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Enhancing Motor Abilities in Basketball Players through Complex Training: A Systematic Review

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INTRODUCTION

Review question / Objective The systematic review will aim to determine the effects of complex training on the motor skills of male basketball players.

Rationale Basketball is a high-intensity, intermittent sport requiring a combination of physical, technical, and tactical preparation for optimal performance. Given the sport's dynamic nature, players engage in rapid transitions between offensive and defensive plays, demanding well-developed motor skills such as explosive jumps, sprints, changes of direction, and precise ball handling (Chen et al., 2010). Without adequate physical preparation, fatigue can impair technique and decision-making, highlighting the importance of effective training strategies (Radovanović, 2020). Strength and plyometric training have been widely recognized as effective methods for enhancing motor performance in basketball players. Plyometric training focuses on explosive movements that improve power and agility, while weight training develops muscle strength and endurance (Ebben & Watts, 2018). The emergence of complex training—a method that integrates both plyometric and weight training in a structured manner—has shown promise in optimizing neuromuscular adaptations (Flórez Gil et al., 2022). Complex training combines high-load strength exercises with low-load plyometric drills within the same training session, maximizing the benefits of both modalities (Cormier et al., 2021).

Previous research suggests that complex training produces superior results compared to isolated strength or plyometric training. Studies have demonstrated improvements in muscle strength, explosive power, speed, and endurance among athletes exposed to complex training protocols (Ebben et al., 2019). Additionally, this training approach has been linked to enhanced body composition, increased bone mineral density, and improved cardiorespiratory endurance (Radovanović, 2020). These benefits extend beyond physical performance, positively

influencing psychological and social aspects of athletic development, making complex training a valuable addition to basketball conditioning programs (Nikolić, 2021).

Despite these advantages, research on complex training in basketball remains limited. Most studies have focused on its effects in other team sports such as soccer, handball, and volleyball (Abade et al., 2021). The limited body of literature specifically addressing basketball players highlights the need for a systematic review to synthesize current findings and establish evidence-based recommendations. While some studies, such as Flórez Gil et al. (2022), have explored the acute and chronic effects of complex training on basketball performance, further research is necessary to determine optimal training protocols.

This systematic review aims to address this gap by evaluating the effects of complex training on the motor skills of male basketball players. By analyzing existing research, the study seeks to determine whether complex training offers superior benefits compared to traditional strength and plyometric training methods. Additionally, it aims to identify best practices for implementing complex training in basketball conditioning programs, ensuring that athletes maximize their physical performance while minimizing the risk of overtraining and fatigue.

Given the increasing emphasis on evidence-based training methodologies in modern sports science, this review will contribute valuable insights for coaches, strength and conditioning specialists, and sports scientists. By consolidating existing knowledge and highlighting the practical applications of complex training, the study will provide a foundation for future research and training program development, ultimately enhancing the athletic performance of basketball players. The obtained results will provide clear evidence that answers the review question. The authors of the prospective study will further aim to demonstrate the role and significance of complex training in basketball.

Condition being studied Basketball is a physically demanding team sport that requires a combination of strength, speed, agility, and endurance. Players must continuously perform high-intensity movements, including sprints, rapid changes of direction, explosive jumps, and ball-handling skills, all of which contribute to the overall complexity of the sport. Given the demanding nature of the game, fatigue is a major concern, as it directly impacts motor performance, technical execution, and tactical decision-making (Radovanović, 2020).

Fatigue in Basketball Players

Fatigue is a multifactorial condition that can be classified into central fatigue (originating from the central nervous system) and peripheral fatigue (occurring at the muscular level). In basketball, both types of fatigue play a crucial role in determining a player's ability to sustain performance throughout a game. Central fatigue affects neuromuscular activation, reducing an athlete's ability to generate force, while peripheral fatigue is associated with the depletion of energy stores and an accumulation of metabolic byproducts such as lactate and hydrogen ions (Ebben et al., 2019). These physiological changes contribute to a decline in movement efficiency, reducing the effectiveness of critical game-related actions such as sprinting, jumping, and shooting accuracy (Flórez Gil et al., 2022).

Impact on Motor Skills and Injury Risk

As fatigue sets in, players experience a decline in their motor skills, which negatively affects their ability to execute precise movements. Reduced coordination, slower reaction times, and impaired balance can lead to an increased risk of injury, particularly in the lower extremities (Nikolić, 2021). Studies have shown that basketball players who experience high levels of fatigue are more prone to sustaining ankle and knee injuries due to improper landing mechanics and decreased muscle activation during rapid movements (Cormier et al., 2021).

