©Journal of Sports Science and Medicine (2024) **23**, 638-646
http://www.jssm.org DOI: https://doi.org/10.52082/jssm.2024.638

Research article

Small-Sided Games with Baskets Are Significantly More Effective at Enhancing Neuromuscular Force Parameters Compared to Ball Possession Games: A Randomized Controlled Study in Young Male Basketball Players

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Abstract

The aim of this study was to compare the effects of 8 weeks of small-sided basketball games (SSG) training using baskets (SSGbk) and ball possession games without baskets (SSGbpg) on various neuromuscular parameters in young male basketball players. Specifically, the study examined unilateral isometric knee flexor strength (KFS), unilateral isometric knee extensor strength (KES), bilateral countermovement jump peak power and peak landing force (CMJ), and leg land and hold test (LHT) peak landing force. This randomized controlled study included two experimental groups (SSGbk and SSGbpg) and one control group. Fifty regional competitive-level male youth basketball players (16.7 ± 0.5 years) were assigned to the groups. The experimental groups participated in two additional SSG weekly training sessions over 8 weeks. Both experimental groups were exposed to the same 2v2 to 4v4 formats of play and training volume, with the only difference being that one group performed ball possession games while the other participated in games targeting to score in the basket. Players were evaluated twice: once at baseline in the week prior to the intervention period, and again in the week post-intervention. The neuromuscular tests were conducted using force platforms. Significant interactions between time and groups were observed in KES (p < 0.001; η_p^2 = 0.902), KFS (p < 0.001; η_p^2 = 0.880), and CMJ peak power (p < 0.001; η_p^2 = 0.630). Significant differences between groups were found post-intervention for the variables of KES (p = 0.017; η_p^2= 0.159), KFS (p = 0.011; η_p^2 = 0.174), CMJ peak power (p = 0.017; η_p^2 = 0.160), CMJ peak landing force (p = 0.020; η_p^2 = 0.154), and LHT peak power (p = 0.012; η_p^2 = 0.171). In conclusion, our study highlights that the SSGbk significantly increases neuromuscular adaptations in young male basketball players. Conversely, our findings do not support the efficacy of SSGbpg in targeting these specific physical fitness variables. Therefore, the use of SSGs must be carefully considered, particularly in selecting task conditions, to ensure efficacy in interventions.

Key words: Team sports, basketball, muscle strength, athletic performance, sports training.

Introduction

Neuromuscular force parameters are important in both enhancing the performance and preventing injuries among basketball players (Bonato et al., 2018). The capacity to generate muscular force is crucial for executing explosive movements like jumping, accelerations, and quick changes in direction, all fundamental to basketball gameplay (Peterson et al., 2006; Suchomel et al., 2016). Strong correlations have been observed between these neuromuscular force parameters and key athletic performance measures such as vertical jump height and sprint speed (Swinton et al., 2014; Thomas et al., 2015). This emphasizes how optimized force generation improves overall physical readiness (Young, 2006), potentially heightening competitiveness on the court. Additionally, adequate neuromuscular capacity can help mitigate injury risks by maintaining joint stability during high-intensity activities, thereby reducing the likelihood of injuries (Fort-Vanmeerhaeghe et al., 2016).

Small-sided games (SSG) have gained popularity as effective basketball training drills due to their numerous benefits, including providing a multifactorial stimulus in technical, tactical, physical, and physiological parameters (Clemente, 2016; Jose Figueiredo de Souza et al., 2024). These drills typically involve fewer players on a smaller court, encouraging high-intensity, dynamic movements that closely simulate game scenarios (Klusemann et al., 2012). Beyond enabling coaches to implement strategic and tactical behaviors, SSGs foster a high level of commitment to developing technical skills in realistic situations (Bredt et al., 2018). Moreover, these games are valuable for targeting key physical fitness components crucial for performance (Li et al., 2024). From a physiological perspective, SSG are known to improve aerobic capacity by alternating high-intense bursts of activity with short recovery periods (Delextrat and Martinez, 2014). However, research indicates that these drills not only enhance cardiovascular fitness but also have the potential to positively impact neuromuscular parameters such as force and power (Arslan et al., 2022). The frequent changes in speed, direction, and intensity inherent in SSGs challenge players' muscular strength, thus contributing significantly to the development of neuromuscular strength and power output (Sansone et al., 2019).

