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Relationship Of Hamstring Muscle Length With Dynamic Balance And Agility In Untrained Soccer Players: A Cross-Sectional Analysis

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Abstract:
Background: *Existing literature on enhancing athletic performance indicates a link between balance and agility. However, inconsistencies exist in research findings regarding how hamstring flexibility affects these performance factors among untrained soccer players. Unlike trained players, untrained ones often lack regular training and proper warm-up routines, increasing their risk of injuries. Thus, this study aimed to assess the relationship of agility and dynamic balance with hamstring muscle length in untrained soccer players.*
Materials and Methods*: A total of 92 university male soccer players (age 23.73 ± 2.35 years) were recruited in this cross-sectional study using convenience sampling. The Y Balance Test- Lower Quarter (YBT-LQ) was used to assess dynamic balance in the anterior, posterolateral and posteromedial directions. Agility was evaluated using the modified agility T-test. Hamstring flexibility was assessed using the Active Knee Extension (AKE) test. Karl Pearson correlation coefficient was used to estimate the relationship between the variables.*
Results*: There was a positive correlation between AKE test scores the YBT-LQ composite and direction scores ($p<0.05$). Similarly, there was a positive correlation between AKE test and modified agility T-test ($p<0.05$). Similar findings were noted irrespective of leg dominance.*
Conclusion: *Hamstring flexibility was significantly related to dynamic balance and agility. These findings imply the need for suitable testing and training protocols to enhance both balance and agility performance.*
Key Words: *agility, fitness, flexibility, hamstrings, soccer, YBT-LQ*

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I. Introduction

Soccer is widely recognized as a demanding team sport characterized by intermittent high-intensity activities, necessitating attributes beyond just speed and endurance, including agility, balance, and more. Throughout a game, players engage in approximately 150-250 brief bursts of intense energy expenditure, interspersed by phases of low-intensity jogging or running[1,2].

The hamstrings are active throughout the gait cycle with peak activation during the terminal swing and initial stance of sprinting[3,4]. During the terminal swing phase, the hamstrings are required to contract forcefully whilst lengthening to decelerate the extending knee and flexing hip. The biarticular hamstrings are active and undergo a stretch-shortening cycle during the second half of the swing phase of sprinting. In contrast, the maximum torques for hip extension and knee flexion are found to occur during ground contact during sprinting[4,5].

The hamstring muscle is particularly prone to injury and accounts for a notable portion of musculotendinous injuries in athletic competitions involving the lower extremities[6,7]. Injuries to the hamstring muscle present a multifaceted challenge for athletes, physicians, physical therapists, and athletic trainers, as they often recur and constrain participation in athletic competitions[8]. Most experts consider aerobic conditioning, strength training, and flexibility to be the three key components of a conditioning program[9,10]. By definition, flexibility is the ability of a muscle to lengthen and allow one or more joints to move through a range of motion (ROM), and the loss of flexibility may decrease the ability of a muscle to perform optimally[11].

Agility can be defined as the ability to maintain and regulate correct positions of the body while rapidly changing direction through a series of movements[12]. This skill is a determinant of sport success in field and court competition, demonstrated by analysis of time-motion, evaluation of testing batteries for elite and non-elite athletes, and coaching analyses for different team sports[13]. Soccer involves multiple sprints consisting of various explosive motions such as forward and backward shuffles, to be executed at varying intensities during a match[14]. Whether attacking or defending, agility skill requires the ability to perceive and respond rapidly and accurately to relevant information about opponent's movements. Owing to its various embodiments (forward-backward, rotational, lateral, etc.), agility is challenging to generally develop through strength and conditioning training[15].

Dynamic balance refers to maintaining equilibrium during motion or re-establishing equilibrium by rapidly and successively shifting positions[16]. Soccer requires a unipedal balance to execute various technical motions such as dribbling, shooting and passing[17]. Players must learn compulsory motor skills and monitor their posture during the match, while using visual inputs about the opposing team members[18]. Authors claim that apart from speed and explosive strength, balance training should be considered as one of the main features of improving agility[12].

