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Impact of Corrective Exercises on Postural Stability in 16-Year-Old Female Basketball Players in Albania

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Abstract

Spinal abnormalities are seen even in team sports. The purpose of this study was to assess how a 14-week corrective exercise program affected the improvement of postural stability in 16-year-old female basketball players. In total, 50 female basketball players from 4 different Sports Associations in Tirana, Albania, aged 16 years, were chosen at random and split into two groups: the Experimental Group (n=25; EXG) and the Control Group (n=25; COG). Anthropometric measures were taken of the two study groups in Body Height (cm; EXG: 165.12±4.73, COG: 169.26±2.89), Body Weight (kg; EXG: 64.84±9.72, COG: 62.27±6.24), and BMI (kg\m2; EXG: 21.73±3.34, COG: 22.27±1.42). Zebris system software, Win Spine 2.3, was used to examine body posture in parameters: Kyphosis/°, Lordosis/°, Left Scoliosis/°, Right Scoliosis/° before and after training for 14 weeks. Group differences measured in a 95% confidence interval were applied to variables. At p<0.05, statistical significance was recognized. Corrective exercises produced a significant change (p=0.014), with possible normalization of the lordotic curve. The results of this study showed improvements in postural stability in kyphosis-lordosis by practicing corrective exercises for 14 weeks in U-16 female basketball players. The overall sagittal shape of the spine may change under the influence of corrective exercises in this age group. These findings highlight the importance of practicing some corrective exercises to maintain correct body posture and contribute to the physical health of adolescents.

Keywords: *posture, kyphosis, basketball girls, lordosis, corrective exercises*

Introduction

Basketball is one of the most popular sports in the world, requiring a combination of physical, tactical, physiological, and mental skills for success (Erčulj & Štrumbelj, 2015). To meet the demands of this sport, players must demonstrate high levels of both anaerobic and aerobic capacity, as well as attributes such as strength, agility, multidirectional mobility, leaping ability, endurance, and sprinting performance (Ramos et al., 2019). Because of these requirements, coaches working with young athletes are encouraged to conduct regular physical and anthropometric assessments. Such evaluations help tailor training programs to athletes' developmental stages and maturity levels, ensuring that biological diversity among players is properly addressed (Lloyd et al., 2014; Malina et al., 2004).

Previous studies have demonstrated a complex relationship between biological maturity and physical performance (Lloyd et al., 2014; Malina et al., 2004; Ramos et al., 2019). One important aspect of performance in basketball is balance, or postural stability, which plays a vital role in both daily activities and athletic competition (Goldie et al., 1989; Guskiewicz et al., 2001). Postural stability is defined as the ability to maintain the body's center of gravity within the base of support (Huang & Brown, 2013). Effective postural control is achieved through neuromuscular adaptations and sensory feedback, improving athletic performance and lowering the risk of injury (Greig & Walker-Johnson, 2007; Ribeiro et al., 2008). However, fatigue can negatively affect balance, making it a critical factor to consider in training and performance.

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Spinal asymmetries and disorders of spinal statics are also common in sports, particularly those involving unilateral or repetitive loads, such as gymnastics, rowing, weightlifting, and figure skating (Baranto et al., 2009; Grabara & Hadzik, 2009). Such conditions may impair postural control and increase the risk of musculoskeletal problems. Importantly, female athletes may be at higher risk of injury due to biomechanical and neuromuscular differences, particularly during landing tasks (Bahr & Bahr, 1997; Renstrom et al., 2008).

In basketball, physiological demands extend beyond isolated physical attributes, as the sport requires repeated high-intensity efforts, rapid recovery, and the ability to sustain performance under varying tactical and competitive conditions (Montgomery et al., 2010; Ziv & Lidor, 2009). Seasonal fluctuations in training intensity and quality can further influence performance (Montgomery et al., 2008). Furthermore, spinal alignment has been linked to adolescent idiopathic scoliosis (AIS), with sagittal spine form emerging as a key factor in understanding risks of spinal deformities, particularly among females (Gardner et al., 2022). Metrics such as the kyphosis–lordosis (KL) difference have been proposed to better investigate these associations.

Differences in anthropometric characteristics and playing positions may also influence postural control in basketball (Ostojic et al., 2006). Muscle strength and power—two critical components of neuromuscular fitness—are fundamental for maintaining balance and preventing injuries (Caspersen et al., 1985; Gruber et al., 2007). Athletes must be able to generate muscular force quickly to stabilize their center of gravity under external constraints (Orr, 2010). Training interventions such as isometric strength training, corrective exercises, and proprioceptive drills have been shown to improve postural stability in basketball players (Arazi & Asadi, 2011; Zemková & Hamar, 2010).

