



Effects of a Structured Sports Massage Program on Hamstring Flexibility Among Male University Football Athletes

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Abstract:

Background: Hamstring tightness is a common issue among football players, increasing the risk of injury and reducing performance. Sports massage is frequently used to enhance flexibility, but limited evidence exists regarding its structured, longitudinal application in university-level athletes.

Aims: This study investigated the effect of a six-week structured sports massage program on hamstring flexibility among male university football players.

Methods: A two-group, pre-test–post-test quasi-experimental design was employed with 20 male football players from Sabaragamuwa University of Sri Lanka. Participants were allocated to a treatment group ($n = 10$; mean age = 22.7 ± 1.2 years; body mass = 66.4 ± 4.8 kg; height = 1.67 ± 0.04 m) or a control group ($n = 10$; mean age = 22.8 ± 1.3 years; body mass = 66.9 ± 5.1 kg; height = 1.68 ± 0.05 m). The treatment group received 15-minute effleurage-based sports massage sessions twice weekly for six weeks, while the control group continued regular football training without massage. Flexibility was assessed using seven measures: the Sit-and-Reach Test (SRT), left and right Active Knee Extension Tests (AKET), left and right Passive Knee Extension Tests (PKET), and left and right Straight-Leg Raise tests (SLR). Data were analyzed using 2×2 mixed analysis of variance (ANOVA), with Bonferroni-adjusted post-hoc comparisons.

Result: The treatment group demonstrated improvements across all seven flexibility measures, whereas the control group showed small declines in the reported mean scores. The original analysis reported significant Time $\times$ Group interactions for all outcomes ($p < 0.001$), with partial eta-squared values of 0.52–0.61. Reported within-group improvements in the treatment group ranged from 1.77° to 4.11° across the angular measures, while the SRT reportedly increased by 3.56 cm. The reported effect sizes were very large (Cohen's $d = 2.32$ – 3.78). However, these inferential statistics and change scores require verification against the participant-level data and final descriptive tables before publication.

Conclusion: A six-week effleurage-based sports massage program was associated with improvements in hamstring flexibility among male university football players. Sports massage may be a useful supplementary strategy for flexibility management within football training programs. Further research with larger samples and longer follow-up periods is needed to establish the durability of these improvements and determine whether they translate into meaningful performance or injury-prevention benefits.

Keywords: Effleurage; Hamstring flexibility; Sports massage; University football players

1. INTRODUCTION

Football (soccer) is recognized as one of the most strenuous sporting activities globally, forcing players to manage complex physiological, biomechanical, and neuromuscular demands. The

sport requires a synergy of physical preparation, skill, tactical awareness, and psychological readiness. The intermittent, high-intensity nature of football, comprising short sprints, rapid accelerations and decelerations, changes of direction, jumping, tackling, and powerful kicking, demands tremendous levels of muscular strength, power, speed, agility, aerobic and anaerobic endurance, and muscular flexibility. While speed and strength often dominate performance considerations, flexibility remains a basic yet frequently ignored element.

Hamstring flexibility is particularly important for football players. The hamstring muscle group encompassing the biceps femoris, semitendinosus, and semimembranosus crosses both the hip and

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knee joints and is essential for lower limb movement. The hamstrings contribute to hip extension during sprinting and knee flexion during recovery phases. They undergo substantial eccentric loading during intense running and kicking, especially during the terminal swing phase when they help resist knee extension and stabilize the hip joint (Bramah et al., 2024). Poor hamstring flexibility may lead to coordination problems, decreased movement economy, and altered biomechanics that predispose athletes to injury. Afshar et al. (2025), in a comprehensive narrative review, identified key factors influencing hamstring muscle strains in football players, including reduced flexibility, previous injury history, eccentric weakness, and fatigue. Their analysis emphasized that flexibility deficits represent one of the most modifiable risk factors, making targeted interventions particularly valuable for injury prevention programs.

The clinical significance of hamstring extensibility is well-established, given the robust association between restricted range of motion and subsequent musculoskeletal injury. In football, hamstring strains rank among the most prevalent non-contact muscle injuries, contributing to 12–17% of all documented injuries and resulting in considerable time lost from both training and competitive play (Ekstrand et al., 2016). Longitudinal evidence indicates that diminished posterior thigh flexibility constitutes a substantial predisposing factor for hamstring pathology (Afshar et al., 2025). Excessive myofascial stiffness may compromise the muscle's capacity to withstand high-velocity tensile loading, disturb coordinated lumbo-pelvic mechanics, and elevate susceptibility to acute strains during high-intensity activities such as sprinting and cutting.

In a related investigation, Iguchi et al. (2016) examined injury predictors among Japanese collegiate American football players and identified vertical jump performance as a notable indicator of hamstring strain risk ($p = 0.02$), alongside several other independent variables associated with lower extremity injuries. Although their cohort comprised American football athletes, these observations carry translational value for soccer players, who frequently perform analogous explosive movements. Collectively, these findings underscore the importance of interventions designed to enhance hamstring flexibility, both for optimizing athletic performance and for implementing evidence-informed injury reduction strategies.

In contemporary sport training and rehabilitation, sports massage has emerged as a commonly practiced therapeutic modality. Sports massage involves systematic manipulation of soft tissues, primarily aimed at enhancing rehabilitation, muscle relaxation, and sport performance. The therapeutic potential of sports massage is associated with several mechanisms: enhanced blood and lymphatic flow, improved removal of metabolic waste products, reduction of muscle adhesions, neuromuscular relaxation, and decreased pain perception via neurophysiological mechanisms. Davis et al. (2020) and Dakić et al. (2023) Basic massage components such as effleurage and petrissage serve as fundamental techniques for inducing tissue relaxation and extensibility among athletes.

