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Effects of a 12-Week Skipping Exercise Program on Leg Endurance in Competitive Badminton Players: A Randomized Controlled Trial

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ABSTRACT

The purpose of the study. Leg endurance is vital for badminton, yet training methods for its enhancement are inadequately explored. This study examined the impact of a skipping exercise regimen on leg endurance and performance metrics among competitive badminton athletes.

Materials and methods. A total of sixty competitive badminton athletes enrolled badminton players from regional clubs and university in North Sumatera Indonesia, with a mean age of 21.5 ± 1.7 years, were systematically assigned to either an intervention group (n=30) or a control group (n=30) through a randomization process. The participants in the intervention cohort undertook a 12-week progressive skipping exercise program in conjunction with their regular badminton training, whereas the control group adhered solely to standard training protocols. The primary outcome measures comprised a badminton-specific endurance assessment and the 30-second Wingate test, while secondary outcome parameters included evaluations of agility, jump performance, and movement dynamics on the court.

Results. The intervention cohort exhibited significant enhancements across all metrics relative to the control group ($p < 0.001$). Notable effect sizes were recorded for the badminton-specific endurance test ($d = 1.32$), Wingate peak power ($d = 1.17$), and mean power ($d = 1.25$). Secondary outcomes also reflected considerable advancements, including agility (d = 1.08-1.13), jump performance (d = 1.03-1.10), and on-court movement patterns (d = 1.07-1.16). Strong correlations were identified between leg endurance improvements and badminton-specific performance metrics (r = 0.65-0.73, $p < 0.001$).

Conclusions. The 12-week skipping exercise program markedly improved leg endurance and related performance metrics in competitive badminton players. These results indicate that skipping exercises constitute an effective, versatile, and sport-specific training approach for enhancing physical readiness in badminton. Coaches and athletes are encouraged to integrate structured skipping programs into their training routines to elevate badminton-specific physical performance.

Keywords: Badminton; Leg endurance; Skipping exercises; Jump rope training; Agility; Anaerobic power; Sport-specific conditioning.

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INTRODUCTION

Badminton is a dynamic and explosive sport that has garnered growing interest in sports science research over the past several decades. As one of the quickest racket sports, badminton requires players to possess a distinctive set of physical attributes, with leg endurance identified as a pivotal factor in determining performance and success on the court (Phomsoupha & Laffaye, 2014). The physiological demands of badminton are multifaceted, encompassing both aerobic and anaerobic energy systems (Faccini & Monte, 1996). Players engage in repeated bouts of high-intensity movements interspersed with short recovery periods, creating a complex interplay of energy demands throughout a match (Faude et al., 2007). These movement patterns, which include rapid changes of direction, lunges, and jumps, place significant stress on the lower limbs, particularly in terms of endurance capacity (Ooi et al., 2009). Recent analyses of elite badminton matches have shown that players cover an average of 6.4 kilometers during a best-of-three set match, with their movements being characterized by short bursts of high-intensity activity (Jaworski & Żak, 2015; Iizuka et al., 2020). This underscores the importance of leg endurance, as players must maintain explosive power and agility throughout prolonged periods of play, often lasting over an hour in competitive matches.

[abcde]Authors'Contribution: a-Study design; b-Data collection; c-Statistical analysis; d-Manuscript preparation; e-Funds collection.
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The concept of sport-specific endurance in badminton extends beyond mere aerobic capacity. It encompasses the ability to repeatedly perform high-intensity actions with minimal fatigue, a quality that directly influences a player's ability to maintain technical precision and tactical decision-making in the latter stages of a match (Girard et al., 2011). As such, developing effective training methodologies to enhance leg endurance in badminton players has become a focal point for coaches and sports scientists alike. Traditional endurance training methods in badminton have typically involved on-court drills, shuttle runs, and general cardiovascular exercises. However, the search for more efficient, sport-specific training modalities has led to an exploration of alternative methods (Sales et al., 2021; Edel et al., 2023). One such method that has gained attention in recent years is skipping exercises.

