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Balance and postural control in basketball players

Equilíbrio e controle postural em atletas de basquetebol

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Abstract

Introduction: Basketball is one of the most popular sports involving gestures and movements that require single-leg based support. Dorsiflexion range of motion (DROM), balance and postural control may influence the performance of this sport. **Objective**: To compare and correlate measures of balance, postural control and ankle DROM between amateur basketball athletes and non-athletes. **Methods**: Cross-sectional study, composed by 122 subjects allocated into one control group (CG = 61) and one basketball group (BG = 61). These groups were subdivided into two other groups by age: 12-14 years and 15-18 years. The participants were all tested for postural balance with the Star Excursion Balance Test (SEBT), postural control with the Step-down test and DROM with the Weight-bearing lunge test (WBLT). Between-groups differences were compared using repeated-measures multivariate analysis of variance. Normalized reaching distances were analyzed and correlated with the WBLT and Step-down test. **Results**: There was no difference in the scores of WBLT (P = .488) and Step-down test (P =. 916) between the groups. Scores for the anterior reach (P = .001) and total score of SEBT (P = .030) were higher in BG. The values for the posterolateral (P = .001) and posteromedial reach (P = .001) of SEBT were higher in BG at the age of 15-18. The correlation between the anterior reach of the SEBT and WBLT was significant in BG between 12-14 years (r = 0.578, P = .008), and in the CG between 15-18 years (r = 0.608, P=.001). **Conclusion**: The balance was better in the BG, although adolescents between 15-18 years have better balance control for the posteromedial and posterolateral reaches of the SEBT.

Keywords: Adolescent. Postural Balance. Proprioception. Ankle.

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Resumo

Introdução: *O basquetebol é um dos esportes mais praticados na atualidade, o qual envolve gestos e movimentos que exigem apoio unipodal. Amplitude de movimento de dorsiflexão (ADMD), equilíbrio e controle postural podem influenciar o desempenho deste esporte.* ***Objetivo****: Comparar e correlacionar medidas de equilíbrio, controle postural e ADMD de tornozelo entre atletas de basquetebol amadores e não-atletas.* ***Métodos****: Trata-se de um estudo transversal, composto por 122 participantes. Estes foram distribuídos em grupo controle (GC = 61) e grupo basquete (GB = 61). Cada grupo foi subdivido em outros dois, de acordo com a idade: 12-14 e 15-18 anos. Todos foram avaliados para equilíbrio postural com Star Excursion Balance Test (SEBT), controle postural com Step-down teste e ADMD foi testada com Weight-bearing lunge test (WBLT). As diferenças entre os grupos foram comparadas pelo teste de medidas repetidas e análise de variância multivariada. Distâncias normalizadas dos alcances no SEBT foram analisadas e correlacionados com o WBLT e Step-down test.* ***Resultados****: Não houve diferença entre os grupos nos escores do WBLT (P = .488) e Step-down test (P = .916). A pontuação para alcance anterior (P = .001) e escore total de SEBT (P = .030) foram maiores no GB. Os valores para alcance posterolateral (P = .001) e posteromedial (P = .001) do SEBT foram maiores no GB de 15-18 anos. A correlação entre distância anterior do SEBT e WBLT foi significativa no GB de 12-14 anos (r = 0.578, P = .008) e no GC de 15-18 anos (r = 0.608, P = .001).* ***Conclusão****: O equilíbrio foi melhor no GB, embora adolescentes de 15-18 anos possuam melhor controle de equilíbrio para alcances posteromedial e posterolateral do SEBT.*

Palavras-chave: *Adolescente. Equilíbrio Postural. Propriocepção. Tornozelo.*

Introduction

Basketball is one of the most popular sports among high school students, which includes changing direction, jumping and running, promoting a great deal of overload in the lower limbs (LL) (1). The influence of balance and neuromuscular control with overload seems related to injuries in the structures involved, such as ligaments and articular capsule, which may put an early end to the athlete's career (2).

Ankle sprain is the most frequent injury in basketball. Fong et al. (3) reported that ankle sprain was the main type of injury in athletes in 33 out of the 43 sports investigated in their study, which included basketball, volleyball and team handball. The loss of afferent signals from the joint that suffers from joint functional instability is due to damage to the joint capsule and ligaments, producing delayed and diminished reflex responses of the ankle evertor muscles (4). After injury, these muscles would not be able to respond with an activation time suitable to any unexpected disturbance, making the ankle joint vulnerable to repeated inversion injuries (5, 6, 7, 8, 9).