Despite the growing number of initiatives promoting youth sports participation, data on the effects of structured training programs on postural control remain limited, particularly in female basketball players in Albania. Addressing this gap is crucial, as postural stability is directly linked to both performance optimization and injury prevention.

Therefore, the present study aims to evaluate the effects of a specific training program on the postural control of female basketball players. By addressing the lack of data in this context, the study seeks to provide evidence-based recommendations for improving balance, reducing injury risk, and supporting athletic development among young female athletes in Albania.

Methods

Participants

For our study, 50 female basketball players from four different Sports Associations in Tirana, Albania, were chosen at random and split into two groups: Experimental Group (EXG; n=25) and Control Group (COG; n=25). The subjects are female basketball players with at least 4 years of experience who practice for 90 minutes four times a week. All of the participants chosen for the study from the 4 sports associations were supposed to be equivalent in terms of age, competitive experience, and training methods; training days and hours were also supposed to be identical across groups. Anthropometric measures were taken of the two study groups (EXG and COG). Anthropometric measurements did not differ between the two groups, based on the data shown in Table 1.

Table 1. Anthropometric measurements of the female basketball players

Measure	Experimental Group	Control Group
Age	16.20 ± 0.53	16.10 ± 0.32
BH cm	165.12 ± 4.73	169.26 ± 2.89
BW kg	64.84 ± 9.72	62.27 ± 6.24
BMI kg/m^2	21.73 ± 3.34	22.27 ± 1.42

Procedure

All of the female basketball players agreed to participate in the study after being informed about the intervention process. In compliance with the Declaration of Helsinki's ethical guidelines, this study was approved by the Sports University of Tirana, Albania's Ethics Council (Nr. 1594/6 Prot., dated 01.07.2024), and all participants, together with their parents/coaches, signed a written informed consent form voluntarily before participating. The body posture and spinal deviation were assessed before and after a controlled exercise intervention using the Zebris System, Win Spine 2.3 software, which is housed in the University of Sports of Tirana's "Biomechanics" laboratory. Postural asymmetries were shown by posture analysis in the upright standing sagittal projection.

Instruments and test protocol

Zebris' spinal examination method is an external, non-invasive measurement method that uses an ultrasound-based motion analysis system. Zebris System (Zebris Medical GmbH, Isny im Allgaeu, Germany), Win Spine 2.3 software, which is housed in the University of Sports of Tirana's "Biomechanics" laboratory, was used to evaluate female basketball players in column deviation in the parameters: Kyphosis/°- Lordosis/° (KL), Left Scoliosis/° Right, with 95% confidence interval for the mean. The Win-Spine program (Zebris Medical GmbH, Isny im Allgaeu, Germany) records and stores the spatial positions of the receivers numerically. The basketball players were taken in the sagittal and frontal planes, and analysed using the free internet Postural Analysis Software to obtain quantitative measures of the shoulders and trunk. The spinous processes were determined on each subject, and each measurement was performed before and after training for 14 weeks in the experimental group.

Intervention

The experimental group underwent a 14-week corrective training program, which was conducted 3 times a week

(Monday, Wednesday, Friday) with a duration of 15-20 minutes, at the end of the training. In contrast, the control group underwent only 4 training sessions according to the method of their trainer. The intervention program consists of 5 corrective exercises selected from the literature research:

a) Glute Bridge Exercise; Position lying on the floor on your back, using a mat. Arms extended at your sides, knees bent. Tighten your abdominal and hip muscles, pushing your lower back. Lift your hips, creating a straight line from your knees to your shoulders (Gong, 2018). Work; Hold for 20 to 30 seconds and 3 repetitions.

b) Scapular Wall Hold; Stand with your back to the wall. Step a couple of inches away and bend your arms to 90 degrees. Keep your elbows in by your sides and drive them back toward the wall. Do not shrug your shoulders as you drive your elbows back and pinch your shoulder blades down and together. With your elbows back, lean into the wall so that only your elbows are touching. Do not let your upper arms or back touch the wall (Kim & Lim, 2016). Work; standing 15 seconds and 3 repetitions.

c) Opposite arm and leg raise; Extend your left leg off the floor behind you while reaching your right arm forward. Keeping your hips and shoulders straight, try to bring your leg and extended arm parallel to the floor, alternating sides (Corliss, 2023). Work; hold for 15 seconds and repeat 3 times with a 30-second rest.

