

Effects of a 12-week neuromuscular training program on youth basketball players: a pilot study

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Abstract

Introduction. Optimizing youth basketball training to improve balance, agility, and technical skills is essential for athletic development and performance. Although proprioceptive training has demonstrated benefits in various sports, its specific effects on agility and shooting accuracy in adolescent basketball players remain insufficiently investigated. Proprioceptive exercises are a key component of neuromuscular training programs designed to enhance motor control and movement efficiency. **Aim of Study.** This pilot study aimed to evaluate the effects of a 12-week neuromuscular (proprioceptive-focused) training program on balance, agility, and shooting accuracy in youth basketball players. **Material and Methods.** Forty-four male athletes aged 12–14 years participated in the intervention, which was integrated into regular basketball practice sessions. Dynamic balance was assessed using the Star Excursion Balance Test, agility through the Agility T-Test and Defensive Cone Drill Test, upper-limb stability via the Closed Kinetic Chain Upper Extremity Stability Test, and shooting accuracy using the Speed Spot Shooting Test. Pre- and post-intervention results were compared using paired sample t-tests, with statistical significance set at $p < 0.05$. **Results.** Following the intervention, significant improvements were observed in dynamic balance ($p < 0.001$) and agility ($p < 0.05$). Upper-limb stability also improved significantly. Shooting accuracy demonstrated a positive but non-significant trend ($p = 0.08$). These findings suggest that enhanced neuromuscular control and proprioceptive awareness contribute to more efficient movement patterns, greater stability, and potentially reduced injury risk. **Conclusions.** The results indicate that a structured 12-week neuromuscular training program can effectively improve key physical performance components in adolescent basketball players. While improvements in shooting accuracy were modest, the overall findings support the inclusion of proprioceptive-focused exercises in youth basketball training to enhance athletic performance and motor development.

KEYWORDS: proprioception, agility, youth basketball, motor performance, shooting accuracy, neuromuscular training.

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Introduction

Basketball is an exceptionally popular sport that demands a wide range of abilities, including physical attributes such as speed, coordination, neuromuscular control, strength, and endurance, as well as technical and tactical knowledge. In youth basketball players, the development of technical and motor skills represents an important component of player development [1, 2]. Numerous studies have examined basketball performance metrics, focusing on areas such as offensive strategy effectiveness and shooting trends [3, 4].

Additional research has examined basketball-specific biomechanics, including the effect of arm dominance on knee joint biomechanics during single-leg landing following a block shot [5], as well as the relationship between load variables and playing positions [6].

Although proprioceptive training has been shown to improve balance in athletes, its specific impact on agility and shooting accuracy among youth basketball players remains underexplored. The aim of our research

is to evaluate the effects of proprioceptive training on basketball performance. We aim to provide coaches with a novel perspective that may contribute to long-term success for youth basketball teams. The findings of this study support the refinement of sport-specific training methodologies, notably by promoting injury-prevention strategies and enhancing technical performance.

Basketball players must develop a variety of technical skills. The sport demands rapid directional changes, precise passing, and accurate shooting, all of which require static and dynamic balance, coordination, and neuromuscular control [7]. Enhancing balance and neuromuscular control is crucial for injury prevention and the improvement of athletic performance. These types of training strengthen muscles, enhance joint stability, and improve motor control [8].

Exercises performed on unstable surfaces can be particularly effective in improving balance and athletic performance [9]. Research indicates that proprioceptive training may improve selected physiological attributes and sport-specific technical skills, including shooting, passing, and dribbling [10].

Aim of Study

The primary objective of this study was to investigate the effects of a structured 12-week proprioceptive training program on the physical and technical abilities of youth basketball players.

We hypothesized that: H1: Proprioceptive training significantly improves dynamic balance, as measured by the Star Excursion Balance Test (SEBT); H2: Proprioceptive training enhance agility, as measured by the Agility T-Test and Defensive Cone Drill Test; H3: Proprioceptive training improve shooting accuracy, as assessed by the Speed Spot Shooting Test.