Therefore, the development of effective strategies for the prevention of injuries to the lower limbs can result in a major reduction in expenses on rehabilitation. Thus, one of the main objectives of the evaluations of postural balance in LL is the guidance on treatment and sports training, aiming to prevent LL injuries (8). Research related to prevention is based on the identification of the causes and risk factors, but there is a lack of the information related to court sports (10).

Until date, only the study by Hoch et al. (11) correlated the measures of balance and ankle dorsiflexion range of motion (DROM) in healthy non-athletes, noting the need to verify if such correlations would also be found in basketball players, who constantly suffer from injuries such as ankle sprains, compromising postural balance.

Given the above, studies intended to investigate the causes and risk factors that may withdraw basketball players from their activities are important to further clarify this issue, contributing to help and design specific rehabilitation exercise and prevention programs. Therefore, the aims of this study were: (1) to compare the measures of balance, postural control and ankle dorsiflexion range of motion between amateur basketball players and non-athletes, (2) to correlate the tests applied in the study population.

Methods

One hundred and twenty two male adolescents between 12 and 18 years of age were evaluated. The subjects were divided into two groups: Control Group (CG = 61) and Basketball Group (BG = 61). Subjects' demographic characteristics are shown in Table 1. The groups were subdivided into two other groups: the Control Group 12-14 years (CG 12-14 = 30) and Control Group 15-18 years (CG 15-18 = 31), composed of non-athletes; Basketball Group 12 to 14 years (BG 12-14 = 31) and Basketball Group 15-18 years (BG 15-18 = 30), composed of amateur basketball players. This division was made for the differences found in the maturation of the sensorimotor system in children and adolescents (12, 13).

Using the variable SEBT Final Score as the main variable of the study, compared between the four groups, the ANOVA test was used to calculate the sample size needed for the experiment. Considering an 83% power, a 5% significance level, and based on previous studies, a difference of ten units on average for the SEBT final score and four units between groups, a sample size of thirty subjects in each group was set (14).

Inclusion criteria for basketball group were amateur basketball practicing subjects, training with a frequency greater than or equal to two times per week and, for the control group, only subjects who practiced physical activities less frequently than twice a week were included. We excluded all subjects with a history of lower limb injury in the past six months, self-reported disability in foot and ankle, surgery or balance disorder history and lower limb discrepancy greater than 1.25 cm. All volunteers agreed to sign the term of assent and their parents accepted signing the consent form. This study received approval from the Research Ethics Committee under number 19627.

Weight-bearing lunge test (WBLT)

To perform the WBLT, an "L-shaped" wooden structure was built, using the knee-to-wall principle described by Vicenzino et al. (9) Subjects performed only one trial of the WBLT on each limb. Subjects were in a standing position facing the structure wall with the test foot parallel to a tape measure secured to the bottom of the wooden structure, with the second toe, center of the heel and knee perpendicular to the wall (11). To promote up right balance during the test, the opposite limb was positioned at approximately one foot length behind the test foot in a comfortable tandem stance and subjects placed their hands on the wall. While maintaining this position, subjects were instructed to perform a lunge, in which the knee was flexed with the goal of making contact between the anterior knee and the wall of the wooden structure while keeping the heel firmly planted on the floor (Figure 1) (11). When subjects were not able to maintain heel and knee contact, the test foot was progressed away from the wall and the subjects repeated the modified lunge (15). Subjects were progressed in 1 cm increments until the first lunge in which the heel and knee contact could be maintained. Maximum lunge distance on the WBLT was measured to the nearest 0.5 cm by a tape measure secured to the floor. Previous research indicates that every 1 cm away from the wall is equivalent to approximately 3.6º of ankle dorsiflexion. Maximum lunge distance was defined as the distance of the second toe from the wall, based on the furthest distance the foot could be placed without the heel lifting from the ground while the knee was able to touch the wall (15). The same investigator administered the WBLT across all subjects (Figure 2).

