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ORIGINAL RESEARCH ARTICLE

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A correlation study of weak core muscles with hamstring muscles flexibility in young adults

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Abstract

Background Hamstring, being a two-joint muscle, tends to shorten over time, resulting in tightness, affecting performance in daily activities and is also capable of generating exaggerated posterior pelvic tilt, leading to decreased lumbar lordosis. Weak core muscles have been associated with hamstring tightness, and strengthening the core has been attempted in an effort to relax the hamstring tightness. It is believed that the hamstrings overact and over a period of time tightens, when the core is weak, to compensate for postural stability.

Method Thirty-three subjects, both male and females with and without hamstring tightness, were assessed for their core endurance through McGill's core endurance test battery. It was followed by active knee extension test to determine degree of hamstring tightness on both sides. Correlation between the two variables was statistically analyzed.

Results Pearson's correlation was used to analyze the collected data. A moderate positive but significant correlation ($p = 0.02$) was found between flexor endurance test and active knee extension (both sides). A weak positive but significant correlation ($p = 0.05$) was found between extensor endurance test and active knee extension (both sides). Correlation between the right and left lateral bridge with their respective side hamstring flexibility was negative and not significant ($p = 0.916$ (right lateral torso endurance); $p = 0.339$ (left lateral torso endurance)).

Conclusion Since there is a moderate positive but significant correlation between the flexion torso endurance test and both side hamstring flexibility and a weak positive but significant correlation between extension torso endurance test and both side hamstring flexibility, the core (flexor, extensor, and lateral) should be thought of as a whole unit when strengthening in order to maintain and improve hamstring flexibility.

Keywords Core, Hamstrings, Back muscles

Background

A reduction in the muscle's capacity to flex is the root cause of muscular tightness. It might enhance the musculotendinous units' resistance to different anatomical structures and make them more prone to injury, which could result in overuse syndrome. Because hamstrings, which is attached to the ischial tuberosity, is a two-joint muscle, it tends to shorten over time and compromises the spine's ability to hold the body upright against gravity, thereby causing posterior pelvic tilt and reduced lumbar lordosis [1]. Activities of daily living (ADLs) can be hampered by hamstring tightness, which puts the individual at risk for other health issues such as plantar fasciitis, sacroiliac joint pain, decreased lumbar lordosis, knee discomfort, quadriceps dysfunction, postural abnormalities, overstretched lumbar ligaments, and decreased muscular strength, patellar tendinopathy, patellofemoral discomfort, hamstring strains, and signs of muscle damage after intense activity [2, 3].

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Many studies in the past have reported the effect of tight hamstrings leading to a weak core and trunk musculature. However, a weak core can also lead to hamstring tightness, and in this case, hamstring overacts and over a period of time tightens, to compensate for postural instability. The engagement and stamina of the core muscles are the primary sources of spinal stability. The diaphragm (superior), abdominal and oblique muscles (anterior-lateral), paraspinal and gluteal muscles (posterior), and pelvic floor and hip girdle (inferior) serve as the muscles that define the three-dimensional space that is the core [4]. A common malformation in adulthood, flexible flatfoot, has been linked to numerous lower limb injuries as well as back problems. A person who lacks strength in their core muscles is more susceptible to lower back pain and damage to their lower limbs. Furthermore, the idea of "anatomy trains" implied that any strain at one point in the "anatomy train" may have a negative impact on the other points of the related fascial line. The dysfunction of the core muscles, which are the trunk, pelvis, and hips and are thought to be the center of the kinetic chain, has been linked to lower limb injuries and lower back pain (LBP) [5]. The isometric length-tension relationship states that a muscle fiber's capacity to produce an ideal amount of active tension decreases when it stretches beyond its optimal length. The posterior pelvic tilt may cause the back extensor muscles to extend because of their attachment to the pelvis. Thus, back extensors must exert more effort. The low back muscles weaken and tire more quickly if the shortened muscles are pulled continuously for an extended period of time. Reduced endurance in the back extensor muscle may overwork the soft tissue and passive structure of the spine, such as hamstrings, leading to various other musculoskeletal disorders including low back pain being the most common [6, 7]. The aim of the study was to find out if there is a correlation of core endurance with hamstring tightness in healthy young adults. Objectives of the study were to find out correlation between flexor torso endurance and hamstring tightness, correlation between extensor torso endurance and hamstring tightness, and correlation between lateral torso endurance (both sides) and hamstring tightness. If correlated, to see if strengthening of the core should be considered as a whole or side-specific depending on the correlation of the two variables.

