

Review

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

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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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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

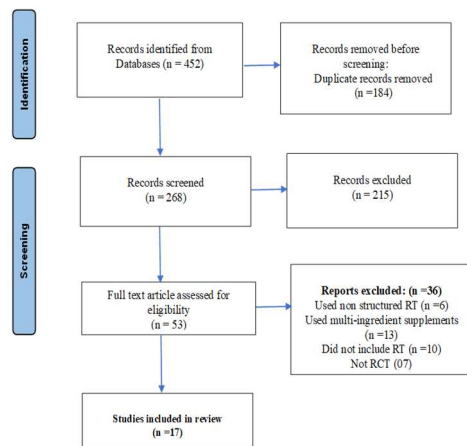
A multi-stage strategy was developed to select the studies. Using reference management software (Mendeley), the duplicate records were removed. The titles and abstracts of the remaining records, in contrast to the inclusion criteria screened by three independent reviewers. For all potentially relevant 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.

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