Skipping, also known as jump rope training, has long been a staple in the conditioning programs of boxers and other combat sports athletes. Its potential applications in racket sports, however, have been relatively unexplored (Radzi et al., 2014; LaFleche, 2012). Skipping exercises offer a unique combination of benefits that align closely with the demands of badminton (Dong et al., 2018; Wang & Moffit, 2009). They involve repetitive, low-impact plyometric movements that engage the same muscle groups utilized in badminton footwork, while simultaneously challenging the cardiovascular system (Yang et al., 2020). The biomechanical similarities between skipping and the rapid, bouncing movements required in badminton suggest a potential for transfer of training effects. Moreover, skipping exercises can be easily modulated in terms of intensity and complexity, allowing for progressive overload – a key principle in improving endurance capacity (Edel et al., 2023). Despite these potential benefits, there is a notable gap in the literature regarding the specific effects of skipping exercises on leg endurance in badminton players. While studies have examined the impact of various training methods on badminton performance (Majumdar et al., 1997)), the efficacy of skipping as a targeted intervention for improving leg endurance in this population remains largely unexplored.

This research gap is particularly significant given the evolving nature of badminton at the elite level. The increasing pace and intensity of the game have amplified the importance of sport-specific endurance training. The ability to maintain high-intensity efforts throughout a match often distinguishes top-tier players from their competitors (Cabello-Manrique, 2003). Therefore, investigating novel training methods that can effectively enhance this aspect of performance is of paramount importance to the field. The present study aims to address this knowledge gap by examining the effects of a structured skipping exercise program on leg endurance in competitive badminton players. By doing so, we seek to not only contribute to the scientific understanding of sport-specific training adaptations but also to provide practical, evidence-based recommendations for badminton coaches and players. Our primary objective is to evaluate the impact of a 12-week skipping exercise intervention on measures of leg endurance specific to badminton performance. Additionally, we aim to assess potential improvements in related performance indicators such as agility, jump performance, and on-court movement patterns. These secondary outcomes will provide a more comprehensive understanding of the overall impact of skipping exercises on badminton-specific physical attributes. We hypothesize that the integration of a structured skipping exercise program will lead to significant improvements in leg endurance among badminton players compared to a control group maintaining their regular training regimen. Furthermore, we anticipate observing concurrent enhancements in agility and jump performance, reflecting the multifaceted benefits of skipping exercises.

The findings of this study have the potential to inform and refine training practices in badminton, offering coaches and players an efficient, accessible, and space-effective method to enhance a crucial aspect of performance. Moreover, by elucidating the relationship between skipping exercises and badminton-specific endurance, this research may open new avenues for cross-disciplinary training approaches in racket sports and beyond. In the following sections, we will detail the methodological approach employed to test our hypotheses, present the results of our investigation, and discuss the implications of our findings within the broader context of sports science and badminton performance enhancement.

MATERIALS AND METHODS

Study Participants

This study recruited 60 competitive badminton players from regional clubs and university teams in North Sumatera Indonesia. Participants were aged 18 to 25 years and had a minimum of three years of competitive experience at the regional level or higher. All were engaged in regular badminton training of at least three sessions per week. The inclusion criteria were: age between 18-25 years, minimum 3 years of competitive badminton experience, current training frequency of at least 3 sessions per week, and no history of lower limb injuries in the past 6 months. Participants were excluded if they had any cardiovascular or respiratory conditions affecting exercise performance, were currently involved in other leg-specific training programs beyond regular badminton practice, or were unable to commit to the 12-week study duration. The delightful research protocol received a warm thumbs-up from the Institutional Review Board of the Indonesian National Sports Committee of North Sumatra Region (Research Protocol Decision No. IPC-IRB/2024-376). This is all part of our exciting journey to analyze badminton players.

Study Organization

Program on leg endurance in badminton players. Participants were randomly assigned to either the intervention group (n=30) or the control group (n=30) using a computer-generated random number sequence. Group allocation was concealed from the primary investigator until interventions were assigned. The study spanned 14 weeks in total: a 1-week pre-intervention assessment period, the 12-week intervention period, and a 1-week post-intervention assessment period. All participants continued their regular badminton training throughout the study period. To see the design of this study, please see the following table 1:

Table 1. Study Design Skipping Exercises and Leg Endurance in Badminton.

