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Original Article

Preseason functional testing in young basketball players: asymmetries and intercorrelations

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Abstract. [Purpose] The present study aimed to examine the existence and degree of possible asymmetries of functional test performance and their intercorrelations in the lower extremities of young basketball players. [Participants and Methods] Twenty-seven healthy male basketball players (age: 15.52 ± 1.37 years) were examined for the symmetric function of their lower extremities using triple hop for distance tests in the sagittal and frontal plane (medial-lateral), the Y-balance test and a vertical jump test. [Results] Participants exhibited statistically significant side-to-side differences in only the medial triple hop test, as they jumped further on their non-dominant for stability lower limb. No other asymmetries were observed in the rest of the functional tests. Significant correlations were also indicated between the vertical jumptest and the three directions of the triple hop test for both lower limbs. [Conclusion] Our findings proved that young basketball players present a symmetrical picture of functional performance, as revealed by the evaluation of various functional tests. The only significant asymmetric adaptation observed in the medial triple hop test will have to be strengthened by future studies to be implemented in injury prevention programs.

Key words: Asymmetries, Basketball, Hop-tests

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INTRODUCTION

Participation in team sports like basketball, both at the amateur and professional levels, is prevalent among all age groups. However, increases in the number of athletes and intense competition have yielded not only positive results, such as better quality of life and performance, but also adverse effects, such as an increased risk of sports injury. The incidence rate of sports injuries in basketball ranges from 4.3 and 9.9 per 1,000 practices and game athlete exposures, respectively[1)], affecting mostly the lower extremities. The most common types of basketball injuries are ligamentous injuries affecting the knee (anterior cruciate ligament rupture) and the ankle (sprains)[2, 3)]. Most ankle sprains in male and female basketball players are lateral ankle sprains[3, 4)], which is logical, as basketball players jump vertically and shuffle laterally more frequently than other team sports players[5, 6)].

Many studies have proposed potential extrinsic and intrinsic factors of lower extremity injuries in basketball players[7)]. The primary extrinsic risk factors are direct contact with an opponent, overtraining and insufficient warm-up and shoes. Intrinsic risk factors include altered neuromuscular control, asymmetries in the ankle's range of motion and isokinetic strength, increased body mass index (BMI), previous injuries and anatomical malformations. In addition, strength asymmetries have also been connected with increased risk of ankle sprains in professional soccer players[8)].

The majority of the abovementioned etiological factors can be modified and corrected, and this highlights the need for

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greater awareness of the significance of the athletes' preseason evaluation with appropriate musculoskeletal screening and functional tests in an effort to prevent musculoskeletal injuries and pathologies. As most basketball injuries affect the lower extremities, preseason testing should focus on the complex evaluation of intrinsic (functional asymmetries) and extrinsic (previous injuries, direct contact with the opponent) etiological factors. More precisely, asymmetries in lower extremity functional capacities like strength, flexibility and neuromuscular control should be examined and corrected[9, 10]. Furthermore, lower extremity injury prevention programs should be sport-specific, covering the special biomechanical and ergophysiological demands of each athlete by reducing risk injury factor pathologies and reinforcing neuromuscular prevention efforts[3, 11].

Despite the numerous studies that have been conducted on intrinsic and extrinsic risk factors in basketball, and the generally accepted relationship between asymmetrical physical performance and the production of high and asymmetric stresses in athletes' musculoskeletal structures, few studies have focused on detailed functional evaluation with tests that simulate the kinetic protypes of basketball. Therefore, the primary purpose of the present study was to investigate whether a wide range of hop tests for distance, including medial and lateral hops, can reveal statistical side-to-side differences in young, healthy male basketball players. A secondary aim was to analyse the possible correlation between hop tests for distance, explosive strength tests and traditional tests of dynamic balance and performance.

PARTICIPANTS AND METHODS

Twenty-seven healthy male basketball players (mean ± SD; age: 15.5 ± 1.4 years; weight: 78.3 ± 12 kg; height: 189 ± 8.6 cm; BMI: 22 ± 2.3 kg/m^2) participated in the study. Exclusion criteria included history of severe injury to the lower limbs and any other injury, regardless of severity, within the last six months. Informed written consent was ensured prior to the assessment, signed by the adults and guardians of the players, along with a general health and medical history form to assure the athletes' suitability for participation in this study.

