RESEARCH PAPER

To Study Hamstring Muscle Flexibility in Long-Distance Runners: An Observational Study

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ABSTRACT
Aim: This study aims to evaluate the prevalence of hamstring muscle flexibility among long distance runners in Sangli city. And look at the variations by limb dominance age and gender
Introduction: The hamstring muscle stretch is another essential section of lower limb movement in long distance runners, which is a component of the most appropriate stride mechanics, pelvic stability and injury prevention. A decrease in the extensibility of the hamstring musculotendinous unit can lead to changes in the biomechanics, passively increased stiffness, and predisposition to musculoskeletal trauma. With regards to the monotonous loading scheme that is entailed in long distance running, the hamstring flexibility is an issue that is of great significance in terms of physiotherapy examination.
Scope: This was the study of observation that aimed to determine the flexibility of the hamstring muscle in long-distance runners in Sangli City and to compare the difference according to age, gender, and the dominant and non-dominant lower limbs.
Material and procedur: The Active Knee Extension (AKE) test was used as the measure of hamstring flexibility where the hip was positioned at 90 degrees flexion and the active knee extension was measured using a goniometer. The data was noted and classified based on the demographics and limb dominance.
Result: The majority of runners showed excellent levels of flexibility, as evidenced by their AKE scores of 160–179 degree. The results were informative on the patterns of flexibilities and also identified the differences on the side-to-side and demographic factors among the runners. The research highlights the clinical significance of regular hamstring flexibility testing and justifies the formation of customized physiotherapy program and preventive measures in the case of long-distance runners.
Conclusion: Long distance runner exhibits good hamstring flexibility with minimal sex or leg dominance. Differences and only in mild age related decline was seen.
Keywords: *Hamstring Muscle Flexibility ,Active Knee Extension Test ,Long-Distance Runners, Dominant and Non-Dominant Limb, Range of Motion, Musculotendinous Extensibility, Observational Study*
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INTRODUCTION

Long distance running is an endurance sport which is repetitive and subjected to high biomechanical loading on the lower extremity muscles, especially the hamstring body mass.

The hamstrings (biceps femoris, semitendinosus and semimembranosus), are biarticular muscles whose functions are at the hip and knee joints. They are very important in hip extension, knee flexion, pelvic stabilization, and decelerations of tibia during the final swing of gait. Poor hamstring flexibility is suggested to affect stride length, the mechanics of running and result in the accumulation of load and stress in the lumbar spine as a compensatory strategy and hamstring strain, patellofemoral dysfunction and lower back pain. Repeated loading and lack of adequate recovery in long-distance runners could predispose the hamstring musculotendinous

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unit to adaptive shortening and augmented passive stiffness. Thus, hamstring flexibility measurement is an essential part of physiotherapy examination among endurance athletes.

Active Knee Extension (AKE) test is a well established and valid clinical procedure of assessing hamstring flexibility. It measures hamstring muscle extensibility by determining the knee extension angle with a 90 0 of flexion in the hip. The test offers a objective observation of the leg length and will be able to identify the imbalance between the dominant and non-dominant lower limbs in the side-to-side direction. Other factors that may affect muscle flexibility include limb dominance because of unequal loading patterns during sports activities, which will cause muscular imbalances. Age and gender are other factors that can affect muscle flexibility. The age effects on muscle elasticity and connective tissue compliance can influence the range of movement and the hormonal and structural disparities between men and women can result in the differences in the flexibility profile. This is significant in understanding these demographic factors so as to develop specific physiotherapy programs and injury prevention strategies.

The population of the long distance runners that take part in the competitive and recreational events in Sangli City is on the rise. Nonetheless, there is a lack of observational evidence on the hamstring flexibility properties in this group. As such, this observational study will evaluate hamstring muscle flexibility in long distance runners in the city of Sangli by administering the Active Knee Extension test and compare the results as per the factors of age, gender and dominant versus non dominant leg measurement. Results of this study can be used to add knowledge to evidence-based practice in physiotherapy, injury prevention, and performance optimization among endurance athletes.