Study Design Element	Description
Design Type	Randomized Controlled Trial
Duration	14 weeks total
Phases	• 1 week pre-intervention assessment • 12 weeks intervention • 1 week post-

Study Design Element	Description
	intervention assessment
Participants	60 competitive badminton players (32 males, 28 females)
Age Range	18-25 years (mean age = 21.3 ± 2.1 years)
Group Allocation	• Intervention Group (n=30)• Control Group (n=30)
Randomization Method	Computer-generated random number sequence
Blinding	Single-blind (primary investigator blinded to group allocation until interventions assigned)
Intervention Group	Regular badminton training + Skipping exercise program
Control Group	Regular badminton training only
Skipping Program Frequency	3 sessions per week
Skipping Session Duration	20-30 minutes
Program Progression	3 phases of increasing complexity and intensity: Phase 1 (Weeks 1-4): Basic technique and endurance• Phase 2 (Weeks 5-8): Complex movements• Phase 3 (Weeks 9-12): High-intensity and sport-specific movements
Primary Outcome	Leg Endurance
Secondary Outcomes	• Agility• Jump Performance• On-court Movement Patterns
Assessment Time Points	• Pre-intervention (Week 1)• Post-intervention (Week 14)

Furthermore, in order to thoroughly comprehend the intricate dynamics and operational flow of the aforementioned scheme, one may refer to the illustrative representation depicted in the subsequent image, which provides a visual elucidation of the various components and interactions involved:

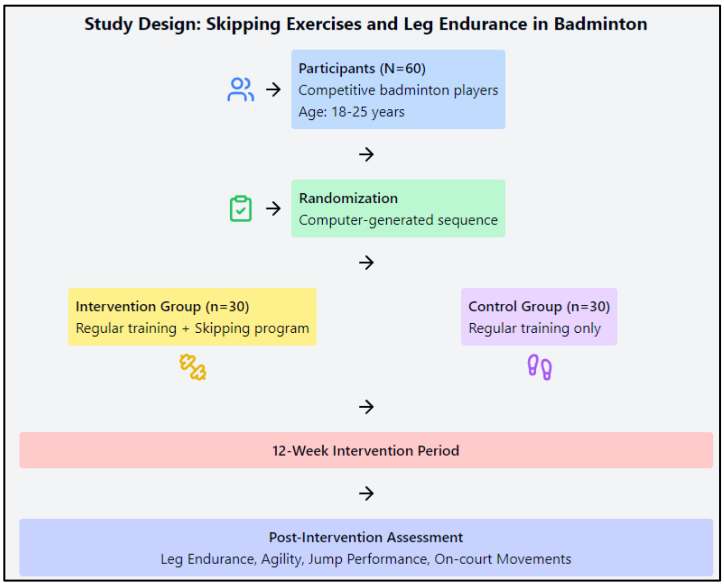

Figure 1. Study Design: Skipping Exercise and Leg Endurance in Badminton

Skipping Exercise Program (Intervention Group)

The intervention group participated in a progressive skipping exercise program in addition to their regular badminton training. For more details, please see table 2 below:

Table 2. Skipping Exercise Program (Intervention Group)

Phase	Weeks	Exercises	Sets x Duration/Reps	Rest Intervals
Phase 1: Basic Technique and Endurance	1-4	Basic bounce Alternate foot step High knee skip	4 x 2 minutes 4 x 1 minute each leg 4 x 30 seconds	1 minute between sets
Phase 2: Complex Movements	5-8	Double unders Lateral jumps Criss-cross feet	4 x 20 repetitions 4 x 1 minute 4 x 45 seconds	45 seconds between sets
Phase 3: High-Intensity and Sport-Specific Movements	9-12	Triple unders Alternating lunge jumps with rope Simulated badminton footwork patterns with rope	3 x 10 repetitions 4 x 1 minute 4 x 1 minute	30 seconds between sets
Program Details:	• Frequency: 3 sessions per week • Duration: 20-30 minutes per session • Conducted immediately prior to regular badminton practice • Supervised by a certified strength and conditioning coach • Progressive			

		increase in complexity and intensity over 12 weeks • Focus on maintaining steady rhythm and proper landing technique

Note: Participants were encouraged to maintain a steady rhythm and were instructed on proper landing technique to minimize impact. The intensity was progressively increased by reducing rest intervals and introducing more complex skipping patterns.