The current body of literature focusing on improving athletic performance suggests a relationship between balance and agility. Nonetheless, there are inconsistencies in the research findings regarding the association of these performance factors with hamstring flexibility among untrained soccer players. Unlike their trained counterparts, untrained players typically do not engage in regular training or adequate pre-event warm-up, which is crucial for injury prevention, such as muscle sprains[19]. Therefore, the purpose of this study was to estimate the relationship of agility and dynamic balance with length of hamstring muscle in untrained soccer players.

II. Material And Methods

Subjects and Study Setting: A total of 92 male soccer players between ages 18 to 30 years were recruited in this descriptive cross-sectional study. University soccer players with hamstring tightness, competing at lower levels such as college and inter-college competitions who not indulge in regular soccer specific training, not participated in any type of regular physical training for the last two years were included in the study. Hamstring tightness was defined as a deficit of 30^0 from full knee extension with the hip at 90^0 [20]. Professional soccer players, and those who reported vestibular problems, low back pain or lower limb injuries that required treatment or that may have impeded performance in the past year were excluded from the study. The study was undertaken between October 2023 to February 2024 in a low resource setting. A written informed consent was obtained from each participant. The study was approved by the Institutional Ethics Committee (FMMC/ FMIEC/167/2022) and registered under the Clinical Trials Registry - India (CTRI/2023/10/058288).

Procedure: An initial examination including demographic information and anthropometric factors such as BMI, limb length, and leg dominance was carried out prior to the study. The side preferred to kick the ball was defined as the dominant leg. Participants underwent assessments of dynamic balance utilizing the Y Balance Test – Lower Quarter (YBT-LQ) and agility using a modified version of the agility T-test. Hamstring flexibility was measured using the Active Knee extension (AKE) Test. During testing, participants wore their preferred footwear, except for the balance evaluation, which was conducted barefoot. The first day of testing involved anthropometric measurements, flexibility and balance assessments, while the second day focused on the modified agility T-test. To mitigate diurnal variations in fitness abilities, all tests were administered consistently during the late afternoon (4-6 PM).

Outcome Measures:

1. For the AKE test, the participant was positioned supine with the hip and knee flexed at a 90^0 [20,21]. A universal goniometer was aligned with the lateral malleolus and greater trochanter, centered over the lateral epicondyle. Following this setup, the subject was instructed to gradually extend their knee until they experienced a noticeable resistance or stretch. This point, referred to as terminal extension, was identified, and the corresponding measurement on the goniometer was noted. The test was performed on bilaterally, and an average of three trials was recorded for each.
2. Participants completed the YBT-LQ in three directions: anterior, posterolateral, and posteromedial [22-24]. Before the test, the therapist provided verbal instructions and a visual demonstration. During the test, participants placed both hands on their iliac crest and used the leg they typically kick with as the stance limb. The distal end of the big toe was positioned at the intersection of three measuring tapes on the floor. Participants maintained a single-leg stance while using their opposite leg to reach along each direction, touching the ground as far as possible with the distal end of the big toe before returning to the starting position. To eliminate the influence of footwear, the test was conducted barefoot. After three practice trials, participants rested for two minutes before performing three test trials in each direction. The order of reaching directions was randomized for each test trial. If a participant couldn't maintain the stance leg or return the reaching foot to the starting position, the trial was discarded and repeated. In each direction, the longest reach distance was used for further analysis. In order to account for the potential influence of limb length, it was

standardized with the reach distances of each subject[25,26]. The limb length was measured from the anterior superior iliac spine to the center of the ipsilateral medial malleolus[26]. The composite score was calculated using the formula: {sum of three directions/ (limb length*3)*100}[22].

3. Agility was assessed using the modified agility T-test protocol devised by Sassi et al[27]. A stopwatch was used to record the time taken to complete the test. Participants followed the same instructions as the standard T-test, except lateral movements and facing forward were excluded. Instead of touching the bases, they targeted the top of cones. The test comprised sequential movements: sprinting from A to B (5 meters), shuffling from B to C (2.5 meters), shuffling from C to D (5 meters), shuffling from D back to B (2.5 meters), and finally sprinting back from B to A (5 meters). Each subject executed two maximal attempts, and the fastest time was selected for statistical analysis.

