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Effect of exercise training on physical and technical performance among athletes: a systematic review with mata-analysis

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ADMINISTRATIVE INFORMATION

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 16 June 2024 and was last updated on 16 June 2024.

INTRODUCTION

Review question / Objective This systematic review and meta-analysis aim to ascertain the effects of exercise training on performance outcomes in badminton athletes. Review Question Using the PICOS Framework Population (P): Badminton athletes. Intervention (I): exercise training. Comparison (C): Normal badminton training routines or no intervention. Outcomes (O): Measures of physical performance (muscle strength, agility, balance, speed) and badminton-specific technical performance (power, technical). Study Design (S): Randomized controlled trials (RCTs). Formulated Question What are the effects of exercise training compared to normal badminton training routines or no intervention on physical performance and badminton-specific skill performance in badminton athletes as determined by randomized controlled trials?

Rationale Badminton is a globally popular sport requiring a combination of speed, agility, strength, and technical. exercise training is crucial for enhancing these physical attributes, yet the specific impacts of such exercise training on badminton performance lack comprehensive review and quantification. Rationale for the Study Addressing Gaps in Literature: While physical training in sports has been widely studied, there is a distinct lack of comprehensive reviews focused on badminton. Existing research often compares single training methods with traditional routines without exploring the comparative effectiveness of different or combined training approaches. This review aims to fill this gap by synthesizing evidence on the effects of exercise training on badminton athletes.
Targeting Specific Performance Outcomes: Badminton requires optimal physical and technical. Key performance metrics include muscle strength, agility, balance, speed, power, and badminton-specific technical. Understanding how exercise training influences these metrics can help design more effective training regimens.
Ensuring Quality and Consistency in Research: Existing studies vary in methodologies, making

definitive conclusions challenging. This review employs rigorous selection criteria and statistical analyses to provide clearer insights, guiding future research and practice.
Developing Tailored Training Programs: Findings from this review can inform the creation of tailored training programs for badminton athletes, addressing the sport's unique demands. This can enhance performance and reduce injury risk.
Informed Decision-Making for Stakeholders: Coaches, athletes, and sports scientists can use insights from this review to make evidence-based decisions about training strategies, leading to structured and effective programs that maximize athletes' potential in competitive settings.
In summary, this systematic review and meta-analysis aim to advance understanding of how exercise training impacts badminton performance, addressing literature gaps, and providing detailed analysis to inform future research and practice.

Condition being studied The condition being studied is the physical performance and technical proficiency of badminton athletes. Badminton, a high-intensity racket sport, demands a combination of speed, agility, strength, and technical due to its rapid movements, swift direction changes, and sustained rallies.
Description of the Condition
Physical Performance: Muscle Strength: Essential for powerful shots and quick movements. Agility: Critical for rapid direction changes. Balance: Necessary for stability during fast-paced play. Speed: Vital for covering the court quickly. Power: Important for dynamic actions like jumping smashes and lunges. Technical Proficiency: Technical: These include shot accuracy, technique, and tactical awareness. Exercise training aim to enhance these attributes, thereby improving overall performance and reducing injury risk. This study, therefore, assesses the effectiveness of such programs in enhancing these physical and technical-related outcomes, providing valuable insights for optimizing training protocols for badminton athletes.

METHODS

Search strategy On 20 April 2024 and updated on 1 June 2024, a systematic search was performed to retrieve articles related to the topic from six electronic databases: PumMed, Scopus, ProQuest, Springer Link, SPORTSDiscus, Taylor & Francis Online. A Boolean search syntax using the operators “AND” and “OR” was applied. The keywords “strength training”, “power training”, “endurance training”, “agility training”, “flexibility training”, “plyometrics exercises”, “resistance training”, “cardiovascular exercises”, “speed training”, “core exercises”, “functional movements”, “Isolation exercise”, “agility and speed drills”, “plyometrics”, “compound exercises”, “olympic lifts”, “conditioning drills”, “core stability exercises”, “lifting weights” and “balance training”. Additionally, we conducted a manual search on Google Scholar and referenced articles (Shedge et al., 2024; Deng et al., 2024; Deng et al., 2023) to ensure no pertinent articles were overlooked. Concurrently, skilled librarians supported the data-gathering process to ensure its accuracy and completeness. The selection process for the study involved several distinct steps, as outlined in Figure 1. Initially, duplicate articles were purged. Following this, the titles and abstracts were scrutinized in the second stage. The subsequent phase comprised a thorough examination of the full texts against predetermined eligibility criteria. This screening process was carried out independently by two reviewers (xxxand xxx). Any discrepancies were thoroughly addressed, with a third reviewer (xxx), stepping in when necessary to facilitate consensus.