A systematic review conducted by Dakić et al. (2023) examined the impact of massage interventions on athletic performance outcomes, concluding that flexibility represents the primary motor ability influenced by such treatments, with limited effects observed on other performance parameters. Their synthesis of the available literature indicated that moderate-pressure techniques specifically effleurage and petrissage delivered in 10 to 15-minute sessions yielded the most pronounced improvements in joint range of motion. In a related meta-analytic review, Davis et al. (2020) compared massage against passive recovery modalities, reporting superior outcomes for massage in terms of both enhanced range of motion and attenuated post-exercise muscle soreness.

Complementing these findings, Edholm et al. (2024) explored recovery optimization strategies in their review, highlighting the role of regular soft-tissue manipulation in mitigating perceived muscle tightness and preserving flexibility throughout demanding training periods. Although their work was developed with winter sport athletes preparing for the Milano-Cortina 2026 Olympic Games, the principles translate effectively to football contexts, where players encounter analogous recovery challenges between consecutive high-intensity sessions. Despite widespread practical use, empirical evidence regarding the impact of massage on objective flexibility indices remains somewhat unclear. While some studies have shown positive changes in range of motion and sit-and-reach test performance immediately following massage procedures (Davis et al., 2020 and Dakić et al., 2023), other research suggests such changes



may reflect altered stretch tolerance rather than actual changes in muscle tissue properties Moreno.

Best et al. (2016) critically evaluated the effectiveness of sports massage for recovery of skeletal muscle from strenuous exercise, concluding that massage reduces delayed-onset muscle soreness (DOMS) and improves subjective recovery. Kargarfard et al. (2016) demonstrated that post-exercise massage improved recovery rate and exercise performance in male bodybuilders, with the massage group showing better recovery in jumping, agility, and isometric torque. Lestari et al. (2025) found that massage therapy effectively prevented DOMS in sprinters, with the massage group maintaining range of motion while the control group exhibited declines. The influence of non-specific treatment factors was examined by Clapis et al. (2024), who investigated the interplay between communication, participant expectations, and percussive therapy on acute hamstring extensibility in healthy individuals. Their intervention group, which received positive communication alongside treatment, demonstrated substantially greater flexibility gains (mean increase = 9.5°) relative to controls (4.1° ; $p = 0.002$), yielding a large effect size (Cohen's $d = 1.7$). These findings underscore the contribution of contextual factors to flexibility outcomes.

The authors concluded that both modalities represented effective recovery strategies. Separately, a 2025 investigation comparing eccentric exercise with and without adjunctive massage found that the combined approach elicited greater and more sustained flexibility improvements relative to eccentric training alone. Regarding measurement properties, a 2025 reliability study examining flexibility tests in developmental-age populations reported acceptable intrasession and intersession reliability coefficients for the sit-and-reach test, active knee extension, passive knee extension, and straight leg raise. Additionally, Kamaruddin et al. (2026) conducted a systematic review assessing the validity of the sit-and-reach test for hamstring and lumbar flexibility, confirming its appropriateness as a field-based screening tool, while acknowledging its inherent limitation in distinguishing hamstring length from lumbar spine contribution.

Hopper et al. (2021) evaluated two distinct massage protocols on hamstring muscle length in competitive female hockey players, observing

significant post-intervention increases. Their results support the applicability of massage-induced flexibility benefits across diverse sporting populations and both sexes.

Within the Sri Lankan university sport context, recovery methods may be limited by available resources. Male football players at Sabaragamuwa University of Sri Lanka engage in intensive training sessions and inter-university matches, frequently reporting sensations of hamstring tightness and discomfort following physical activities. Informal observations, athlete feedback, and preliminary flexibility testing have highlighted persistent problems of hamstring tightness and lower-limb inflexibility, particularly following training and competitive matches. Athletes commonly report tightness and discomfort in the posterior thigh that may persist for 24 – 48 hours, adversely impacting subsequent training readiness.

While sports massage is widely used in athletic environments globally, its role as a systematic, longitudinal intervention for hamstring flexibility among university footballers in Sri Lanka remains underexplored. Most existing data on massage effects have been gathered regarding single or acute effects in heterogeneous athletic populations. There remains considerable scarcity regarding longitudinal changes in hamstring flexibility within uniform athletic populations such as university football players. This evidence gap constrains the ability of coaches, physiotherapists, and sports administrators to make evidence-based decisions regarding regular inclusion of massage therapy in training and recovery programs. The objective of this study was to investigate the effect of a six-week structured sports massage program on hamstring flexibility among male university football players.

2. MATERIAL AND METHOD

2.1 Research Design

This study employed a two-group, pre-test, post-test quasi-experimental research design. The design included a treatment group (Massage Group) that received a standardized massage intervention and a control group (Control Group) that continued with their usual training sessions without any massage intervention. This design was selected to allow comparison of the effects of the sports massage program against a comparable group not receiving the intervention while

controlling for the natural history of hamstring flexibility changes over the six-week study period.

2.2 Population and Sample

Twenty male football players were purposively selected from the football team of Sabaragamuwa University of Sri Lanka. Participants were then randomly assigned to either the Massage Group (n=10) or the Control Group (n=10). Inclusion criteria were: (a) male sex, (b) age between 20 and 25 years, (c) active membership in the university football team, (d) regular participation in team training sessions, and (e) willingness to provide informed consent. Exclusion criteria were: (a) history of lower limb surgery within the past 12 months, (b) acute musculoskeletal injury at the time of recruitment, (c) chronic neurological or neuromuscular disorders affecting lower limb function, (d) known allergy to massage cream ingredients, and (e) concurrent participation in another structured recovery or flexibility intervention program.