SSG can be utilized in various ways, particularly through different task conditions that can influence performance (Davids et al., 2013). The use of these games, when adjusted to specific task conditions, can produce immediate impacts on individual tactical behaviors, which ultimately affect locomotor demands during matches. This differentiation in magnitude and stimulus profile is influenced by the manipulation of player numbers and court dimensions. Additionally, varying the scoring methods can further shape the demands placed on players in these games (Bredt et al., 2018; 2022; Clemente et al., 2021). For instance, the decision to incorporate a basket or not in basketball SSGs can significantly affect the physical demands

Received: 28 June 2024 / Accepted: 24 July 2024 / Published (online): 01 September 2024

and neuromuscular adaptations of players (Coutinho et al., 2016). Using SSGs with a basket can emphasize shooting proficiency and strategic positioning around scoring opportunities, thereby potentially increasing the frequency of jumps, high-accelerations and decelerations, and rapid changes in movement direction (Bredt et al., 2022). In contrast, SSGs without a basket, which prioritize ball possession and passing, may emphasize continuous movement while reducing the intensity of running actions and the frequency of jumps (Ferioli et al., 2023). These acute physical responses to different task conditions can have long-term implications (Gomes et al., 2021), potentially influencing neuromuscular adaptations based on the specific demands of each variant. For example, games with a basket may enhance the explosive strength and power needed for shooting and jumping, whereas games without a basket may improve endurance for sustained play.

While experimental research has addressed the effects of SSG on basketball players, most studies have compared SSG with alternative options such as running high-intensity interval training (Delextrat and Martinez, 2014; Delextrat et al., 2018; Arslan et al., 2022; Zeng et al., 2022). There is a lack of research comparing the effects of different SSG task conditions on physical adaptations, a topic that has only recently begun to emerge in other sports such as soccer (Wang et al., 2024). Existing studies comparing SSG in basketball are typically cross-sectional and focus on acute responses, thus failing to explore long-term impacts (Clemente, 2016; Jose Figueiredo de Souza et al., 2024). Therefore, it is crucial to expand our understanding of employing different SSG conditions over the long term, particularly in critical aspects such as neuromuscular force and power adaptations. This type of research could be pivotal in helping coaches identify the most appropriate SSG formats that contribute positively to neuromuscular development.

Based on these considerations, this study aimed to compare the effects of 8 weeks of training using SSG with baskets (SSGbk) versus ball possession games without baskets (SSGbpg) on various neuromuscular parameters in young male basketball players. Specifically, the study assessed unilateral isometric knee flexor strength (KFS), unilateral isometric knee extensor strength (KES), bilateral countermovement jump peak power and peak landing force (CMJ), and leg land and hold test (LHT) peak landing force.

Methods

Participants

In our randomized experimental study, we followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines to report the primary methodological characteristics (Merkow et al.,2021). The Ethics Committee of the Chengdu Institute of Physical Education (approval code 10/2024) initially authorized the study protocol. Additionally, informed consent was secured from all participants and their legal guardians. The study adhered to the ethical guidelines outlined in the Declaration of Helsinki for research involving human subjects.

Study design

The study utilized a randomized controlled design with two experimental intervention groups (SSGbk and SSGbpg) in addition to the standard training regimen, while a control group maintained regular basketball training only. Convenience sampling was used to recruit participants from five local basketball teams. To avoid the influence of specific club training routines on the study's outcomes, players from each team were randomly assigned to one of three groups, ensuring that the number of participants in each group was balanced within each team. This random assignment was conducted using a software for randomization (Research Randomizer) that assigned randomly the players before the initial assessment, ensuring equal chances of group placement for each player (ensuring allocation concealment). Evaluators who were not directly part of the research team, and were unaware of the group assignments and training interventions, conducted assessments one week before the intervention began and immediately after the eighth week. Due to logistical constraints in the training process, neither the players nor the researchers administering the training protocols were blinded to the group assignments.

Participants

The sample size for the study was calculated using the G*power software (version 3.1.9., Universität Düsseldorf, Germany). This calculation was based on an effect size of 0.25, taking into account four three groups and two measurement points. To achieve a desired statistical power of 0.95 and a significance level of 0.05 for ANOVA repeated measures within-between interaction, a total sample size of 48 participants was recommended.

The study's inclusion criteria were: (i) participation at both evaluation points, (ii) a minimum of three years of basketball experience, (iii) attendance at least 90% of regular training sessions, (iv) absence of injury or illness during the experiment, (v) no involvement in additional strength and conditioning programs, and (vi) being male.

After the recruitment process conducted in five teams, 52 players volunteered for the study. However, two players were excluded because they missed the initial evaluation due to injury. Consequently, 50 eligible players were randomly assigned to one of the three groups (Figure 1).

The study enrolled fifty male basketball players classified at the trained/developmental level using the Participants Classification Framework (McKay et al., 2022). These players compete at the regional level, engaging in regular training sessions three times a week, focused on competitive preparation. Training sessions (80-100 minutes each) were structured to enhance both competitive readiness and skill specialization. On average, the players were 16.7 years old (standard deviation, SD = 0.5 years), with an average height of 180.6 cm (SD = 5.7 cm) and an average body mass of 68.8 kg (SD = 7.4 kg). Their average body mass index was 21.1 kg/m² (SD = 1.6 kg/m²).