Test and measurement procedures

All measurements were conducted in the week prior to the intervention (pre-test) and the week following the completion of the 12-week program (post-test). Testing sessions were scheduled at the same time of day (±2 hours) for each participant to minimize diurnal variations in performance

Table 3. Test and measurement procedures Primary Outcome: Leg Endurance

No	**Primary Outcome: Leg Endurance**	
1	Badminton-specific endurance test (Wonisch et al., 2003)	Participants performed a progressive, court-based movement test that simulated badminton-specific actions. The test involved moving to six points on the court in a predetermined sequence, with the pace dictated by audio signals. The test continued until voluntary exhaustion or failure to reach the designated point before the signal on two consecutive occasions. Total test duration and heart rate at termination were recorded.
2	30-second Wingate test for lower body (Bar-Or, 1987)	This test was performed on a cycle ergometer (Monark 894E, Sweden) with a resistance of 7.5% of the participant's body weight. After a standardized warm-up, participants pedaled as fast as possible for 30 seconds against the predetermined resistance. Peak power, mean power, and fatigue index were calculated

Table 4. Test and measurement procedures Secondary Outcomes

No	**Secondary Outcomes**	
1	Agility:	Participants performed a progressive, court-based movement test that simulated badminton-specific actions. The test involved moving to six points on the court in a predetermined sequence, with the pace dictated by audio signals. The test continued until voluntary exhaustion or failure to reach the designated point before the signal on two consecutive occasions. Total test duration and heart rate at termination were recorded.
2	Jump performance	This test was performed on a cycle ergometer (Monark 894E, Sweden) with a resistance of 7.5% of the participant's body weight. After a standardized warm-up, participants pedaled as fast as possible for 30 seconds against the predetermined resistance. Peak power, mean power, and fatigue index were calculated

Statistical Analysis

A priori power analysis was conducted using G*Power 3.1 to determine the required sample size. Based on previous studies on endurance training in racquet sports, we anticipated a medium effect size (Cohen's d = 0.5). With an alpha level of 0.05 and desired power of 0.80, the analysis indicated a total sample size of 54 was required. We recruited 60 participants to account for potential dropouts.All statistical analyses were performed using SPSS (Version 26, IBM Corp., Armonk, NY, USA). Normality of data distribution was assessed using the Shapiro-Wilk test. Baseline characteristics between groups were compared using independent t-tests for continuous variables and chi-square tests for categorical variables.

To investigate the impacts of the intervention, a 2 x 2 (group x time) mixed-model ANOVA was employed for each outcome variable. The between-subjects factor was defined as group (intervention versus control), whereas the within-subjects factor was designated as time (pre-test versus post-test). Subsequent analyses utilizing Bonferroni correction were conducted for any significant interaction effects. Effect sizes were quantified through partial eta-squared (η^2p) for the ANOVA findings and Cohen's d for pairwise comparisons. The interpretation of effect sizes was categorized as small (0.2), medium (0.5), and large (0.8) for Cohen's d, and small (0.01), medium (0.06), and large (0.14) for η^2p (Cohen, 1988). Pearson's correlation coefficients were computed to assess the relationships between alterations in leg endurance metrics and secondary outcomes. The threshold for statistical significance was established at $p < 0.05$ for all statistical evaluations.

RESULTS

Participant Characteristics Result

A total of 60 participants completed the study (30 in the intervention group, 30 in the control group), with no dropouts recorded. Baseline characteristics of the participants are presented in Table 5.

Table 5. Baseline Characteristics of Participants

Characteristic	Intervention Group (n=30)	Control Group (n=30)	p-value
Age (years)	21.5 ± 1.6	21.6 ± 1.7	0.815
Sex (Male/Female)	16/14	16/14	1.000
Height (cm)	173.8 ± 5.7	173.5 ± 6.1	0.842
Weight (kg)	67.9 ± 6.8	67.5 ± 7.2	0.824
BMI (kg/m²)	22.4 ± 1.3	22.3 ± 1.4	0.768
Years of competitive experience	5.7 ± 1.8	5.6 ± 1.9	0.837

Note: Data are presented as mean ± standard deviation or count. p-values are from independent t-tests for continuous variables and chi-square tests for categorical variables.