Testing occurred as a part of an extended preseason injury risk factor screening and performance predicting session at the Therapeutic Exercise and Sports Rehabilitation Laboratory of the University of Patras. This study was approved by the Bioethics Committee of the University of Patras (14-07/04/2019). After anthropometric measurements, the Waterloo Footedness Questionnaire[12] was used to differentiate the dominant lower limb from the non-dominant lower limb in terms of stability. In this way, the stability lower extremity was set as the dominant lower limb for basketball activities. A Chronojump Boscosystem (Barcelona, Spain) contact mat was used to analyse vertical jump measurements[13]. Athletes did a specific 10-minute warm-up and then performed a unilateral assessment of the lower extremities via a series of measurements involving the Y-balance test (YBT), triple hop tests for distance in the frontal and sagittal plane and a vertical (cyclic) jump test. All the participants started each performance test supporting themselves on their right lower limb and holding their arms at the pelvis level throughout the test to minimize the contribution of stability of the upper extremities and trunk. They were asked to remain stabilized in the final position for about three seconds, to validate their YBT and triple hop test scores. In regard to vertical jump testing, the participants were guided to perform consecutive jumps without pause, execute double landings and then step off of the platform.

After all test processes had been presented by the examiners, some familiarization trials were allowed before the measured attempts. The procedure was started with the YBT, during which the toes of the tested foot were carefully placed on the intersection of a 'Y' marked on the floor with white tape. Athletes tried to reach as far as they could, without touching the floor, in each of the three directions, maintaining their balance according to the directions given. Two attempts were made and the best attempt was recorded.

Then, anterior, lateral and medial triple hop tests were performed. In a single-leg stance, participants positioned their toes against the end of a strip of a white tape fixed on the floor of the laboratory; the strip had demarcated metre-long increments to measure the anterior hops. The participants were instructed to do three consecutive jumps as far as they could on the line and remain stabilized in their final position. The measurements were taken from the final placement of their toes after landing. For the lateral and medial hops, the stability foot was placed perpendicular to the starting line. The participants were instructed to jump in the lateral and medial directions, with reference to supporting the lower limb, and the measurements were taken from the lateral and medial surface of their shoes, respectively. As with the YBT, two attempts were made in each direction and the best attempt was recorded.

Assessment concluded with vertical jumps on the Chronojump platform. The test was performed as previously described by Maulder and Cronin[14], except four consecutive jumps were performed. The participants started in a single-leg stance on the contact mat with their hands resting on their pelvis. Then they were instructed to sink (approximately 120° knee angle) as quickly as possible to utilize the maximum elastic energy and jump as high as possible for four consecutive jumps. Participants were asked to jump to their maximum height while exhibiting as minimal contact with the mat between jumps as possible. One valid attempt was measured and analysed by the instrument's software. The highest of the four jumps was recorded for the assessment.

SPSS (version 20.0) was used for statistical analyses. Paired sample t-tests were performed to identify statistically significant side-to-side differences, analysing raw and normalized to height measurements. Pearson's correlation coefficient (r) was used to investigate any statistically significant association between the tests. Pearson's r categorization was carried out according to Cohen[15] (r=0.10 small, r=0.30 medium, r=0.50 large). In order to investigate neuromuscular asymmetries between the dominant (DL) and non-dominant (NDL) lower extremities, we also calculated the asymmetry index (ASI), as an absolute value, by the following formula:

$$ASI=\frac{DL-NDL}{MAX\ (DL,\ NDL)}\times 100.$$

Statistical significance was set a priori at $p<0.05$ for all analyses.

RESULTS

The anthropometric characteristics of the participants are reported in Table 1. Descriptive statistics of the dynamic balance and functional measurements are reported in Table 2.

A statistically significant difference between the dominant and non-dominant lower limb scores was identified only for the medial direction of the triple hop for distance test ($p<0.01$). Basketball players proved that they were able to jump significantly further with the non-dominant for stability lower limb, when analysing both pure measurements ($t=-3.054$, $p=0.005$) and normalized to height data ($t=-3.015$, $p=0.006$).

Statistical analysis indicated a statistically significant correlation between the vertical jump and each of the three triple hop test directions for both lower extremities. The Pearson r correlation coefficient ranged from 0.43 to 0.66, concerning raw and normalized to height measurements ($p<0.05$). Moreover, a statistically significant correlation was demonstrated between the absolute scores of the medial triple hop and the posteromedial direction of the YBT when the stability lower limb was being tested ($r=0.44$, $p=0.02$; Table 3).