Star excursion balance test (SEBT)

Each subject also completed a modified SEBT modeled, following the method described by Plisky et al. (16) and used by Filipa et al. (17) Subjects received verbal instruction and visual demonstration of the SEBT from the same examiner. The subjects stood on the dominant lower extremity, with the most distal aspect of their great toe on the center of the grid. The subjects were then asked to reach in the anterior, posteromedial and posterolateral direction, while maintaining their single-limb stance (Figure 1). Six practice trials were performed on each limb for each of the 3 reach directions prior to official testing (18). On the seventh trial, the examiner visually recorded the most distal location of the reach foot as it contacted the grid in the 3 directions. The trial was discarded and the subject repeated the testing trial if (1) the subject was unable to maintain single-limb stance, (2) the heel of the stance foot did not remain in contact with the floor, (3) weight was shifted on to the reach foot in any of the 3 directions, or (4) their each foot did not return to the starting position prior to reaching in another direction. The process was then repeated while standing on the non-dominant lower extremity. The order of limb testing was always the same: first the dominant and then the non-dominant. The subject's limb length measures, from the most distal end of the anterior superior iliac spine to the most distal end of the lateral malleolus on each limb, were taken and recorded.

Figure 1 - Star excursion balance test reaches - A: Posterolateral. B: Anterior. C: Posteromedial

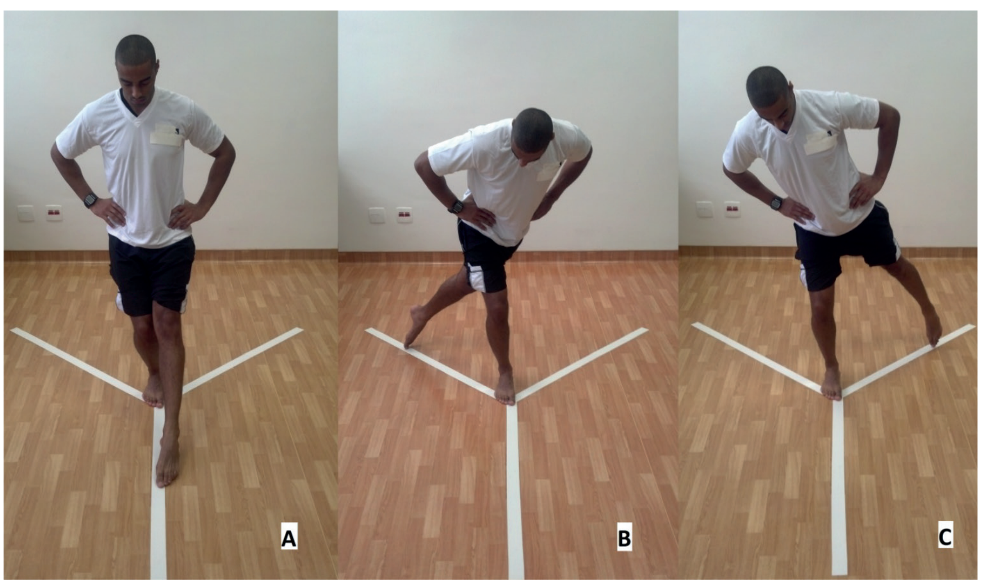

Figure 2 - A: Weight-bearing lunge test (view from above). B: Weight-bearing lunge test (view from the side)

Step-down test

The Step-down test was performed using a standardized protocol described by Piva et al. (19) First (1) the patient was asked to stand in single-limb support with the hands on the waist, the knee straight, and the foot positioned close to the edge of a 20 cm high step; (2) the contralateral leg was positioned over the floor adjacent to the step and is maintained with the knee in extension; (3) the subject then bends the tested knee until the contralateral leg gently contacts the floor and then extends the knee to the start position; (4) this maneuver was repeated 5 times. A tripod with a camera was positioned at

3.5 meters of distance from the step to record the movement. The examiner faces the subject and scores the test based on 5 criteria: (1) Arm strategy: If the subject used an arm strategy in an attempt to recover balance, 1 point is added. (2) Torso movement: If the torso leaned to any side, 1 point is added. (3) Pelvis plane: If pelvis rotated or elevated one side compared with the other, 1 point is added. (4) Knee position: If the knee deviates medially and the tibial tuberosity crosses an imaginary vertical line over the second toe, add 1 point or, if the knee deviates medially and the tibial tuberosity crosses an imaginary vertical line over the medial border of the foot, 2 points are added. (5) Maintain steady unilateral stance: If the subjects stepped down on the non-tested side, or if the subject's tested limb became unsteady (i.e. wavered from side to side on the tested side), add 1 point (19).

The evaluations were conducted by three senior physiotherapists, each responsible for one assessment, to avoid potential interference with the results. The evaluators were trained and had prior knowledge of the tests, which were performed in random order according to the order of arrival of the volunteers. All tests were performed in both lower limbs, always starting with the dominant limb.

