with retrograde perfusion supplying the inferior-posterior territories. (B) Corresponding 3D volume-rendered (3D-VR) CCTA reconstruction highlights the hypertrophied, super-dominant left circumflex (LCx) artery wrapping around the atrioventricular groove to sustain global myocardial perfusion.

a clear differentiation between true congenital agenesis, LAD artery, categorized under the CAD-RADS an acquired atherosclerotic Chronic Total Occlusion framework⁵. This finding revealed that the patient's (CTO), and an anomalous coronary origin [5,7]. In our single-vessel dependent heart was in a highly vulnerable patient, a true congenital absence was confirmed by the state, as any progression of the LAD lesion could compromise global anterior myocardial perfusion and a residual blind-ended vascular stump at the right without any safety net.

aortic sinus [6]. This conclusion was reinforced by a dedicated Agatston calcium score of 0 along the expected RCA and PDA tract, effectively ruling out a long-standing, heavily calcified occluded native vessel [5]. Concurrently, multiplanar reconstruction verified the definitive classification of a single left coronary artery network [7].

To compensate for the embryonic developmental failure of the right coronary system, the heart undergoes profound intrauterine hemodynamic remodeling, triggering structural hypertrophy and compensatory elongation of the left circulation [3,8]. In this specific architecture, the LCx artery functions as a "super-dominant" vessel [2,6]. As demonstrated in our patient's CCTA, this super-dominant LCx tracked continuously along the left atrioventricular groove, extended well past the cardiac crux, and retrogradely entered the right atrioventricular sulcus to successfully supply the posterior and inferior myocardial walls—territories normally served exclusively by a native RCA [5,8].

The primary clinical hazard of an isolated single left coronary system is its extreme vulnerability to atherosclerotic progression [2,4]. Because global myocardial perfusion is entirely single-trunk dependent, a hemodynamically significant stenosis cannot be bypassed or mitigated by alternative contralateral collateral channels [4,9]. In this case, the pre-procedural CCTA played a pivotal role by identifying a critical, severe calcified stenosis in the middle segment of the

Guided by the precise CCTA-derived anatomical roadmap, subsequent invasive coronary angiography (ICA) confirmed the absent RCA origin and retrograde left circulation with 100% diagnostic accuracy [10]. This dual-modality correlation provided the definitive diagnostic confirmation required to safely proceed with an immediate, successful Percutaneous Coronary Intervention (PCI). Stent implantation across the severe mid-LAD lesion successfully secured the patient's lone functioning vascular tree and immediately restored optimal anterograde flow.

Conclusion

This case provides an illustrative example of the remarkable boundaries of long-term human myocardial adaptation, demonstrating that a single left coronary network can successfully sustain global cardiac function into late senescence despite the complete congenital absence of the RCA [2]. For radiology residents and practicing cardiovascular specialists, maintaining a high level of vigilance when evaluating asymmetric coronary distributions on cardiac CT is paramount [3,6,10]. Performing an initial CCTA-based evaluation is essential to prevent the erroneous diagnosis of an acquired atherosclerotic occlusion, avoid hazardous or unnecessary invasive procedural attempts to selectively engage a non-existent right ostium, and provide a precise anatomical roadmap that ensures safer, targeted planning for subsequent high-stakes confirmatory invasive angiography and percutaneous therapeutic

interventions^{3,6}.

References

1. **Desmet W, Vanhaecke J, Vrolix M, Van de Werf F, Piessens J, Willems J, et al.** Isolated single coronary artery: a review of 50,000 consecutive coronary angiographies. *European Heart Journal*. 1992;13(12):1637–40.
2. **Rajbhandari R, Shah JP, Pradhan A, Dangol R, Dangol U.** A rare case of single coronary artery with congenital absence of right coronary artery. *Case Report*. 2021;1–4.
3. **Bruna-Mejias A, del Villar-Valdebenito J, Roman C, Alcaïno-Adasme C, Sepulveda-Loyola W, Orellana-Donoso M, et al.** Hypoplastic and Congenital Absence of Coronary Arteries and Its Correlation with Clinical Implications of Cardiac Circulation: A Systematic Review and Meta-Analysis. *Journal of Clinical Medicine*. 2024;13(11):3085.
4. **Mahmoud A, Saadeh M, Alfawara MS, Maaiah WG, Al-awaisheh A.** Absence of Right Coronary Ostium with Single Coronary Artery: A Rare Anomaly. *Methodist DeBakey Cardiovascular Journal*. 2024;20(1):94–7.
5. **Yan GW, Bhetuwal A, Yang GQ, Fu QS, Hu N, Zhao LW, et al.** Congenital absence of the right coronary artery: A case report and literature review. *Medicine (Baltimore)*. 2018;97(40):e0187.
6. **Canan A, Batra K.** Superdominant Left Circumflex Artery with Absent Right Coronary Artery. *Radiology*. 2022;304(2):294.
7. **Wang X, Cui H, Xu Z.** Reevaluating the diagnosis of right coronary artery absence: A thoughtful analysis of a case report. *Medicine (Baltimore)*. 2025;104(1):e43620.
8. **Barakoti MP, Shafiu M, Tiwari KK, Pant S.** Congenital absence of right coronary artery: a rare coronary anomaly: case report. *Oxford Medical Case Reports*. 2024;2024(2):48–51.
9. **Zhu XY, Tang XH.** Congenital absence of the right coronary artery: A case report. *World Journal of Clinical Cases*. 2022;10(34):12799–803.
10. **Khurana KV, Singh A, Rao T, Toshniwal S, Acharya S, Agrawal G, et al.** Congenital Absence of the Left Circumflex Artery Presenting With Inferoposterior Wall Myocardial Infarction Due to Stenosis of the Super Dominant Right Coronary Artery: A Rare Case. *Cureus*. 2023;15(10):e46709.