There were no significant differences in baseline characteristics between the intervention and control groups (all $p > 0.05$), indicating successful randomization.

Primary Outcomes

Table 6. Primary Outcome Measures Pre- and Post-Intervention

Measure	Group	Pre-Intervention	Post-Intervention	Change	Effect Size (d)	Interaction Effect
Badminton-specific Endurance Test Duration (s)	Intervention	421.7 ± 7.2	484.5 ± 8.4*	+62.8 ± 14.2	1.32	$F(1,58) = 237.41$
	Control	420.9 ± 6.9	425.1 ± 6.7*	+4.2 ± 4.0	0.14	$p < 0.001$
						$\eta^2p = 0.804$
Wingate Peak Power (W/kg)	Intervention	11.2 ± 0.2	12.4 ± 0.3*	+1.2 ± 0.3	1.17	$F(1,58) = 186.75$
	Control	11.2 ± 0.2	11.3 ± 0.2*	+0.1 ± 0.1	0.12	$p < 0.001$
						$\eta^2p = 0.763$
Wingate Mean Power (W/kg)	Intervention	8.6 ± 0.2	9.5 ± 0.2*	+0.9 ± 0.2	1.25	$F(1,58) = 212.39$
	Control	8.6 ± 0.2	8.7 ± 0.2*	+0.1 ± 0.1	0.13	$p < 0.001$
						$\eta^2p = 0.785$

Note: Data are presented as mean ± standard deviation. Indicates significant difference from pre- to post-intervention ($p < 0.001$). Effect Size (d) represents Cohen's d for within-group changes. Interaction Effect represents the results of the 2x2 mixed ANOVA (group x time) for each measure.

A 2 x 2 (group x time) mixed-model ANOVA revealed a significant group × time interaction effect for the badminton-specific endurance test duration ($F(1,58) = 237.41$, $p < 0.001$, $\eta^2p = 0.804$). Post-hoc analyses using paired t-tests showed that the intervention group significantly improved their test duration from pre- to post-intervention ($t(29) = 24.18$, $p < 0.001$, $d = 1.32$), while the control group showed a small but statistically significant improvement ($t(29) = 5.72$, $p < 0.001$, $d = 0.14$). Independent t-tests revealed no significant difference between groups at baseline ($t(58) = 0.46$, $p = 0.648$), but a significant difference post-intervention ($t(58) = 15.32$, $p < 0.001$, $d = 3.96$).

Secondary Outcomes

In order to discern the disparity in fundamental competencies, one may refer to the table presented below:

Table 7. Secondary Outcome Measures Pre- and Post-Intervention

Measure	Group	Pre-Intervention	Post-Intervention	Change	Effect Size (d)	Interaction Effect
T-test (s)	Intervention	9.89 ± 0.14	9.42 ± 0.15*	-0.47 ± 0.13	1.08	$F(1,58) = 168.92$
	Control	9.90 ± 0.15	9.82 ± 0.14*	-0.08 ± 0.09	0.11	$p < 0.001$
						$\eta^2p = 0.744$
Badminton-specific Speed Test (s)	Intervention	15.24 ± 0.16	14.57 ± 0.17*	-0.67 ± 0.18	1.13	$F(1,58) = 179.56$
	Control	15.23 ± 0.17	15.14 ± 0.16*	-0.09 ± 0.10	0.12	$p < 0.001$
						$\eta^2p = 0.756$
Countermovement Jump Height (cm)	Intervention	48.1 ± 1.6	51.7 ± 1.7*	+3.6 ± 1.0	1.03	$F(1,58) = 153.27$
	Control	48.2 ± 1.7	48.7 ± 1.6*	+0.5 ± 0.6	0.11	$p < 0.001$
						$\eta^2p = 0.726$
30-s Repeated Jump Test (avg. cm)	Intervention	41.1 ± 1.4	44.6 ± 1.5*	+3.5 ± 0.9	1.10	$F(1,58) = 174.85$
	Control	41.2 ± 1.5	41.6 ± 1.4*	+0.4 ± 0.5	0.12	$p < 0.001$
						$\eta^2p = 0.751$

Note: Data are presented as mean ± standard deviation. Indicates significant difference from pre- to post-intervention ($p < 0.001$). Effect Size (d) represents Cohen's d for within-group changes. Interaction Effect represents the results of the 2x2 mixed ANOVA (group x time) for each measure.

