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Impact of hamstring flexibility on functional performance of collegiate football players

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Abstract
Introduction: Football is the most popular high-intensity intermittent team sport that requires speed, strength, agility, and endurance. During official matches, elite football players perform 150–250 short-lasting, energy-demanding intense actions interspersed with periods of low-intensity jogging or running. Collegiate football programs place great importance on controlling player's body weight, body composition, muscle strength, and length. Of all the muscle strains associated with competitive sport, hamstring strains are the most common and problematic.
Objectives: To determine the correlation between hamstring flexibility and functional performance of collegiate football players.
Methods: 100 subjects who met the inclusion criteria were enrolled in the study. Once the baseline data was collected the subject's hamstring flexibility was assessed by the Active knee extension test (AKE) and limb length was measured. Subjects were then asked to perform Illinois Agility Test, 30m Sprint Test and Wall Mount test, and Star Excursion Balance Test (SEBT). Three trials of each test were performed, and the mean was taken for statistical evaluation.
Result: There exists weak correlation between sprint, agility, SEBT, and hamstrings length; however, results indicate a moderate correlation between posterolateral reach distance and hamstring flexibility and a statistically significant relationship between hamstring length and vertical height of jump with $p < 0.05$.
Conclusion: Hamstring flexibility has a weak correlation with functional performance of collegiate football players. However, it has positive correlation with vertical jump height and posterolateral reach distance of SEBT.

Keywords: Football, hamstring flexibility, agility, sprint, vertical height jump

Introduction
Football is the most popular high-intensity intermittent team sport that requires speed, strength, agility, and endurance. During official matches, elite football players perform 150–250 short-lasting, energy-demanding intense actions interspersed with periods of low-intensity jogging or running [1]. Team sports are demanding activities and musculoskeletal injuries are some of the most severe health problems in sports medicine, resulting in high economic costs, withdrawal of athletes from training and competitions, and potentially affecting athlete performance [2, 3, 4].
The hamstrings are active throughout the gait cycle with peak activation during the terminal swing and initial stance of sprinting cycle. During the terminal swing phase, the hamstrings are required to contract forcefully whilst lengthening to decelerate the extending knee and flexing hip [5, 6]. 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 in over ground sprinting [6, 7].
Approximately 7.8 million adolescents take part in interscholastic sports and activities each year. It is a well-known fact that physical activity is associated with an improved quality of life as well as an overall reduction in morbidity and mortality in adolescence and adulthood. However, physical activities and sports participation during adolescence is associated with an increased risk of musculoskeletal injuries.

A large proportion of these injuries are lower extremity injuries accounting for 60-75% of all injuries in the high school athletic population [8].

Despite the emphasis placed on enhancing these physical characteristics, many people are seen in the emergency department each day for sports, recreational and exercise-related musculoskeletal injuries [8]. The prevalence of injury types and locations is different according to sport modality, varying from 5 to 60% for joint injuries, 20–60% for muscle injuries and 10–50% for tendinopathy [9]. Around 17% of injuries in football has been attributed to muscle tightness and lack of flexibility, among which hamstring tightness has a higher risk of non-contact injuries [10, 11]. As collegiate football programs place great importance on controlling player's body weight, body composition, muscle strength, and length therefore this study was conducted to see whether hamstring flexibility has an impact on functional performance of collegiate football players.

Methodology
For the study 100 male football players age 18-25 years were taken from Padmashree Group of Institutions, Kengeri, Bangalore through convenience sampling. Subjects with muscular pain, neuromuscular disorder affecting the lower extremity and lower extremity or back surgery in the previous 12 months were not included in the study. The written consent form was taken from subjects who fulfill the inclusion criteria. Demographic data such as name, age, weight, height, limb length, and BMI were collected from each subject. Then the length of hamstring muscle was assessed for everyone through the Active Knee Extension (AKE) Test.

Active Knee Extension Test
To perform the test subjects were asked to lie supine on the treatment couch and the lower extremity not being measured was secured to the couch, another strap was placed over ASIA to stabilize the pelvis. The goniometer was then aligned to the long axis of the tibia with the axis being on the lateral knee joint line [12]. The subject then extended his knee while maintaining contact with cross wire or metal frame apparatus.

Followed by AKE each subject then performed Illinois Agility Test, 30m Sprint Test and Wall Mount test, and Star Excursion Balance Test.

Illinois Agility Test
The IAGT was set up with 4 cones forming the agility area. On command, the athlete sprint 9.20 m, turns and returned to the starting line. After returning to the starting line, he swerved in and out of 4 markers, completing two 9.20m sprints to complete the agility course. Performance's time was recorded using a stopwatch. The best performance of the 3 trials was recorded for statistical analyse [13].

30m Sprint Test
A stopwatch was used to record the time. The participants were instructed to run at maximal speed from the starting point to the finish line. The best of 3 test trials was used for statistical analyses [13].

Wall Mount Test
The subjects were asked to stand straight with the dominant side next to the wall with both feet firmly on the ground. The subject's fingertip was marked with the chalk, and they were instructed to jump as high as possible and touch the wall. The best of 3 trials will be taken for statistical analysis [14].

Star Excursion Balance Test
For SEBT the players were allowed to practice 6 trials on each leg in each of the 3 reach directions before formal testing. The player then stood on 1 leg in the center of a grid, with the most distal aspect of the great toe at the starting line. While maintaining a single-leg stance, the player was asked to reach with the free limb in the anterior, posteromedial, and posterolateral directions in relation to the stance foot. The maximal reach distance was measured by marking the tape measure at the point where the most distal part of the foot reached. The trial was discarded and repeated if the player failed to maintain unilateral stance, lifted, or moved the stance foot from the grid, touched down with the reach foot, or failed to return the reach foot to the starting position. The process was repeated while standing on the other leg. The greatest of 3 trials for each reach direction was used for the analysis of the reach distance in each direction [15].