Specifically, the SSGbk group (n = 17), were 16.6 years old (SD = 0.6 years), with an average height of 178.1 cm (SD = 4.8 cm), an average body mass of 66.5 kg (SD = 6.9 kg), and an average body mass index of 20.9 kg/m² (SD = 1.8 kg/m²). The SSGbpg (n = 17), were 16.7 years old

(SD = 0.5 years), with an average height of 182.5 cm (SD = 6.0 cm), an average body mass of 70.8 kg (SD = 7.1 kg), and an average body mass index of 21.2 kg/m² (SD = 1.7 kg/m²). Finally, the control group (n=16), were 16.8 years old (SD = 0.4 years), with an average height of 181.3 cm (SD = 5.6 cm), an average body mass of 69.3 kg (SD = 7.9 kg), and an average body mass index of 21.0 kg/m² (SD = 1.5 kg/m²). The adherence rates to the intervention sessions consisting in SSG were 93.9% for SSGbk and 95.2% for SSGbpg.

The small-sided games programs

The study incorporated SSG interventions as an extra-time program to regular in-court training sessions. The researchers only implemented the experimental interventions, while the remaining in-court sessions were exclusively managed by the basketball coaches of the teams. While the control group exclusively participated in standard in-court sessions, players in the experimental groups engaged in two additional SSG sessions per week over an eight-week period. The sessions were scheduled 48 hours after the match, with the second session taking place 72 hours after the first one. The sessions were conducted prior to the regular on-court session, beginning with a standardized warm-up comprising 5 minutes of jogging, followed by 10 minutes of dynamic stretching for the upper and lower limbs, 5 minutes of jumping exercises, and concluding with 5 minutes of individual technical actions. Table 1 below illustrates the training plans for each session throughout the intervention period.

In games employing a single shared basket (SSGbk), specific rules required teams to return to the baseline (the line opposite the basket) after each score or change of possession, thus restarting the attacking process. Rebounds were allowed immediately after a shot. In the SSGbk, three-point shots were not allowed. In the case of SSGbpg, the game involved maintaining ball possession among teammates, requiring five consecutive successful and uninterrupted passes to score one point. To ensure competitiveness, intervention sessions were structured in a competitive setting where teams faced different opponents throughout the repetitions. Each game's score contributed to the team's overall points. Teams in various formats were organized by the coach based on proficiency level,