Methods

It was a one-time cross-sectional observational study. The study was conducted in the Exercise Therapy Lab, Physiotherapy Department of a teaching institute in India.

Ethical clearance was obtained from the ABSMARI Ethics Committee of the institute before carrying out the study.

Participants

As illustrated in the flow diagram in Fig. 1, 36 healthy young adults both male and female between the age of 18–25 years of both genders, with and without hamstring tightness who were willing to participate, were screened out of which 33 subjects were included in the study based on the selection criteria (age between 18 and 25 years, with and without hamstring tightness, and gave consent and willingness to participate in the study). Subjects with a history of low back pain, previous fractures or surgery of their back, pelvis, hips, or knees in the last 1 year, and professional sports players were excluded. Basic demographic data (age) was collected. Then active knee extension (AKE) test was done with the readings recorded by the investigator (first author) to assess the degree of hamstring flexibility. AKE was followed by the subjects performing McGill's core endurance test battery which was used to measure the core endurance in four static positions.

Outcome measures

Active knee extension test (Fig. 2)

A test for hamstring flexibility is the active knee extension (AKE) test. The subjects were examined while lying down and extending both of their lower limbs. To ensure that the thigh and lower leg were perpendicular to one another, the participants were instructed to flex the right hip followed by the left hip, separately, in any order, one after the other. The next task given to the participants was to extend their leg as far as they could while maintaining a relaxed foot, and they were to hold this position for roughly 5 s. A common universal goniometer was positioned parallel to the fibula and femur. The degree of knee flexion from terminal knee extension was the definition of the AKE measurement. The mean angle of the AKE test was utilized for analysis after each knee was assessed three times [8]. This test has a reliability of 0.99 [9, 10].

McGill's core endurance test battery

This test has a reliability of 0.97–0.99 [4].

There are three components to this test which are as follows:

- Lateral torso endurance test (both sides) (Fig. 3)

A patient was allowed a maximum of two trials for the McGill torso endurance battery. The endurance score was calculated using the best of two trials. In every core endurance test, the test was stopped if the participant could not maintain the posture, felt uncomfortable, or if the therapist saw a notable change in the patient's position.