2.3 Intervention Protocol

The massage intervention was administered over a period of six weeks, consisting of two sessions per week, totaling twelve sessions. Each session lasted approximately fifteen minutes. The effleurage technique characterized by long, gliding, rhythmic strokes was performed using light to moderate pressure in a distal-to-proximal direction, consistent with established sports massage guidelines [Davis et al. \(2020\)](#). A neutral, commercially available massage cream commonly used in Sri Lankan practice was employed to reduce friction, improve therapist control, and enhance participant comfort. The muscle groups targeted during each massage session included the hamstrings (biceps femoris, semitendinosus, semimembranosus), gluteus maximus, gluteus medius, adductors, and the erector spinae muscles, thereby encompassing the entire posterior chain ([Fauris et al., 2021](#)). This comprehensive approach was adopted based on the myofascial chain concept, recognizing that restriction in any component of the posterior chain may impair flexibility elsewhere [Krause et al. \(2016\)](#) and [Oranchuk et al. \(2019\)](#).

All massage sessions were conducted on a treatment table within the Faculty of Physiotherapy laboratory to ensure participant comfort and proper positioning. An NVQ Level 4 qualified sports therapist delivered the intervention under the supervision of licensed physiotherapy personnel to

ensure adherence to professional standards and ethical practices. Control group participants continued their regular training routine without any massage intervention but were instructed to maintain their usual activities and to avoid seeking any additional massage or structured flexibility programs during the study period.

2.4 Outcome Measures and Assessment Procedures

Hamstring flexibility was assessed at two time points: baseline (pre-intervention) and following the six-week intervention period (post-intervention). All assessments were conducted by trained research assistants who were blinded to participants' group allocation where feasible. Standardized testing procedures were consistently applied across both assessment sessions to ensure measurement reliability and minimize potential measurement error ([Liu et al., 2022](#)). Sit and Reach Test (SRT): To evaluate general posterior chain extensibility with a focus on the hamstrings and lumbar spine the SRT was administered ([Liu et al., 2022](#)). Subjects assumed a seated posture on the floor, maintaining straight legs and positioning their soles against the testing apparatus. With overlapping hands, they were instructed to lean forward and slide along the measurement scale in a slow, controlled manner, avoiding any jerky movements. The maximal displacement reached (cm) was documented. Each participant completed two attempts, with the superior outcome retained for subsequent analysis ([Thotawaththa & Chandana, 2023](#)).

Active Knee Extension Test (AKET): Hamstring-specific flexibility was assessed via the AKET (Shepherd, Winter and Gordon, 2017). While lying supine on a treatment table, participants held the examined limb at a 90° hip angle, keeping the opposite extremity rested on the surface. They then performed a maximal active knee straightening, striving to extend the joint while stabilizing the hip position. A standard goniometer quantified the available range, where a completely straightened knee was designated as 0°, and any residual flexion was expressed as a positive value. This procedure was carried out bilaterally, yielding separate scores for the left (AKET-L) and right (AKET-R) sides.

Passive Knee Extension Test (PKET): The PKET employed identical hip positioning to the AKET, with the tested limb fixed at 90° of flexion. From this starting point, the examiner manually extended the knee joint to its physiological limit, with the endpoint determined either by the onset of firm



tissue resistance or verbal indication of discomfort from the participant. Angular measurement of knee extension was captured using a standard universal goniometer. Left and right limbs were evaluated independently, yielding separate scores designated as PKET-L and PKET-R.

Straight Leg Raise (SLR): Assessment of posterior chain flexibility encompassing both hamstring length and neural tissue tension was undertaken via the passive SLR protocol (Liu et al., 2022). The participant adopted a supine posture with both lower extremities fully straightened. The examiner then elevated the participant's extended leg through passive hip flexion, ensuring the knee remained locked in extension throughout the movement. Termination criteria comprised three conditions: participant-reported pain or stretching sensation, elevation of the contralateral limb off the supporting surface, or observable knee flexion. Hip range of motion was quantified with a universal goniometer.

This procedure was conducted bilaterally, producing separate values for the left (SLR-L) and right (SLR-R) sides. Instrumentation: A universal goniometer (baseline plastic goniometer, 360-degree scale) was used for AKET, PKET, and SLR measurements. A standard sit-and-reach box (Acumaster, with centimeter scale) was used for the SRT. All instruments were calibrated and checked for accuracy prior to each assessment session. A standardized treatment table (height adjustable, with padded surface) was used for all massage sessions and flexibility assessments requiring a supine or prone position. A commercially available, neutral massage cream (non-medicated, non-analgesic) was used exclusively to facilitate massage strokes without introducing confounding pharmacological effects Whalen et al. (2019).

2.5 Data Collection Procedures

All participants were fully briefed on the experimental protocol prior to any data collection, and each individual provided voluntary written consent. Baseline demographic characteristics including age, playing position, and years of competitive football experience were recorded. A single testing session was then scheduled, during which all flexibility measures (SRT, AKET-L/R, PKET-L/R, and SLR-L/R) were administered. This session was preceded by a standardized 5-minute warm-up comprising light jogging and dynamic exercises targeting the lower extremities.

Following completion of baseline testing, a simple coin-toss allocation procedure was employed to assign participants to either the Massage or Control condition. Those in the intervention group commenced the 6-week protocol immediately, which involved two 15-minute effleurage massage sessions per week, typically delivered on non-consecutive days (e.g., Mondays and Thursdays). To minimize circadian influences on tissue extensibility, all sessions were consistently scheduled during the late afternoon, immediately following the team's regular practice. Participants assigned to the Control group adhered to their habitual training regimen and received no massage-based intervention. Crucially, all individuals across both groups maintained their usual team activities comprising technical drills, tactical work, conditioning, and friendly fixtures throughout the study duration, thereby controlling for potential confounding effects of differential physical activity exposure.

At the six-week endpoint, post-intervention testing was conducted using identical protocols and the same evaluators who performed the initial assessments. Research assistants were responsible for data recording, while physiotherapy personnel subsequently verified all entries for completeness and accuracy.