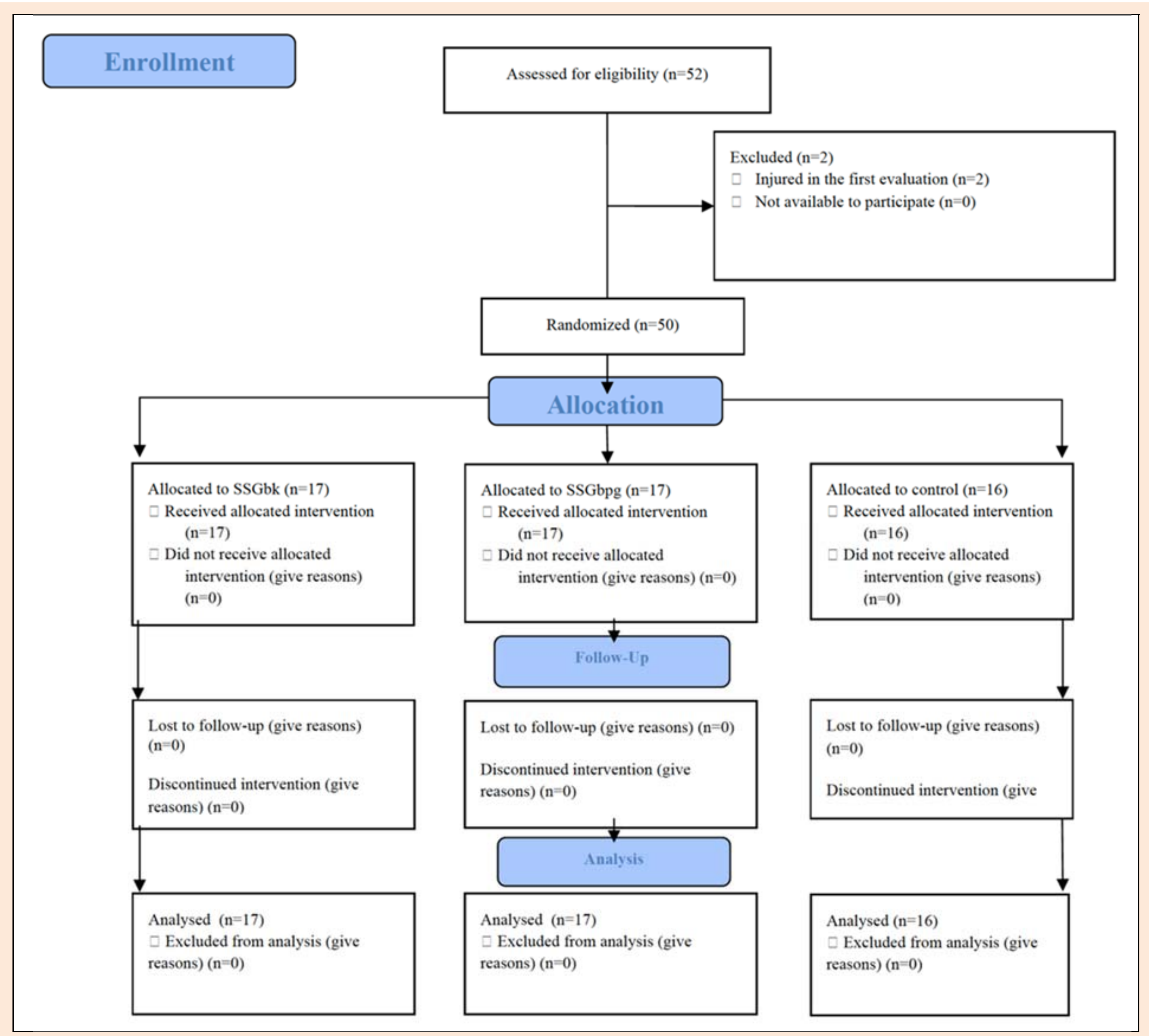

Figure 1. Flow of participants throughout the stages of the experimental investigation. SSGbk: small-sided games with baskets; SSGbpg: small-sided games without baskets and focused on ball possession games.

playing position, and physical attributes to maintain balanced competition. Players were assigned to consistent teams for the entire duration of the study, with coaches refraining from giving tactical or strategic guidance and abstaining from verbal encouragement during game sessions. To facilitate quicker ball repositioning, balls were strategically positioned closer to the baskets.

Context of the assessments

The evaluations were conducted once in the week before and once in the week after the intervention, consistently scheduled on identical days each week to maintain uniformity (48 hours after the last match). The assessments were conducted indoors in a controlled environment set at 23°C with a relative humidity of 55%, during the afternoon hours.

Each evaluation followed the same structured protocol. Initially, demographic information was gathered, followed by anthropometric measurements. A standardized warm-up routine was then conducted and supervised by the evaluators team, comprising 5 minutes of jogging, followed by 10 minutes of dynamic stretching for the upper and lower limbs, 5 minutes of jumping exercises, and concluding with 5 minutes of individual technical actions.

Table 1. Description of the SSGs contents over the intervention period.

	SSGbk – session1	SSGbpg – session 2	SSGbpg – session 1	SSGbpg – session 2
Week 1	3 rounds of 4 minutes each with 2 minutes of rest, played in a 4v4 format on a half court with one basket shared by both teams	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with one basket shared by both teams	3 rounds of 4 minutes each, with 2 minutes of rest in between, played in a 4v4 format on a half court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 2	3 rounds of 4 minutes each with 2 minutes of rest, played in a 4v4 format on a half court with one basket shared by both teams	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with one basket shared by both teams	3 rounds of 4 minutes each, with 2 minutes of rest in between, played in a 4v4 format on a half court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 3	3 rounds of 4 minutes each with 2 minutes of rest, played in a 4v4 format on a half court with two baskets (one for each team)	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with two baskets (one for each team)	3 rounds of 4 minutes each, with 2 minutes of rest in between, played in a 4v4 format on a half court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 4	3 rounds of 4 minutes each with 2 minutes of rest, played in a 4v4 format on a half court with two baskets (one for each team)	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with two baskets (one for each team)	3 rounds of 4 minutes each, with 2 minutes of rest in between, played in a 4v4 format on a half court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 5	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with two baskets (one for each team)	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 6	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court with two baskets (one for each team)	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible	4 rounds of 3 minutes each with 2 minutes of rest, played in a 3v3 format on a half court without baskets, focusing on maintaining ball possession for as long as possible
Week 7	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible
Week 8	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court with one basket shared by both teams	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible	5 rounds of 2 minutes each with 2 minutes of rest, played in a 2v2 format on a quarter of the court without baskets, focusing on maintaining ball possession for as long as possible

SSGbk: small-sided games with baskets; SSGbpg: small-sided games without baskets and focused on ball possession games.

Following the warm-up, participants undertook the following sequence of tests: (i) KFS test; (ii) KES test; (iii) CMJ test; and (iv) LHT test. A 5-minute rest period separated each test, while a 3-minute rest was provided between repetitions within each test. The evaluation order and sequence were identical for all participants across both pre- and post-intervention assessments.

Anthropometric Measurements

Anthropometric measurements were conducted as follows: Height was assessed using a stadiometer (Seca 217, Seca, Hamburg), and body mass was recorded using an electronic scale (SECA 813; Seca GmbH & Co., Hamburg, Germany) with a precision of 0.1 kg. Participants wore standard clothing of a t-shirt and basketball shorts for uniformity during these measurements.

