The Effect of Hamstring Shortness on Vertical Jump and Balance Performance in Youth Basketball Players

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Abstract

**Background:** Hamstring flexibility significantly influences athletic performance, particularly in dynamic actions like vertical jumps and balance. This study seeks to uncover the connection between hamstring shortness and the dynamic interplay of vertical jump height and balance in these youth basketball athletes.

**Material Method:** The study included 84 male youth basketball players with hamstring shortness. Participants underwent assessments including hamstring flexibility, hip flexed and knee extended (HF-KE), Sit and Reach Test, popliteal angle measurement, vertical jump measurement with the Optojump device, and balance measurement with the Y balance test.

**Results:** The findings from our study indicate a significant association between the results of the vertical jump test and both the left HF-KE ($p < 0.001$) and the popliteal angle ($p < 0.001$). Y balance was significantly correlated with the test ($p=0.011$). Multiple regression analysis revealed a relationship between right HF-KE and jumping performance ($\beta= 0.363$, $R^2 = 0.213$; $F = 10.798$, $p =0.002$) and between left HF-KE and jump ($\beta= 0.523$, $R^2 = 0.472$; $F = 35.712$, $p< 0.001$).

**Conclusion:** In conclusion, our study underscores the crucial role of hamstring flexibility in vertical jump performance among youth basketball players. The significant associations found between left HF-KE and popliteal angle with vertical jump performance highlight the importance of addressing hamstring shortness in training programs aimed at enhancing jump performance. These findings emphasize the need for targeted interventions to improve hamstring flexibility, which could ultimately contribute to better athletic performance and injury prevention in this population.

Introduction

Basketball is a team sport that requires various skills such as physical strength, speed, balance, coordination, jumping, and flexibility [1]. Therefore, players need adequate balance and strength to successfully perform high-intensity movements [2]. Repetitive pressures, changes in direction and jumping performance in training and competitions are directly related to both decreased neuromuscular performance and increased muscular loading, which increases the risk of injury [3][4].

Effective assessment methods focus on improving strength, speed, balance, jump performance and power characteristics against the risk of injury for basketball players are essential for optimizing their performance during matches [5][6]. The importance of jumping for basketball players goes beyond just elevation and emphasizes the need for a comprehensive assessment that includes balance [7].

In the intricate web of human movement, hamstring flexibility emerges as a critical factor influencing dynamic sports performance. The hamstring muscles located at the back of the thigh are responsible for fundamental movements like jumping and maintaining balance [8]. In basketball and other team sports,
jumping ability is key, often used to gauge lower extremity power, highlighting the significance of hamstring flexibility [9].

However, information regarding the potential relationship between these assessments and specific sport-related risk factors for injuries, which can reduce pathologies associated with sports, is still insufficient. Furthermore, to prevent lower extremity injuries, each athlete’s specific neuromuscular performance should be evaluated. The emphasis on comprehensive functional assessments with specific tests specifically designed for basketball players is very limited. [10][11]. Therefore, there is a need for further research and investigation in this area. This study aims to fill this gap by investigating the impact of hamstring shortness on vertical jump and balance performance in young basketball players and contribute to the scientific understanding of the complex relationship between hamstring flexibility and fundamental athletic skills that are crucial for dynamic movements in young athletes. The findings have the potential to inform evidence-based interventions and specific training strategies to improve overall athletic performance and well-being in youth basketball players.

**Methods**

**Study design**

The study was conducted from December 2023 to February 2024 with the aim of multidimensionally evaluating basketball players with hamstring shortness. Ethics approval was obtained under committee number E-85646034-604.02.02-67240, and the study was registered with clinical Trials.gov under number NCT06179862.

**Participants**

Licensed basketball players between the ages of 18–25 years, with a hamstring shortness of 30 cm or less according to the sit-stand test, a range of motion of less than 80 degrees according to the active straight leg raise test, and playing in the Istanbul Local Basketball League run by the Turkish Basketball Federation were included in the study. Exclusion criteria included previous foot or ankle surgery, lower limb injury and playing a match within the previous 48 hours. In addition, participants have suffered an injury in the previous 3 months, any systemic, locomotor or lower limb-related disease was required, as well as no sensory loss, systemic disease or peripheral neuropathy.