2.6 Data Analysis

All statistical analyses were conducted using IBM SPSS Statistics, Version 26.0. Descriptive statistics, including means and standard deviations, were calculated for each dependent variable separately for the experimental and control groups at both pre-intervention and post-intervention assessment points. To determine the effects of the intervention, a series of 2×2 mixed-design analyses of variance (ANOVAs) were conducted, with Time (pre-test and post-test) treated as the within-subjects factor and Group (Massage and Control) treated as the between-subjects factor. Statistical significance was set at an a priori alpha level of 0.05 for all analyses. Effect sizes were reported using partial eta squared (η^2), with values of 0.01, 0.06, and 0.14 interpreted as small, medium, and large effects, respectively. Before conducting the primary analyses, the relevant assumptions of the statistical models, including normality of residuals and sphericity, were examined to ensure the appropriateness and validity of the analyses.

2.7 Ethical Considerations

The investigation adhered to internationally recognized research ethics frameworks, encompassing voluntary enrollment, documented consent, data privacy protections, and the unconditional right for participants to discontinue involvement at any stage without consequence. Prior to initiating data collection, formal ethical clearance was secured from the Institutional Review Board of Sabaragamuwa University of Sri Lanka. All individuals provided signed consent forms subsequent to receiving comprehensive verbal and written information regarding the research protocol, anticipated advantages, and negligible associated hazards. Throughout the intervention period, all massage procedures were administered under the direct oversight of qualified physiotherapy personnel. The study was classified as minimal risk, with contingency protocols in place for recording and addressing any untoward incidents, adhering strictly to professional standards.

3. RESULTS AND DISCUSSION

3.1 Participant Characteristics

Table 1. Baseline participant characteristics (Mean $\pm$ SD)

Variable	Treatment (n=10)	Control (n=10)
Age (years)	22.7 $\pm$ 1.2	22.8 $\pm$ 1.3
Weight (kg)	66.4 $\pm$ 4.8	66.9 $\pm$ 5.1
Height (m)	1.67 $\pm$ 0.04	1.68 $\pm$ 0.05
Pre-test SRT (cm)	161.15 $\pm$ 0.98	163.43 $\pm$ 3.01

Note. AKE = active knee extension; PKE = passive knee extension; SLR = passive straight-leg raise.

A total of 20 male university football players completed the study, comprising 10 participants in the treatment group and 10 in the control group. No participant withdrawals were reported. The baseline demographic and anthropometric characteristics of the participants are presented in Table 1, including age, body weight, height, and baseline flexibility measures. The descriptive statistics suggest broadly comparable demographic characteristics between the groups.

3.2 Descriptive Statistics and Normality Assessment

Table 2. Descriptive Statistics for All Flexibility Measures by Group and Time

Measure	Treatment		Control	
	Pre - test (M $\pm$ SD)	Post - test (M $\pm$ SD)	Pre - test (M $\pm$ SD)	Post - test (M $\pm$ SD)
Sit-and-Reach (cm)	3.13 $\pm$ 0.09	4.64 $\pm$ 0.10	3.19 $\pm$ 0.14	3.08 $\pm$ 0.18
AKE Left ($^{\circ}$)	161.35 $\pm$ 0.91	164.95 $\pm$ 0.91	162.33 $\pm$ 2.50	161.33 $\pm$ 2.45
AKE Right ($^{\circ}$)	160.35 $\pm$ 0.91	163.95 $\pm$ 0.91	161.34 $\pm$ 2.87	161.06 $\pm$ 2.55
PKE Left ($^{\circ}$)	169.35 $\pm$ 0.91	172.95 $\pm$ 0.91	166.13 $\pm$ 3.35	165.20 $\pm$ 3.46
PKE Right ($^{\circ}$)	168.35 $\pm$ 0.91	171.95 $\pm$ 0.91	165.94 $\pm$ 3.14	164.59 $\pm$ 3.42
SLR Left ($^{\circ}$)	88.00 $\pm$ 0.00	90.00 $\pm$ 0.00	90.27 $\pm$ 1.71	89.45 $\pm$ 1.12
SLR Right ($^{\circ}$)	87.00 $\pm$ 0.00	89.00 $\pm$ 0.00	89.68 $\pm$ 0.86	88.76 $\pm$ 1.81

Note. AKE = active knee extension; PKE = passive knee extension; SLR = passive straight-leg raise.

Descriptive statistics for the seven flexibility outcomes at pre-test and post-test are presented in Table 2. The outcomes comprised the Sit-and-Reach Test (SRT), Active Knee Extension Tests for the left and right legs (AKE-L and AKE-R),

Passive Knee Extension Tests for the left and right legs (PKE-L and PKE-R), and passive Straight-Leg Raise Tests for the left and right legs (SLR-L and SLR-R).

**Table 3.** Summary of 2 (Time: Pre-test, Post-test) $\times$ 2 (Group: Treatment, Control) Mixed ANOVA for All Hamstring Flexibility Measures

Measure	Effect	F (1, 18)	p-value	Partial η^2
Active Knee Extension – Left	Group	2.60	0.125	0.126
	Time	74.01	< 0.001	0.804
	Time $\times$ Group	231.68	< 0.001	0.928
Active Knee Extension – Right	Group	1.11	0.306	0.058
	Time	552.35	< 0.001	0.968
	Time $\times$ Group	754.40	< 0.001	0.977
Passive Knee Extension – Left	Group	24.49	< 0.001	0.576
	Time	133.64	< 0.001	0.881
	Time $\times$ Group	384.69	< 0.001	0.955
Passive Knee Extension – Right	Group	20.99	< 0.001	0.538
	Time	58.08	< 0.001	0.763
	Time $\times$ Group	281.10	< 0.001	0.940
Passive Straight-Leg Raise – Left	Group	3.90	0.064	0.178
	Time	18.07	< 0.001	0.501
	Time $\times$ Group	103.19	< 0.001	0.851
Passive Straight-Leg Raise – Right	Group	8.97	0.008	0.333
	Time	8.36	0.010	0.317
	Time $\times$ Group	61.12	< 0.001	0.772
Sit-and-Reach	Group	171.32	< 0.001	0.905
	Time	4,642.11	< 0.001	0.996
	Time $\times$ Group	6,215.68	< 0.001	0.997

Note. *AKE* = active knee extension; *PKE* = passive knee extension; *SLR* = straight-leg raise; η^2 = eta-squared. Group compares treatment and control participants averaged across time; Time compares pre- and post-intervention measurements averaged across groups; Time $\times$ Group tests whether the pre-post change differs between groups. Degrees of freedom are 1 and 18 for each effect.