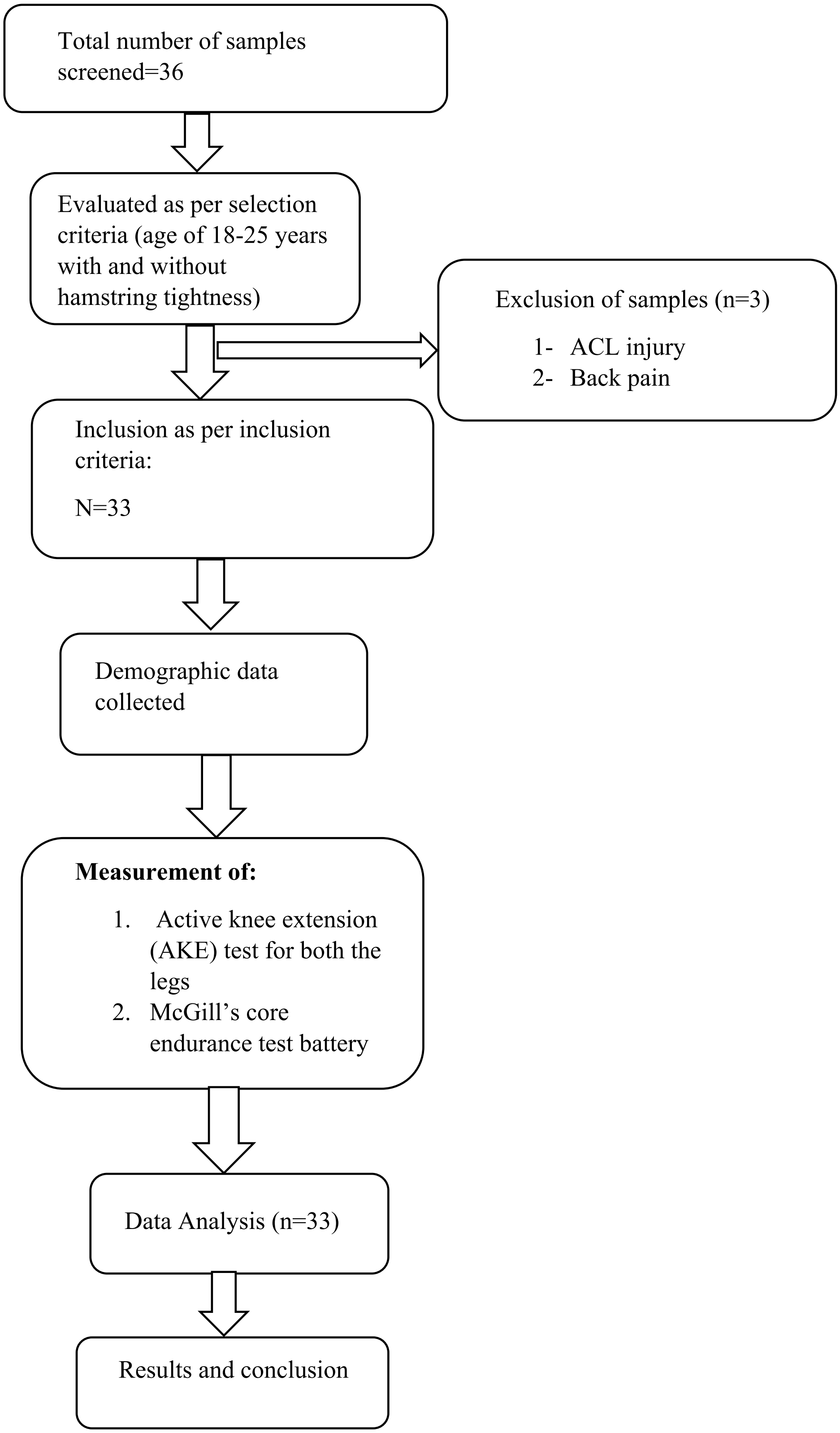

Fig. 1 Flow diagram of the study

Fig. 2 Active knee extension (AKE) test

Before the test began, every participant was lying on their side. The legs remained outstretched. Participants used their feet and elbows to support themselves. Using only their feet and lower elbow for support, they were instructed to raise their hip off the bed and keep their entire body in a straight line for the duration of the test.

The subject's inability to hold the position, discomfort, or agony signalled the end of the test. Time was recorded in seconds, and the test was repeated on the other side.

- Flexor torso endurance test (Fig. 4)

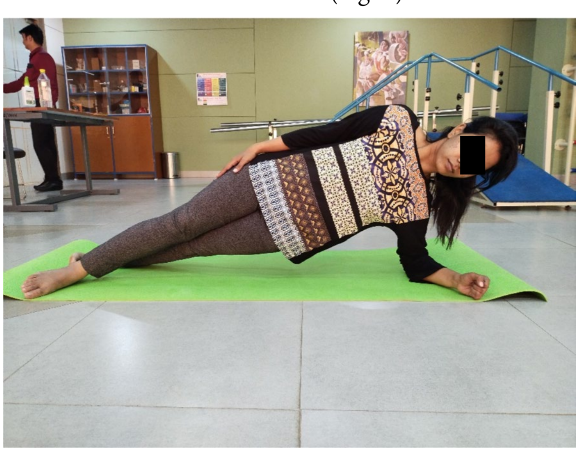

Fig. 3 Lateral torso endurance test

Fig. 4 Flexor torso endurance test

The subjects were positioned on a plinth with their backs resting against a wedge that maintained a 60° flexion from the horizontal as the starting position for the trunk flexor endurance test. Feet were strapped in with belts, and knees were bent at a 90-degree angle. First, the subject was instructed to retain the body position for as long as possible after the support was removed.

The test was stopped if the patient became uncomfortable or experienced more discomfort, or if there was a discernible shift in the trunk position, such as the shoulders rounding forward or rising over the neutral spine. The back rested untouchably on any region of the back. The time was noted.