Participant or population The pertinent details concerning the characteristics of the studies are presented in Table 3. The total participant count amounted to 806 individual. The age of the athletes ranged from 10.8 ± 0.3 to 22.07 ± 1.39 years. Concerning athletes' expertise level, 4 studies employed aspiring state or national league badminton athletes, while 6 studies examined elite (club elite and national elite) athletes. 6 studies recruited collegiate athletes. 6 studies selected amateurs or beginners. 3 studies did not report on the athletes' expertise level. Additionally, seven studies reported between 1 year and 13 years of specific badminton experience. However, 6 papers did not mention athletes' experience.

Intervention A total of 24 intervention programs were employed in the included studies. These programs encompassed a combination of regular training with prior repeated sprint training, the combination of plyometric training with a co-curriculum programme, combination of high intensity interval circuit training with normal training program. combination of core strength training with regularly scheduled training, combination of Core stability training with badminton traditional training, combination of high intensity intermittent badminton multi-shuttle training with normal badminton training routines, step forward lunge, jump forward lunge, combination of Pilates training with conventional exercises, combination of Swiss ball training program with conventional badminton exercises, combination of core training with normal

training sessions, ballistic six exercise, combination of balance with plyometric training, combination of balance training with ordinary badminton training, combination of balance-plyometric training with technical training, weight training, combination of elastic resistance band training with regular badminton training, speed agility quickness training (SAQ), and autoregulatory progressive resistance exercise (APRE).

Comparator The comparative intervention applied to the target population in this study includes normal badminton training routines or no intervention. This serves as a control group to assess the relative effectiveness of exercise training programs. By comparing the outcomes of athletes who undergo specialized exercise training with those who continue with their regular training or receive no additional intervention, the study aims to isolate and measure the specific benefits of exercise programs on physical performance and technical proficiency in badminton athletes.

Study designs to be included The study designs to be included are randomized controlled trials (RCTs). These trials are selected because they provide the highest level of evidence for assessing the effectiveness of interventions by minimizing bias. Including RCTs ensures that the findings on the impact of exercise training programs on badminton athletes' performance are robust and reliable.

Eligibility criteria The review encompassed academic literature published in English without any restrictions on the publication year. This study is required to meet the criteria outlined in the PICOS framework for consideration in the analysis (McKenzie et al., 2019). Specifically, the protocol for this systematic review (Amir-Behghadami & Janati, 2020) has been meticulously developed following the population, intervention, comparison, outcomes, and study design (PICOS) approach detailed in the online supplemental file. Table 1 presents the inclusion and exclusion criteria for the systematic review and meta-analysis. Articles meeting all the conditions outlined below were considered for inclusion: 1) Population: Participants were badminton athletes, without any restrictions on age, gender, experience of badminton, or athletic level; 2) Intervention: The minimum duration for exercise training program interventions was set at 3 weeks; 3) Comparison: The control group was in a routine badminton practice and related training program; 4) Outcome: At least one badminton performance outcome, association with physical performance areas (e.g., strength, power, agility) or technical performance indicators (e.g., drop, smash, clear, etc.); and 5) Study design: Original research articles in English-language peer-reviewed journals and Randomized Control Trial (RCT).

Information sources The intended information sources for this systematic review and meta-analysis include the following electronic databases: PubMed, Scopus, ProQuest, Springer Link, SPORTDiscus, Taylor & Francis Online. Additionally, the review will consider contacting authors for unpublished data or clarifications, searching trial registers for ongoing or unpublished trials, and including grey literature such as conference abstracts, theses, and dissertations. This comprehensive search strategy ensures a thorough collection of relevant studies to address the review's objective.

Main outcome(s) The main outcomes of the review focus on the effects of exercise training programs on various performance metrics in badminton athletes.
These outcomes include: Physical Performance: Muscle Strength: Measured using standard strength tests. Agility: Assessed through agility drills and tests. Balance: Evaluated using both dynamic and static balance tests. Speed: Measured through linear and non-linear sprint tests. Power: Assessed via vertical and horizontal jump tests. technical Proficiency: Technical Skills: Evaluated through badminton-specific skill tests, including shot accuracy and technique. Timing and Effect Measures Duration: Outcomes will be assessed over intervention periods ranging from 3 to 12 weeks. Effect Measures: Standardized Mean Differences (SMD) with 95% Confidence Intervals (CI) will be used to quantify the effect sizes of the training interventions on each outcome. Statistical heterogeneity will be assessed using the I^2 statistic, and potential publication bias will be evaluated using Egger's test. These measures will provide a comprehensive understanding of the effectiveness of exercise training on improving performance in badminton athletes.