Sample Size: The sample size was estimated with 95% confidence level and 80% test power based on the parameters of Sharma et al.[2] where the Karl Pearson correlation coefficient (r value) was 0.547. The study subjects were recruited using convenience sampling on the basis of the inclusion and exclusion criteria.

Statistical Analysis: Data were analyzed using SPSS software (IBM SPSS Statistics for Windows, Version 21.0; Armonk, NY: IBM Corp.). Demographic variables and outcome measures were summarized as mean and standard deviation (SD). The distribution of data was examined using the Shapiro–Wilk test to assess normality. As the data were normally distributed, relationships between the AKE test, the modified agility T-test, and YBT-LQ composite scores (including reach distances in the anterior, posterolateral, and posteromedial directions) were evaluated using the Karl Pearson correlation coefficient (*r*). The strength of correlation was interpreted as follows: 0–0.25 = negligible, 0.25–0.50 = fair, 0.50–0.75 = moderate to good, and ≥0.75 = good to excellent. Statistical significance was set at $p < 0.05$.

III. Result

Out of 113 participants that were initially screened for the study, 21 subjects did not meet the inclusion criteria (12 participants were professional soccer players; 9 players had a history of recent lower limb injury). Since there were no further dropouts, data collected from 92 participants was finally subjected to statistical analysis. The mean age and BMI of the participants was 23.73 ± 2.35 years and 23.14 ± 1.06 kg/m^2 respectively. The descriptive statistics of the primary outcome measures are described in Table1.

For the **dominant leg**, the AKE test showed a good to excellent correlation with the YBT-LQ composite score ($p < 0.01$). Correlations with anterior and posteromedial reaches were moderate to good, while posterolateral reach demonstrated a good to excellent association. The relationship with the modified agility T-test was moderate (Table2). For the **non-dominant leg**, the AKE test again displayed a good to excellent correlation with the YBT-LQ composite score ($p < 0.01$). All three reach directions (anterior, posterolateral, and posteromedial) showed moderate to good to good to excellent correlations, while the association with the modified agility T-test was fair to moderate (Table3). Overall, these results indicate that better hamstring flexibility, as measured by the AKE test, is strongly linked to dynamic balance performance in both limbs, with additional moderate associations with agility.

Table no 1: Descriptive Characteristics of Outcome Measures

Outcome Measure	N	Minimum	Maximum	Mean ± SD
AKE Test dominant leg (degrees)	92	18	26	24.61 ± 2.14
AKE Test non- dominant leg (degrees)	92	18	25	23.25 ± 2.19
YBT-LQ Composite Scores (centimetres)	92	99.12	110.53	106.62 ± 3.56
YBT-LQ Anterior (centimetres)	92	86	95	92.43 ± 2.63
YBT-LQ Posterolateral (centimetres)	92	87	108	102.71 ± 5.37
YBT-LQ Posteromedial (centimetres)	92	91	113	96.20 ± 2.89
Modified Agility T-test (seconds)	92	9.56	12.64	10.61 ± 1.02
AKE: Active Knee Extension; N: Number of participants; SD: Standard deviation; YBT-LQ: Y Balance Test- Lower Quarter				

Table no 2: Karl Pearson Correlation between outcome measures (dominant leg)

Outcomes		r value*
AKE Test (dominant leg)	YBT-LQ Composite Scores	0.936
	YBT-LQ Anterior	0.725
	YBT-LQ Posterolateral	0.823
	YBT-LQ Posteromedial	0.742
	Modified Agility T-test	0.572

*Correlation significant at the 0.01 level (2 tailed)
r value = Karl Pearson correlation coefficient;
AKE: Active Knee Extension; YBT-LQ: Y Balance Test- Lower Quarter

Table no 2: Karl Pearson Correlation between outcome measures (non-dominant leg)

		r value*
AKE Test (non-dominant leg)	YBT-LQ Composite Scores	0.816
	YBT-LQ Anterior	0.783
	YBT-LQ Posterolateral	0.791
	YBT-LQ Posteromedial	0.715
	Modified Agility T-test	0.480