The LL dominance was determined by asking the participant to kick a ball thrown in his direction by the evaluator. The lower limb that performed the kick was considered the dominant limb (20).

Data Analysis

One single attempt to WBLT was used, using a single measure to analyze the results. The SEBT composite score was calculated by dividing the sum of the maximum reach distance in the anterior (A), posteromedial (PM), and posterolateral (PL) directions by 3 times the limb length (LL) of the individual, then multiplied by 100 {[(ANT + PM + PL) / (LL x 3)] x 100}. The data analysis of the step-down test was done if any of the criteria repeated in either five attempts, and only one was deemed an error. A total score of 0 or 1 is classified as good quality of movement, a total score of 2 or 3 is classified as medium quality, and a total score of 4 or higher is classified as poor quality of movement (20).

For all tests, the dominant and non-dominant intra-group sides were compared. In addition, the three tests were correlated taking into consideration Pearson's correlation coefficient (r), considering r > 0.3 as a weak correlation, r > 0.5 as a moderate correlation and r > 0.7 as an excellent correlation.

Statistical Analysis

To compare the basketball and control groups regarding the variables weight, height and Body Mass Index (BMI), considering age as an independent variable, we used the analysis of variance (ANOVA) with two factors.

In order to compare the variables between the groups, we used the ANOVA with repeated measures. After the analysis, the Bonferroni post-hoc test was performed for interactions with a significance level lower than or equal to 5% ($p \leq .05$). The correlations between the variables in each group were calculated using the Pearson correlation coefficient, considering only moderate correlations with r > 0.5. The significance level adopted was 5% ($p \leq .05$).

Results

The results of the anthropometric data analysis showed that the weight (*P* = .03), height (*P* = .009) and lower limb length (*P* = .001) in the BG were higher than in the CG. Regarding the BMI variable (*P* = 0.533), the groups did not differ. The data are shown in Table 1.

The results showed no differences between the groups BG and CG for the Weight-bearing lunge test (P = .488) and Step-down test (P = .916). The basketball group presented higher values than the control group for the anterior reach of SEBT (P = .001) and the SEBT final score (P = .030), independently of side dominance and age. The non-dominant side showed higher values than the dominant side for anterior reach of SEBT (P = .018). In both groups, the reach of the SEBT PM and PL are higher at the age of 15-18 years, compared with the ages 12-14 and, in BG these values are higher at the age 15-18 when compared with CG. The data are presented in Table 2.

Table 3 shows that there was a moderate correlation between the variables anterior reach and Weight-bearing lunge test in the BG for the age groups 12-14 years old (r = 0.578, *P* = .008) and in the CG for the group 15-18 years old (r = 0.608, *P* = .001).

Table 1 - Participant characteristics

	Control Group (n = 61)	Basketball Group (n=61)	P Value
Age, y	14.39 ± 1.75	14.36 ± 1.74	Paired
Height, m	1.66 ± .12	1.80 ± .15	.009*
Weight, kg	60.82 ± 13.92	72.10 ± 18.16	.003*
BMI, kg/m²	21.52 ± 3.23	21.85 ± 3.18	.533
LL (cm)	89.99 ± 6.45	95.31 ± 9.43	.001*

Note: m, meters; kg, kilogram: BMI, Body Mass Index; LL, Limb Length; cm, centimeters.
Source: Research data.

Table 2 - Comparation between groups

	Groups							
	BG 12-14		BG 15-18		CG 12-14		CG 15-18	
	Dominant	Non Dominant	Dominant	Non Dominant	Dominant	Non Dominant	Dominant	Non Dominant
WBLT	13.42 ±2.96	13.05 ± 2.77	11.73 ± 3.61	11.95 ± 3.60	12.87 ± 3.22	13.12 ± 3,24	12.73 ± 4.27	13.23 ± 4.67
Step-down Test	3.81 ±.87	4.00 ± 1.13	4.00 ± 1.08	3.97 ± 1.16	4.07 ±.94	4.23 +.77	3.84 ±.82	3.71 ± 1.10
SEBT Ant	58.56 ± 5.46*	60.77 ± 6.39†	66.62 ± 6.03‡	67.65 ± 5.56§	52.72 ± 6.63*	54.55 ± 6.37†	58.95 ± 4.94‡	61.58 ± 5.03§
SEBT PL	74.34 ± 9.95	72.26 ± 9.61	87.77 ± 12.9‖	87.17 ± 7.79‖	78.83 ± 11.10	70.67 ± 13.03	77.79 ± 11.27‖	75.29 ±10.60‖
SEBT PM	80.23 ± 7,41	82.81 ± 7.56	93.25 ± 7.87#	92.87 ± 13.24#	76.00 ± 8.90	77.92 ± 10.05	81.92 ± 9.25#	83.24 ± 9.55#
Score final SBET	80.10 ± 6.52**	81.18 ± 7.26**	80.48 ± 7.47††	81.49 ± 6.91††	78.50 ± 7.00**	78.68 ± 7.86**	77.60 ± 6.45††	78.10 ± 7.07††