d) Cat Pose; Get on your hands and knees in a tabletop position. Your shoulders are directly over your elbows and wrists, while your hips are directly over your knees. Toes out, back extended, creating a flat back that is parallel to the floor (Batool et al., 2021). Work; hold for 2 seconds in each position and do 10 repetitions.

e) Half Cobra pose; Fully extended position on the floor, arms slightly in front of the body and at a 90-degree angle with the forearm. Looking straight ahead. Good stretch in the lower back and a little neck stretch, also doing a little chest and abdominal stretch. Keeping your hips on the floor (Wellness, 2022). Work; Half cobra position 15 seconds, rest 30 seconds, repetitions 10 times.

The ratio of work time to rest time was 1:2. This intervention did not affect the duration of their usual training program. Special emphasis was placed on the phase of familiarizing and mastering the technique of performing the exercises, which was extended over the first 2 weeks.

Data analysis

The data were analyzed by applying descriptive statistics (mean, mode, standard deviation, etc.) for Kyphosis/°, Lordosis/°, Scoliosis/°_L, and finally for Scoliosis/°_R. Then, the Shapiro-Wilk test was applied to assess the normality of the data distribution, in order to understand which statistics to proceed with. Given the result of non-normality, the Wilcoxon test was used to compare the pre- and post-measurements within the same group. Meanwhile, the Mann-Whitney U test was used to analyze the comparison between the two groups. All statistical tests were performed using JASP software (version 0.16) (JASP Team, University of Amsterdam, Holland), developed by the Department of Psychological Methods at the University of Amsterdam. At $p < 0.05$, statistical significance was recognized.

Results

The general characteristics of the measurements conducted with U-16 female basketball players are presented in Table 2. The results show a statistically significant difference in the changes related to kyphosis. Specifically, EXG reported an average reduction in kyphosis angle of -1.134°, compared to a reduction of only -0.273° in the COG. All four variables violate normality ($p<0.05$), some very markedly (e.g., left and right scoliosis, with values close to zero and skewed distribution). The p-value of =0.001 (U=213) confirms the significance of the effect. This result, consistent with the pre-post comparison within the EXG alone, suggests that the protocol had a significant effect on the correction of the sagittal alignment of the spine, particularly at the thoracic level. This is why we must proceed with non-parametric statistics.

Table 2. Descriptive Statistics before and after intervention

	Group	N	Mean	SD	SE	Coefficient of variation	Mean Rank	Sum Rank
Kifoz/°_Delta	COG	15	-0.27	0.70	0.18	-2.57	22.20	333.00
	EXG	15	-2.36	1.13	0.29	-0.48	8.80	132.00
Lordoz/°_Delta	COG	15	-0.02	0.50	0.13	-25.09	18.27	274.00
	EXG	15	-0.89	1.11	0.29	-1.25	12.73	191.00
Skoljoz/°_L_Delta	COG	15	0.13	0.52	0.13	3.87	17.20	258.00
	EXG	15	-0.25	0.87	0.23	-3.45	13.80	207.00
Skoljoz/°_R_Delta	COG	15	-0.07	0.46	0.12	-6.87	17.07	256.00
	EXG	15	-0.47	0.83	0.22	-1.79	13.93	209.00

The analysis of the differences between EXG and COG at the initial phase (pre-test), conducted by means of the Mann-Whitney U test, showed no statistically significant differences in any of the variables analysed: kyphosis, lordosis, left-sided scoliosis, and right-sided scoliosis (all $p>0.05$). The means and standard deviations were very similar between the two groups, particularly for kyphosis (COG: 36.56°; EXG: 36.79°) and scoliosis (both components). Also, for lordosis, despite a greater numerical difference (COG: 25.35°; EXG: 30.31°), the internal variability is high (SD=10.22 for COG), and the test did not reach significance (p=0.213). These results confirm the initial homogeneity between the groups, which is crucial for validating subsequent post-intervention comparisons. The results are summarized in Table 3.