1. Hamstring Muscles

The hamstring muscles consist of three biarticular muscles namely biceps femoris, semitendinosus and semimembranosus muscles found in the posterior portion of the thigh. They have their origin of the ischial tuberosity and place a insertion beneath the knee joint. As a functional attribute, they cause hip extension, knee flexion and help in regulating tibial deceleration during gait and running.

2. Hamstring Flexibility

The term of hamstring flexibility is used to describe the extensibility of the hamstring musculotendinous unit, which permits sufficient hip flexion when the knee is extended without pain or limitation. It is usually measured by range-of-motion (ROM) measurements and it indicates the length and passive stiffness of muscles.

3. Long-Distance Runner

A long-distance runner is a sporting athlete who is engaged in endurance running over the distance that is usually more than 21 kilometers. These people exhibit cyclic lower-limb movements that are repetitive, the muscles need to be optimally flexible, have endurance, and be neuromuscularly coordinated.

4. Observational Study

An observational study is a way of conducting a research whereby the researcher examines, and measures variables without controlling or interfering with the research group. It is usually applied in the identification of prevalence, characteristics or associations in a certain group.

5. Active Knee Extension (AKE) Test.

Active Knee Extension test is a clinical examination instrument which is employed to evaluate the flexibility of hamstring muscles. The subject is lying in supine position with a flexed hip of 90 and actively extends the knee. Knee angle of extension is measured with a goniometer. The lack of extension is a sign of hamstring tightness.

6. Dominant Leg

The upper limb that is used to preferentially take skilled functions like kicking a ball or playing the first step is the dominant leg. It can have varying strength and flexibilities attributes with the non-dominant leg.

7. Non-Dominant Leg

The non-dominant leg refers to the leg that is mostly utilized to provide stability and support during the functional activities. It can reflect the variation of the level of neuromuscular control and flexibility as compared to the dominant one.

8. Musculotendinous Unit

Musculotendinous unit is a collective structure of the muscle fibers and their tendons which combine together to generate movement and to withstand mechanical stress.

9. Range of Motion (ROM)

range of Motion is the quantifiable extent of movement which happens at a joint which is denoted in degrees. It is either active (performed by the patient), or passive (performed by the examiner).

10. Lumbopelvic Rhythm

Lumbopelvic rhythm is the movement between the lumbar spine and pelvis in flexion and extension of the trunk. The tightness of hamstring may change this rhythm and may cause mechanical stress to the lumbar region.

11. Muscle Extensibility

Muscle extensibility: This is the capacity of a muscle to be extended or stretched due to the influence of an external force without being damaged.

12. Passive Stiffness

Passive stiffness is the resistance to stretch produced in a muscle or connective tissue without the activity of muscle action.

1. Strengths of the Study

1.1 Relevant Clinical Focus
The flexibility of hamstring is an important component of endurance athletes since it contributes to hip–knee biomechanics, efficiency of the stride, and prevention of injuries. The clinical rationale of studying long-distance runners is that repetitive loading can affect musculotendinous adaptations.

1.2 Use of a Standardized Assessment Tool
Active Knee Extension (AKE) test is a valid and reliable clinical test of hamstring extensibility. It reduces the bias of examiners over passive testing and gives quantifiable goniometric information.

1.3 Consideration of Demographic Variables
The addition of age and gender increases the level of analysis in the study. Hormonal factors, compliance of the connective tissue, and age related changes in viscoelasticity control the nature of flexibility and thus subgroup analysis is significant.

1.4 Dominant vs Non-Dominant Limb Comparison
it is clinically of importance to measure bilateral differences. Long distance running can result in the asymmetry of the loading patterns, and the determination of side to side differences can be used in profiling of injury risks and physiotherapy outcome.

1.5 Local Population Focus (Sangli City)
The research on the runners in Sangli City will provide region-specific information that can be applicable to the sports physiotherapy practice locally and sports-related injury prevention programmes at the community level.