Material and Methods

The participants ($n = 44$) were male basketball players aged 12–14 years from the Sopron Sports Academy, with an average body height of 155.27 ± 7.19 cm and an average body weight of 42.5 ± 8.2 kg. Inclusion criteria required that participants had no injuries during the study or within the six weeks preceding it. Participants attended regular 90-minute training sessions five times per week. A longitudinal, quantitative study design was employed. The intervention integrated a neuromuscular training program into regular basketball practices three times per week over a 12-week period.

Training intervention: Exercises focused on dynamic balance, coordination, and strength using unstable surfaces (Dynair pads), with progressive increases in difficulty.

Outcome measures: Dynamic balance: Star Excursion Balance Test (SEBT). The SEBT is a reliable and validated test for dynamic balance in young athletes [11]; Agility: Agility T-Test and Defensive Cone Drill Test; Upper-limb stability: Closed Kinetic Chain Upper Extremity Stability Test; Shooting accuracy: Speed Spot Shooting Test. Ethical approval was obtained from the Institutional Review Board of Sopron University. Informed consent was secured from all participants and their guardians.

Data were analyzed using paired sample t-tests (significance set at $p < 0.05$), and Microsoft Excel 2013 was used for data management and to compare pre- and post-intervention results. Before analysis, the Shapiro-Wilk test was used to verify the normality of the data distribution. Effect sizes were calculated using Cohen's d to determine the magnitude of the changes. To account for multiple comparisons in the SEBT, a Bonferroni correction was applied. Given the absence of a control group, the study follows an observational pilot design. However, the standardized training exposure and repeated-measures within-subject approach allowed each participant to serve as their own reference condition, thereby partially strengthening internal consistency despite the lack of a control group.

Data collection methods and tools

Agility was assessed using the Agility T-Test. The test involved a T-shaped setup with four cones, arranged according to the dimensions shown in Figure 1. The athlete began at the starting point, proceeded to touch