Table 4 shows the proportions of participants (%) who presented side-to-side differences equal to or greater than 4 cm and 12 cm for each direction of the YBT and composite score, respectively. Furthermore, 48.1% to 66.7% of the athletes passed the 10% absolute symmetry cut-off in the triple hop tests, and 40.7% to 48.1% passed the 15% cut-off for the same tests. In the vertical jump, none of the participants presented any difference equal to or greater than 10% between the lower limbs. The specific thresholds were defined according to recent research, which suggested that these asymmetry magnitudes are typical and acceptable[16–20].

DISCUSSION

The present study was novel, as it examined asymmetries in a wide range of hop, explosive strength, and neuromuscular control tests in young basketball players. The tests were chosen to simulate the dynamic activities of the sport and, in

Table 1. Demographic and anthropometric characteristics of the participants (N=27)

	Minimum	Maximum	Mean	Standard Deviation
Age (years)	13	19	15.52	1.37
Height (cm)	172	203	189.07	8.57
Weight (kg)	57.6	105	78.26	11.97
BMI (kg/m^2)	18.8	27.7	21.97	2.34

Table 2. Descriptive statistics and t-test results for the Y-balance test (YBT), triple hop (TH) tests and vertical jump (VJ) scores between the dominant and non-dominant for stability lower extremities

Parameter		Absolute scores (cm)		Normalized to height scores (%)	
		Dominant lower limb (mean ± SD)	Non-dominant lower limb (mean ± SD)	Dominant lower limb (mean ± SD)	Non-dominant lower limb (mean ± SD)
YBT	Anterior direction	71.43 ± 5.2	71.7 ± 4.75	0.38 ± 0.02	0.38 ± 0.02
	Posteromedial direction	107.3 ± 6.62	106.74 ± 6.87	0.57 ± 0.03	0.56 ± 0.03
	Posterolateral direction	100.93 ± 9.6	101.04 ± 8.3	0.53 ± 0.04	0.53 ± 0.04
	Total	279.65 ± 17.77	279.48 ± 16.01	1.48 ± 0.06	1.48 ± 0.06
THs	Anterior direction	523.37 ± 71.41	534.43 ± 73.83	2.77 ± 0.38	2.83 ± 0.39
	Lateral	359.61 ± 56.17	358.91 ± 58.41	1.9 ± 0.28	1.9 ± 0.31
	Medial	402.72 ± 59.09	421.28 ± 62.91*	2.13 ± 0.3	2.23 ± 0.32*
VJ		15.82 ± 4.19	15.75 ± 3.99	0.08 ± 0.02	0.08 ± 0.02

*p<0.05.

Table 3. Pearson r correlation coefficients between dynamic balance and functional performance tests

		Absolute scores		Normalized to height scores
Lower limb testing	Test	VJ	YBT PM	VJ
Dominant	THF	0.6		0.59
	THL	0.66		0.66
	THM	0.63	0.44*	0.62
Non-dominant	THF	0.44*		0.43*
	THL	0.59		0.60
	THM	0.58		0.56

*p=0.02 in these cases. For the rest results p<0.01.

Table 4. Percentages of participants who presented asymmetries ≥4 cm for each direction of the Y-balance test, ≥12 cm for the Y-balance composite score, ≥10% and ≥15% for the triple hop tests and ≥15% for the vertical jump test

	Test	≥4cm	≥12cm	≥10%	≥15%
YBT	AN	33.3%			
	PM	29.6%			
	PL	37%			
	Total		11.1%		
THs	THF			66.7%	48.1%
	THL			48.1%	33.3%
	THM			51.9%	40.7%
VJ					0%

particular, load the structures of the lower extremities in a sideways direction. The results indicated an overall symmetrical functional capacity at the lower extremities in young, male basketball players aged 13 to 19 years old. This is an expected finding, as basketball is generally balanced in the movements of the lower extremities. That is, basketball players use their lower extremities symmetrically in most motor activities of the sport.

The only asymmetrical functional adaptation observed was in the medial triple hop for distance test performance. More specifically, the non-dominant for stability lower extremity performed significantly better than the dominant extremity in the medial triple hop test for distance. This functional superiority of the non-dominant for stability lower extremity can be explained considering that the medial triple hop test constitutes a more demanding task than the YBT and the anterior triple hop tests. During the YBT and anterior triple hop tests, the athletes have to either maintain central stability in a single-leg stance while the other leg moves distantly from the body or jumps to the front, which is usual in sports tasks. In contrast, the medial triple hop test demands advanced neuromuscular control, as explosive power production is alternated vigorously with balance reassurance on one leg orientated in the medial direction. Therefore, it is likely that the non-dominant for stability lower extremity, which was primarily the stronger limb in this study, can cope with this demanding task better than the dominant limb, which is generally more stable. Secondly, the low age and level of play of the athletes probably make them rely on their lower limb that is perceived as stronger, mostly to achieve a technical task that they are not used to. In other words, they achieved more significant adaptations on the non-dominant for stability lower limb, allowing them to be more efficient.

