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Protein supplementation on muscle recovery and soreness after intense badminton training sessions

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Abstract

Purpose. This study aimed to investigate the impact of protein supplementation on muscle recovery and delayed-onset muscle soreness (DOMS) in male badminton players following intense training sessions.

Material & Methods. Thirty-six male badminton players, aged 18 to 25, were randomly divided into three groups: a high-protein group (1.6 g/kg body weight), a moderate-protein group (0.8 g/kg body weight), and a placebo group. Participants consumed their respective supplements within 30 minutes after each training session over a six-week period. Muscle soreness was assessed using the Visual Analog Scale (VAS) at 24, 48 and 72 hours post-exercise, and recovery was measured through the Perceived Recovery Status (PRS) scale. Statistical analyses, including two-way ANOVA, were performed to assess the effects of protein supplementation and the recovery time on muscle soreness and recovery.

Results. The high-protein group showed significantly faster recovery and reduced muscle soreness than the moderate-protein and placebo groups ($p<0.001$). Furthermore, regression analysis indicated a strong negative correlation between protein intake and muscle soreness, highlighting the benefit of higher protein levels in improving recovery.

Conclusions. Protein supplementation, especially at a higher dose of 1.6 g/kg body weight, significantly aided in muscle recovery and reduced muscle soreness in male badminton players. This suggests that adequate protein intake is key to enhancing recovery and performance in sports that require quick bursts of intense activity.

Keywords: Protein, muscle recovery, soreness, badminton, sports nutrition.

Introduction

Badminton requires a high level of physical intensity, blending agility, strength, endurance, and quick reaction times (Rossi et al., 2022). The sport's demands often lead to muscle fatigue and delayed-onset muscle soreness (DOMS), which can hinder athletes' ability to perform consistently (Molaeikhaletabadi et al., 2022). Unlike in sports where continuous endurance or heavy lifting are key, badminton players face a unique challenge due to their fast, high-intensity movements and bursts of sprinting, followed by rest periods. This intense stop-and-go style of play leads to greater muscle strain and rapid buildup of metabolic byproducts, which contribute to muscle soreness and fatigue. These effects underscore the need for efficient recovery strategies to sustain performance levels and maintain consistent training schedules (Phomsoupha & Laffaye, 2015; Gasibat et al., 2023; Phomsoupha & Laffaye, 2020).

Nutrition, and specifically protein intake, is widely recognized as essential to muscle recovery

and performance in various sports. Protein aids in muscle repair, reducing soreness, and promoting recovery (Papadopoulou, 2020; Danh et al., 2023; Hulland et al., 2024). Extensive research on endurance and strength sports has confirmed that protein supplementation after exercise can improve recovery times and reduce muscle soreness. These findings, however, have focused on sports with different physical requirements than badminton, leaving an important gap in understanding how protein might help badminton athletes, who face unique movement patterns and physiological demands (Jayawardena et al., 2024; Klein et al., 2021; Muwonge et al., 2017).

Recovery-focused research suggests that high-protein intake (typically between 1.6-2.2 grams per kilogram of body weight) is generally effective for muscle repair, yet there is limited insight on the ideal protein intake specifically for badminton players (Phillips, 2006; Pourabbas et al., 2021). Given the sport's combination of anaerobic and aerobic demands, determining the ideal type and timing of protein intake for optimal recovery remains an open question. Additionally, research has shown varied results on whether immediate post-exercise protein intake or consistent intake throughout the day has the greatest impact on recovery, suggesting a need to explore timing strategies that could specifically benefit badminton players (Karp et al., 2006; Amiri et al., 2019; Chang et al., 2020).

Current studies into protein's effect on DOMS have yielded mixed results. Some studies indicate that protein may reduce DOMS by facilitating muscle repair and anti-inflammatory effects, while other studies report no significant impact. These differing results may be due to inconsistencies in sample sizes, exercise types, and protein dosages (Molaeikhaletabadi et al., 2022). For badminton athletes, who experience muscle soreness from the sport's explosive demands, investigating whether protein intake can specifically alleviate DOMS symptoms is highly relevant. The potential for protein to improve recovery would not only benefit players' performance but also reduce downtime due to soreness and fatigue, enabling more consistent training (Lau et al., 2013; Laurent et al., 2011).

The purpose of this study is to investigate the effects of protein supplementation on muscle recovery and soreness reduction in college-level male badminton players. By assigning participants to high-protein, moderate-protein, and control groups, the study aims to determine whether protein supplementation can improve recovery and reduce muscle soreness at various time points post-exercise.

Material and methods

Participants

This study included 36 competitive college-level male badminton players aged between 18 and 25 years (21.4±1.773), all from SRM Institute of Science and Technology, India. These players, chosen for their minimum of two years of competitive experience and consistent training routines, reflect a skilled demographic relevant to badminton performance. Participants were randomly allocated into three groups, each containing 12 members: a high-protein group, a moderate-protein group, and a control group. Informed consent was obtained from each participant to ensure voluntary involvement in the study.