The treatment group demonstrated increases in mean scores across all seven outcomes following the six-week sports massage intervention. SRT scores increased from 3.13 ± 0.09 cm at pre-test to 4.64 ± 0.10 cm at post-test. For the AKE tests, mean scores increased from 161.35° to 164.95° for the left leg and from 160.35° to 163.95° for the right leg. Similarly, PKE scores increased from 169.35° to 172.95° for the left leg and from 168.35° to 171.95° for the right leg. The SLR scores also increased, from 88.00° to 90.00° for the left leg and from 87.00° to 89.00° for the right leg.

In contrast, the control group exhibited decreases in mean scores across all seven outcomes. SRT scores declined from 3.19 ± 0.14 cm at pre-test to 3.08 ± 0.18 cm at post-test. AKE scores decreased from 162.33° to 161.33° for the left leg and from 161.34° to 161.06° for the right leg. PKE scores decreased from 166.13° to 165.20° for the left leg and from 165.94° to 164.59° for the right leg. Likewise, SLR scores declined from 90.27° to

89.45° for the left leg and from 89.68° to 88.76° for the right leg.

Prior to the inferential analyses, normality was assessed using the Shapiro–Wilk test. The normality of the outcome distributions and model residuals should be evaluated using the corresponding diagnostic statistics. As the Shapiro–Wilk statistics and associated p-values were not provided in the available results, the assumption of normality cannot be independently confirmed from the descriptive data alone.

3.3 Mixed ANOVA

Separate 2×2 mixed-design analyses of variance (ANOVAs) were specified for the seven flexibility outcomes, with Time (pre-test and post-test) as the within-subjects factor and Group (treatment and control) as the between-subjects factor. The main effects of Group and Time, together with the Time $\times$ Group interaction effects, are presented in Table 3.

The main effect of Group was statistically significant for PKE-L, $F(1, 18) = 24.49, p < .001$, partial $\eta^2 = .576$; PKE-R, $F(1, 18) = 20.99, p < .001$, partial $\eta^2 = .538$; SLR-R, $F(1, 18) = 8.97, p = .008$, partial $\eta^2 = .333$; and SRT, $F(1, 18) = 171.32, p < .001$, partial $\eta^2 = .905$. No statistically

significant Group effects were reported for AKE-L, $F(1, 18) = 2.60, p = .125$, partial $\eta^2 = .126$; AKE-R, $F(1, 18) = 1.11, p = .306$, partial $\eta^2 = .058$; or SLR-L, $F(1, 18) = 3.90, p = .064$, partial $\eta^2 = .178$.

Table 4. Post-hoc Pairwise Comparisons for All Flexibility Measures

Measure	Comparison	Mean Difference	95% CI	Adjusted p
Sit-and-Reach (cm)	Treatment: Post – Pre	1.51	[1.49, 1.53]	< 0.001
	Control: Post – Pre	–0.11	[–0.15, –0.07]	0.003
	Treatment – Control at Post	1.56	[1.42, 1.70]	< 0.001
AKE Left (°)	Treatment: Post – Pre	3.60	[2.62, 4.70]	< 0.001
	Control: Post – Pre	–1.00	[–1.68, –0.32]	0.100
	Treatment – Control at Post	3.62	[1.81, 5.43]	0.016
AKE Right (°)	Treatment: Post – Pre	3.60	[2.68, 4.66]	< 0.001
	Control: Post – Pre	–0.28	[–0.60, 0.04]	0.473
	Treatment – Control at Post	2.89	[1.01, 4.77]	0.073
PKE Left (°)	Treatment: Post – Pre	3.60	[2.77, 4.79]	< 0.001
	Control: Post – Pre	–0.93	[–1.45, –0.41]	0.039
	Treatment – Control at Post	7.75	[5.24, 10.26]	< 0.001
PKE Right (°)	Treatment: Post – Pre	3.60	[3.06, 5.16]	< 0.001
	Control: Post – Pre	–1.35	[–2.02, –0.68]	0.020
	Treatment – Control at Post	7.36	[4.88, 9.84]	< 0.001
SLR Left (°)	Treatment: Post – Pre	2.00	[1.22, 2.32]	< 0.001
	Control: Post – Pre	–0.82	[–1.45, –0.19]	0.145
	Treatment – Control at Post	0.55	[–0.25, 1.35]	0.769
SLR Right (°)	Treatment: Post – Pre	2.00	[1.27, 2.29]	< 0.001
	Control: Post – Pre	–0.92	[–1.76, –0.08]	0.288
	Treatment – Control at Post	0.24	[–1.05, 1.53]	1.000

Note. AKE = active knee extension; PKE = passive knee extension; SLR = passive straight-leg raise; CI = confidence interval. Adjusted p-values should be calculated using the chosen multiple-comparison correction across the complete set of planned comparisons

A statistically significant main effect of Time was reported for all seven outcomes. The corresponding results were AKE-L, $F(1, 18) = 74.01, p < .001$, partial $\eta^2 = .804$; AKE-R, $F(1, 18) = 552.35, p < .001$, partial $\eta^2 = .968$; PKE-L, $F(1, 18) = 133.64, p < .001$, partial $\eta^2 = .881$; PKE-R, $F(1, 18) = 58.08, p < .001$, partial $\eta^2 = .763$; SLR-L, $F(1, 18) = 18.07, p < .001$, partial $\eta^2 = .501$; SLR-R, $F(1, 18) = 8.36, p = .010$, partial $\eta^2 = .317$; and SRT, $F(1, 18) = 4,642.11, p < .001$, partial $\eta^2 = .996$.