- Extensor torso endurance test (Fig. 5)

The patient was placed face down on a treatment couch, with three straps holding the lower body below the level of the anterior superior iliac spines: at the level of the greater trochanter of the femur, at the knee

Fig. 5 Extensor torso endurance test

Table 1 Demographic data of the subjects

Variable	Mean (years)	Standard deviation (SD)	Range
Age	20.0909	2.50454	8.00

creases, and as near to the ankles as feasible. While taking into account the subject's degree of comfort, the stabilization belts were adjusted as tightly as possible.

The subject was permitted to rest the upper portion of their body on a chair prior to starting the test. The participant was then informed that upon starting the test, they would have to raise their upper body off the chair, cross their arms over their chest, and keep their trunk in a neutral position for the duration of the exercise. Test termination criteria were as follows: Rater ended the test if the subject failed to maintain the upper trunk in neutral, the subject terminated the test due to extreme exhaustion, and pain or other symptoms were intolerable [1].

Statistical analysis

Data was analyzed using the Statistical Package SPSS 22.0 (SPSS Inc., Chicago, IL, USA), and level of significance was set at $p < 0.05$. Kolmogorov–Smirnov test was used to check normality. As the data was normally distributed, inferential statistics was done using Pearson's correlation test to correlate active knee extension test with all the four tests of McGill's core endurance test battery. The tests were applied at a power of 80% and confidence interval of 95% and level of significance.

Results (Tables 1, 2, 3, and 4)

The analyzed data were tabulated, and the results interpreted are as shown in Table 5, Figures 6 and 7.

Results found a moderate positive but significant correlation ($p = 0.02$) was found between flexor endurance test and active knee extension (both sides). A weak positive but significant correlation ($p = 0.05$) was found between extensor endurance test and active knee extension (both sides). Correlation between the right and left lateral bridge with their respective side hamstring flexibility was negative and not significant ($p = 0.916$ (right lateral torso endurance); $p = 0.339$ (left lateral torso endurance)).

Table 2 Descriptive data for hamstring length of the subjects

Hamstring length testing variable (AKE)	Mean (degrees)	Range (degrees)	Standard deviation (SD)
AKE (*right*)	64.0000	53.00	14.35
AKE (*left*)	64.8182	55.00	16.024

Table 3 Descriptive data for core endurance of the subjects

McGill's core endurance test battery variable	Mean (s)	Range (s)	Standard deviation (SD)
Flexor torso endurance	304.4545	470.00	121.73
Extensor torso endurance	86.7273	151.00	32.92
Lateral torso endurance (*right*)	39.1515	115.00	26.56
Lateral torso endurance (*left*)	42.8788	69.00	19.56

Discussion

The study aimed to find out if there is a correlation of core endurance with hamstring tightness in healthy young adults. The results of the study showed a moderately significant correlation was found between flexor torso endurance test and active knee extension (both sides). Janda et al. discovered that when muscles are dysfunctional, they tend to be either tight or weak. Hamstring tightness was observed in lower cross syndrome (LCS) in which certain muscles become overactive while others get suppressed as they adjust to shield the body from harm or discomfort [12, 13]. Consequently, joint stress and muscle fatigue arise. According to the Sherrington's law of reciprocal inhibition, the opposing muscle relaxes when one muscle is shortened or tensed [14]. The pelvis, hip joint, and lumbar spine relax as a result of the stretched muscles and increased muscle strength. When there is overactivity and hence tightness of hip flexors and lumbar extensors, along with underactivity and weakness of the deep abdominal muscles on the ventral side and of the gluteus maximus and medius on the dorsal side, the condition is called as LCS. Many circumstances can lead to lower cross syndrome, including prolonged durations of sitting, and bad posture at work can also negatively affect the body's mechanics. There was no significant correlation between the right and left lateral bridge with their respective side hamstring flexibility. Since there are no changes in pelvic motion in the coronal plane, so hamstring tightness had no effect on lateral trunk muscles, and hence, no correlation was obtained between the

Table 4 Normative data for McGill's core endurance test of the subjects [11]

	Mean (SD) (s)	Range (s)
Flexor torso endurance	160 (102)	15–292
Extensor torso endurance	101 (51)	17–592
Right lateral torso endurance	54 (25)	9–136
Left lateral torso endurance	55 (28)	2–139

Table 5 Correlation (r) between active knee extension test with all the three tests of McGill's core endurance test battery

