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The Effect of Spinal Stabilisation Exercises on the Static and Dynamic Balance of Young Basketball Players

Eglė Lencevičiūtė*, Dalia Mickevičienė, Jūratė Požėrienė
Lithuanian Sports University, Kaunas, Lithuania
** Correspondence: egle.lenceviciute@stud.lsu.lt; +370 676 50 982*

ABSTRACT

Background: This study addresses the need to better understand the effects of spinal stabilisation on movement biomechanics and injury prevention in young basketball players. Such knowledge may support the development of more effective training programmes aimed at improving performance and reducing injury risk.

Methods: The study involved 30 subjects who play basketball four times a week, all of whom were born in the same year and belong to the U15 age group. The subjects were divided into two groups: experimental ($n = 18$) and control ($n = 12$). The assessment was carried out twice, before and after a four-week core stabilisation exercise programme. Static balance was assessed using a one-leg standing test with eyes closed. Dynamic balance was assessed using the Y-Balance Test.

Results: After four weeks of the exercise programme, the experimental group's static balance improved significantly ($p < 0.05$). The dynamic balance results of the experimental group, assessed by the distance pushed away in cm and the composite score % for each direction, improved ($p < 0.05$) in all three directions for the left leg and in the posterolateral and posteromedial directions for the right leg. In the control group, improvement ($p < 0.05$) was observed in the posterolateral direction with the left leg and in the posteromedial direction with the right leg. When evaluating the composite score, the results improved ($p < 0.05$) in both groups.

Conclusion: Spinal stabilisation exercises can effectively improve both static and dynamic balance in young basketball players, indicating their potential value for performance enhancement and injury prevention.

Keywords: Core stability, postural control, youth athletes

1. INTRODUCTION

Basketball is one of the most widely practiced team sports worldwide which places high physical and neuromuscular demands on young athletes. During the game, players repeatedly perform sprinting, jumping, landing, rapid changes of direction, and engage in contact situations, all of which require well-developed balance, postural control, and coordinated movement patterns. Recent research highlights that neuromuscular control plays a key role in injury prevention and functional performance, particularly during adolescence, when the developing musculoskeletal system is especially vulnerable (McGinley et al., 2024; Park et al., 2025). Effective trunk and spinal stabilisation is therefore essential for maintaining body alignment, ensuring efficient force transfer between body segments, and controlling movement under dynamic conditions (Huang et al., 2025).

Balance is a multifactorial motor ability regulated by the sensory, vestibular, visual, and proprioceptive systems, as well as the central nervous system. Both static and dynamic balance are crucial for basketball performance: static balance ensures stability during shooting or defensive stance, while dynamic balance supports efficient movement during cutting, landing, and accelerating (García et al., 2020; Yılmaz et al., 2024). Poor balance has been associated with reduced movement efficiency and a higher risk of lower-limb injuries, especially ankle sprains and knee ligament damage (Stiffler et al., 2017; Zhang et al., 2025). These risks are amplified during the adolescent growth spurt (peak height velocity), when rapid changes in anthropometric characteristics can temporarily impair coordination and postural stability (Chaari et al., 2022; Wik, 2022).

Core or spinal stabilisation training has been increasingly recognised as an effective method for improving neuromuscular control, enhancing functional stability, and reducing injury risk in young athletes. Strengthening the deep and superficial trunk muscle groups contributes to improved postural control and more efficient kinetic-chain function during sport-specific tasks (Luo et al., 2023; Wang et al., 2025). Previous studies show that structured core stability programmes can significantly improve balance outcomes in youth athletes and may mitigate the temporary loss of coordination typical of the adolescent maturation phase (Feng et al., 2024; Gong et al., 2024).

Despite growing scientific interest, research investigating the effects of spinal stabilisation exercises on both static and dynamic balance among young basketball players remains limited. Understanding these effects may contribute to the development of more effective training programmes and targeted injury prevention strategies for youth sport.

Therefore, the aim of this study was to determine the effect of spinal stabilisation exercises on the static and dynamic balance of young basketball players.

2. METHODS

Participants.