**Sample calculation**

The power of the study was calculated using G*Power software version 3.1.9.4 (G*Power, Universität Düsseldorf, Düsseldorf, Germany). In the study, the effect size value 0.27 was taken as and it was determined that a subject group of at least 81 individuals was required with 80% power and 0.05 type 1 error. Taking into account potential participant dropouts, the study aimed to include a total of 84 individuals [12]

**Procedures**
Data collection for all test measurements was conducted under the supervision of the same physiotherapist to ensure consistency. A demographic survey was created using Google Form to gather information about participants’ age, gender, body measurements, education level, health status, and other relevant details. Prior to testing, all participants underwent a 10-minute warm-up session led by the principal investigator. The actual measurements took place in a school gymnasium, with participants rotating through four test stations (balance, jump, hamstring length, and popliteal angle assessment). Standardized instructions were provided for each test to ensure uniformity and minimize learning time. If a participant made an error during a test, they were allowed to repeat it after a brief rest period. No feedback was given during testing to maintain objectivity.

**Measurements**

The assessment of hamstring shortness involves positioning the dominant leg supine with the hip flexed and knee extended (HF-KE), maintaining the ankle in a neutral position. As the participant extends the knee until encountering resistance or discomfort, the angle between the thigh and lower leg is measured using a goniometer. The pivot point for measurement is the trochanter major, with the fixed arm of the goniometer aligned parallel to the body. An angle measurement below 80 degrees suggests hamstring shortness [13].

The popliteal angle test evaluates hamstring flexibility by measuring the angle between the knee and hip joints when the knee is extended against resistance from a flexed position. This test is conducted with the individual lying on their back, with both the knee and hip flexed at 90 degrees. As the knee extends against resistance, the angle between the vertical axis of the knee and the end point of movement is recorded. A popliteal angle exceeding 10 degrees suggests hamstring tightness or shortness [13].

Sit and Reach Test (SRT), they are placed in a long sitting position with naked feet in full contact with the measuring board and required to push the bar with both hands reaching towards the toes without bending the knees. If the bar is less than 30 cm, the test is positive and indicates hamstring shortness [14].

The Y Balance Test, a method for assessing lower extremity function, involves balancing on one foot while reaching predetermined distances in various directions on a Y-shaped line. Participants extend their non-weight-bearing foot in anterior, posterolateral, and posteromedial directions while maintaining balance on the weight-bearing foot. The maximal reach distances in each direction are recorded, normalized to leg length, and averaged to yield a composite score. Y Balance Test is widely used in assessing balance and extremity control, providing valuable insights into functional performance and injury risk in various populations, including athletes and individuals with musculoskeletal conditions [15].

Optojump is a system utilized for assessing athletes' jumping performance, comprising a platform equipped with optical sensors and computer-based software. Athletes measure their performance by executing jumps from predetermined distances on the optojump platform. Through the measurement of parameters like jump height, speed, power, and others, the optojump system aids in analyzing athletes'
athletic capabilities. This data serves a pivotal role in designing training regimens and devising strategies for enhancing performance [16].

**Statistical analysis**

The data analysis for this study will be conducted utilizing the Statistical Package for Social Sciences (SPSS) Version 22.0 (SPSS Inc., Chicago, IL, USA). To assess the normal distribution conformity of variables, the Shapiro-Wilks test will be employed. Descriptive statistics, such as mean and standard deviation (Mean ± SD), will be used for normally distributed variables. The statistical analysis will involve a range of tests, including Student’s-t tests, Chi-square tests, non-parametric tests, and correlation analyses using Pearson and Spearman coefficients. Multiple regression analysis was conducted. A significance level of p < 0.05 will be applied to determine statistical significance.

**Results**

The study included 130 youth basketball players, with 84 of them (mean age: 13.14 ± 1.41 years) voluntarily participating, meeting the inclusion criteria. Table 1 presents descriptive statistics for the assessed outcomes in the overall sample, indicating that the athletes have an average height of 175.5 (± 15.14) meters (m), weight of 61.45 (± 16.40) kg, and Body Mass Index of 19.78 (± 2.62) kg/m².

<table>
<thead>
<tr>
<th>Demographic Information</th>
<th>Mean ± Std</th>
<th>Minimum-maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>13.14 ± 1.41</td>
<td>10.00–16.00</td>
</tr>
<tr>
<td>Height</td>
<td>175.5 ± 15.14</td>
<td>141–2.07</td>
</tr>
<tr>
<td>Weight</td>
<td>61.45 ± 16.40</td>
<td>38–97</td>
</tr>
<tr>
<td>Body Mass Index</td>
<td>19.78 ± 2.62</td>
<td>16–28.68</td>
</tr>
<tr>
<td>Shoe Size</td>
<td>43.74 ± 3.17</td>
<td>38–49</td>
</tr>
<tr>
<td>Dominant Foot</td>
<td>72 Right</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12 Left</td>
<td></td>
</tr>
</tbody>
</table>