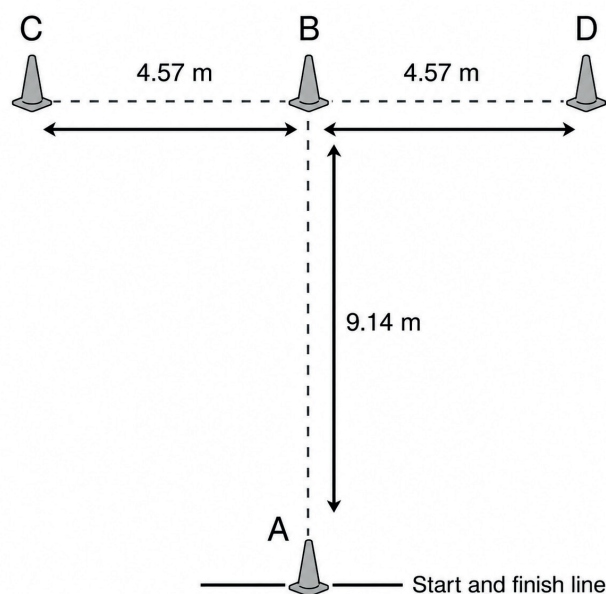


Figure 1. Agility T-test

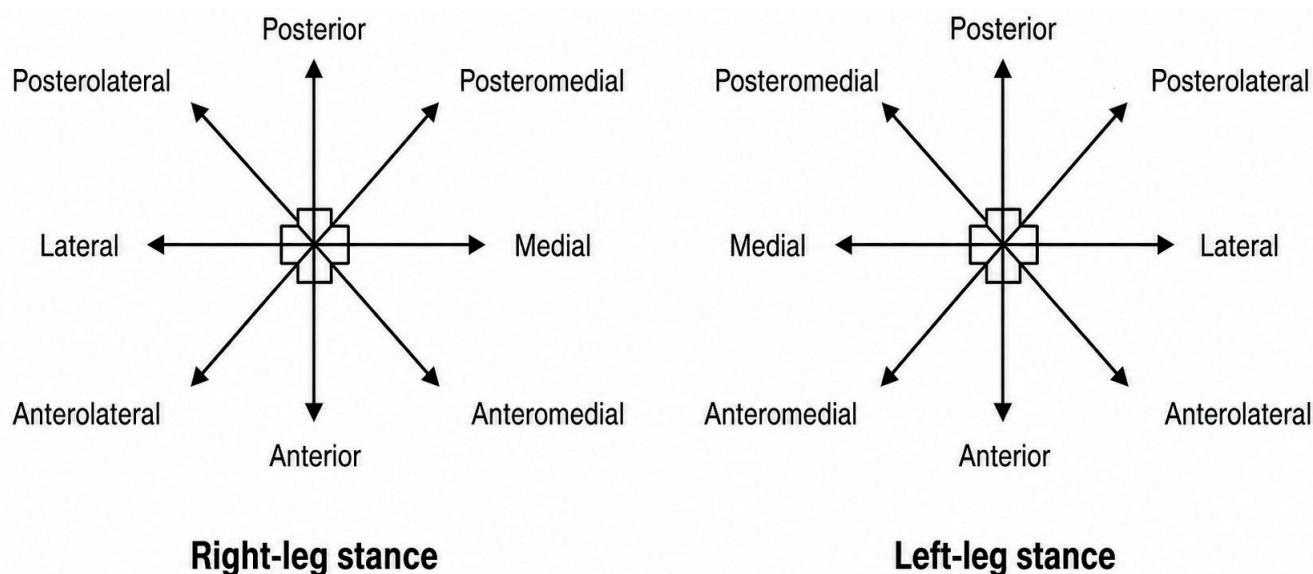


Figure 2. Directions of movement in the Star Excursion Balance Test (SEBT), based on the standard SEBT protocol [11]

each cone in the designated order, and returned to the starting point (Figure 1).

A stopwatch was used to time the trials. Each athlete performed two trials, and the average of the recorded times was calculated. The objective was to complete the task in the shortest possible time.

Dynamic balance was assessed using the Star Excursion Balance Test (SEBT) [11], as shown in Figure 2. Athletes stood on one leg at the center of the star and attempted to reach the ground with the opposite foot in all directions. If balance was lost, the attempt was corrected and repeated. The test was performed on both legs, and the maximum reach distance was recorded using a tape measure. To account for individual differences in anthropometry, SEBT reach distances were normalized to participants' body height [normalized score = (reach distance / body height) × 100].

The Closed Kinetic Chain Upper Extremity Stability Test was used to assess upper-limb stability in athletes. In a push-up position, with the hands placed 91 cm apart, athletes alternated touching designated points for 15 seconds. Two trials were performed, and the average result was recorded. The test was repeated if the torso was not kept horizontal, the hands missed the designated points, or the feet moved apart.

Athletes' agility was assessed using the Defensive Sliding Test (Figure 3). Five cones were arranged, and participants performed movements (sprinting, backward running, and defensive footwork) between the cones as instructed. The test ended when both feet crossed the finish line. After one trial, two timed attempts were

performed using a stopwatch, and the average result was recorded. The test was considered invalid if the cones were not properly navigated or if legs were crossed during defensive footwork.

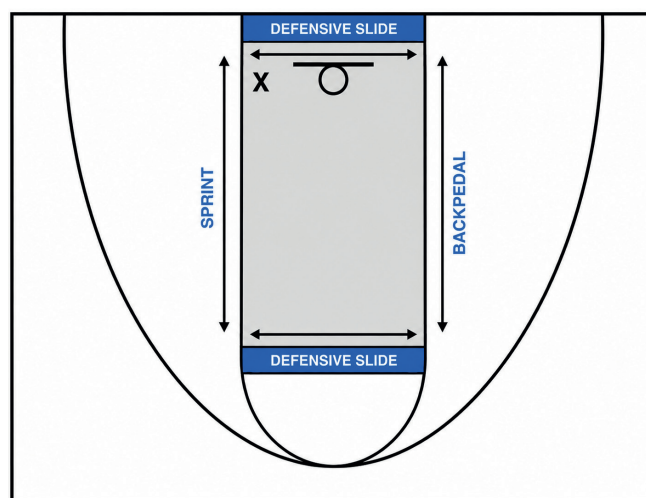


Figure 3. Defensive Sliding

Shooting accuracy and speed were assessed using the Speed Spot Shooting Test [12], as shown in Figure 4. Athletes aimed to score as many points as possible within 60 seconds from five designated shooting spots. The first shot was taken from the free-throw line, after which players could freely choose the order of their remaining shots, ensuring one close-range attempt from each spot. A shot was considered invalid if the player attempted it from an undesigned location or failed to

complete the required close-range attempt. Points were awarded for successful shots, and the best result from three attempts was recorded.