Isometric knee flexors and extensors strength

Muscle strength in the knee flexors (KFS) and knee extensors (KES) of participants was evaluated using the ForceFrame Strength Testing System (Vald Performance, Brisbane, Australia). During the KES assessment, participants maintained a single-leg stance while the dynamometer, fitted with 50 Hz sensors, captured force measurements from the other leg bent at a 30° angle. In the case of KFS test, each participant stood upright with one knee flexed to 30°, positioning the lower leg's front portion at the center of the dynamometer equipped with 50 Hz sensors to measure force. The opposite leg remained straight to maintain stability during the assessment. Participants performed two maximum voluntary contractions lasting five seconds each per leg. Maximum force (N) was recorded for both legs. The average result from both trials was used for subsequent data analysis of the average values for both legs.

Countermovement jump test (CMJ)

Participants began the assessment by assuming a standard standing position on the force platform (ForceDecks, Vald Performance, Brisbane, Australia), hands on hips, and eyes fixed straight ahead. They were instructed to maintain complete stillness for 2 - 3 seconds before and between each jump. Following this, participants executed a series of two CMJ to achieve maximum height. Outcome variables including peak power (W/kg) and peak landing force (N) were measured using the VALD ForceDecks software. Mean variables used for analysis were computed based on the average values obtained from the two jumps performed.

Single leg lend and hold (LHT)

Participants began the evaluation by standing on force plates (ForceDecks, Vald Performance, Brisbane, Australia), positioned 30 cm in front of them. They assumed a stance with feet together, hands on hips, and gaze fixed straight ahead. After maintaining complete stillness for 2-3 seconds, they executed a single-leg jump upon instruction, holding the landing position until further direction (minimum 3 seconds). This process was repeated twice per leg. Data, including peak drop landing force (N), were recorded and analyzed using the VALD ForceDecks software. The average result from both trials was used for subsequent data analysis of the average values for both legs.

Statistical procedures

Prior to conducting inferential analyses, the normal distribution of the sample was assessed using the Kolmogorov-Smirnov test ($p > 0.05$). Homogeneity of variance assumptions was verified with Levene's test ($p > 0.05$). A mixed ANOVA (time * group) was employed, incorporating partial eta squared (η_p^2) to gauge effect sizes, interpreted as follows: > 0.01 (small), > 0.06 (moderate), and > 0.14 (large) based on established thresholds (Richardson, 2011). Post-hoc comparisons were conducted using the Bonferroni test. Statistical analyses were conducted using JASP software (version 0.18.3, University of Amsterdam, The Netherlands), with a predetermined significance level set at $p < 0.05$.

Results

The figure 2 shows the comparisons within and between groups considering KES, KFS, and CMJ peak power. Significant interactions between time and groups were observed in KES ($F = 216.332$; $p < 0.001$; $\eta_p^2 = 0.902$), KFS ($F = 171.964$; $p < 0.001$; $\eta_p^2 = 0.880$), and CMJ peak power ($F = 40.088$; $p < 0.001$; $\eta_p^2 = 0.630$).

The between-group analysis revealed no significant differences at baseline for the variables of KES ($F = 0.019$; $p = 0.981$; $\eta_p^2 = 0.001$), KFS ($F = 0.030$; $p = 0.971$; $\eta_p^2 = 0.001$), and CMJ peak power ($F = 0.247$; $p = 0.782$; $\eta_p^2 = 0.010$). However, significant differences between groups were found post-intervention for the variables of KES ($F = 4.445$; $p = 0.017$; $\eta_p^2 = 0.159$), KFS ($F = 4.942$; $p = 0.011$; $\eta_p^2 = 0.174$), and CMJ peak power ($F = 4.469$; $p = 0.017$; $\eta_p^2 = 0.160$). Specifically, for the variable of KES, post-intervention values were significantly greater in the SSGbk group compared to the SSGbpg group (287.7 ± 78.8 vs. 231.7 ± 59.0 N; $p = 0.036$) and the control group (287.7 ± 78.8 vs. 232.4 ± 43.8 N; $p = 0.043$). Similarly, post-intervention KFS values were significantly greater in the SSGbk group compared to the SSGbpg group (363.7 ± 65.2 vs. 312.2 ± 47.7 N; $p = 0.029$) and the control group (363.7 ± 65.2 vs. 310.7 ± 52.2 N; $p = 0.027$). Finally, for the variable of CMJ peak power, post-intervention values were significantly greater in the SSGbk group compared to the SSGbpg group (42.5 ± 4.4 vs. 38.2 ± 6.5 W/kg; $p = 0.046$) and the control group (42.5 vs. 38.0 W/kg; $p = 0.043$).

The figure 3 shows the comparisons within and between groups considering CMJ peak landing force, and LHT peak landing force. Significant interactions between time and groups were observed in CMJ peak landing force ($F = 50.015$; $p < 0.001$; $\eta_p^2 = 0.680$), and LHT peak landing force ($F = 15.613$; $p < 0.001$; $\eta_p^2 = 0.399$).