Training and Conditioning Strategies

To mitigate the effects of fatigue and enhance motor performance, strength and conditioning programs play a vital role in basketball training. Traditional training methods, such as weight training and plyometric exercises, have been widely used to develop muscular strength and explosive power. However, complex training—a combination of high-load resistance exercises and low-load plyometric drills—has emerged as a highly effective approach to optimizing neuromuscular adaptations (Abade et al., 2021).

Complex training enhances force production, muscle activation, and movement efficiency, allowing players to maintain high-intensity performance levels for longer durations. By incorporating both strength and plyometric components within a single workout, athletes can improve their ability to execute explosive actions while minimizing the risk of fatigue-related performance decline (Radovanović, 2020).

METHODS

Search strategy To ensure a comprehensive and systematic collection of relevant studies, a

structured search strategy will be employed using predefined keywords and specific electronic databases. The selection of search terms will aim to capture studies related to complex training and its effects on basketball players' motor skills. The search strategy will follow the PRISMA guidelines (Page et al., 2021) to enhance the transparency and reproducibility of the review process.

Search Terms
The search terms will be carefully chosen to encompass different aspects of complex training and basketball performance. The keywords will include a combination of sport-specific terms and training methodologies to ensure relevant studies are identified. The terms will be used either separately or in combination using Boolean operators (AND, OR) to maximize the retrieval of relevant articles.

The keywords to be used in the database search will include:

Basketball-Specific Terms: "Basketball players"; "Basketball performance"; "Basketball conditioning"

Training Methods: "Complex training"; "Contrast training"; "Combined training"; "Plyometric training"; "Strength training"; "Neuromuscular training"
Motor Performance Parameters: "Explosive power"; "Speed"; "Agility"; "Strength"; "Change of direction speed"; "Jump performance".

The search terms will be applied with different combinations to identify studies examining the effects of complex training on basketball-specific motor abilities. The use of Boolean operators will ensure that studies including multiple relevant concepts are retrieved efficiently. For example, searches will be structured as follows: "Basketball players" AND ("Complex training" OR "Contrast training" OR "Combined training" OR "Plyometric training")
"Basketball players" AND ("Explosive power" OR "Speed" OR "Agility" OR "Strength" OR "Change of direction speed")

Electronic Databases
To collect a wide range of scientific literature, the review will include six well-established electronic databases that provide access to peer-reviewed articles in sports science, exercise physiology, and basketball performance research. These databases will be selected based on their relevance to the topic, ensuring that both applied and theoretical research articles are considered.

The databases to be searched will include: PubMed; Web of Science; Scopus; MEDLINE; ERIC; Google Scholar.

Search Timeframe
The review will include studies published between January 2008 and December 2024. This timeframe will be selected to ensure that only recent and relevant research on complex training in basketball is considered. Given the continuous advancements in strength and conditioning methodologies, focusing on studies from the last 17 years will ensure that the review captures the most current evidence-based practices.

Data Extraction and PRISMA Flowchart
The results of the search process will be presented in a PRISMA flowchart to illustrate the number of studies identified, screened, and included in the final analysis. This flowchart will ensure transparency by documenting how studies are selected and excluded at different stages of the review process. The PRISMA diagram will follow the criteria established by Page et al. (2021), providing a clear representation of the research selection process.

Participant or population This systematic review will focus on studies examining the effects of complex training on healthy male basketball players across different competitive levels. To ensure the relevance and applicability of the findings, specific inclusion criteria regarding participant characteristics will be applied.

1. Health Status and Injury-Free Condition
The review will include only healthy male basketball players who do not have any current or chronic injuries. This criterion is essential to ensure that the training adaptations observed in the studies are not influenced by pre-existing injuries or rehabilitation processes. Studies involving injured or recovering athletes will be excluded to maintain a clear focus on performance enhancement rather than rehabilitation.

2. Type of Training: Complex Training
The participants in the included studies must have undergone complex training, which is defined as a combination of high-load resistance exercises (e.g., weightlifting) and low-load plyometric exercises (e.g., jumping drills) performed within the same training session. Studies investigating other training modalities, such as plyometric-only training or resistance training alone, will not be included unless they serve as control conditions for comparisons with complex training.

3. Competitive Level
The review will include basketball players across a broad spectrum of competition levels:
Amateur-Level Players: Participants engaged in structured but non-professional basketball competitions, such as recreational leagues, college, and school-level teams.
Elite-Level Players: Participants competing at the highest levels, including professional leagues and national teams.