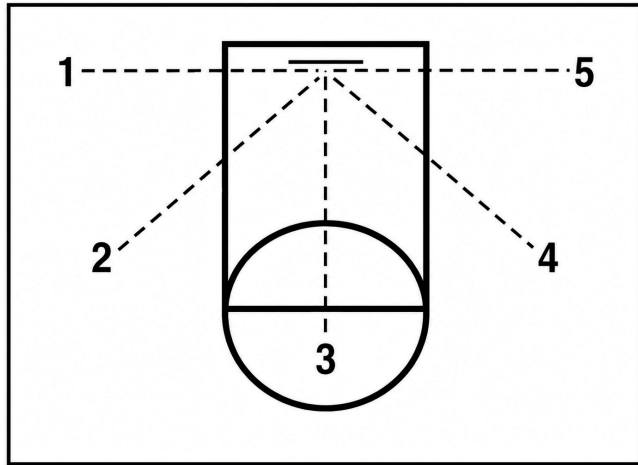


Figure 4. Throwing accuracy test

The implemented neuromuscular training program was conducted over a 12-week period, integrated into regular training sessions every Monday, Wednesday, and Friday during the spring season. Prior to the first session, the basketball players were introduced to the training program, which included a detailed explanation of the exercise sequence and the required equipment. The program was structured according to the principle of progression. Each session began with a warm-up phase, emphasizing its importance. This was followed by the main phase, consisting of three sport-specific balance exercises and a five-minute dynamic stretching routine. The main phase was then succeeded by sport-specific training as directed by the coach. The cool-down phase included three balance exercises, which were followed by stretching the muscles engaged during the session. Balance exercises performed on the Dynair pad were executed barefoot to maximize proprioceptive engagement.

Proper execution of the program required initiating and completing the movements from the correct starting position. Success relied on focus, avoiding excessive speed or hurried execution, and maintaining proper balance. For certain exercises, athletes performed the tasks barefoot on a Dynair pad to maximize proprioceptive engagement.

Data were recorded and analyzed using Microsoft Excel 2013. Differences between pre- and post-program measurements were examined using a paired sample t-test, with the significance level set at $p < 0.05$.

For the SEBT, the dependent variable was the reach distance (in centimeters) in the anterior, anteromedial,

medial, posteromedial, posterior, posterolateral, lateral, and anterolateral directions for both the right and left legs. For the Closed Kinetic Chain Upper Extremity Stability Test, the dependent variable was the number of hand touches completed within the specified time interval.

Independent variables included the intervention (neuromuscular training program) and participant characteristics (age and height). Standardized contextual conditions included consistent equipment and basketball size across sessions.

Literature review

Zacharakis et al. [12] found that proprioceptive and balance training improved both dynamic and static balance, as well as passing ability, in male and female basketball players.

Kostopoulos et al. [13] investigated the effects of a 12-week balance and proprioceptive training program on amateur basketball players. The training program progressively increased in difficulty and focused on exercises related to passing. The study involved 26 amateur basketball players, with the experimental group consisting of 13 players (mean age 22.69 ± 0.70 years) and the control group also comprising 13 players (mean age 21.61 ± 0.71 years). Both groups included players in all positions (point guard, forward, center). The program utilized balance boards, Bosu balls, Togus, and trampolines. Data were statistically analyzed, with the significance level set at $p = 0.05$. The results revealed that the experimental group significantly improved their performance by 14.92%, compared to a 1.72% improvement in the control group ($p = 0.002 < 0.05$). These findings demonstrated that balance and proprioceptive training significantly enhance passing skills in amateur basketball players.