The between-group analysis revealed no significant differences at baseline for the variables of CMJ peak landing force ($F = 0.079$; $p = 0.924$; $\eta_p^2 = 0.003$), and LHT peak landing force ($F = 0.762$; $p = 0.472$; $\eta_p^2 = 0.031$). However, significant differences between groups were found post-intervention for the variables of CMJ peak landing force ($F = 4.284$; $p = 0.020$; $\eta_p^2 = 0.154$), and LHT peak power ($F = 4.832$; $p = 0.012$; $\eta_p^2 = 0.171$). Specifically, for the variable of CMJ peak landing force, post-intervention values were significantly greater in the SSGbk group compared to the SSGbpg group (1507.2 ± 345.9 vs. 1893.7 ± 253.9 N; p = 0.046) and the control group (1507.2 ± 345.9 vs. 1903.3 ± 657.0 N; p = 0.043). Similarly, post-intervention LHT peak landing force values were significantly greater in the SSGbk group compared to the SSGbpg group (802.8 ± 176.1 vs. 911.9 ± 74.9 N; p = 0.044) and the control group (802.8 ± 176.1 vs. 925.6 ± 100.8 N; p = 0.021).

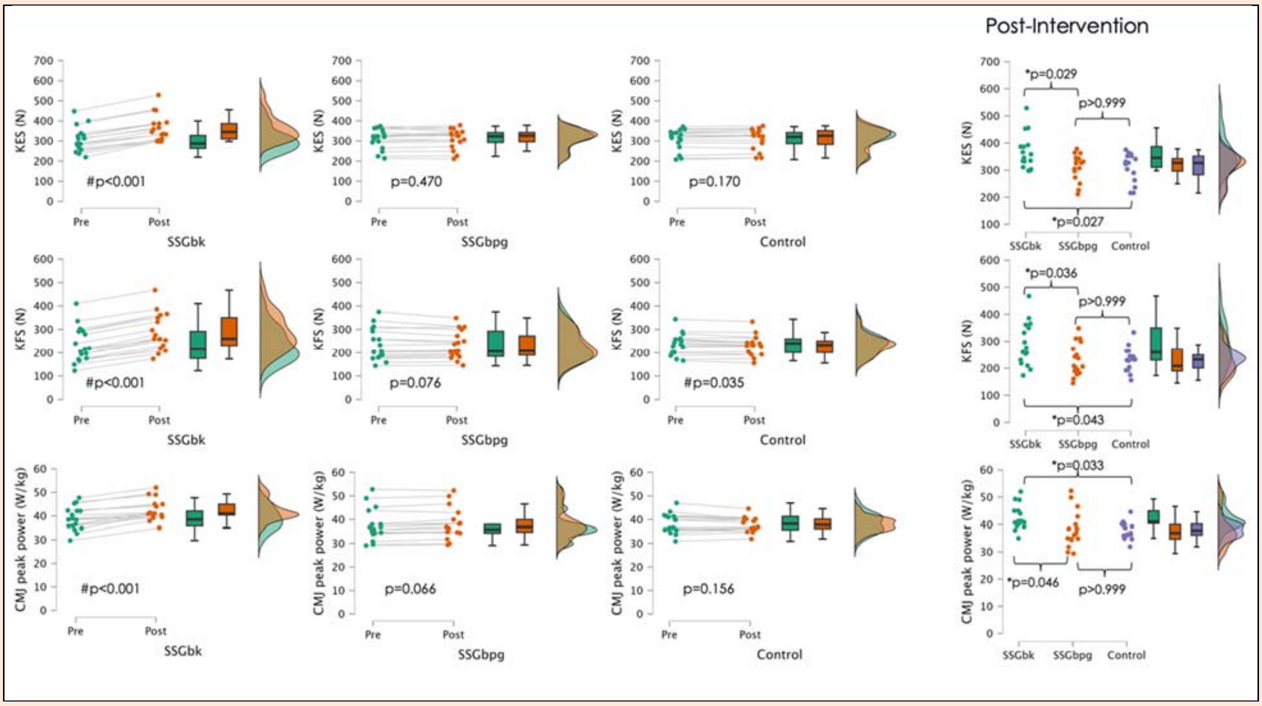

Figure 2. Comparisons within and between groups considering knee extensor strength (KES), knee flexor strength (KFS), and countermovement jump (CMJ) peak power. SSGbk: small-sided games with baskets; SSGbpg: small-sided games without baskets and focused on ball possession games. *significantly different between groups ($p < 0.05$); #significantly different between pre and post-intervention ($p < 0.05$).