Intervention This systematic review will aim to evaluate the effects of complex training on the motor skills of male basketball players. The review will assess how complex training influences explosive power, speed, agility, strength, and change of direction speed, providing insights into its effectiveness across different competitive levels.
To ensure the inclusion of high-quality studies, three authors will independently evaluate the inclusion and exclusion criteria. The PICOS criteria (Population, Intervention, Comparators, Outcomes, and Study Design) will be applied to identify eligible studies. The results of the descriptive statistical analysis will be presented in Table 1, summarizing the key characteristics and findings of the included research.
For literature screening and management, EndNote will be used for citation management, while Mendeley reference management software (v. 2.111.0, Copyright © 2024 Elsevier Ltd., Barcelona, Spain) will assist in detecting duplicates. A thorough duplicate identification process will be conducted to ensure accuracy in study selection.
Although a meta-analysis will not be performed, the review will critically assess the quality of the included research and acknowledge potential limitations, such as sample variability and differences in competition levels. These aspects will be explained in detail in the discussion section. Due to the heterogeneity of the studies, a qualitative approach will be employed to describe the characteristics of motor skills in male basketball players, making it impractical to perform a meta-analysis.
All disagreements during the study selection process will be resolved through consensus between two researchers or, if necessary, with the assistance of a third researcher. Two authors (A.N. and B.S.) will independently review and select the relevant studies, which will then be cross-checked for consistency. The final decision on inclusion will be made by a third author (A.R.).
To evaluate methodological quality, the Physical Therapy Database (PEDro) scale will be applied, which consists of 11 items rated on a binary scale (+ or -) or numerically (1 or 0). Studies scoring six or more will be considered high quality, scores between 4 and 5 will indicate moderate quality, while studies scoring below 4 will be classified as low quality.
In addition to the PEDro scale, the Methodological Index for Non-Randomized Studies (MINORS) will be utilized to enhance the methodological rigor of the review.

Comparator The comparative intervention in this review will include studies that compare different training approaches applied to male basketball players. Specifically, the included studies must compare:
An experimental group (EXP) vs. a control group (CON), where the EXP group undergoes complex training, while the CON group follows a different training method or no intervention.
Two experimental groups (EXP1 vs. EXP2), where both groups engage in training but with variations in intensity, volume, or type of complex training (e.g., contrast training vs. combined training).
Single-group studies, if they provide pre- and post-intervention comparisons evaluating the impact of complex training on motor skills.
Studies will be excluded if they compare:
Male vs. female basketball players
Male basketball players vs. athletes from other sports (e.g., football, handball, volleyball).

Study designs to be included The review will include randomized and non-randomized controlled studies written in Serbian or English, focusing on the effects of complex training in male basketball players. Excluded studies will be duplicates, conference abstracts, case reports with fewer than five participants per group, review articles, and studies with an inappropriate frame of analysis outside the 2008-2024 period. Additionally, studies published in languages other than Serbian or English will not be considered.

Eligibility criteria The additional inclusion and exclusion criteria could be framed as follows:

Inclusion Criteria - Studies will be included if they are assessed for methodological quality using both the PEDro scale and the MINORS tool.
Studies that report sufficient methodological information to allow for evaluation using the 11 items of the PEDro scale and the 12 items of the MINORS scale will be included.
Studies with a PEDro score of 6 or more will be considered of high quality, and studies with a MINORS score of 20 will be considered as ideal in terms of methodological rigor.

Exclusion Criteria - Studies will be excluded if they fail to report sufficient information for evaluation using the PEDro or MINORS scales.
Studies with a PEDro score of less than 4 will be excluded due to low methodological quality.
Studies that do not report the necessary details for a complete evaluation using the MINORS scale, leading to an inability to assign a score, will be excluded.

Information sources The literature will be searched using multiple electronic databases, including PubMed, Web of Science, Scopus, MEDLINE, ERIC, and Google Scholar, covering studies published from January 2008 to October 2024. Specific keywords, either individually or in combination, will be used in the search process. These keywords will include terms such as "basketball players," and ("complex training," "contrast training," "combine training," "plyometric training") or "basketball players" and ("explosive power," "speed," "agility," "strength," "change of direction speed"). In addition to database searches, reference lists from the included studies will be reviewed to identify further relevant research.
The authors will also consult prior and original research to find additional studies that meet the inclusion criteria. All retrieved titles and abstracts will be carefully reviewed for potential inclusion in the review. EndNote citation management software will be employed for screening the literature, and Mendeley reference management software will be used for duplicate detection.
Grey literature, including unpublished studies or reports, will also be considered where relevant. Any disagreements in study inclusion will be resolved through consensus between the two researchers or with the assistance of a third researcher. The final selection of papers will be made by the third author.

Main outcome(s) The outcomes of the review will focus on the effects of complex training on motor skills, specifically explosive power, speed, muscle strength, agility, and other relevant motor skill outcomes. The review will assess studies that measure these outcomes as a result of complex training interventions in basketball players. Timing of the outcomes will be considered based on the follow-up periods reported in the included studies, ranging from immediate post-intervention effects to long-term changes.
Effect measures will include quantitative indicators such as changes in performance tests (e.g., vertical jump height for explosive power, sprint times for speed, strength tests for muscle strength, and agility drills for agility). These measures will be used to assess the impact of complex training on motor skill development. Studies will be included if they report specific, measurable outcomes related to the targeted motor skills.
The review will exclude studies that investigate other unrelated variables, such as those focused on cognitive or nutrition-related interventions, as they do not meet the inclusion criteria. Additionally, studies without clear, quantifiable results on the specified motor skills will be excluded from the review.