Note: CG, Control Group; BG, Basketball Group; WBLT, Weight-bearing lunge test; SEBT, Star Excursion Balance Test A, anterior; PL, posterolateral; PM, posteromedial; *, Statistically significant difference from the dominant side for anterior reach of the SEBT between BG 12-14 GB and GC 12-14; †, Statistically significant difference from the non-dominant side for anterior reach of the SEBT between BG 12-14 and CG 12-14; ‡ , statistically significant difference between the dominant side for anterior reach of the SEBT between 15-18 BG and CG 15-18; §, statistically significant difference between the non-dominant side for anterior reach of the SEBT between BG 15-18 and CG 15-18; ‖ and #, statistically significant difference for the variable PL and PM of the SEBT, respectively, between the BG 15-18 and CG 15-18 for the dominant and non-dominant sides; **, Statistically significant difference for the variable final score of SEBT, between BG 12-14 and CG 12-14, for the dominant and non-dominant sides; ††, Difference statistically significant for the variable final score of SBET, between BG the 15-18 and CC 15-18 for the dominant and non-dominant sides.
Source: Research data.

Table 3 - Pearson's correlation coefficient for basketball and control groups according to age

		Basketball Group			Control Group		
AGE	Correlations	*r*	CI		*r*	CI	
12 to 14 years old	Weight-bearing lunge test × Step-Down Test	- 0.313	- 0.522	- 0.069	- 0.267	- 0.488	- 0.014
	Weight-bearing lunge test × SEBT A	0.578*	0.383	0.723	0.451	0.223	0.633
	Weight-bearing lunge test × SEBT PL	0.143	- 0.111	0.379	0.400	0.162	0.593
	Weight-bearing lunge test × SEBT PM	0.130	- 0.124	0.368	0.345	0.100	0.551
	Weight-bearing lunge test × Score total SEBT	0.249	- 0.001	0.469	0.229	- 0.026	0.457
	Step-Down test × SEBT A	- 0.222	- 0.447	0.029	- 0.203	- 0.435	0.053
	Step-Down test × SEBT PL	- 0.007	- 0.256	0.243	- 0.051	- 0.301	- 0.051
	Step-Down test × SEBT PM	0.037	- 0.215	0.284	- 0.176	- 0.412	0.081
	Step-Down test × Score total SEBT	- 0.144	- 0.380	0.110	- 0.166	- 0.403	0.091

(To be continued)

Table 3 - Pearson's correlation coefficient for basketball and control groups according to age

(Conclusion)

		Basketball Group			Control Group		
AGE	Correlations	*r*	CI		*r*	CI	
15 to 18 years old	Weight-bearing lunge test × Step-Down Test	- 0.167	- 0.404	0.090	- 0.419	- 0.606	- 0.190
	Weight-bearing lunge test × SEBT A	0.228	- 0.027	0.456	0.608†	0.422	0.745
	Weight-bearing lunge test × SEBT PL	0.001	- 0.254	0.254	0.168	- 0.085	0.401
	Weight-bearing lunge test × SEBT PM	- 0.032	- 0.283	0.224	0.347	0.107	0.549
	Weight-bearing lunge test × Score total SEBT	0.181	- 0.076	0.416	0.096	- 0.157	0.338
	Step-Down test × SEBT A	- 0.026	- 0.278	0.229	- 0.295	- 0.507	- 0.048
	Step-Down test × SEBT PL	- 0.129	-0.371	0.129	0.058	- 0.195	0.303
	Step-Down test × SEBT PM	- 0.075	-0.323	0.183	- 0.081	- 0.324	0.173
	Step-Down test × Score total SEBT	- 0.327	-0.536	-0.079	0.099	- 0.154	0.341

Note: SEBT: Star excursion balance test; A: Anterior; PL: posterolateral; PM: posteromedial; * *P* value = .008; † *P* value= .001.

Source: Research data.