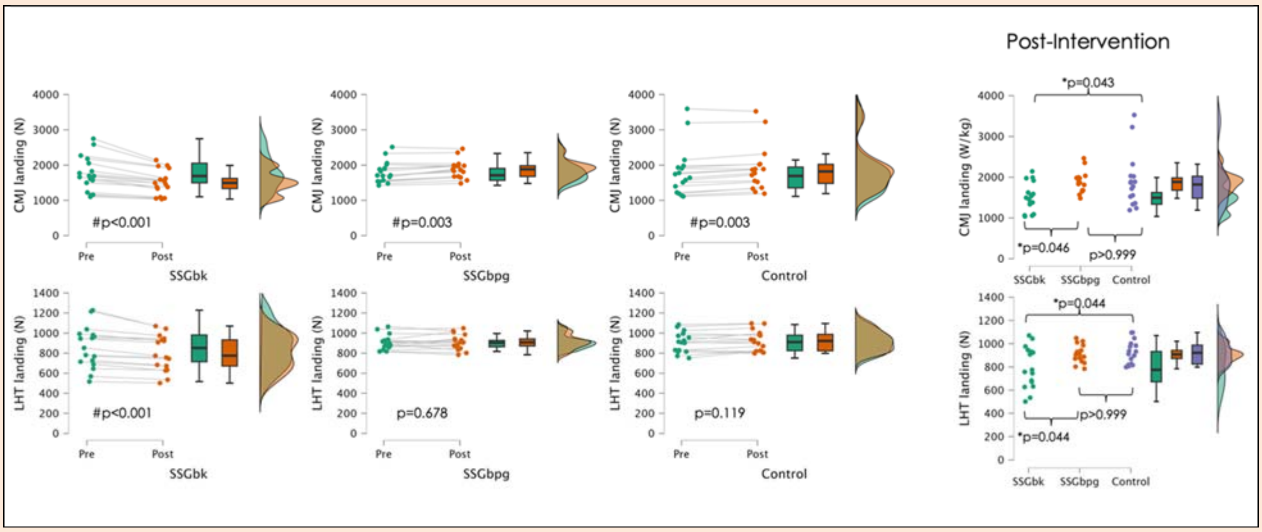

Figure 3. Comparisons within and between groups considering countermovement jump (CMJ) peak landing force and single leg lend and hold (LHT) peak landing force. SSGbk: small-sided games with baskets; SSGbpg: small-sided games without baskets and focused on ball possession games. *significantly different between groups ($p < 0.05$); #significantly different between pre and post-intervention ($p < 0.05$).

Discussion

Our experimental study, to our knowledge, was the first to compare how different task objectives in SSG could impact neuromuscular adaptations in young male basketball players. We observed that the groups of players engaged in games with baskets significantly improved isometric strength in both knee flexors and extensors, as well as significantly enhancing peak power in the CMJ and reducing peak landing forces in both CMJ and LHT tests. These improvements were significantly greater compared to players in the parallel experimental group that participated only in ball possession games, as well as the control group. On the other hand, players in the SSGbpg group did not show significant differences from the control group in any of the measured outcomes after the intervention.

Our results revealed that SSGbk conducted to significant improvements in KFS and KES in comparison to both SSGbpg and control groups. The significant improvements in KFS and KES observed among the SSGbk group can possible be attributed to the use of baskets, which likely enforced higher intensity jumping and landing movements (Struzik et al., 2014). These actions stimulate adaptations in knee extensor strength by increasing demand on quadriceps activation and force production (Kabaciński et al., 2018), since each time a player jumps, the quadriceps muscles, which are the primary knee extensors, are heavily engaged to extend the knee and generate the force needed for the jump. Moreover, jumping requires powerful, explosive movements, demanding high levels of force production from the quadriceps. This scenario not only may enhance muscle fiber recruitment but also promotes neuromuscular adaptations (Ferioli et al., 2018), potentially leading to greater force generation capabilities in knee extensors over time. Furthermore, the presence of baskets demands more frequent and forceful knee flexion movements during shooting and rebounding actions (Taylor et al., 2020), thereby facilitating improvements in knee flexor strength. These movements are critical for activating the hamstrings and gastrocnemius muscles, which significantly contribute to knee flexor strength and stability (Walsh et al., 2012). Despite this hypothesis, it is important to consider the variability and heterogeneity among players. Understanding how larger formats can increase heterogeneity and potentially affect adaptations might be crucial.

In contrast, the SSGbpg group may have primarily focused on accumulating total distance covered, frequent accelerations and decelerations, and developing passing and tactical skills rather than targeting specific strength training adaptations such as explosive jumps or locomotor movements. While beneficial for skill development and cardiovascular fitness (Lacome et al., 2018), these activities may not have provided the same stimulus for maximal muscle force production and neuromuscular adaptations observed in the basket-oriented sessions.