The study involved 30 male adolescent basketball players (U15 age group), all born in the same year and practicing basketball at least four times per week. The participants had a minimum of two years of sport experience and no musculoskeletal injuries that could influence balance performance. They were divided into two groups based on their teams: an experimental group (n = 18) and a control group (n = 12). All participants and their parents were informed about the study procedures and provided written consent prior to participation. The study was approved by the Lithuanian Sports University Bioethics Committee (approval No. MI-KIN (M)-2025-781).

Procedures.

The assessments were conducted twice: before and after a four-week spinal stabilisation exercise programme. Both testing sessions were completed in a school gymnasium where regular basketball training took place. Prior to testing, all participants performed a standardised 10-minute warm-up.

- **Experimental group:** Performed a spinal stabilisation exercise programme for four weeks, four times per week, before each basketball practice. The programme consisted of five core stabilisation exercises and lasted approximately 12 minutes per session.
- **Control group:** Continued their regular basketball warm-up and training without additional stabilisation exercises.

Static balance assessment.

Static balance was evaluated using the One-Leg Standing Test with eyes closed. Participants stood barefoot on a flat surface with hands on hips and one leg flexed at approximately 90°. Each participant performed three attempts on each leg, with 30-second rest intervals. Time was recorded until balance was lost or a maximum of 60 seconds was reached. The best trial was used for analysis (Blodgett et al., 2023; Springer et al., 2007).

Dynamic balance assessment.

Dynamic balance was assessed using the Y-Balance Test (YBT). Participants reached in three directions – anterior, posteromedial, and posterolateral – while standing on the test leg. Three trials were performed in each direction with 30-second rest intervals. Leg length was measured from the anterior superior iliac spine to the medial malleolus, and composite scores (%) were calculated following standardised formulas (Bertrand-Charette et al., 2023; Zając et al., 2024). Trials were repeated if participants lost balance, touched the ground, or failed to return to the starting position.

Spinal stabilisation exercise programme.

The four-week programme included five core stabilisation exercises targeting deep and superficial trunk muscles. Exercises progressed gradually and emphasised maintaining neutral spine alignment, controlled breathing, and proper movement execution. Each session lasted approximately 12 minutes and was supervised to ensure correct technique. The programme followed recognised principles of youth training load, progression, and neuromuscular control development (Gong et al., 2024; Luo et al., 2023).

Statistical analysis.

Data were analysed using *Microsoft Excel 2013* and *IBM SPSS Statistics version 28.0*. Descriptive statistics, including means and standard deviations, were calculated to characterise the study variables.

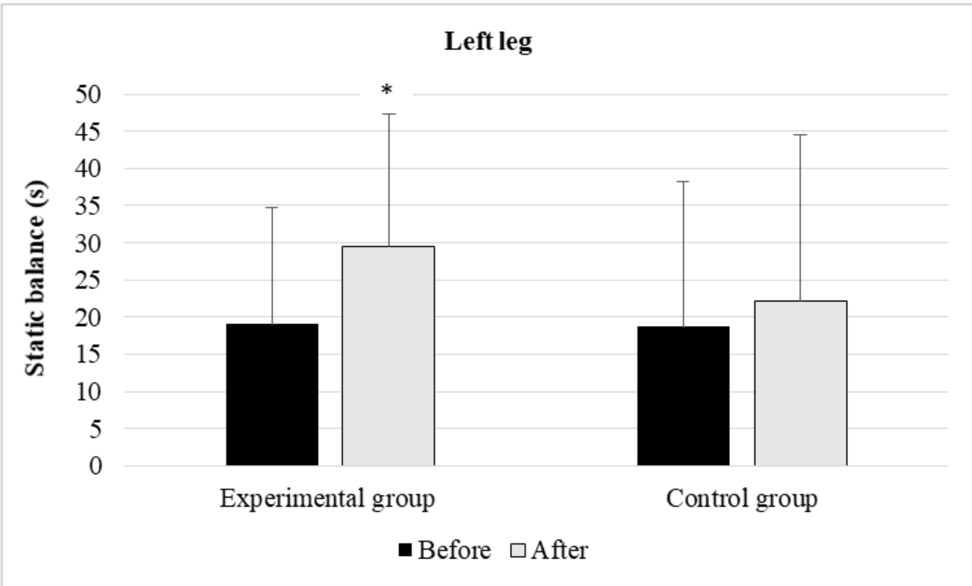
Within-group differences between pre- and post-intervention measurements were assessed using the paired-samples Student's *t*-test to determine the effects of the intervention. Between-group differences were analysed using the independent-samples Student's *t*-test.