Effects of neuromuscular training

Ondra et al. [14] demonstrated that a 20-week neuromuscular training program positively impacted the postural stability of male youth basketball players, which is crucial for preventing lower limb injuries.

Eils et al. [15] found that a proprioceptive training program effectively reduced the incidence of ankle injuries and improved neuromuscular performance in basketball players. Their study included 232 players from 35 teams, with 198 athletes ultimately included after excluding those using external braces. During the season, the experimental group (performing proprioceptive training) reported 7 ankle injuries compared to 21 in the control group.

Fisek and Agopyan [16] investigated the effects of neuromuscular training on male youth basketball players (mean age: 15.53 ± 0.57 years). Over the period of six weeks, 25 participants trained twice a week for 35–50 minutes on stable and unstable surfaces. Results showed that training on unstable surfaces improved shooting accuracy, balance, and passing speed, while training on stable surfaces did not enhance passing speed and had a smaller effect on shooting accuracy.

Canlı [17] examined the impact of an 8-week neuromuscular training program on prepubescent male basketball players. The experimental group participated in specialized training twice a week, while the control group engaged in traditional basketball training. The results revealed positive effects of the program on motor and basketball-specific skills.

Sevrez and Bourdin [18] studied the influence of upper-limb proprioception on shooting accuracy in basketball players. The data demonstrate that the success of free throws is partially determined by the players' ability to sense the position of distal joints in their shooting arm. From a motor control perspective, this indicates that basketball players may organize compensatory behavior across their shooting arm joints based on proprioceptive input.

These studies highlight the importance of balance and neuromuscular training in improving motor and basketball-specific technical skills.

Basketball is a high-contact sport that challenges balance and stability. Players often experience balance deficits or neuromuscular control issues, increasing the risk of injuries. Domeika et al. [19] investigated the effects of an 8-week basketball-specific balance training program using a newly developed uniaxial instability balance board among Lithuanian university basketball players. The training, conducted three times per week for 20 minutes, significantly improved dynamic balance and emphasized the importance of proprioception in injury prevention.

Bajramović et al. [20] evaluated the effects of a 6-week balance training program on the stability of young basketball players. Using the Biodex Balance System, they measured the ability to maintain dynamic unilateral and bilateral posture on stable and unstable surfaces. Results suggested that the program effectively improved motor coordination, core stability, and muscle strength, leading to enhanced agility—an essential skill in basketball.

Gidu et al. [21] explored the effects of proprioceptive training on 14-year-old soccer players, finding that an 8-week program improved balance, agility, strength, and sport-specific performance.

Overall, these studies indicate that specialized balance and neuromuscular training positively influence balance, stability, and performance across various sports and age groups.

Filipa et al. [22] examined the effects of a neuromuscular training program on adolescent female soccer players using the SEBT, a functional screening tool for dynamic stability. Following the 8-week training period, the experimental group showed significant improvements in SEBT scores for both limbs, whereas the control group showed no significant changes. The study suggests that neuromuscular training enhances core stability and lower-limb strength in adolescent female soccer players. Munro and Herrington [11] demonstrated that SEBT is a reliable tool for measuring dynamic balance in healthy athletes. They found that normalized score changes of at least 6–8% are required to confirm genuine improvements in SEBT performance.

These studies collectively suggest that neuromuscular training programs can enhance balance and stability, particularly in athletes, and that SEBT is a reliable measure for assessing dynamic balance.

Results

The purpose of the study was to examine the improvement in basketball players' balance abilities as a result of proprioceptive training, with a specific focus on the SEBT results. Differences between pre- and post-training results were analyzed using paired t-tests.

The results for the left leg demonstrate that the basketball players' balance abilities significantly improved in several SEBT directions as a result of the training. The most substantial improvement occurred in the posterior direction, where the average reach distance increased by 11 cm ($p < 0.003$). The maximum reach distance in this direction improved from 98 cm to 107 cm, and the largest individual improvement was observed in one player, whose reach distance increased from 55 cm to 107 cm.

Significant improvements were also observed in the anterior direction ($p < 0.004$), with an average increase of 9 cm in reach distance. The largest individual improvement in this direction was from 47 cm to 105 cm. In the lateral direction, a significant improvement was recorded ($p < 0.007$), with an average increase of 7 cm in reach distance. The largest individual improvement was 37 cm.