The Time $\times$ Group interaction was also reported to be statistically significant for all seven flexibility outcomes. The interaction effects were AKE-L, $F(1, 18) = 231.68, p < .001$, partial $\eta^2 = .928$; AKE-

R, $F(1, 18) = 754.40, p < .001$, partial $\eta^2 = .977$; PKE-L, $F(1, 18) = 384.69, p < .001$, partial $\eta^2 = .955$; PKE-R, $F(1, 18) = 281.10, p < .001$, partial $\eta^2 = .940$; SLR-L, $F(1, 18) = 103.19, p < .001$, partial $\eta^2 = .851$; SLR-R, $F(1, 18) = 61.12, p < .001$, partial $\eta^2 = .772$; and SRT, $F(1, 18) = 6,215.68, p < .001$, partial $\eta^2 = .997$.

If confirmed through reanalysis of the participant-level data, these interaction effects would indicate that changes in flexibility from pre-test to post-test differed significantly between the treatment and control groups. The descriptive statistics show a consistent pattern of increased scores in the treatment group and decreased scores in the control



group. Nevertheless, the reported F-statistics and effect sizes require verification before publication because the treatment-group data exhibit identical changes across participants for several outcomes, potentially resulting in unusually large test statistics.

3.4 Post-hoc Comparisons

Post-hoc comparisons were intended to examine the direction and magnitude of the observed differences by evaluating pre-post changes within each group and between-group differences at post-test. The comparisons are summarized in Table 4 and comprise treatment-group change, control-group change, and the difference between the treatment and control groups at post-test. Based on the descriptive statistics, the treatment group demonstrated a mean increase of 1.51 cm in SRT, 3.60° in each of the four knee-extension measures, and 2.00° in each of the two SLR measures. Conversely, the control group demonstrated mean decreases of 0.11 cm in SRT, 1.00° in AKE-L, 0.28° in AKE-R, 0.93° in PKE-L, 1.35° in PKE-R, 0.82° in SLR-L, and 0.92° in SLR-R.

These descriptive findings indicate a more favorable pattern of change in the treatment group than in the control group. However, conclusions regarding the statistical significance of individual within-group changes and between-group differences require verified post-hoc estimates, confidence intervals, and multiplicity-adjusted p-values. The available pairwise-comparison results should therefore be considered provisional until they have been recalculated using the original participant-level data and a clearly specified multiple-comparison correction procedure. Overall, the descriptive findings suggest that the six-week sports massage intervention may be associated with improvements in hamstring flexibility among male university football players. However, definitive conclusions regarding the magnitude and statistical reliability of the intervention effects should be reserved until the ANOVA and post-hoc analyses have been independently verified.

3.5 Discussion

The present study examined the effects of a six-week structured sports massage program, consisting of 15 minutes of effleurage administered twice weekly, on hamstring flexibility among male university football players. The updated descriptive results indicate improvements in all seven flexibility outcomes in the treatment group.

The mean Sit-and-Reach Test (SRT) score increased from 3.13 to 4.64 cm, while active and passive knee-extension scores increased by 3.60° on both sides. Similarly, the passive straight-leg-raise (SLR) scores increased by 2.00° bilaterally. In contrast, the control group demonstrated small declines in the mean scores across the outcome measures. These findings suggest that regular sports massage may be a useful supplementary strategy for improving flexibility in university-level football players.

The observed improvements are consistent with the growing body of literature examining massage as a recovery and flexibility intervention. [Poppendieck et al. \(2016\)](#) highlighted the potential contribution of massage to athletic recovery, while [Kim and Lee \(2025\)](#) examined its effects on hamstring flexibility in comparison with other commonly used interventions. The present findings extend this literature by examining repeated massage sessions over six weeks rather than focusing exclusively on immediate responses to a single treatment. Nevertheless, the magnitude and statistical significance of the intervention effects should be interpreted using the final verified inferential results, particularly the Time × Group interaction effects.

The findings are broadly consistent with the systematic review by [Dakić et al. \(2023\)](#), which examined the effects of massage on flexibility across athletic populations. Their review supports the potential of massage to improve range of motion, although the magnitude of the response may vary according to the massage technique, treatment duration, participant characteristics, and flexibility test used. The present protocol, which involved 15 minutes of effleurage twice weekly, provides evidence concerning the application of a relatively straightforward manual technique within a university football setting. Similarly, [Edholm et al. \(2024\)](#) discussed recovery strategies used by athletes and the potential role of soft-tissue interventions in managing perceived stiffness and supporting recovery during intensive training periods. The improvement observed in the treatment group, alongside the declines in the control group, suggests that massage may be beneficial when incorporated into a regular training program. However, because perceived stiffness was not measured directly, the present findings cannot establish that reductions in stiffness explain the observed changes in flexibility. Furthermore, the control-group pattern should not be interpreted

as definitive evidence of cumulative training-induced stiffness without direct assessment of training load, muscle soreness, and recovery status (Madoni et al., 2018).

Research by Davis et al. (2020), Liyanage et al. (2024), and Martinez-Aranda et al. (2024) has also examined massage in relation to post-exercise recovery, muscle soreness, and range of motion. This literature provides a broader context for understanding massage as a potential component of athlete recovery management. Whereas acute studies primarily investigate immediate or short-term responses following a massage session, the six-week intervention in the present study examined changes following repeated exposure. The findings therefore contribute longitudinal observations to this area of research. However, because the present study did not include multiple post-treatment follow-ups, it cannot establish whether the observed improvements persisted after the intervention ended or whether they represent cumulative physiological adaptations.

Several mechanisms have been proposed to explain the relationship between massage and flexibility. Weerapong et al. (2016) discussed possible physiological and perceptual pathways, including changes in local circulation and tissue temperature, neuromuscular responses, and stretch tolerance. These mechanisms provide plausible explanations for improvements in range of motion following massage. Nevertheless, they should be considered potential explanations rather than confirmed mechanisms in the present study because variables such as tissue temperature, muscle stiffness, neural excitability, and stretch tolerance were not directly measured.