Statistical significance was set at $p < 0.05$.

3. RESULTS

Comparison of static balance performance before and after the intervention (Figure 1) showed a significant improvement in the experimental group when standing on the left leg. Static balance time increased from 16 ± 15.6 s to 27 ± 16.29 s, representing an improvement of 11 s ($p < 0.05$). In the control group, static balance time while standing on the left leg increased from 15 ± 15.7 s to 19 ± 20.2 s (an improvement of 4 s); however, this change was not statistically significant.

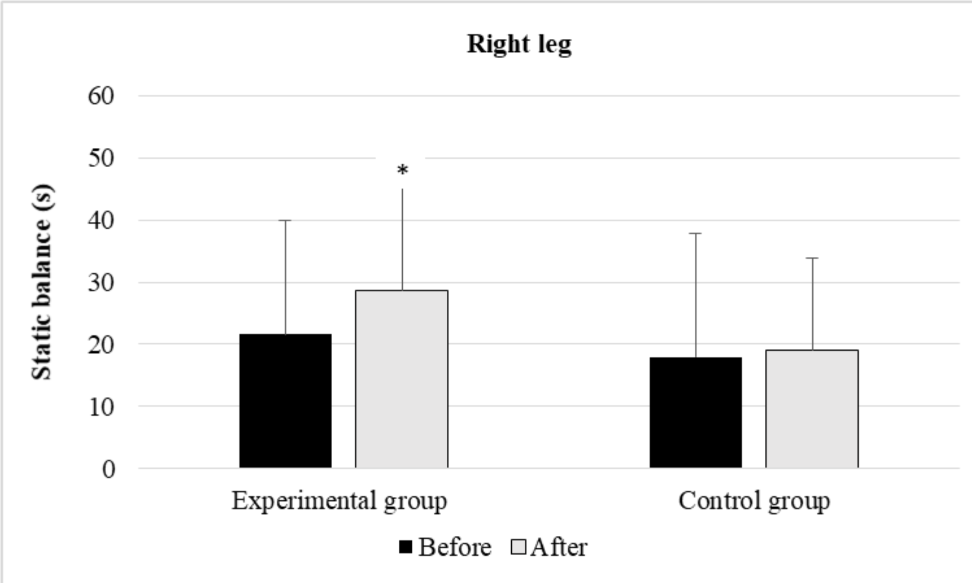
Figure 1. **Static balance results of the left leg in the experimental and control groups**



Note: $p < 0.05$.

Comparison of static balance performance before and after the intervention (Figure 2) revealed a significant improvement in the experimental group when standing on the right leg. Static balance time increased from 19 ± 16.2 s to 25 ± 17.5 s, corresponding to an improvement of 6 s ($p < 0.05$). In the control group, static balance time while standing on the right leg increased from 14 ± 16.2 s to 16 ± 8.6 s (an improvement of 2 s); however, this change was not statistically significant.

Figure 2. **Static balance results of the right leg in the experimental and control groups**