These explanations also apply to the significant improvements in CMJ peak power observed in the SSGbk group. The act of repeatedly jumping to reach and score baskets, particularly in smaller formats where each player's frequency increases (Klusemann et al., 2012), imposes a higher demand on the stretch-shortening cycle of muscle fibers (Philipp et al., 2024). This rapid stretch followed by a forceful contraction may enhances the efficiency of muscular force production during explosive movements like the CMJ (Young and Elliott, 2001). Such activities stimulate adaptations in muscle-tendon unit stiffness and neural activation (Pożarowszczyk et al., 2018), crucial for optimizing power output during jumping tasks. Furthermore, the presence of baskets may encourage athletes to perform maximal effort jumps, thereby promoting greater recruitment and synchronization of motor units (Ramirez-Campillo et al., 2022), which enhances power generation capabilities over time.

The observed reduction in peak landing forces during the CMJ and LHT in the SSGbk group can be attributed to the frequent practice of jumping to reach and score baskets, which promotes enhanced proprioception and landing technique among players (McKay et al., 2005). The fact that the games did not allow 3-point shots may have required closer shooting attempts and more jumping actions for both shooting and rebounding. This likely increased the frequency of subsequent landings and the need to cope with them. This heightened awareness likely facilitates better control over landing mechanics (Myer et al., 2013), leading to smoother force dissipation upon impact and consequently reducing peak landing forces. Additionally, the emphasis on basket-oriented activities may have encouraged athletes to adopt softer landings to optimize subsequent movement efficiency (Taylor et al., 2017). Such landing strategies, characterized by increased knee and ankle flexion upon touchdown, help distribute landing forces more evenly across the lower extremities and reduce the abrupt deceleration forces typically associated with high-impact landings (McKinley and Pedotti, 1992). Thus, the tactical behaviors and the presence of the basket may have increased the players' focus on overcoming their direct opponents, jumping, and shooting. This, in turn, emphasizes the physical demands associated with these actions, which are more related to high-intensity locomotor activities as accelerations, deceleration and jumping. In contrast, the SSGbpg group may have prioritized turns, changes of direction, and tactical skills over specific landing mechanics, as these activities do not require frequent jumps. This focus could potentially result in less pronounced improvements in landing force attenuation.

While our experimental study offers valuable insights into how different task objectives in SSG impact neuromuscular adaptations in young male basketball players, it is important to acknowledge several limitations and areas for future research. Firstly, our study exclusively focused on young male basketball players, which may limit the generalizability of our findings to other demographic groups, particularly those at higher competitive levels where neuromuscular parameters may differ and the impact of SSG may vary. Future studies could explore how these insights translate across different age groups, genders, and competitive levels, thus providing a more comprehensive understanding of the potential benefits of basket-oriented SSG. Furthermore, while our study observed improvements in isometric strength, peak power, and landing forces, the specific mechanisms driving these adaptations remain speculative. Future research could employ electromyography and biomechanical analyses during games to elucidate the neuromuscular mechanisms responsible for these improvements. Lastly, researching the optimal integration of basket-oriented SSG with other training modalities such as strength training and plyometrics could further enhance neuromuscular adaptations in basketball players.

The findings from our study highlight practical implications for basketball training, particularly in designing effective SSG to enhance neuromuscular adaptations in players. Coaches should consider incorporating basket-ori ented SSG, which emphasize activities such as jumping, shooting and rebounding, to specifically target improvements in knee extensor and flexor strength, as well as peak power during explosive movements like the CMJ. The key takeaway for coaches is that using SSGs with baskets in a smaller space can increase neuromuscular engagement, ultimately leading to positive adaptations in strength and power. On the other hand, ball possession-based games are not recommended for high-level neuromuscular engagement and further adaptation. Instead, they should be used for other objectives, such as improving aerobic fitness or technical and tactical skills.

Conclusion

In conclusion, our experimental study provides evidence that the integration of basket-oriented games (SSGbk) significantly enhances neuromuscular adaptations among young male basketball players. By emphasizing activities like jumping, shooting, and rebounding, SSGbk may led to substantial improvements in knee extensor and flexor strength, as well as peak power during explosive movements such as the CMJ. These improvements were accompanied by a significant reduction in peak landing forces. In contrast, games focused solely on ball possession (SSGbpg) showed less pronounced benefits in these neuromuscular parameters. These findings highlight the importance of properly designing games based on the specific adaptations coaches aim to stimulate and promote.

Acknowledgements

The authors declare that there are no conflicts of interest. The experiments comply with the current laws of the country where they were performed. The data that support the findings of this study are available on request from the corresponding author.

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Key points

- The study found that young male basketball players who participated in small-sided games targeting scoring in the basket (SSGbk) showed significant improvements in knee extensor and flexor strength, as well as peak power during countermovement jumps, compared to those who played ball possession games without baskets (SSGbpg).
- SSGbk training led to substantial gains in countermovement jump peak power and a significant reduction in peak landing forces, suggesting that activities like jumping, shooting, and rebounding in basket-oriented games effectively enhance explosive neuromuscular performance.

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