The improvements observed across active and passive knee-extension tests suggest that the intervention may have influenced factors relevant to both active and externally assisted range of motion. However, the results do not establish that massage reduced adhesions, altered fascial properties, or increased sarcomere length. Such explanations require direct biomechanical, physiological, or imaging-based evidence. Freitas et al. (2018) provide relevant context for considering the role of perceptual and neuromuscular factors in flexibility responses. The current findings should therefore be interpreted as evidence of changes in measured flexibility rather than proof of a specific underlying biological mechanism.

Best et al. (2016) evaluated sports massage in the context of skeletal muscle recovery following strenuous exercise and discussed its potential benefits for delayed-onset muscle soreness (DOMS) and perceived recovery. Although recovery and flexibility are distinct outcomes, the findings of the present study complement this broader literature by demonstrating improvements in measured flexibility following a structured massage program. The effleurage technique involved repeated manual strokes along the treated regions, potentially providing sensory and mechanical stimulation to the soft tissues. However, the proposition that this stimulation reduced perimuscular fibrosis, decreased intramuscular adhesions, or facilitated greater sarcomere lengthening remains speculative in the absence of direct measurements (Moraska, 2016; Niewiadomy et al., 2021; Pinto et al., 2024).

Kargarfard et al. (2016) reported beneficial effects of post-exercise massage on recovery-related outcomes and exercise performance among male bodybuilders, including measures of jumping, agility, and isometric torque. Although their population and outcome measures differed from those of the present study, their findings provide supporting context for investigating massage as part of an athlete recovery program. Clapis et al. (2024) examined the combined influence of communication, expectations, and percussive therapy on acute hamstring flexibility. Their findings highlight the potential importance of both the physical intervention and contextual factors in shaping flexibility responses. The present study used manual effleurage rather than percussive therapy; consequently, direct comparisons between the magnitude of the observed changes should be made cautiously. Differences in treatment methods, participant characteristics, study designs, and outcome assessments may account for variations between studies.

A 2024 randomized controlled trial comparing percussive massage therapy, foam rolling, and hamstring stretching reported improvements in SRT performance following each intervention. These findings provide a useful comparison with the improvement in SRT observed in the present study. However, differences in protocols and study populations prevent the conclusion that manual effleurage is equivalent or superior to other flexibility interventions (Tulu et al., 2024). Similarly, Kim and Lee (2025) compared the acute effects of massage, static stretching, and foam rolling on hamstring flexibility. Their findings



indicated that static stretching produced greater immediate improvements than massage and foam rolling, while the difference between massage and foam rolling was not statistically significant. These findings suggest that the relative effectiveness of flexibility interventions may depend on whether the outcome is assessed immediately after a single session or following a longer program. The present six-week intervention contributes to the longitudinal evidence, although direct comparisons require studies using standardized protocols and equivalent follow-up periods. [Kargarfard et al. \(2016\)](#) also reported improvements in recovery-related outcomes, including creatine kinase (CK), following post-exercise massage. In addition, a 2025 study investigating pneumatic compression and manual massage in elite Brazilian under-20 soccer players reported a reduction in CK following manual massage and concluded that both approaches could be considered recovery strategies under the conditions studied.

These findings are relevant because biochemical markers such as CK are sometimes used to examine muscle damage following exercise. However, the present study did not measure CK, other biochemical markers, or direct indicators of exercise-induced muscle damage. Consequently, the improvements in flexibility cannot be taken as evidence that the massage intervention reduced muscle damage or accelerated biochemical recovery. The findings support the potential value of massage for flexibility management, while its effects on muscle damage and recovery in university football players require further investigation. The potential relevance of hamstring flexibility to football injury management provides an important applied context for the present findings. [Afshar et al. \(2025\)](#), in a narrative review of hamstring strains in football players, discussed flexibility among the factors considered in hamstring injury assessment and prevention. Research has also documented the continuing burden of hamstring injuries in football, including the trends reported by [Ekstrand et al. \(2016\)](#). [Häggglund et al. \(2016\)](#) identified previous injury and age as important injury-related factors, while [Witvrouw et al. \(2016\)](#) and [Engebretsen et al. \(2016\)](#) examined the relationship between flexibility and injury risk in football and soccer populations.

The treatment-group improvements observed in the present study may be relevant to conditioning programs that aim to maintain or improve

flexibility. Nevertheless, flexibility is only one component of a multifactorial injury-risk profile. The relationship between flexibility measurements and injury occurrence cannot be assumed to be direct, and an improvement in range of motion does not necessarily translate into a lower injury incidence. Because the present study did not monitor hamstring injuries or evaluate a defined injury-risk threshold, it cannot establish that sports massage prevents hamstring strains. The practical implications should therefore be framed cautiously. A twice-weekly massage program may be considered a supplementary flexibility-management option for university football teams, particularly where accessible recovery strategies are needed. However, it should not replace established injury-prevention measures, such as appropriate strength training, progressive load management, and sport-specific conditioning. The broader literature on injury risk and flexibility, including [Behara and Jacobson \(2017\)](#) and [Mughal et al. \(2026\)](#), provides a basis for further investigation of how massage-based flexibility interventions might be integrated into comprehensive athlete-management programs.

The intervention was designed to address the posterior chain rather than treating the hamstrings in isolation. This approach is consistent with the concept that movement and perceived muscle tightness may involve interactions among multiple anatomical regions. [Krause et al. \(2016\)](#) and [Fauris et al. \(2021\)](#) provide relevant context for considering myofascial relationships when interpreting movement and flexibility outcomes. A 2025 comparison of eccentric exercise with and without massage reportedly found greater or more sustained flexibility improvements when massage was added to eccentric training. This provides a rationale for investigating massage as an adjunct to exercise-based flexibility and conditioning programs. However, because the present study did not compare posterior-chain treatment with isolated hamstring massage or eccentric exercise, it cannot determine whether treating multiple regions was more effective than targeting the hamstrings alone.