Obituaries



Dr. Sheikh Mustafa Kamal Senior National Conference (NC) leader, physician-turned-politician, and younger brother of Dr. Farooq Abdullah, passed away in Srinagar on July 14, 2026, at the age of 83. His demise has been widely mourned across Jammu and Kashmir's political and medical circles

Dr. Sheikh Mustafa Kamal served Kashmir with a rare combination of compassion and conviction. As a physician he tended the sick without fanfare, often putting the needs of the poor before his own. As a public servant and National Conference leader he carried forward a family legacy while forging his own path—speaking plainly, defending principles, and working at the grassroots where change is felt most.

Born into a family that shaped the modern history of Jammu and Kashmir, Mustafa Kamal might have been destined for public life, yet he chose first to learn the art of healing. Trained as a physician, he carried his medical knowledge into the valleys and villages of Kashmir, where his clinic became a refuge for the poor and the sick. He treated bodies and soothed anxieties with equal care, often offering medicines and consultations without charge. That early practice was not merely a profession; it was the formation of a character defined by compassion.

Legacy

- Dual Identity: A physician who served the poor and a politician who shaped NC's organizational strength



Prof. (Dr.) Mohammad Yousuf of Brien Nishat, Srinagar, a distinguished physician and academician, passed away on October 1, 2026. His demise has been deeply mourned by both GMC Srinagar and SKIMS, where he was remembered as an astute teacher, compassionate clinician, and a noble soul whose contributions to medicine and medical education left a lasting legacy.

Prof. Yousuf's career was defined by two complementary commitments: to the advancement of medical knowledge and to the care of individual patients. As a professor he translated complex science into clear, memorable lessons; as a clinician he listened with patience and treated with compassion. Students recall his calm authority and the way a single sentence in his lecture could change how they thought about patient care. Patients remember a physician who made time, explained with kindness, and treated each person as more than a diagnosis. Colleagues describe him as modest in manner and exacting in standards, a mentor who corrected gently and celebrated quietly. Former students speak of his encouragement at pivotal moments — the nudge to pursue research, the steady counsel before an exam, the handwritten note after a successful presentation. In a community that often measures success by titles and awards, Prof. Yousuf was admired for something simpler: the consistency of his care and the integrity of his example.

Legacy

His insistence on ethical practice, his respect for patients' dignity, and his belief that teaching is itself a form of service are values that will continue to shape medical care in the Valley.



Prof. (Dr.) Ghulam Mohammad Dhar

(widely known as Dr. G.M. Dhaar), a pioneering public health expert, distinguished medical educator, and the revered "Father of Community Medicine" in Jammu & Kashmir. He passed away peacefully on June 10, 2026, at the age of 91.

Born in 1935 in the historic Aali Kadal area of Srinagar, Dr. Dhaar belonged to a respected and distinguished family from downtown Srinagar. The son of Haji Ghulam Hassan Dhaar, he obtained his MBBS degree from Osmania Medical College, Hyderabad, in 1959. He was the first postgraduate in Public Health/Community Medicine from Jammu and Kashmir, having earned his MD from the prestigious King George's Medical College. Dr. Dhaar began his career as a Medical Officer at SMHS Hospital, Srinagar, where he had the opportunity to work closely with some of the foremost leaders of medicine in the state, including Prof. Ghulam Rasool, Prof. Ali Mohammad Jan, and Prof. Harbhajan Singh. He later rose to become Professor and Head of the Department at Government Medical College (GMC), Srinagar.

Dr. Dharr served for many years at Government Medical College Srinagar where he taught and mentored students in Social and Preventive Medicine. His work combined clinical insight with a deep commitment to community health, emphasising disease prevention, health education, and the social determinants of wellbeing. Colleagues remember him for his methodical approach to public health problems and for bringing compassion into both the classroom and the clinic

Legacy

Dr. G. M. Darr leaves behind a legacy of service to medical education and community health in Srinagar. His influence will live on through the physicians he trained and the public health work he helped to advance