Table 3. Mann-Whitney U EXG-COG pre test

Variable	COG Mean ± SD	EXG Mean ± SD	U	p	r (effect size)
Kyphosis	36.56 ± 4.66	36.79 ± 3.48	112.000	1.000	-0.004
Lordosis	25.35 ± 10.22	30.31 ± 3.36	82.000	0.213	-0.271
Scoliosis L	1.93 ± 2.26	1.86 ± 2.07	112.000	1.000	-0.004
Scoliosis R	1.93 ± 2.59	1.80 ± 2.57	113.000	1.000	0.004

The comparison between the pre- and post-data of the EXG is carried out. The Wilcoxon test is used, which is a non-parametric statistical test used to compare two sets of data, especially when normal distributions of the data cannot be assumed or when you have paired or dependent data. It is a non-parametric alternative to Student's t-test for paired samples. The results are summarized in Table 4.

After the protocol was applied, a significant reduction in the kyphosis angle was observed (p=0.001). This suggests that the protocol had a positive impact on the sagittal alignment of the spine. This is also the case for the data concerning lordosis, i.e., the protocol produced a significant change (p=0.014), with possible normalization of the lordotic curve. This indicates a potential corrective effect on the lumbar side as well. In contrast to the previous results, for scoliosis on the left, the intervention did not lead to any statistically significant changes (p=0.395). Finally, for scoliosis on the right, a trend towards improvement is observed, and although the significance value approaches the threshold, it is still non-significant (p=0.089).

Table 4. Wilcoxon Test pre-post EXG

Measure 1		Measure 2	W	z	p
Kifoz/°_Pre EXG	-	Kifoz/°_Post EXG	105.000	3.296	0.001
Lordoz/°_Pre EXG	-	Lordoz/°_Post EXG	81.000	2.481	0.014
Skoljoz/°_L_Pre EXG	-	Skoljoz/°_L_Post EXG	15.000	0.943	0.395
Skoljoz/°_R_Pre EXG	-	Skoljoz/°_R_Post EXG	10.000	1.826	0.089

In the COG, the analysis of differences between the initial and final measurements conducted by means of the Wilcoxon Signed-Rank Test showed no statistically significant changes for any of the postural variables examined. In particular, kyphosis (p=0.168), lordosis (p=0.798), and the two components of lateral scoliosis (left p=0.424; right p=0.773) did not show appreciable changes over time. These results indicate that, in the group that followed standard training, no significant postural adaptations occurred during the observation period. This reinforces the hypothesis that the specific protocol adopted by the EXG is mainly responsible for the observed improvements. The results are summarized in Table 5.

The test assesses whether two samples come from the same population, or whether one tends to have larger values than the other.

Table 5. Wilcoxon Test pre-post COG

Measure 1		Measure 2	W	z	p
Kifoz/°_Pre COG	-	Kifoz/°_Post COG	22.500	1.437	0.168
Lordoz/°_Pre COG	-	Lordoz/°_Post COG	16.000	0.338	0.798
Skoljoz/°_L_Pre COG	-	Skoljoz/°_L_Post COG	2.500	-0.913	0.424
Skoljoz/°_R_Pre COG	-	Skoljoz/°_R_Post COG	4.000	0.535	0.773

Regarding lordosis, although EXG showed a larger mean change (Delta =-0.887°) than COG (Delta =-0.020°), the difference did not reach statistical significance (p=0.083). However, the observed trend (r=0.369) could indicate a possible positive effect that was not fully detectable with the current sample, suggesting further investigation with a larger number of participants. Finally, there were no significant differences in changes in lateral scoliosis, neither for the left side (p=0.215) nor for the right side (p=0.197). The mean change values were similar between the two groups, with only small effects (r<0.23). This could be due to the less pronounced nature of scoliotic deviations within the sample, or to the protocol's lack of specificity in counteracting transverse components of posture, such as rotations or lateral tilts of the spine. The results are summarized in Table 6.

Table 6. Mann-Whitney U EXG-COG delta post test

	U	p	Rank-Biserial Correlation	SE Rank-Biserial Correlation
Kifoz/°_Delta	213.000	0.000	0.893	0.211
Lordoz/°_Delta	154.000	0.083	0.369	0.211
Skoljoz/°_L_Delta	138.000	0.215	0.227	0.211
Skoljoz/°_R_Delta	136.000	0.197	0.209	0.211

Discussion

Kyphosis and lordosis changes serve as important indicators of spinal curvature in adolescents. In our study, girls in the experimental group showed a significant reduction in thoracic kyphosis (p=0.001), highlighting the effectiveness of the corrective exercise protocol. Exercise interventions have consistently demonstrated a large, significant improvement in thoracic curvature across adolescent populations (González-Gálvez et al., 2019). These findings align with previous studies. For example, Grabara and Hadzik (2009) reported that regular physical activity can lead to flattening of kyphosis and deepening of lordosis, likely through strengthening back extensor muscles. This phenomenon may be related to the strengthening of the back extensor muscles during physical activities. Lumbar lordosis also improved significantly within the experimental group (p=0.014), but the between-group difference was not statistically significant (p=0.083). As such, there is no definitive evidence of intergroup differences for lordotic angle, a finding consistent with meta-analytic results showing a moderate but non-significant effect on lordosis (González-Gálvez et al., 2019). This could indicate that the protocol had a partial corrective influence on the lumbar curvature, which might become more evident in a larger sample or over a longer intervention period.