Descriptive statistics for lower extremity physical parameters and performance tests are shown in Table 2.
Table 2
Descriptive statistics data for lower extremity physical parameters and performance tests

<table>
<thead>
<tr>
<th></th>
<th>Mean ± Std</th>
<th>Minimum-maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sit and Reach</td>
<td>19.70 ± 6.09</td>
<td>4–29.00</td>
</tr>
<tr>
<td>HF-KE- Right</td>
<td>70.69 ± 5.86</td>
<td>42–79</td>
</tr>
<tr>
<td>HF-KE – Left</td>
<td>77.48 ± 6.05</td>
<td>54–79</td>
</tr>
<tr>
<td>Popliteal açı</td>
<td>38.71 ± 10.24</td>
<td>22–62</td>
</tr>
<tr>
<td>Y balance-Right</td>
<td>81.74 ± 11.47</td>
<td>57.10</td>
</tr>
<tr>
<td>Y balance Left</td>
<td>83.67 ± 14.42</td>
<td>54.00–107.30</td>
</tr>
<tr>
<td>Optojump Flight (second )</td>
<td>0.60 ± 0.32</td>
<td>0.52–0.64</td>
</tr>
<tr>
<td>Optojump Height (centimeter)</td>
<td>44.89 ± 4.60</td>
<td>32.90–50.80</td>
</tr>
</tbody>
</table>

Std: standard deviation, HF-KE: hip flexion with knee extended at 0° test for the hamstrings.

Vertical Jump Correlation Analysis is shown in Table 3. In the correlation analysis performed for the right Y Balance Test, a low correlation was determined between the sit-reach test (p = 0.213, r = 0.140). A highly significant correlation was found between right HF-KE and Y Balance Test (p = 0.011, r = 0.921). However, no significant correlation was found between left active HF-KE (p = 0.599, r = 0.060) and popliteal angle (p = 0.331, r = 0.108) and Y Balance Test.

There was no correlation between left y balance test and sit-reach test (p = 0.922, r = 0.011). There was no significant correlation between right HF-KE and Y Balance Test (p = 0.653, r = 0.051). There was also no significant correlation between left HF-KE (p = 0.653, r=-0.51) and popliteal angle (p = 0.555, r=-0.65) and Y Balance Test.

Multiple regression analysis revealed a relationship between right HF-KE and jumping performance (β = 0.363, R² = 0.213; F = 10.798, p = 0.002) and between left HF-KE and jump (β = 0.523, R² = 0.472; F = 35.712, p < 0.001).
Table 3  
Correlation Analysis of Vertical Jump

<table>
<thead>
<tr>
<th></th>
<th>Vertical Jump Height</th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>P</td>
<td>r</td>
</tr>
<tr>
<td>Sit and Reach Test</td>
<td>0.922</td>
<td>0.011</td>
<td></td>
</tr>
<tr>
<td>HF-KE Right</td>
<td>0.056</td>
<td>0.213</td>
<td></td>
</tr>
<tr>
<td>HF-KE- Left</td>
<td>0.00</td>
<td>0.487</td>
<td></td>
</tr>
<tr>
<td>popliteal angle</td>
<td>0.00</td>
<td>0.458</td>
<td></td>
</tr>
<tr>
<td>Y balance sağ R-YBT</td>
<td>0.78</td>
<td>0.031</td>
<td></td>
</tr>
<tr>
<td>Y balance sol L-YBT</td>
<td>0.047</td>
<td>0.670</td>
<td></td>
</tr>
</tbody>
</table>

Insignificant at 0.05 level, HF-KE: hip flexion with knee extended at 0° test for the hamstrings

Discussion

The objective of this investigation is to explore the correlation between hamstring tightness and physical performance, specifically vertical jump and dynamic balance, among youth basketball athletes. Based on our study's outcomes, the vertical jump test results exhibited an association with the left HF-KE angle and popliteal angle, while no significant correlation was found between the results of the right and left Y balance test and other parameters. However, through multiple regression analysis, a notable relationship between the performance of the right and left HF-KE and jumping performance was revealed.