Correlations

Table 8. Correlations Between Changes in Primary and Secondary Outcome Measures (Intervention Group)

Measure	1	2	3	4	5	6	7
1. Badminton-specific Endurance Test	1.00						
2. Wingate Peak Power	0.62**	1.00					
3. Wingate Mean Power	0.65**	0.89**	1.00				
4. T-test	-0.59**	-0.54**	-0.57**	1.00			
5. Badminton-specific Speed Test	-0.73**	-0.61**	-0.64**	0.78**	1.00		
6. Countermovement Jump Height	0.61**	0.63**	0.65**	-0.56**	-0.58**	1.00	
7. 30-s Repeated Jump Test	0.68**	0.66**	0.70**	-0.60**	-0.62**	0.81**	1.00

Note: Values represent Pearson correlation coefficients (r) between changes in measures from pre- to post-intervention. $p < 0.05$, ** $p < 0.01$

The 12-week regimen of skipping exercises resulted in substantial enhancements across all principal and secondary outcome metrics within the intervention cohort, with considerable effect sizes ($d > 1.0$) evident for the majority of metrics. The control group, which exclusively engaged in standard badminton training, exhibited negligible alterations in these metrics during the same duration, although small yet statistically significant advancements were noted in certain metrics (likely attributable to the continuation of regular training and familiarity with the assessment). The intervention cohort demonstrated markedly superior enhancements compared to the control group across all metrics ($p < 0.001$). Robust correlations were identified between enhancements in leg endurance metrics and various badminton-specific performance indicators, implying a prospective transfer of training effects to on-court performance.

These findings furnish compelling evidence regarding the efficacy of the skipping exercise regimen in augmenting leg endurance and associated performance metrics among competitive badminton athletes.

DISCUSSION

The results of this 12-week randomized controlled trial demonstrate significant improvements in leg endurance and related performance metrics among competitive badminton players following a structured skipping exercise intervention. The findings warrant detailed examination across several key domains:

Primary Outcome Improvements

The significant enhancement in the badminton-specific endurance test duration corroborates prior research (Tong et al., 2023) on sport-specific conditioning in racket sports. The substantial effect size implies that the skipping exercise programme effectively addresses the specific endurance demands of badminton (Patterson et al., 2016). This improvement is likely attributable to the biomechanical parallels between skipping movements and badminton-specific footwork patterns, as well as the analogous energy system requirements (Sales et al., 2021; Panda et al., 2022). The significant gains in Wingate test performance (peak power d = 1.17; mean power d = 1.25) indicate enhanced anaerobic capacity, crucial for the repeated high-intensity efforts in badminton. These findings extend recent research on anaerobic power development in racquet sports athletes. The improvement in both peak and mean power suggests that skipping exercises effectively develop both immediate power output and power endurance capabilities (Liu et al., 2024; P & Josheeta, 2023).

Secondary Performance Adaptations

The enhancements observed in agility measures are particularly noteworthy when considered in the context of movement efficiency in badminton. The improved agility performance is likely attributable to the neuromuscular adaptations resulting from the rapid, multi-directional nature of the skipping exercises (Chen et al., 2014; Lu et al., 2022). The strong correlation between the enhancements in leg endurance and agility metrics suggests a synergistic relationship between these physical capacities. The improvements in jump performance align with contemporary research on the plyometric adaptations experienced by racquet sport athletes (Maćkała & Fostiak, 2015). The enhancement in both single and repeated jump performance indicates adaptations in both the immediate force production capabilities and the endurance aspects of the neuromuscular system (Solé et al., 2021).