For the posteromedial direction, significant improvement was also noted ($p < 0.011$), with an average increase of 8 cm in reach distance. The largest individual improvement was 35 cm.

In the anteromedial direction, improvement was observed ($p < 0.034$), with an average increase of 8 cm in reach distance. The largest individual improvement was 54 cm.

No significant improvement was observed in the medial and posterolateral directions ($p < 0.063$, $p < 0.020$), although the average values showed some improvement. Similarly, no significant changes were detected in the anterolateral direction ($p < 0.720$), although minor improvements were observed (Table 1). The normalized SEBT scores showed significant improvements in most directions, with the greatest increase observed in the posterior direction (from 56.03% to 63.11% of body height).

For the right leg, significant improvements were observed in several directions among basketball players ($p < 0.05$). The most substantial improvement occurred in the medial direction ($p < 0.0002$), where the average reach distance increased by 15 cm. The largest individual improvement was recorded in one player, whose reach distance increased from 39 cm to 93 cm.

In the posteromedial direction, significant improvement was also noted ($p < 0.001$), with an average increase of 9 cm in reach distance. The largest individual improvement was 34 cm.

Significant improvement was registered in the anterior direction as well ($p < 0.0016$), with an average increase of 9 cm in reach distance. The largest individual improvement in this direction was an increase of 43 cm. In the lateral direction, although the improvement was not statistically significant ($p < 0.104$), one player showed a notable increase of 50 cm in reach distance. Minimal changes were observed in the anterolateral direction ($p < 0.41$), although some players exhibited improvements.

Comparing the two legs, players standing on their right leg generally demonstrated more significant improvements in SEBT performance than when standing on their left leg. While some improvements were observed for the left leg, the right leg showed a stronger response to the training program.

These findings indicate that proprioceptive training has a positive impact on basketball players' balance abilities. The variability in improvements for the left leg may partially be attributed to differences in motivation and anthropometric characteristics.

Our study results suggest that a 12-week neuromuscular training program, combined with regular basketball training, positively affects the

Table 1. The results of the study on the improvement of balance ability

Direction	Measurement	Minimum (cm)	Maximum (cm)	Average (cm)	Normalized (%)	<i>p</i> -value
Anterior	I. measurement	40	80	59	38.00%	$p < 0.004$
	II. measurement	52	97	68	43.79%	
Anterolateralis	I. measurement	49	80	62	39.93%	$p < 0.720$
	II. measurement	61	100	63	40.57%	
Lateralis	I. measurement	30	77	54	34.78%	$p < 0.007$
	II. measurement	66	79	61	39.29%	
Posterolateralis	I. measurement	44	110	81	52.17%	$p < 0.106$
	II. measurement	77	112	87	56.03%	
Posterior	I. measurement	50	116	87	56.03%	$p < 0.003$
	II. measurement	98	118	98	63.11%	
Posteromedialis	I. measurement	49	150	86	55.39%	$p < 0.011$
	II. measurement	84	155	94	60.54%	
Medialis	I. measurement	51	110	76	48.95%	$p < 0.063$
	II. measurement	55	121	83	53.45%	
Anteromedialis	I. measurement	54	82	65	41.86%	$p < 0.034$
	II. measurement	70	87	73	47.01%	

balance abilities, joint stability, upper-limb stability, agility, and sport-specific technical skills of adolescent basketball players.

Agility T-Test

The results of the Agility T-Test were compared pre- and post-training using paired t-tests.

The evaluation showed a significant improvement in agility performance following the training program, with an average improvement of 0.78 seconds (Cohen's $d = 1.37$, indicating a large effect size; $p < 0.00$).

Before the training, the shortest recorded time was 9.175 seconds, and the longest was 13.25 seconds. By the end of the intervention period, these times had decreased to 8.535 seconds and 11.615 seconds, respectively. All participants showed better results during the second measurement after the neuromuscular training program. Individual improvements ranged from a minimum of 0.055 seconds to a maximum of 2.5 seconds.