In contrast, the control group exhibited no significant changes in kyphosis or other postural variables, suggesting the improvements were attributable to the intervention rather than natural maturation. This aligns with studies showing that untrained adolescents may not experience reductions in sagittal spinal curvature over time—in fact, kyphosis may worsen without intervention (González-Gálvez et al., 2019; Yang et al., 2024). A study conducted by De Vasconcelos et al. (2010) has shown a higher prevalence of kyphosis in girls, suggesting that this phenomenon may be related to physiological changes and physical development of girls during adolescence.

Sports science and the training levels of athletes are constantly evolving. The foundations of this development are mainly based on an ever-expanding understanding of how the body adapts to different physical and psychological loads according to Bompa and Buzzichelli (2015). Postural development during adolescence is heavily influenced by musculoskeletal growth and physical activity (Bompa & Buzzichelli, 2015). Our findings reinforce that targeted exercise protocols during adolescence can effectively improve kyphotic posture. Given the robust effects on thoracic curvature reported (Feng et al., 2017), such interventions should be integrated into youth physical education and therapeutic programs to promote spinal health. According to Cengiz and Delen (2024), it is thought that the effect of the age-training variable on posture structures varies specifically according to sports, where posture is negatively affected as training age increases in volleyball and soccer players. Our values — ~36° kyphosis, ~29–30° lordosis, and 1–2° scoliosis — are typical for adolescent basketball players, with little lordosis as part of the sports postural profile. According to Grabara (2014), among 57 females and 104 males (14–17 years old), including basketball players, it was found that female athletes had lower kyphosis than the control group (p<0.01). Kyphosis in female basketball players is usually lower than in non-athletic women, around 30-35°. This suggests that female basketball players in this age group tend to have below-average kyphosis and flattened lordosis, due to intense training. Our values are typical for teenage basketball players, with little lordosis as part of the sports postural profile.

Regarding scoliosis, the intervention did not lead to statistically significant improvements in either the left or right components (p=0.395; p=0.089). This outcome could be explained by two main factors: first, the relatively mild baseline deviations observed in the sample, which may have limited the potential for detectable change; and second, the exercise protocol itself, which focused primarily on sagittal plane corrections rather than rotational or lateral spine components. Future interventions aimed at correcting scoliosis may benefit from integrating more targeted exercises involving spinal rotation and lateral flexion.

When the studies and the field index are examined, the results obtained show negative and positive results in both postural aspects and performance in basketball players (Cengiz, 2022).

Due to the high susceptibility to postural defects in adolescence, it is thought that training programs applied to adolescent athletes should be supported with corrective exercises, and studies in the literature on the detection of asymmetry should be added to shed light on sports coaches. However, values tend to vary greatly depending on measurement methods (radiographic versus clinical means, age, gender). According to this research, the musculoskeletal systems of basketball players are affected by the applied exercises, which also reveal a process of postural adaptation.

Limitations and Future Directions

This study's relatively small sample size and short intervention period may limit the generalizability of the findings. Additionally, the exercise protocol did not specifically target rotational spine components, which may explain the lack of significant scoliosis improvement. Future research should explore longer-term interventions with larger samples and include exercises addressing all spinal planes. Practical implications include the recommendation that coaches and trainers integrate targeted postural exercises into youth athletic programs to support musculoskeletal health and performance.

Conclusion

The results of the study suggest that this corrective exercise program in basketball players had an impact on the reorientation of the spine posture in adolescent girls. This study presented the change in kyphosis-lordosis from the corrective exercises used for 14 weeks in basketball players, a new parameter that describes how the overall sagittal shape of the spine changes slightly under the influence of exercise at this age. The values shown in this age group indicate a tendency for below-average kyphosis and flat lordosis, due to the intense training performed previously. Girls who are not physically active may be at greater risk of having kyphosis. These findings emphasize the importance of regular physical activity for spinal health in adolescents.

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Conflict of interest
The authors declare that there is no conflict of interest.

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