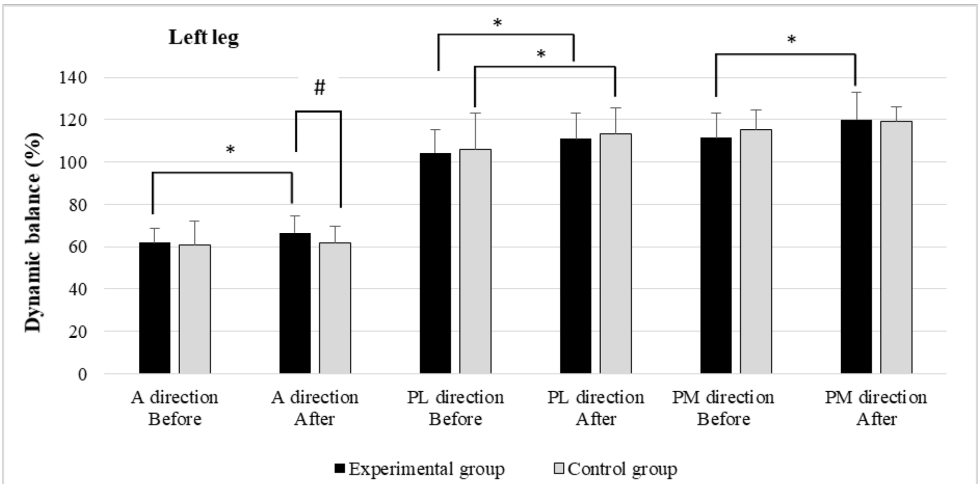
Note: $p < 0.05$.

Comparison of dynamic balance performance before and after the intervention (Figure 3) demonstrated significant improvements in the experimental group when standing on the left leg. In the anterior direction, dynamic balance scores increased from 62 ± 6.6% to 66 ± 8.0%, representing an improvement of 4% ($p < 0.05$). In the posteromedial direction, values increased from 104 ± 11.0% to 111 ± 12.3%, corresponding to an improvement of 7% ($p < 0.05$). In the posterolateral direction, dynamic balance improved from 112 ± 11.6% to 120 ± 13.0%, indicating an increase of 8% ($p < 0.05$).

In the control group, dynamic balance while standing on the left leg increased from 61 ± 11.2% to 62 ± 8.3% in the anterior direction (1% improvement), from 106 ± 17.4% to 113 ± 12.3% in the posteromedial direction (7% improvement, $p < 0.05$), and from 115 ± 9.6% to 119 ± 6.8% in the posterolateral direction (4% improvement); however, not all changes reached statistical significance.

A significant between-group difference was observed in the anterior direction of the left leg after the intervention ($p < 0.05$).

Figure 3. **Dynamic balance results of the left leg in the experimental and control groups**

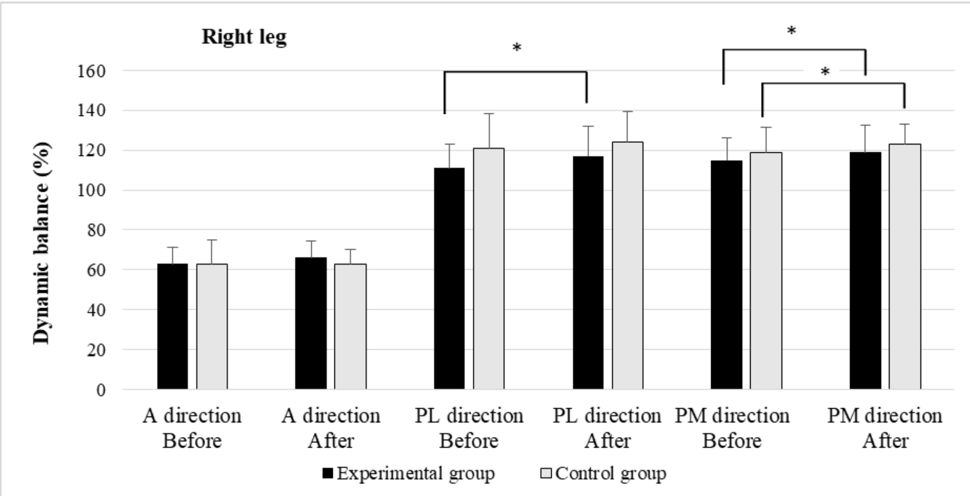


Notes: A – anterior direction; PL – posterolateral direction; PM – posteromedial direction. $p < 0.05$.