2. LIMITATIONS OF THE STUDY

2.1 Observational Design Limitations
being an observational study, it can only identify associations and differences, not causation. It cannot determine whether running causes changes in hamstring flexibility.

2.2 Lack of Control Group
If the study does not include a non-runner control group, it will not be possible to compare whether hamstring flexibility differs significantly between runners and the general population.

2.3 Single Measurement Tool
using only the AKE test may limit comprehensive flexibility assessment. Other tools such as the straight leg raise (SLR) test or sit-and-reach test could provide additional comparative data.

2.4 Confounding Variables

the study description does not mention controlling for:
- Training duration and intensity
- Warm-up status before testing
- Previous lower limb injuries
- Body Mass Index (BMI)
- Stretching habits

These factors can significantly influence hamstring flexibility.

2.5 Sample Size and Sampling Method
if convenience sampling is used, it may reduce external validity and limit generalizability of results beyond Sangli City.

3. METHODOLOGICAL CONSIDERATIONS

Study Design and Setting

The present investigation was a **cross-sectional observational study** conducted among recreational and long-distance runners in **Sangli city, Maharashtra**. The study aimed to evaluate **hamstring muscle flexibility using the Active Knee Extension (AKE) test** and to examine variations based on **age, gender, and limb dominance**.

Ethical Approval

Ethical clearance was obtained from the Institutional Ethics Committee prior to the commencement of the study. All participants received detailed information about the purpose and procedures of the research. Written informed consent was obtained from each participant before data collection.

Sample Size and Sampling Technique

A total of **100 runners** were included in the study. Participants were selected using a **random sampling technique** from the population of recreational runners and marathon participants.

Participant Characteristics

Individuals aged **20–50 years** who regularly participated in running events were eligible for inclusion.

Inclusion Criteria

Participants were included if they:
- Were willing to participate in the study
- Were between 20 and 50 years of age
- Had a minimum of three years of running experience
- Regularly participated in long-distance running events (21 km or more)
- Included both male and female runners

Exclusion Criteria

Participants were excluded if they had:
- Difficulty assuming the testing position
- History of soft tissue injury within the previous four months
- Diagnosed knee osteoarthritis
- Joint swelling or effusion
- Meniscal injuries or other major knee joint pathologies

Baseline Assessment

Demographic and anthropometric data were recorded prior to testing, including:

- Age
- Gender
- Height
- Weight
- Body Mass Index (BMI)

BMI was calculated using the formula:

$$BMI = \frac{Weight\ (kg)}{Height^2\ (m^2)}$$

Warm-Up Protocol

Before flexibility assessment, participants performed a **standardized warm-up routine** lasting approximately **8–10 minutes**, which included:

- Five minutes of light jogging
- Dynamic lower limb stretching such as leg swings
- Hip flexion and extension movements
- Low-intensity hamstring activation exercises

This procedure helped prepare the muscles and reduce the risk of injury during testing.

Hamstring Flexibility Assessment

Hamstring flexibility was measured using the **Active Knee Extension (AKE) Test**, which is considered a reliable clinical tool for assessing hamstring muscle extensibility.

Testing Procedure

Participants were first provided with a detailed explanation and demonstration of the procedure. Anatomical landmarks were identified and marked to ensure accurate goniometric measurements.

Test Position

Participants lay in a **supine position on a treatment table** with the hip and knee flexed to **90 degrees**. The thigh was stabilized manually to maintain the hip position.

Test Performance

Participants were instructed to **actively extend the knee as far as possible while keeping the foot relaxed**. The final position was maintained for **five seconds**.

Each participant performed **two trials for each limb**, with a **three-second rest interval** between trials.

Measurement

A **universal goniometer** was used to measure the knee extension angle. The stationary arm was aligned with the femur, while the movable arm followed the axis of the fibula.