*Correlation significant at the 0.01 level (2 tailed)
r value = Karl Pearson correlation coefficient;
AKE: Active Knee Extension; YBT-LQ: Y Balance Test- Lower Quarter

IV. Discussion

The findings of this study revealed that the AKE test scores of both the dominant and non-dominant leg were positively associated with the scores of the YBT-LQ and modified agility test scores. In other words, participants with greater hamstring muscle flexibility performed better in the balance and agility tests. Similar findings were noted by Sharma et al. where the posterolateral reach distance of the Star Excursion Balance Test moderately correlated with hamstring flexibility[2]. Khilnani et al. also found that individuals without hamstring tightness exhibited higher star excursion balance test values compared to those with tightness, suggesting that subjects without tightness generally have better dynamic balance than those with hamstring tightness[28].

Pinillos F et al. examined how restricted hamstring flexibility affects performance metrics such as agility, concluding that hamstring flexibility plays a crucial role in executing soccer-specific skills among young players. These findings reinforce the importance of incorporating targeted muscle flexibility training in football players from a young age[29]. Soccer players, regardless of their position on the field, engage in short bursts of high-intensity activity such as agility, interspersed with longer periods of low-intensity movements and rest. Hamza et al. examined the static and dynamic balance performance of soccer players according to their positions, concluding that dynamic balance is particularly crucial for midfielders[30]. Midfielders serve as the link between defenders and forwards, fulfilling various roles both defensively and offensively for the team. Additionally, midfielders typically cover the most distance during a soccer match. However, our study did not directly investigate this argument.

Maintaining balance during daily activities and exercises is crucial for injury prevention. Any disruption in balance can impair performance and increase the risk of injury. Muscle tightness, including in the hamstrings, is a common factor that affects an individual's balance[6,7]. The hamstring muscle, a key player in the hip and ankle strategy for balance, helps maintain equilibrium by adjusting the centre of gravity. Thus, dysfunction in the hamstrings can impact balance, leading to reduced performance and potential injury[11].

A study conducted by Yasuhiro et al. demonstrated a significant correlation between hamstring tightness and medial reach distance on the Star Excursion Balance Test among junior high school basketball players[29]. Similarly, research by Shah et al. indicated a strong negative correlation between hamstring and calf muscle tightness and static dynamic balance[21]. Additionally, Zagyapan et al. found in their study that hamstring tightness induces postural changes that disrupt balance[30].

Pinillos F et al. examined how restricted hamstring flexibility affects performance metrics such as agility, concluding that hamstring flexibility plays a crucial role in executing soccer-specific skills among young players. These findings reinforce the importance of incorporating targeted muscle flexibility training in football players from a young age[31]. Soccer players, regardless of their position on the field, engage in short bursts of high-intensity activity such as agility, interspersed with longer periods of low-intensity movements and rest. Hamza et al. examined the static and dynamic balance performance of soccer players according to their positions, concluding that dynamic balance is particularly crucial for midfielders[32]. Midfielders serve as the link between defenders and forwards, fulfilling various roles both defensively and offensively for the team. Additionally, midfielders typically cover the most distance during a soccer match. However, our study did not directly investigate this argument.

Several limitations should be acknowledged in this study. Firstly, the sample size was small, comprising solely male university soccer players. Therefore, it is imperative to validate these findings in more diverse populations, including female athletes and larger cohorts. Secondly, this study did not account for other factors that could influence agility tasks, such as sprinting and cognitive abilities. Thirdly, while use of the YBT-LQ grid could potentially offer greater precision in our results, their absence may represent a limitation. Nevertheless, the use of manual stopwatch and floor-adhered measuring tapes is more cost-effective and practical in a limited-resource clinical environment.

V. Conclusion

There is a statistically significant correlation of hamstring muscle tightness with dynamic balance and agility in untrained male soccer players. It is evident that maintaining muscle flexibility is a crucial aspect of fitness for university players. Consequently, physical therapists, coaches, and trainers should advocate for flexibility training exercises to improve players' dynamic balance and agility, with the goal of enhancing agility skills and overall performance.

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