All the tests were performed thrice, and 3 minutes of rest was given in between the trials and the best trial was retained for statistical analysis, and 30 minutes of rest was given between the tests to reduce fatigue [14]. Karl Pearson's method was then performed to obtain correlation between hamstring flexibility and sprinting ability, agility, vertical jump and dynamic balance (SEBT).

Results
Results indicate there exists a positive correlation between vertical jump height and hamstring flexibility of both the legs as shown to be r=0.241 for the right leg and r=0.284 for the left leg at 5% level ($p < 0.05$). This indicates that vertical jump height is dependent on hamstring flexibility. The correlation between sprint and hamstring flexibility is weak as r=0.054 right leg and r=-0.025 left leg) and agility (r=-0.039 right leg and r=-0.038 left leg) also show a weak and negative correlation and thus are not significant at 5% level (i.e. $p > 0.05$). This indicates there exists no correlation between hamstring flexibility and sprint speed and agility.

Table 1: Correlation between flexibility with sprint, vertical jump, and agility

S.No.	Correlation	Sprint	Vertical Jump	Agility
1	Limb length –Right	-0.016	0.065	-0.087
2	Limb length- Left	-0.101	0.066	-0.101
3	Active knee extension-Right	0.054	0.241*	-0.039
4	Active knee extension-Left	-0.025	0.284*	-0.038

Table below presents correlation between right active knee extensions with left SEBT reach distance anterior (r=0.135) and posteromedial (r=-0.002) is not significant at 5% level (i.e., $p > 0.05$). There exists no relationship between hamstring flexibility and SEBT reach distance of left leg. The results indicate a significant relationship between left posterolateral reach distance (r=0.233) and right hamstring flexibility at 5% level (i.e., $p < 0.05$). This signifies that right side hamstring flexibility influences left posterolateral reach distance. There exists no significant relationship between SEBT reach distances and right (anterior r=0.039, posterolateral r=0.153 and posteromedial r=0.117) and left (anterior r=0.049, posterolateral r=0.162 and posteromedial r=0.163) limb length.

Table 2: Correlation between flexibility with SEBT of the left leg

S.No.	Correlation	SEBT Left Leg		
		Anterior	Posterolateral	Posteromedial
1.	Limb length –Right	0.039	0.153	0.117
2.	Limb length –Left	0.049	0.162	0.163
3.	Active knee extension-Right	0.135	0.233*	-0.002

Discussion

The objective of the study is to determine the impact of hamstring flexibility on functional performance of collegiate football players. The result showed that hamstring flexibility shows no correlation with sprint, agility, and SEBT reach distance however it shows some correlation with posterolateral reach distance and is only correlated with vertical jump performance.

It has been observed, an exercise that stretches hamstrings have a positive effect on injury prevention and rehabilitation. The larger the angle of knee extension when vertical jumping, the lower the risk of hamstring injury [16]. This is in line with the current study as hamstring flexibility shows a positive correlation with vertical jump performance (r=0.241 for the right leg and r=0.284 for the left leg).

Studies have shown that agility or change of direction in football players is affected by muscular imbalance in dominant limb and non-dominant limb rather than flexibility this is in line with the current study [17].

Current study shows a significant relationship between posterolateral left leg reach with right hamstring flexibility(r=0.233). Whereas, there exists no correlation between SEBT reach distance of right leg and anterior and posteromedial reach distance of left leg and active knee extension of both the legs. Hence, we can say hamstring flexibility has no or very limited impact on the performance and dynamic balance of collegiate football players however, its correlation with posterolateral reach distance could be because of increased abduction ROM or increased abductor flexibility in subjects [18]. The significant relationship between the anterior reach distances seen in results could be due to the flexibility of ankle dorsiflexors [19].

The jumping ability of a soccer player is also considered crucial in performance. The vertical jump is a complex movement that greatly depends on interlimb coordination, muscle fiber type, and stiffness and occasionally on maximum strength, depending on the level of the athlete's performance [20]. In the current study, we have obtained 38.66±9.07 as the mean of vertical jump ability and it also shows a significant correlation with hamstring flexibility.

In the current study, as per the results obtained subjects were categorized into 3 categories for hamstring flexibility as: Severe tightness (90°-100°), Moderate tightness (101°-110°) and Normal flexibility (111°-120°). In all three categories it was observed that the sprint and agility performance was similar (4.80sec and 14.44 on average respectively). The findings of this study are similar to study by Gleim GW *et al*. where they mentioned that individuals with tightness are 12% more economical than those with flexible muscles. The increase in tightness leads to less active contraction of postural muscles or perhaps more elastic recoil from the previous stride [21].

The vertical jump height was 41.96cm in collegiate players with normal hamstring flexibility, while it was 34.78 and 37.76 in subjects with severe and moderate hamstring flexibility respectively. This is because the dynamic movement requires the contraction and elongation of the muscle-tendon unit. This stretch-shortening cycle relies on muscle and tendon to enable the release of potential energy that enhances the muscle performance.

Fig 1: Illinois Agility Test

Fig 2: 30m Sprint test

Conclusion

The result of the study shows that there is a weak correlation of hamstring flexibility on the performance of collegiate football players. However there is a positive correlation between hamstrings flexibility and vertical jump height, there is no significant correlations between hamstrings flexibility, speed, agility, and SEBT. However, there exists a positive correlation between posterolateral reach distance and hamstring flexibility.

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