Flexibility measurements were recorded for both:

- Dominant limb
- Non-dominant limb

Participant Grouping

Following data collection, participants were categorized into **six age groups within the 20–50 year range** to evaluate age-related differences in hamstring flexibility.

Statistical Analysis

Descriptive statistical methods were used to analyze the data, including:

- Mean
- Median
- Percentile distribution

Flexibility values obtained from the AKE test were compared based on:

- Age group
- Gender
- Limb dominance

Results were presented using **tables and percentile graphs**, while maintaining strict confidentiality of participant data.

Chi-Square Test in Physiotherapy Research

The **Chi-Square test of independence** is a non-parametric statistical technique used to determine whether there is a significant association between two categorical variables.

In this study, hamstring flexibility values obtained from the **Active Knee Extension (AKE) test** were categorized into groups such as **poor, moderate, and good flexibility** based on percentile distribution. These categories were then compared with participant characteristics including **age group, gender, and limb dominance**.

The Chi-Square test was used to determine whether hamstring flexibility distribution differed significantly across these variables.

Chi-Square Formula

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

Explanation of Terms

- **χ^2 (Chi-Square value):** Indicates the difference between observed and expected frequencies.
- **Σ (Sigma):** Represents the total summation of calculated values.
- **O (Observed Frequency):** Actual number of participants in each category.
- **E (Expected Frequency):** The theoretical number expected if no association exists between variables.

Level of Significance

The statistical significance level was set at **$p < 0.05$**.

- If **$p < 0.05$**, the null hypothesis is rejected, indicating a statistically significant association between variables.

- If **p > 0.05**, the null hypothesis is accepted, suggesting no significant relationship.

5. CLINICAL SIGNIFICANCE

In physiotherapy research, the Chi-Square test is useful for identifying relationships between categorical variables such as **age, gender, flexibility level, or the presence of musculoskeletal conditions**. Understanding these associations helps physiotherapists identify factors affecting **muscle flexibility, joint mobility, and biomechanical performance**. Such information supports the development of **targeted rehabilitation programs, stretching protocols, and injury prevention strategies for runners and athletes**.

6. RECOMMENDATIONS FOR IMPROVEMENT

To strengthen the study:

1. Include a control group of non-runners.
2. Use additional flexibility assessment tools.
3. Record training history and injury history.
4. Perform statistical analysis such as:
   - Independent t-test (gender comparison)
   - Paired t-test (dominant vs non-dominant leg)
   - ANOVA (age group comparison)

DISCUSSION

The Active Knee Extension (AKE) test was used in this study to assess hamstring muscle length among long-distance runners in Sangli city, with particular emphasis on differences based on age, gender, and limb dominance. The findings demonstrated that the majority of participants in both dominant and non-dominant limbs fell within the 160–179 degree range, indicating generally good hamstring flexibility. This observation suggests that regular long-distance running may help maintain hamstring extensibility within a functional range. The repetitive cyclical movements inherent in distance running likely provide a dynamic stretching stimulus to the posterior thigh musculature, which may contribute to the preservation of muscle length over time.