The critical importance of vertical jumps in basketball is a fundamental requirement to ensure maximum performance through rapid muscle tension and reflexive contractions[6] [17]. Studies have reported that insufficient flexibility in the muscles leads to decreased jumping force. Domínguez-Díez et al. examined the relationship between passive joint mobility of the lower extremities and jumping performance in soccer and basketball young players. They found insufficient correlation between joint mobility and jumping performance, but concluded that it is a characteristic that needs to be evaluated and developed in these athletes [18]. In another study, Panoutsakopoulos et al. reported that mechanical energy transfer during a vertical jump is facilitated by dual-joint lower extremity muscles. They also reported that a flexible ankle joint contributes to higher jump performance in volleyball players, emphasizing the importance of flexibility in the hip, knee, and ankle joints during jumping [19].

In our study, we found a relationship between jumping performance and flexibility in both correlation and regression analysis results. However, existing studies examining the effect of hamstring flexibility on jumping performance in youth or professional basketball players are insufficient. Past studies in other sports have reported conflicting results regarding hamstring flexibility. Rey et al. conducted physical fitness tests, including jumping, in professional soccer players with low and high hamstring flexibility,
finding no significant difference between the two groups [19]. We believe that the variation among studies is due to the different study populations, being composed of various amateur and professional athlete groups.

The positions of the lower extremities during jumping affect the jumping distance. Additionally, maintaining body stability is crucial. Therefore, proprioception and balance tests are important for athletes, alongside flexibility [20]. In a study investigating the effects of different jump directions on dynamic balance in the dominant and non-dominant legs, it was reported that vertical jumping is more suitable for evaluating dynamic postural stability. The dominant leg demonstrated better dynamic postural stability, associated with leg muscle strength [21]. In a study by Bogal et al., examining the impact of hamstring flexibility on vertical jump and balance, a relationship was found between left hamstring flexibility and jumping, but not with the right hamstring. However, no significant correlation was found between balance and hamstring flexibility [22]. Kramer et al. explored the relationship between dynamic balance measured by the Y Balance Test (YBT) and physical performance tests in high school students (aged 16–17), finding no significant relationship between YBT results for both legs and vertical jump [17]. In contrast to Demir et al.’s findings, moderate correlation was found between balance and hamstring tightness in children aged 10–12[23] .

Based on the available data, conflicting results have been reported regarding the relationship between hamstring flexibility and balance. Asan et al. found a particularly positive correlation between balance and flexibility averages, especially when the left foot was the balance foot in soccer players [24]. Similarly, in our study, we also identified a correlation between balance on the left foot and hamstring flexibility. This discrepancy may be attributed to the dominance of the right foot among the majority of participants, leading them to assume a supine position with the right foot grounded while balancing on the left foot.

Cejudo examined lower extremity flexibility in basketball players, determining hip flexion to be 78° and 83° during knee extension. Cejudo suggested that evaluating these flexibility measurements and asymmetries in a multi-component training program involving strength and neuromotor elements could prevent injuries. Additionally, investigating the impact of bilateral asymmetries in hip flexion range of motion during knee extension on physical performance is warranted [25]. In our study, the right hip flexion was determined to be 70.69, and the left was 77.48, indicating a similar asymmetry between extremities. This finding suggests the importance of a multicomponent training program and emphasizes the importance of asymmetric movement examination of athletes.

**Conclusions**

It is essential to consider that vertical jump performance is influenced by a variety of factors such as muscular strength, power, coordination and technique. While hamstring shortness is potentially a factor, it is only one component when it comes to determining jumping skills. Athletes and coaches should take an
approach to optimizing vertical jumping abilities by considering hamstring flexibility as well as other relevant factors.

**Limitation**

Several limitations warrant consideration in this study. Primarily, the participant pool was exclusively composed of males due to our concern regarding potential variations in hamstring properties between male and female athletes [26]. Consequently, caution should be exercised when attempting to extrapolate the study's findings to the broader female population. Moreover, the cross-sectional design of this study may make it difficult to identify causal relationships. In addition, limitations regarding the reliability and validity of the measurement tools used (e.g., the Y Balance Test) should also be taken into account. Such limitations should be considered in future research and addressed in more comprehensive studies.

**Declarations**

**Conflict of interest**

The authors reported that there is no funding associated with the work featured in this article

**Ethical approval**

This trial was approved by the ethics committee of our Istanbul Medipol Hospital under the number E- E-85646034-604.02.02-67240.

**Informent consent**

Informed consent was obtained from all participants who agreed to participate in the study.

**Funding**

There is no funding support.

**Author Contribution**

Author contributions Conceptualization: HG; Methodology: GD and HG; software: GD and HG; Formal Analysis: HG; Investigation: GD; Data Curation: GD and HG. Writing-Original draft preparation: GD and HG; Writing-review and editing: GD; Supervision: HG.

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