Averaging the results for all athletes, the mean Agility T-Test time decreased from 11.12 seconds before the training to 10.33 seconds after the training, indicating an average improvement of 1.022 seconds.

Agility and Defensive Cone Drills Test

The Agility and Defensive Cone Drills Test was also assessed before and after the neuromuscular training program, showing a significant improvement in agility performance ($p < 0.05$). Before the training, the best recorded time was 9.17 seconds, and the worst was 14.44 seconds. By the end of the intervention, these times had decreased to 8.65 seconds and 13.86 seconds, respectively.

Averaging the results for all athletes, the mean test time decreased from 12.05 seconds to 11.67 seconds, reflecting an average improvement of 0.38 seconds. Statistical analysis confirmed this improvement as significant ($p < 0.034$) (Table 2). Cohen's $d = 1.37$, indicating a large effect size.

Closed Kinetic Chain Upper Extremity Stability Test results

The results of the Closed Kinetic Chain Upper Extremity Stability Test were analyzed using paired t-tests. The evaluation demonstrated a significant improvement in upper-limb stability among basketball players following the neuromuscular training program ($p < 0.05$).

Before the training, the number of touches achieved in 15 seconds ranged from 24 to 48. After the training, nearly all participants improved their performance, except for three players. The smallest improvement was an increase of 3 touches, whereas the largest was 21

Table 2. Agility and Defensive Cone Drills Test Results

	1. measurement	2. measurement	improvement
	11,96	11,085	0,875
	13,25	11,29	1,96
	9,175	8,535	0,64
	11,05	10,465	0,585
	10,645	10,13	0,515
	12,87	11,4	1,47
	12,05	11,115	0,935
	10,205	9,8	0,405
	9,38	9,15	0,23
	9,915	9,86	0,055
	12,145	11,08	1,065
	10,45	9,99	0,46
	11,055	10,055	1
	11,275	10,925	0,35
	10,165	9,425	0,74
	11,95	10,435	1,515
	11,25	9,315	1,935
	9,72	9,69	0,03
	9,935	9,525	0,41
	12,925	11,35	1,575
	10,045	9,67	0,375
	11,93	11,365	0,565
	13,4	11,615	1,785
	9,89	9,715	0,175
average	11	10	
average improvement	1		

Note: Cohen's $d = 1.37$ (large effect)

touches. Two players showed decreased performance, with results ranging from -10 to -1, and one player exhibited no change between the two measurements. The average number of touches increased from 33 before the training to 41 afterward. Statistical analysis confirmed this improvement as significant ($p < 0.00$).

Shooting accuracy test results

Shooting accuracy is a critical component of basketball performance. The shooting accuracy test was conducted at the beginning and the end of the 12-week program,

and the results were analyzed using paired t-tests. The statistical analysis showed a non-significant trend toward improvement ($p = 0.08$), although average scores indicated progress.

Before the training, the average total score was 13, which increased to 15 after the program, reflecting an average improvement of 1.45 points. The lowest performance before training was 4 points, and the highest was 22 points. After the intervention, these scores improved to 6 and 24 points, respectively. Although a slight improvement in shooting accuracy was observed based on average values, the lack of statistical significance indicates considerable variability among participants.

It is important to note that individual differences in performance may stem from motivational or other personal factors. However, overall, our study indicates that proprioceptive training is an effective method for enhancing basketball players' performance in balance, agility, and upper-body stability, while also showing a positive trend in shooting accuracy.

Discussion

The present study evaluated the effects of a structured 12-week neuromuscular (proprioceptive-focused) training program integrated into regular basketball practice on adolescent basketball players' dynamic balance, agility, upper-limb stability, and shooting accuracy. The significant improvement in SEBT scores suggests that neuromuscular training, by enhancing proprioceptive feedback and motor control, effectively stabilizes the joints and improves postural stability in young athletes. The findings indicate that dynamic balance and agility improved significantly, upper-limb stability was enhanced, and moderate - though statistically non-significant - improvements were observed in shooting accuracy.