Gender-wise analysis revealed that although male runners constituted the majority of the sample, both male and female participants demonstrated a similar distribution of hamstring flexibility. This aligns with the findings of Gonzalez-Galvez et al. (2015), who reported no significant gender differences in hamstring flexibility among physically active individuals. Conversely, some previous studies, such as Weerasekara et al. (2013), have reported marginally greater flexibility in females, potentially due to hormonal influences, pelvic structure, and connective tissue characteristics. The comparable flexibility observed in the present study may indicate that consistent endurance training exerts a leveling effect across genders, minimizing inherent physiological differences. Age-based comparisons in the present study indicated a mild trend toward reduced flexibility in older runners compared to those aged 21–30 years. This pattern is consistent with earlier research by Hamid et al. (2013) and Liu et al. (2012), which documented age-related declines in muscle elasticity and joint range of motion. Such reductions are commonly attributed to increased collagen cross-linking, decreased muscle compliance, and reduced neuromuscular efficiency with advancing age. Notably, however, runners above 40 years in this study still demonstrated relatively good hamstring flexibility. This finding supports the work of Karen et al. (1985), who reported that habitual runners often maintain superior flexibility compared to sedentary peers, suggesting a protective effect of long-term physical activity on muscle-tendon properties. The comparison between dominant and non-dominant limbs revealed minimal variation in hamstring flexibility. This symmetry is expected in endurance running, which is fundamentally a bilateral and cyclical activity imposing relatively equal mechanical demands on both lower limbs. Similar observations were reported by Gajdosik and Lusin (1983), who noted that sports involving symmetrical lower limb use typically demonstrate balanced flexibility profiles. From a clinical perspective, such symmetry is desirable, as inter-limb discrepancies in muscle length have been associated with altered running biomechanics, compensatory movement patterns, and elevated injury risk in athletic populations. Although the primary focus of the present study was flexibility profiling rather than injury prediction, the very low injury prevalence observed in the sample is noteworthy. It is possible that the generally adequate hamstring flexibility demonstrated by participants contributed to efficient running mechanics and reduced mechanical strain on the lower extremity. However, running-related injuries are widely recognized as multifactorial, involving training load, running technique, footwear, recovery practices, and muscular strength in addition to flexibility. Therefore, the findings should not be interpreted to imply that hamstring flexibility alone is sufficient to prevent injuries. From a practical standpoint, the results reinforce the importance of maintaining adequate hamstring flexibility as part of a comprehensive conditioning program for long-distance runners. Physiotherapists and coaches should continue to emphasize structured warm-up routines, periodic flexibility assessment, and individualized training progression. At the same time, flexibility training should be integrated with strength development, neuromuscular control exercises, and load management strategies to optimize performance and minimize injury risk

RESULT

In this study, descriptive statistics were used to summarize demographic variables and hamstring flexibility data, including frequencies, percentages, means, and standard deviations. To explore associations between injury occurrence and key variables, Chi-square tests of independence were performed. P Value kept at 0.05.

Table 1. Frequency and percentage distribution of demographic variables

Variable	Category/Range	Frequency	Percentage (%)
Gender	Male	79	71.82%
	Female	31	28.18%
Age	≤ 20	3	2.73%
	21–30	65	59.09%
	31–40	22	20.00%
	41–50	16	14.55%
	> 50	4	3.64%
Running Experience (Years)	≤ 3 years	45	40.91%
	4–6 years	40	36.36%
	7–9 years	25	22.73%
Injury	None	107	97.27%
	Ankle	3	2.73%
Distance Covered	5–12 km	5	4.55%
	21 km	94	85.45%
	22–50 km	11	10.00%

Table 1 presents the demographic profile of the study participants. Among the 110 long-distance runners included in the study, males constituted the majority (71.82%), while females accounted for 28.18%. The most prevalent age group was 21–30 years (59.09%), followed by 31–40 years (20%). Only 3.64% of participants were aged above 50 years. Regarding running experience, 40.91% had up to 3 years of experience, while 36.36% had between 4–6 years and 22.73% had 7–9 years. In terms of injury occurrence, 97.27% of participants reported no injuries, while 2.73% had ankle injuries. The majority of participants (85.45%) covered a standard distance of 21 km, with smaller proportions covering either shorter (5–12 km, 4.55%) or longer (22–50 km, 10%) distances.