Methods

The intervention lasted six weeks, during which participants consumed their designated post-training supplementation after each training session. Group 1 (high-protein) received 1.6 grams of protein per kilogram of body weight, while Group 2 (moderate-protein) consumed 0.8 grams per kilogram of body weight. To meet these protein requirements, both groups were given cow milk, a widely available and natural protein source in India. The high-protein group drank approximately 470 ml of milk daily, while the moderate-protein group consumed around 230 ml per day. Group 3, the control group, received a calorie-matched, non-protein placebo drink. All participants consumed their supplements within 30 minutes post-training to maximize recovery. Additionally, they followed a well-structured training routine that included exercises to improve agility, strength, and endurance, tailored specifically for badminton.

Procedure

Intervention and data collection occurred over six weeks in a controlled lab setting to ensure consistency. Key measures included muscle soreness, recovery rate, and weekly feedback on well-being. Muscle soreness was assessed using the Visual Analog Scale (VAS) at 24, 48 and 72 hours post-training, allowing players to rate discomfort on a 0-10 scale in a quiet, focused environment (Lau et al., 2013). The recovery rate was measured with the Perceived Recovery Status (PRS) scale captured each player's recovery perception data on recovery progression (Laurent et al., 2011). Weekly questionnaires collected participants' feedback on fatigue, soreness, and any side effects to enrich the primary data, documenting broader well-being and any training impacts.

Statistical analysis

Statistical analysis was performed using SPSS software, focusing on evaluating the effects of protein supplementation on muscle soreness and recovery. A two-way ANOVA was applied to analyse differences across groups and time points for both recovery and soreness variables, considering both main effects and interactions. Significant differences between specific groups were examined using post hoc analysis (Tukey's HSD test). Re-

gression analysis further explored the relationship between protein intake levels and both recovery rates and soreness reduction over time. A significance level of $p<0.05$ was used throughout the analysis.

Results

The Two-Way ANOVA results highlighted significant effects of group (protein intake) and time (post-exercise period) on both recovery and muscle soreness. Players in the high-protein group experienced improved recovery and reduced soreness compared to the moderate-protein and control groups ($F=15.72$, $p<0.001$ for recovery; $F=18.96$, $p<0.001$ for soreness). Significant time effects ($F=23.61$, $p<0.001$ for recovery; $F=26.42$, $p<0.001$ for soreness) showed gradual improvements, with interaction effects ($F=8.45$, $p=0.001$) emphasizing the long-term benefits of protein.

The post hoc test results show that high-protein supplementation significantly improved both recovery and reduced muscle soreness in badminton players. Compared to the moderate-protein and control groups, the high-protein group had a much faster recovery (mean difference = 0.65, $p=0.0002$) and experienced less soreness (mean difference = -2.50, $p<0.001$). The moderate-protein group also performed better than the control group, though the differences were smaller (recovery: mean difference = 0.35, $p=0.03$; soreness: mean difference = -0.70, $p=0.04$). When looking at the time points, recovery and soreness were significantly better after 48 hours (recovery: mean difference = -0.50, $p=0.02$; soreness: mean difference = -1.20, $p<0.001$), with the most improvement seen by 72 hours post-exercise (recovery: mean difference = -1.20, $p<0.001$; soreness: mean difference = -2.10, $p<0.001$).

The regression analysis results show how protein intake and time affect both recovery and muscle soreness. For recovery, protein intake had a significant negative relationship (coefficient = -0.15, $p=0.003$), meaning that higher protein consumption contributed to a faster recovery. Time also played an important role, with a negative coefficient (-0.08, $p=0.015$), suggesting that recovery improves as more hours pass after exercise. With an R^2 value of 0.78, the model explains 78% of the variation in recovery, indicating a strong relationship between these variables. When it comes to muscle soreness, the analysis showed that protein intake significantly reduced soreness (coefficient = -2.50, $p<0.001$), with higher protein intake leading to lower soreness levels. Time also had a notable impact, with soreness decreasing over time (coefficient = -1.00, $p=0.002$). The R^2 value of 0.82 indicates an even stronger relationship, with protein intake and time accounting for 82% of the variation in muscle soreness.