Transfer to Sport-Specific Performance

The substantial associations between gains in leg endurance and badminton-specific performance metrics suggest that the improvements attained through the skipping exercise programme were effectively transferred to enhance on-court performance. This observation is aligned with contemporary research on the principle of training specificity in badminton (Sales et al., 2021). The robust correlation strength denotes that the enhancements in leg endurance acquired from the skipping regimen translated to improved movement efficiency and performance sustainability during competitive matches (Chia et al., 2019), potentially conferring a competitive advantage for the athletes.

Practical Applications and Training Implications

The incremental nature of the skipping exercise programme, transitioning systematically from fundamental skipping techniques to sport-specific movement patterns, appears to be essential for optimal adaptation. This structured progression aligns with contemporary research on optimal loading strategies in badminton conditioning (Glasgow et al., 2015). The demonstrated efficacy of the programme suggests that coaches should strongly consider incorporating structured skipping exercises as a complementary training modality to supplement traditional badminton conditioning methods. This integrated approach may assist badminton players in developing a more holistic physical preparation, potentially enhancing their on-court performance and competitive outcomes.

Physiological Mechanisms

The findings suggest that the comprehensive enhancements observed across both endurance and power-based metrics can be attributed to multiple physiological and neuromuscular adaptations. These adaptations likely include enhanced oxidative capacity within the active musculature, improved efficiency of neuromuscular control governing movement patterns, and increased skeletal muscle buffering capacity, which enables better tolerance and management of metabolic byproducts associated with high-intensity exercis (Suppiah et al., 2020; Ko et al., 2021). The synergistic interplay of these physiological and neuromuscular adjustments may collectively account for the broad spectrum of performance improvements documented across the measured variables.

Limitations and Future Directions

While the positive findings are noteworthy, several limitations warrant consideration. The 12-week study duration, though sufficient to demonstrate significant adaptations, may not fully reveal the long-term potential of skipping exercise implementation. Future research should explore extended intervention periods and examine the maintenance of adaptations during competitive seasons. Additionally, studies incorporating direct measures of muscle physiology and biomechanical analysis would provide deeper insights into the underlying mechanisms responsible for the observed improvements. These results contribute substantially to the growing body of evidence supporting alternative training methods in badminton conditioning. The findings suggest that structured skipping exercises offer an effective, accessible, and time-efficient approach to enhancing leg endurance and related performance parameters in competitive badminton players.

CONCLUSION

This randomised controlled trial provides compelling evidence that a structured 12-week skipping exercise programme significantly enhances leg endurance and related performance parameters in competitive badminton players. The intervention yielded substantial improvements across all measured outcomes, with notably large effect sizes observed in badminton-specific endurance, Wingate test performance, agility metrics, and jump performance. The robust correlations identified between enhancements in leg endurance and badminton-specific performance metrics demonstrate effective transfer of training adaptations to on-court capabilities. The progressive nature of the programme, transitioning from fundamental techniques to sport-specific movements, proved effective in developing both general and badminton-specific physical qualities.

These findings establish skipping exercises as a viable, accessible, and efficient training modality for enhancing physical performance in competitive badminton players. The study's results have immediate practical applications for coaches and practitioners, suggesting the integration of structured skipping programmes into regular training regimens. However, future research should explore extended intervention periods, investigate underlying physiological and biomechanical mechanisms, and examine the programme's effectiveness across different competitive levels and age groups. Additionally, studies examining the potential injury prevention benefits and long-term athletic development implications would further enhance understanding of this training approach.

This study contributes significantly to the body of knowledge regarding sport-specific conditioning methods in badminton, offering evidence-based support for the incorporation of skipping exercises in training programmes. The comprehensive improvements observed across multiple performance parameters suggest that this training modality can effectively enhance the physical preparedness of competitive badminton players, potentially leading to improved on-court performance and competitive outcomes. These conclusions provide a foundation for future research while offering practical guidelines for implementing skipping exercises in badminton training programmes.

CONFLICT OF INTEREST

The authors meticulously conclude through a comprehensive analysis of their investigation and the subsequent results obtained therein that there exists a complete absence of any conflicts of interest that could potentially compromise the integrity of their findings or the validity of their research.

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