McGill's core endurance test battery	Active knee extension test (AKE)		*p*-value of significance
	Left ("r" value)	Right ("r" value)	
Flexor torso endurance test	0.4	0.525	0.02
Extensor torso endurance test	0.345	0.2	0.05
Lateral torso endurance test (right)	−0.03	0.1	0.916
Lateral torso endurance test (left)	−0.2	−0.17	0.339

right and left lateral bridge or lateral core endurance with their respective side hamstring flexibility. However, previous studies have demonstrated the contribution of the lateral abdominal muscles to trunk strength and core stability, which might indirectly affect athletes' performance and enable them to exercise with fewer injuries. The capacity of these muscles to generate concordant forward flexion, lateral flexion, and rotating motions is responsible for their role in stability. They also have the ability to exert control on outside forces that act in the opposite direction of these movements. They are also in charge of preserving posture and distributing muscle forces in the trunk to enable quick motions and the production of power [15]. Significantly weak correlation was found between extensor torso endurance test and active knee extension (both sides). Kendall et al. explained the association between back extensors endurance and hamstring flexibility theoretically. Because the hamstring muscles attach to the ischial tuberosity, it is hypothesized that tightness of these muscles may induce posterior pelvic tilt. This in turn decreases pelvic mobility, increases load on spinal tissues, and hence invariably leads to a decrease in extensor endurance of the core, which is the rationale for a weak significant correlation found between extensor torso endurance test and active knee extension (both sides) [7]. The hamstrings have the potential to restrict pelvic mobility if they get too tight. Thus, restricted movement of the pelvis may result in tense low back muscles, which may then trigger the onset of low back pain. It has been proposed in the past that hamstring tightness may develop as a result of

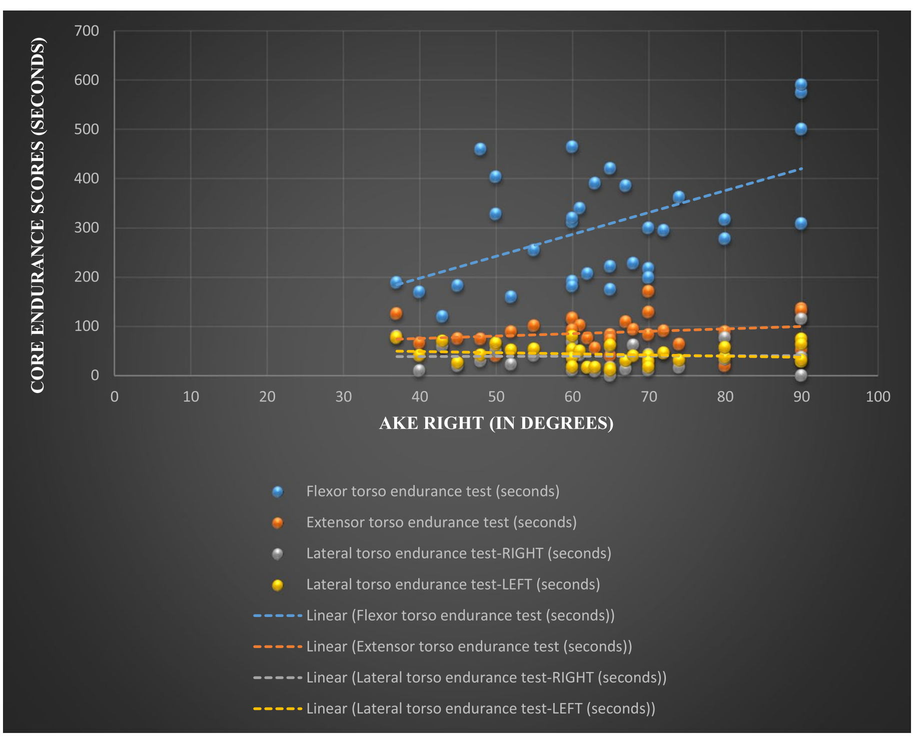

Fig. 6 Correlation between McGill's core endurance test battery and Active knee extension (AKE) test of RIGHT lower extremity