Data management To manage records and data, three authors will independently evaluate the inclusion and exclusion criteria to determine study eligibility. The PICOS criteria (population, intervention, comparators, outcomes, and study design) will be applied to select relevant studies. All identified records will be systematically screened, and disagreements will be resolved through discussion or consultation with a third author. Data will be organized using reference management software to ensure accuracy and consistency throughout the review process.

Quality assessment / Risk of bias analysis The quality of the primary studies included in the review will be assessed using two distinct tools: the PEDro scale and the MINORS tool. In addition to the quality assessment, a risk of bias analysis will be conducted to evaluate potential biases in the included studies. These tools will be applied independently to evaluate the methodological quality and reliability of the studies. or randomized controlled trials, the risk of bias will be evaluated using the criteria outlined in the PEDro scale. For non-randomized studies, the MINORS tool will help assess the risk of bias by considering aspects such as the adequacy of study design, sample size, control for confounding variables, and the reporting of outcome measures.

Strategy of data synthesis In the analysis of the data, a narrative approach will be used to synthesize the findings, as a meta-analysis will not be performed. Instead of pooling numerical data, the authors will provide a descriptive summary of the study outcomes, focusing on the effects of complex training on motor skills in basketball players. This approach will allow for a more comprehensive understanding of the findings, especially given the variability across the included studies. The studies will be analyzed for common themes, trends, and patterns, while acknowledging the diversity of study designs, sample characteristics, and intervention details.
Although the studies are diverse, the quality of the research will be critically assessed to ensure the

validity and reliability of the findings. The analysis will also account for potential limitations in the studies, such as sample variability, level of competition, and other contextual factors. These limitations will be discussed in detail, providing a clearer understanding of how these factors might influence the results. The authors will also address how these potential sources of variability may affect the interpretation of the effects of complex training on motor skills in basketball players. By recognizing and discussing these limitations, the authors aim to present more transparent and realistic conclusions.

The heterogeneity of the effects across studies will be assessed descriptively by considering the variability in the data. This will involve examining the characteristics of the studies, such as differences in sample sizes, training protocols, and outcome measures. The authors will compare these factors to understand how they contribute to the variability in the results. The differences in the studies will be outlined in a table, which will summarize key characteristics of each study, such as the type of complex training used, the motor skills assessed, and the study design.

Given the heterogeneity observed across studies, the authors will use a qualitative method to describe the characteristics of motor skills development in male basketball players, rather than attempting a meta-analysis. This approach is deemed more appropriate due to the diverse nature of the studies included. The authors' extensive experience in conducting systematic reviews, particularly in the field of basketball, will guide the interpretation of the findings and ensure that the results are both meaningful and relevant to the field.

Subgroup analysis A subgroup analysis will be performed based on various factors that may influence the effects of complex training on motor skills in basketball players. The potential subgroups will include: Level of Competition, Type of Complex Training, Outcome Measures (Motor Skills), Sample Size, and Study Design (Randomized vs. Non-Randomized).

Sensitivity analysis In line with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) standards, the search strategy for this review will be modified and adapted for each database to increase the sensitivity of the search. This means that different search terms and filters will be used depending on the characteristics of each database, ensuring that as many relevant studies as possible are captured. The sensitivity analysis will evaluate whether the adaptations in the search strategy lead to significant differences in the number and quality of studies included, thereby ensuring that the systematic review's conclusions are not overly influenced by the search process or the particular database settings.

Language restriction Studies written in languages other than Serbian or English will be excluded from the review.

Country(ies) involved Serbia.

Keywords Team Sport; Motor Skills; Male Basketball Players; Complex Training; Explosive Power; Strength.

Dissemination plans The dissemination of the findings from this systematic review will be carried out through multiple channels to ensure broad accessibility and impact within the academic and professional communities. First, the review will be submitted for publication in a peer-reviewed journal focused on sports science, basketball, or physical therapy. The review will also be made available through academic databases such as PubMed, Web of Science, and Scopus, ensuring that it reaches a broad audience of researchers and practitioners. Additionally, the findings will be shared through conference presentations at basketball-related and sports science conferences. To further ensure accessibility, the review's summary and key findings will be shared on professional websites and blogs dedicated to basketball training and sports performance, targeting coaches and athletes who can directly apply the insights from the review to their training programs.

Contributions of each author

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