Quality assessment / Risk of bias analysis Randomized controlled trial bias risk assessment evaluators (xxx, xxx) used the bias risk assessment tool recommended by the Cochrane Handbook 5.0 to evaluate the methodological quality of the included studies, including 6 aspects: ① Random allocation method; ② Concealed grouping method; ③ Study subjects Blinding of trial participants, treatment plans, implementers, study outcome measures, or statisticians; ④ Completeness of outcome data; ⑤ Selective reporting of research

results; ⑥ Other biases. For each included study, the above 6 items were assessed as “Yes” (low degree of bias), “No” (high degree of bias), and “unclear” (lack of relevant information or uncertainty about bias). Simultaneously, two additional reviewers (xxx and xxx) utilized the Consensus for Exercise Reporting Template (CERT), which includes a 19-item checklist in 7 categories, to assess the suitability of description and reporting of exercise interventions (Slade et al., 2016). Scores < 9 were considered “low” methodological quality and scores ≥ 9 were considered “high”. Two reviewers (LX and YF) assessed the certainty of the evidence and risk of bias. The results were validated by a review team composed of experts in systematic review methods (xxx and xxx). Any disagreements were resolved through further discussion between the teams.

Strategy of data synthesis We conducted a meta-analysis of 23 studies. The studies were integrated for meta-analysis using STATA 15.0 software (Stata Corp, 2017). During the meta-analysis, the quantitative statistical analysis methods I2 and Q statistic were used to evaluate the heterogeneity of the studies (variances) (Huedo-Medina et al., 2006). The I2 value is between 0% and 100%. The "Cochrane Handbook of Systematic Reviews" divides heterogeneity into four levels. The I^2 value is between 0% and 40%. The heterogeneity is not important (mild heterogeneity), between 30% and 60%, moderate heterogeneity; between 50% and 90%, considerable heterogeneity; between 75% and 100%, very large (Von Hippel, 2015). It is generally believed that when I2 > 50%, then Heterogeneity was considered to exist between studies, and Q test P < 0.1 was considered to exist heterogeneity. If heterogeneity exists, a random effects model is used, and sensitivity analysis is further applied to analyze the source of heterogeneity; otherwise, a fixed effects model is used.
Effect size (ES) indicators for continuous data used Cohen’s d standardized mean difference (SMD) and 95% confidence intervals (CIs). The SMD and their corresponding 95%CIs were reported. A Cohens'd standardized mean difference (SMD) 0 - 0.2 is considered to have no statistical significance, 0.2 - 0.5 is considered to be of small significance, 0.5 - 0.8 is considered to be of medium significance, and > 0.8 is considered to be of greater significance (McGough & Faraone, 2009).We utilized a funnel plot to assess publication bias and conducted sensitivity analyses by sequentially excluding the results of each individual study to estimate the stability of the findings. Enter the "difference between the average values pre/post, the combined standard deviation (SD) pre/post, and the sample size of each group (n)" between the experimental group and the control group into Stata for Meta-analysis, using the specified data entry format comprising these parameters. The data was standardized using post-score SD values due to the lack of research revealing the correlation and the inability to compute it with high precision. (Nieminen, 2022).

Subgroup analysis Based on the meta-analysis results: Consistency and Robustness: Agility, balance, muscle strength, and speed consistently favored exercise training, supported by sensitivity analyses that affirmed the findings' stability. Publication Bias: While agility, balance, muscle strength, and speed showed no bias, power and technical exhibited asymmetry in funnel plots and significant Egger's test results, indicating potential bias. Given these findings, subgroup analyses were not conducted to maintain the integrity and reliability of outcomes consistently favoring strength and conditioning training, despite potential biases in explosive power and skills.

Sensitivity analysis By sequentially excluding individual studies and observing the differences between the pooled standardized mean differences of the remaining studies and the overall standardized mean difference, the results showed that agility, balance, power, strength, speed, and technical were all robust. Therefore, this indicates that the findings for these six aspects are consistent and reliable despite the removal of individual studies.

Language restriction The search will be restricted to articles published in English only.

Country(ies) involved Ukraine, Institute of Sports and Management, Department of Combat Sports and Power Sports, National University of Physical Education and Sport of Ukraine, Kyiv, Ukraine.

Keywords Badminton, Exercise training, Athlete performance, Meta-analysis.

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