This finding is supported by the study of Kivlan et al.[21], which reports similar results when using several performance tests in a population of female dancers with hip pain. Furthermore, similar results were reported by Hardesty et al.[22], who indicated that basketball players' performance in frontal plane hop tasks presented side-to-side asymmetries only in the medial triple hop test compared to football players' performance of the same task. Although there are limited data in the literature linking frontal plane tasks with muscle strength,sole side-to-side asymmetries in the medial triple hop test could contribute to the speculation that inadequate concentric and eccentric activation of the hip abductor muscles interact for frontal plane tasks. The study of Kea et al.[23] reported a correlation between hip adductors and abductor isokinetic strength and the medial and lateral triple hop tests in healthy male hockey players. However, one significant limitation of the study was that the researchers assessed only the dominant lower limb of the players. Many studies of soccer players have proved that balance and strength asymmetries are alleviated when training age is increased[8, 24–26], and it can be hypothesized that muscular activation of the non-dominant side cannot be equivalent in the amateur body of a young, growing athlete. Consequently, an explanation of why the medial triple hop test could elicit side-to-side differences may be that it is a more demanding task than the anterior hop test in regards to dynamic balance, power, coordination and eccentric control of the hip abductors and external rotators, as well as skills, training adaptations and confidence[17, 21, 23].

Our findings also indicated a significant correlation between the vertical jump test and each of the three triple hop test directions for both lower extremities. These findings reinforce the results of other research studies reporting the triple hop for distance test as a strong positive predictor of performance on power and strength. In similar athletic populations, other researchers[27, 28] concluded that longer triple hop distances in the sagittal plane predicted higher vertical jump heights. To our knowledge, the present study is the first one that evaluated a correlation between the vertical jump and triple hop in the frontal plane among basketball players.

The final results regarding the presence of functional asymmetries in the lower extremities of young basketball players cannot be deduced from this research under the weight of its limitations. The most important limitation of the present study is that it evaluated young players' functional performance in whom asymmetrical functional adaptations may not have yet occurred to a significant extent. However, it is generally accepted that asymmetric functional adaptations develop as early as childhood and are exacerbated by asymmetric training load in young athletes. Therefore, the functional deficits evaluated in the present study can be considered valid findings. Furthermore, the study utilized functional tests to detect functional performance deficits and not validate examination procedures of strength, flexibility and neuromuscular control. However, this selection was necessary to evaluate the neuromuscular capacity of the athletes' lower extremities and produce clinically meaningful results. Despite its limitations, the clinical value of the findings of this research is particularly important, given that the statistically significant side-to-side differences found in the medial triple hop test may form a potential risk factor for future injury in the specific population. Previous research also suggests that athletes with an asymmetry index ≥15% are at a high risk of injury[16]. According to this, 33.3% to 48.1% of this study population is susceptible to injury if we count on the triple hop scores. Based on the above finding, it is reasonable to suggest that sports scientists should make a systematic effort to evaluate and correct the functional asymmetries of athletes during the preseason period to reduce the risk of musculoskeletal injuries.

Also, based on the findings of the present research, the importance of the medial triple hop test emerges, as it was the only test that managed to highlight the asymmetric function of the lower extremities in young basketball players. Further research is needed to evaluate whether this asymmetry is actually affiliated with future injury or not. This research should have also utilized more valid examination tests of athletes' physical properties, such as strength, flexibility and neuromuscular control.

In conclusion, the lower extremities of young basketball players present a symmetrical picture of functional performance, as revealed by the evaluation of various functional tests, with a unique exception for the medial triple hop test where significant asymmetries were observed. Furthermore, there was a significant association between hop tests and vertical jump scores. Future studies are needed to confirm the asymmetries observed in the medial triple hop jump in a larger sports population. In that case, it is suggested that the medial triple hop test should also be implemented in training and injury prevention programs to provide adequate stimulus for the improvement of multidirectional sports performance.

Conflict of interest

None.

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