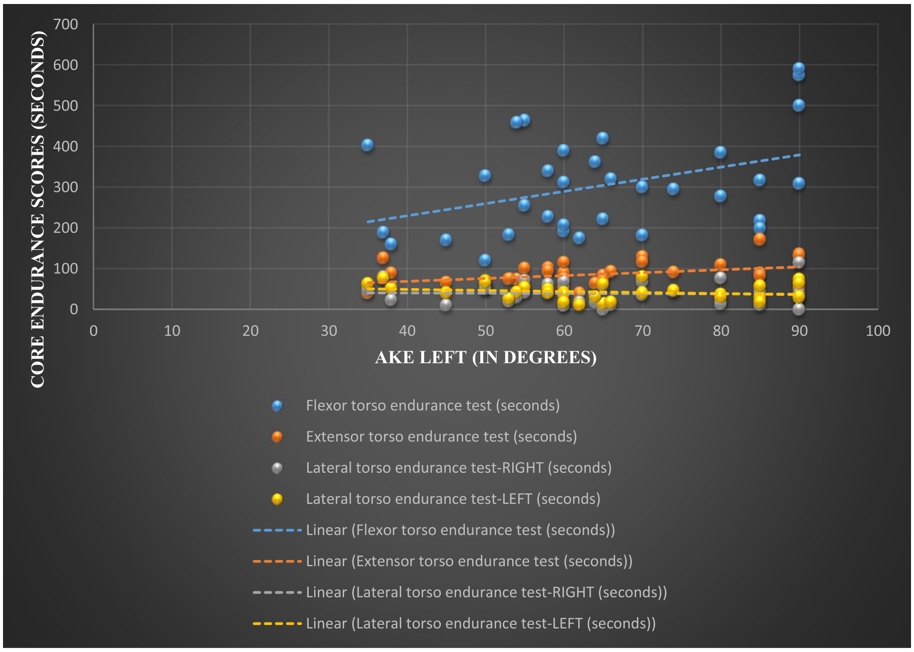

Fig. 7 Correlation between McGill's core endurance test battery and Active knee extension (AKE) test of LEFT lower extremity

restricted pelvic rotation [16]. The second reason could be that the hamstrings' line of action is nearly vertical, and that the ischial tuberosity attachment is only somewhat behind the femoral head. The pelvis rotates posteriorly as a result of this small posterior strain. The hip flexors' ability to rotate the pelvis anteriorly is unable to outweigh this [6]. The results of the study done by Amir Massaoud Arab et al. differed from this study [17]. Arab et al. looked at the relationship between lumbar lordosis and the length of the hamstring muscles in people with various lifestyle and work environments. The hamstring muscle length of people with and without low back pain differed significantly; however, there was no significant difference in lumbar lordosis between those with and without hamstring tightness in subjects with normal and low back pain who had varied work environments and lifestyles [4]. Limitation of this study was the sample size, and this study was limited to young adults, most of whom were college students. The normative values of flexibility were not taken into consideration.

Conclusion and clinical implications

From the observations of the current study, it can be concluded that since there is a moderate positive but significant correlation between the flexion torso endurance test and both side hamstring flexibility and a weak positive but significant correlation between extension torso endurance test and both side hamstring flexibility, the core (flexor, extensor, and lateral) should be thought of as a whole unit when strengthening in order to maintain and improve hamstring flexibility. In racquet sports like badminton and tennis, where core endurance plays a big role, enhanced performance can be achieved by strengthening the core, as it impacts the strength and flexibility of both the upper and lower extremities. Future studies can be performed among healthy injury-free middle-aged and older population. Studies comparing core endurance and flexibility of the hamstring with various other fitness components among nonathletic collegiate population can also be done.

Abbreviations

AKE Active knee extension
LBP Low back pain
LCS Lower cross syndrome

Authors' contributions

TMSK contributed to the manuscript, review of manuscript, collection, and analysis of data. JORA contributed in conception of the study, manuscript, and review of manuscript.

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Data availability

The data collected and/or analyzed during the study are available with the corresponding author.

Declarations

Ethics approval and consent to participate
The study was done at Abhinav Bindra Sports Medicine and Research Institute (ABSMARI), Bhubaneswar, Odisha, India. Ethical clearance was taken from the ABSMARI Ethics Committee of the institute, and informed consent was taken from all the participants. The study is not a clinical trial, so no clinical trial registration was done. The participants were aware of all procedures involved in the study, and a written consent was taken for the same.

Competing interests
The authors declare that they have no competing interests.

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