Comparison of dynamic balance performance before and after the intervention (Figure 4) showed improvements in the experimental group when standing on the right leg. In the anterior direction, dynamic balance scores increased from 62 ± 8.3% to 64 ± 8.2%, representing an improvement of 2%. In the posteromedial direction, values increased from 109 ± 12.2% to 115 ± 14.9%, corresponding to an improvement of 6% ($p < 0.05$). In the posterolateral direction, dynamic balance improved from 111 ± 11.4% to 117 ± 13.6%, also indicating a 6% increase ($p < 0.05$).

In the control group, dynamic balance while standing on the right leg remained unchanged in the anterior direction (62 ± 11.7% before and 62 ± 7.4% after the four-week period). In the posteromedial direction, scores increased from 121 ± 17.3% to 124 ± 15.4%, representing a 3% improvement, whereas in the posterolateral direction, values increased from 118 ± 12.2% to 123 ± 9.9%, corresponding to a 5% improvement ($p < 0.05$).

Figure 4. **Dynamic balance results of the right leg in the experimental and control groups**



Notes: A – anterior direction; PL – posterolateral direction; PM – posteromedial direction. $p < 0.05$.

4. DISCUSSION

Main findings.

The results of this study show that a four-week spinal stabilisation exercise programme improved both static and dynamic balance in young basketball players. Significant changes were observed only in the experimental group, and a between-group difference appeared in the anterior direction of the left leg, suggesting that balance adaptations may be direction-specific.

Effects of spinal stabilisation exercises on static balance.

The improvement in static balance in the experimental group indicates that spinal stabilisation exercises enhance neuromuscular control and postural steadiness in adolescents. Recent research supports this finding, showing that strengthening deep trunk muscles improves postural control and reduces balance asymmetry in youth athletes (Chaari et al., 2025; Zhou et al., 2024). These improvements can be related to enhanced activation of the core musculature, which stabilises the spine and pelvis during single-leg stance tasks (Luo et al., 2023; Wang et al., 2025). The absence of significant changes in the control group confirms that regular basketball warm-ups do not provide sufficient stimulus to improve static balance over a short time frame.

Effects on dynamic balance.

Dynamic balance improved significantly in almost all directions of the Y-Balance Test in the experimental group. These results are consistent with previous studies reporting that core stability training increases reach distances and enhances functional stability in adolescent athletes (Feng et al., 2024; Gong et al., 2024). The greatest improvements occurred in the posteromedial and posterolateral directions, which require coordinated control of the hip and trunk. This aligns with evidence suggesting that these directions are most sensitive to changes in neuromuscular control (Gomes et al., 2024; Zając et al., 2024). In the control group, only small and isolated changes were seen, which matches earlier findings that general training does not substantially influence directional balance performance (Cinarli et al., 2022).

Between-group differences.

Although both groups improved to some extent, only one statistically significant between-group difference was detected: the anterior direction of the left leg. Previous research has shown that the anterior reach is particularly sensitive to lower-limb control and may reflect early improvements in neuromuscular efficiency (McGinley et al., 2024; Stiffler et al., 2017). This directional specificity suggests that stabilisation exercises may initially influence movements requiring sagittal-plane control.

Practical implications.

The findings highlight the importance of including spinal stabilisation exercises in youth basketball training. Improved balance is associated with decreased injury risk, especially in the ankle and knee joints. This is consistent with neuromuscular warm-up studies showing reduced lower-limb injury rates in youth athletes (Emery et al., 2022; Lutz et al., 2024). Therefore, stabilisation training may contribute to safer landings, improved changes of direction, and better overall postural control.

Limitations and future research.

The intervention lasted only four weeks, which may limit the extent of measurable adaptations. Participants were also of similar age and training background, reducing generalisability. Future research should explore longer training periods, include a broader age range, and incorporate biomechanical assessments to better understand how spinal stabilisation training influences performance and injury prevention.

5. CONCLUSIONS

The four-week spinal stabilisation exercise programme improved both static and dynamic balance in young basketball players, with significant changes observed only in the experimental group. These results indicate that spinal stabilisation exercises are an effective means of enhancing postural control in adolescent athletes.

Future studies should evaluate longer training periods and different age groups to better understand the long-term effects of such interventions.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study, and written consent was provided by their parents or legal guardians.

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Conflicts of Interest: The authors declare no conflict of interest.

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