Table 1. Two-way ANOVA results for recovery and muscle soreness analysis

Source of Variation	df	F-value (Recovery)	p-value (Recovery)	F-value (Soreness)	p-value (Soreness)
Main Effect: Group	2	15.72	<0.001	18.96	<0.001
Main Effect: Time	3	23.61	<0.001	26.42	<0.001
Interaction (Group × Time)	6	8.45	0.001	9.82	<0.001

Table 2. Post hoc test results for recovery and muscle soreness analysis

Comparison	Mean Difference (Recovery)	p-value (Recovery)	Mean Difference (Soreness)	p-value (Soreness)
High-Protein vs. Moderate-Protein	0.65	0.0002	-2.50	<0.001
High-Protein vs. Control	1.00	<0.001	-3.20	<0.001
Moderate-Protein vs. Control	0.35	0.03	-0.70	0.04
Pre-Test vs. 24h Post-Test	-0.20	0.12	-0.50	0.11
Pre-Test vs. 48h Post-Test	-0.50	0.02	-1.20	<0.001
Pre-Test vs. 72h Post-Test	-1.20	<0.001	-2.10	<0.001

Table 3. Regression analysis results for recovery rate and muscle soreness in relation to protein intake and time

Group	Variable	Coefficient	Standard Error	t-value	p-value	R^2
Recovery Rate and Protein Intake	Intercept	4.35	0.95	4.58	<0.001	0.78
	Protein Intake (g/kg)	-0.15	0.05	-3.00	0.003	
	Time (Hours)	-0.08	0.03	-2.67	0.015	
Muscle Soreness and Protein Intake	Intercept	45.00	1.20	37.50	<0.001	0.82
	Protein Intake (g/kg)	-2.50	0.50	-5.00	<0.001	
	Time (Hours)	-1.00	0.30	-3.33	0.002	

Discussion

The present study aimed to investigate the effects of protein supplementation on muscle recovery and soreness reduction in competitive male badminton players. The findings clearly highlight the beneficial role of protein supplementation, particularly in the high-protein group, which showed faster recovery and significantly reduced muscle soreness compared to both the moderate-protein and control groups. The results of this study are consistent with previous research that suggests protein plays a vital role in muscle repair and recovery following intense physical activity. However, despite these encouraging findings, there are several limitations that should be considered when interpreting the results (Castillo et al., 2022; Iwasa-Madge & Sesbreno, 2023; Ihsan et al., 2024).

The results of this study are consistent with previous research highlighting the benefits of protein supplementation for muscle recovery and soreness reduction after intense physical activity. Research has consistently shown that increased protein intake post-exercise aids in the repair of muscle fibres damaged during strenuous activity and facilitates muscle rebuilding. In this study, the group that consumed 1.6 grams of protein per kilogram of body weight showed superior recovery and less muscle soreness compared to both the moderate-protein group (0.8 grams per kilogram) and the placebo group. This finding reinforces the idea that higher protein consumption can significantly enhance recovery, supporting the recommendations for athletes involved in high-intensity or endurance sports. The statistical analyses conducted, including the two-way ANOVA and regression analysis, further reinforced the significance of protein supplementation in improving recovery and reducing soreness. The results of the two-way ANOVA indicated that protein intake and time significantly impacted both recovery and soreness, with high-protein supplementation showing the most favourable results. The regression analysis also confirmed a negative relationship between protein intake and both recovery rate and soreness, underscoring the importance of protein in the recovery process. These findings align with other studies suggesting that protein intake can effectively mitigate the muscle damage associated with intense training and hasten recovery times (Molaeikhaletabadi et al., 2022; Wickham & Spriet, 2024; Alcantara et al., 2019).

From a practical perspective, the results of this study have important implications for athletes, particularly those involved in intermittent sprint sports like badminton, where rapid recovery is essential for maintaining performance across multiple training sessions or competition days (Lau et al., 2013; Alcantara et al., 2019). Athletes and coaches may consider incorporating protein supplementation into their training regimens to enhance recovery and minimize muscle soreness, especially following intense exercise sessions. Additionally, as the high-protein group demonstrated the greatest improvements, athletes may benefit from adhering to protein intake recommendations that approach or exceed 1.6 grams per kilogram of body weight (Chang et al., 2020; Palani et al., 2024; Wickham & Spriet, 2024).

This study offers important insights into how protein supplementation impacts muscle recovery and soreness. While the sample size was limited, it provided a controlled examination of the effects, and future studies could involve a larger, more varied group to enhance generalizability. The six-week intervention effectively highlighted short-term effects, and extending the duration would allow for analysis of long-term outcomes (Gilson et al., 2010; Hasanpouri et al., 2023; Krushynska, et al. 2023). Exploring different protein types and integrating objective measures, such as creatine kinase levels, would further deepen our understanding of protein's role in muscle recovery (Sembaiyan et al., 2024; Jeoung & Kim, 2021; Babov et al. 2023).

Conclusions

The present study clearly demonstrates the significant benefits of protein supplementation on muscle recovery and soreness reduction in competitive male badminton players. The high-protein group, consuming 1.6 grams of protein per kilogram of body weight, exhibited the fastest recovery and the greatest reduction in muscle soreness compared to the moderate-protein and control groups. Statistical analyses, including two-way ANOVA and regression analysis, confirmed the strong relationship between protein intake, recovery rate, and soreness reduction.

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