Discussion

Our study compared and correlated reach measures on the SEBT, the Step-down test and the Weight-bearing lunge test between amateur basketball players and non-athletes. We observed that there was no difference between the groups BG and CG for Weight-bearing lunge test and Step-down test. On the other hand, the SEBT final score was higher for the BG when compared with the CG, regardless of the side of dominance and age. This result demonstrates that the BG has a better balance during the SEBT when compared with the CG, which confirms that basketball athletes have a better neuromuscular control than non-athletes. This is justified by the fact that this group performs an activity that requires changing directions, jumping and running (21, 22).

The non-dominant side showed higher values than the dominant side, regardless of group and age, for the SEBT anterior reach. This result may have been obtained by a learning effect, since all SEBT evaluations were performed initially with the dominant leg to standardize the evaluation. One of the possible explanations is that the majority of jumping movements performed during the throws occur in one foot on the contralateral leg to the dominant upper limb, thus providing a better neuromuscular control in the non-dominant leg (23). The prevalent use of one of the lower limbs may be related to the type of task being performed, either holding, kicking or maintaining the standing posture (24, 25). This implies that there are different behaviors between the dominant and non-dominant limbs when performing motor actions (26).

In sports and physical activities, the athlete should have a single-leg support base for gestures and movements that occur. Given this situation, the use of tests with single-leg support with the objective of measuring postural stability becomes important and justified, either at the clinic or in the sports research area (27).

Besides the functional applicability of such tests, there is also a reduction in the number of peripheral sensory sources and muscular strategies that compensate for peripheral deficiencies (4). In a clinical scenario, the convenience of clinical tests when comparing or examining bilateral differences in cases of unilateral orthopedic injury contributes further to the applicability of the single-leg tests to determine the capacity of postural control.

Our results also showed a significant difference in the SEBT posterolateral and posteromedial reaches between the age groups 12-14 and 15-18, supporting the difference in the maturation of the SSM found in the literature. A possible explanation may be the fact that the sensory system develops at different rates in children and teenagers (12, 13). In the literature, studies have reported that the somatosensory function matures between 3-4 years old (28 -30), but other authors report between 9-12 years old. For vision (31), maturing time also varies according to the literature. Cherng et al. (32) has found out that children between 7-10 years old had the same efficiency in the use of vision for balance, while standing on both feet, when compared to an adult (32, 33). However, Hirabayashi & Iwasaki (29) and Cumberworth et al. (28) have reported that visual function matures later, at 15 years of age.

Previous studies agree that vestibular function has a slower development among the three sensory systems, and its maturing time varies. Some researchers reported that it is developed at the age of seven (34), while others reported that it is fully developed at 15 -16 (28, 30, 35). Thus, the maturation time of the three sensory systems for balance remains uncertain.

According to the above mentioned, postural control is under development in the two age groups analyzed in this study but, due to the fact that the basketball group performs an activity that requires more of that system, it presents a better performance when compared to the control group.

Our study found correlation between the Weight-bearing lunge test and the SEBT anterior reach distance in the BG at the ages of 12-14 and in the CG at the ages of 15-18. This shows that, the higher the ankle dorsiflexion in closed kinetic chain, the better the performance on the SEBT anterior reach. Previous studies using goniometry as an assessment for the ankle dorsiflexion, and not Weight-bearing lunge test, had demonstrated that ankle ROM is not related to the SEBT (36). Ours and Hoch et al.'s findings (11) contradict these studies, because the correlation between the SEBT and goniometry is not appropriate, since the latter is performed in an open kinetic chain, while SEBT in a closed kinetic chain.

Therefore, our results provide evidence that mechanical deficiencies in ankle function are probably related to changes in the functional movement patterns and may influence the occurrence of injuries in basketball. Furthermore, there is evidence that the dorsiflexion ROM is an important factor in the landing mechanisms and in the functional movement patterns (37), making its evaluation extremely important.

Limitations of the Study

The kinematic analysis in our study was made observing movements in the sagittal plane only. There are combinations of multiplanar movements that may occur during the three SEBT reaches which could not be quantified in this study. Rotations of the hip and trunk may have influenced the test.

We suggested that future studies continue to investigate changes in motor strategies during the SEBT, through analysis of the contributions of the proximal and distal joints' ROM, by using clinical tests like the Weight-bearing lunge test, or laboratory measures like three-dimensional motion analysis.

Conclusion

The study showed that the balance is better in individuals who practice basketball when compared to people who do not practice this sport. Older teens have a better balance control of the SEBT posteromedial and posterolateral reach.

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