Significant improvements in dynamic balance, as assessed by the SEBT, particularly in the anterior, posterior, anteromedial, and posteromedial directions, confirm the first hypothesis (H1). Our hypothesis that proprioceptive training would improve balance was supported, as significant improvements were observed in SEBT scores ($p < 0.001$). These findings are consistent with previous studies [12, 13], which reported enhanced balance performance following proprioceptive training interventions. However, no significant improvements were recorded in certain directions (anterolateral and lateral), indicating direction-specific variability in the response to the intervention.

The significant improvements in agility, measured through the Agility T-Test and Defensive Cone Drill

Test, support the second hypothesis (H2). These results align with previous research emphasizing the importance of neuromuscular and proprioceptive training in enhancing movement efficiency, reaction time, and coordination [8, 10, 21]. Agility, a key factor in basketball, benefits from enhanced dynamic stability and motor control, both targeted effectively by the implemented training program.

Regarding shooting accuracy (H3), although average performance scores increased after the intervention, the improvement did not reach statistical significance ($p = 0.08$). This partial confirmation is comparable to the findings of Fisek and Agopyan [16] and Sevrez and Bourdin [18], who also noted that proprioceptive training alone may not lead to major improvements in shooting accuracy unless combined with specific technical training targeting the shooting mechanics and shoulder stability.

The significant improvement in upper-limb stability, measured by the Closed Kinetic Chain Upper Extremity Stability Test, indicates that the intervention may also have beneficial effects beyond lower-limb balance. Previous research has highlighted the importance of upper-limb proprioceptive information for shooting performance in basketball [18]. This study provides new insights into the combined effects of proprioceptive training on multiple dimensions of basketball performance, particularly emphasizing its influence on balance, agility, and upper body stability in adolescent athletes. Unlike many previous studies focusing solely on adult or elite athletes, our findings highlight the potential of structured proprioceptive programs at early stages of athletic development, offering a practical and evidence-based approach for youth basketball coaching. The practical implications are substantial: integrating proprioceptive training into regular youth basketball practice can enhance critical physical abilities, contribute to injury prevention, and support the long-term technical and athletic development of young players.

However, several significant limitations must be acknowledged. The most critical limitation is the absence of a control group, which prevents the definitive attribution of the observed improvements solely to the neuromuscular training intervention. Due to this study design, it is impossible to clearly distinguish the intervention's effects from natural biological development (maturation) of the adolescent participants, the potential test-learning effect from repeated assessments, or the influence of regular, sport-specific basketball training. Consequently, while the results show positive trends, the causal inference remains

weakened. As this was a pilot study, future research should employ a randomized controlled trial design with a larger sample size to validate these findings and isolate the specific impact of neuromuscular exercises from other developmental factors. The findings should be interpreted as preliminary observational outcomes rather than causal evidence. This study reinforces the importance of proprioceptive training as an effective tool for developing dynamic balance, agility, and upper-body stability in youth basketball players, while suggesting that improvements in shooting performance may require additional targeted interventions.

Conclusions

The aim of this study was to examine the effects of proprioceptive training on the physical and technical abilities of adolescent basketball players. The 12-week program focused on improving balance, agility, joint stability, and shooting accuracy. Participants were assessed using a longitudinal, quantitative methodology and various tests, including the SEBT and the Speed Spot Shooting Test.

The results indicated that the training led to significant improvements in balance abilities, particularly in the posterior and anterior directions. Agility showed substantial progress, while shooting accuracy exhibited only a non-significant trend toward improvement ($p = 0.08$). Although the training positively influenced physical attributes such as balance and stability, its impact on sport-specific technical skills remains limited. The study suggests that neuromuscular training is an effective method for enhancing adolescent basketball players' physical performance, but shooting accuracy may require more targeted technical interventions. Based on these findings, it is recommended to incorporate such training programs into the development routines of youth basketball players to promote long-term success. Proprioceptive training significantly enhances balance and agility among youth basketball players and should be incorporated into regular training programs to optimize player development and reduce injury risk. The integration of proprioceptive training into youth basketball practices can be implemented, for example, through a three-times-per-week training program to support injury prevention and promote technical development.

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Conflict of Interest

The authors declare no conflict of interest.

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