The inclusion of several flexibility assessments strengthened the evaluation by allowing changes to be examined using different movement tasks. Active knee extension reflects range of motion achieved through active muscular control, whereas passive knee extension assesses range of motion under externally assisted conditions. The SLR

assesses a broader movement involving the hip and lower limb, and the SRT incorporates contributions from the hamstrings, lumbar region, and other aspects of trunk and pelvic movement. These tests therefore provide complementary, but not interchangeable, information about flexibility.

The updated descriptive results showed increases in both active and passive knee-extension measures, suggesting that the observed changes were not confined to one testing condition. The SLR measures also improved, although the mean increases were smaller than those observed in knee extension. This difference may reflect the distinct movement demands and anatomical contributions of the tests. However, without direct assessment of neural mobility, tissue stiffness, or movement mechanics, the reasons for these differences remain uncertain. The interpretation of SRT outcomes requires particular care because the test does not isolate hamstring flexibility. [Kamaruddin et al. \(2026\)](#), in their systematic review of SRT validity for assessing hamstring and lower-back flexibility, highlighted its value as a practical field-based measure alongside its limitations. The present study therefore benefits from interpreting SRT results together with active and passive knee-extension and SLR outcomes rather than relying on the SRT alone.

An important descriptive observation was the contrasting pattern between the treatment and control groups. The treatment group improved across all seven outcome measures, whereas the control group showed small declines in the reported means. This pattern is consistent with the possibility that structured massage contributed to flexibility improvements beyond those observed during regular football training alone. Nevertheless, the strength of this interpretation depends on the verified statistical comparisons, baseline comparability, adherence to the intervention, and control of other factors that could influence flexibility.

The control-group declines should not automatically be attributed to accumulated stiffness, muscle microtrauma, or inadequate recovery. Although these explanations are plausible in the context of football training, the study did not directly measure training load, muscle soreness, or recovery status. [Ekstrand et al. \(2016\)](#) provide relevant background concerning the burden of hamstring injuries in football, but injury epidemiology alone does not establish that the declines in the present control group were caused

by training-related stiffness. [Lestari et al. \(2025\)](#) reported findings relevant to the potential role of massage in managing DOMS and maintaining range of motion among sprinters. The comparison provides context for examining massage as a supplementary recovery strategy, although differences in sports, protocols, and measured outcomes should be considered. Overall, the contrast between the treatment and control group means supports further investigation of regular massage within athlete flexibility-management programs.

Research involving different sports and participant groups also provides context for the present findings. [Iguchi et al. \(2016\)](#) investigated injury predictors among Japanese collegiate American football players, identifying vertical jump height as one of the significant predictors examined. Although the present study did not assess injury incidence or vertical jump performance, their findings illustrate the multifactorial nature of athletic injury risk and the importance of interpreting flexibility as one component within a wider performance and injury-management framework. [Hopper et al. \(2021\)](#) examined the effects of massage techniques on hamstring muscle length among competitive female hockey players and reported increases following massage. The present study adds evidence from male university football players, thereby extending the populations represented in the massage and flexibility literature. Nevertheless, differences in sex, sport, participant characteristics, and intervention protocols mean that the findings should not be assumed to apply uniformly across all athletic populations.

The interpretation of these results also depends on the measurement properties of the flexibility tests. A 2025 study examining the intrasession and intersession reliability of flexibility tests during developmental years reported acceptable reliability for the SRT, active knee extension, passive knee extension, and SLR. However, reliability estimates from one population may not be directly transferable to adult university football players. Future studies should therefore report measurement reliability in the target population where feasible and standardize assessor procedures, positioning, warm-up conditions, and testing instructions.

A strength of the present study was its six-week intervention period, which allowed the effects of repeated massage sessions to be examined rather



than restricting the investigation to an immediate post-treatment response. The inclusion of a control group and seven flexibility outcomes also provided a broader assessment of the intervention than reliance on a single test. In addition, the use of both active and passive measures helped distinguish changes across different movement tasks..

4. CONCLUSION

The findings of this study indicate that a six-week structured sports massage program, consisting of 15-minute effleurage sessions delivered twice weekly, was associated with improvements in hamstring flexibility among male university football players. The treatment group demonstrated increases across all seven flexibility measures, including the Sit-and-Reach Test, active and passive knee extension, and straight-leg raise, whereas the control group showed small declines in the corresponding mean scores. These findings suggest that regular sports massage may be a useful supplementary intervention for flexibility management within university football training programs.

From a practical perspective, structured sports massage may provide coaches and sports science practitioners with an accessible approach to supporting flexibility alongside established training, conditioning, and recovery practices. However, although hamstring flexibility is relevant to athlete conditioning and has been investigated in relation to injury risk, the present study did not directly assess injury incidence, athletic performance, or the physiological mechanisms underlying the observed changes. Therefore, the findings should not be interpreted as direct evidence that sports massage prevents hamstring injuries or improves competitive performance.

Further research involving larger and more diverse athletic populations is required to establish the optimal frequency and duration of massage, the retention of flexibility improvements after the intervention, and the additional benefits of massage when combined with established conditioning programs. Future studies should also investigate injury outcomes and performance-related measures to determine whether improvements in flexibility translate into meaningful benefits for athlete health and performance. Subject to verification of the final statistical analyses, the present findings provide encouraging evidence for considering structured sports massage as a supplementary

component of flexibility management in male university football players.

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6. AUTHOR CONTRIBUTION STATEMENT

W.H.K.T.N. designed the study, developed the research concept, recruited participants, collected and analyzed the data, and contributed to the revision of the manuscript. W.H.K.T.N. also reviewed and approved the final version of the manuscript. P.C.T. supervised the overall research project and provided guidance throughout the

conceptualization, data collection, and data analysis processes. P.C.T. drafted the manuscript, critically reviewed and revised the content, and approved the final version of the manuscript.

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