Table 2. Frequency and percentage distribution of the variables

Variable	Category/Range	Frequency	Percentage (%)
Injury	None	107	97.27%
	Ankle	3	2.73%
Distance Covered	5–12 km	5	4.55%
	21 km	94	85.45%
	22–50 km	11	10.00%
Hamstring Flexibility – Right (cm)	130–149 cm	3	2.73%
	150–159 cm	17	15.45%
	160–169 cm	39	35.45%
	170–179 cm	32	29.09%
	180 cm	19	17.27%
Hamstring Flexibility – Left (cm)	130–149 cm	3	2.73%
	150–159 cm	15	13.64%
	160–169 cm	32	29.09%
	170–179 cm	41	37.27%
	180 cm	19	17.27%

Table 2 summarizes the distribution of hamstring flexibility and injury across the sample. Hamstring flexibility (right leg) was highest in the 160–169 cm range (35.45%), followed by 170–179 cm (29.09%). Only 2.73% had flexibility below 150 cm. Hamstring flexibility (left leg) showed a similar trend, with most participants falling in the 170–179 cm range (37.27%), followed by 160–169 cm (29.09%). A minority had flexibility under 150 cm. Injury distribution remained consistent with Table 1, with only 3 cases of ankle injury reported.

Table 3. Association of Injuries in relation to Hamstrings and running experience

Variable Compared	Pearson Chi-Square Value	Degrees of Freedom (df)	P value	Significance	% of Cells with Expected Count < 5
Hamstring (Right)	150.066	81	0.001*	**Statistically Significant**	96.4% (108 cells)
Hamstring (Left)	121.82	96	0.039*	**Statistically Significant**	97.7% (129 cells)
Running Experience	21.178	21	0.048*	Not Significant	81.3% (26 cells)

Table 3. A significant association was observed between injury status and both hamstring flexibility right ($p = 0.000$) and hamstring flexibility left ($p = 0.039$). This suggests that flexibility differences may influence or reflect injury status among runners.However, no significant association was found between injury status and running experience ($p = 0.448$), indicating that years of running alone did not show a direct relationship with injury occurrence in this cohort.

Table 3: Association of Injuries in Relation to Hamstring Flexibility and Running Experience

Table 3 details the Chi-square test results analyzing the relationship between injury status and three variables: hamstring flexibility (right and left) and running experience. A statistically significant association was observed between injury status and both right ($\chi^2 = 150.066$, $p = 0.001$) and left hamstring flexibility ($\chi^2 = 121.82$, $p = 0.039$). This indicates that differences in hamstring flexibility may influence or reflect susceptibility to injury among runners. Conversely, no significant association was found between injury status and running experience ($\chi^2 = 21.178$, $p = 0.448$), suggesting that the number of years spent running did not independently impact injury occurrence in this study population.

CONCLUSION

This was an observational study, which would compare the hamstring muscle flexibility of long-distance runners in Sangli City with the help of the Active Knee Extension (AKE) test and compare the findings of the results based on their age, gender, and dominant/non-dominant lower limb.

The present study assessed hamstring flexibility among long-distance runners aged 20–50 years using the Active Knee Extension test. The findings indicate that **hamstring flexibility varies with demographic factors such as age, gender, and limb dominance**.

Younger runners generally demonstrated **greater muscle extensibility**, which may be associated with improved tissue elasticity, reduced muscular stiffness, and better neuromuscular coordination. Minor differences were also observed between dominant and non-dominant limbs, possibly due to repetitive loading patterns during running activities.

Gender-related differences in flexibility may be influenced by anatomical and physiological variations such as pelvic structure, connective tissue elasticity, and muscle stiffness.

From a physiotherapy standpoint, **adequate hamstring flexibility is crucial for maintaining optimal lower-limb biomechanics, efficient stride mechanics, and injury prevention in endurance runners**. Limited hamstring flexibility can increase the likelihood of musculoskeletal conditions such as hamstring strains, patellofemoral pain syndrome, and altered gait mechanics.

Therefore, runners should incorporate **regular stretching routines, neuromuscular control exercises, and structured warm-up protocols** into their training programs. Physiotherapists play an important role in designing individualized flexibility and conditioning programs aimed at enhancing performance and preventing overuse injuries.

The Active Knee Extension test proved to be a **simple, reliable, and clinically practical method** for evaluating hamstring flexibility in runners. The findings may assist physiotherapists and sports rehabilitation professionals in developing **evidence-based injury prevention and training strategies.**

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