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Immediate and short-term effects of warm-up, dynamic and static stretching on hamstring flexibility in college students with muscle tightness

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Abstract
Introduction. **Frequently observed in athletes, hamstring muscle tightness impairs their performance and increases injury risk. While static and dynamic stretching are commonly used to improve flexibility, the comparative effectiveness and short-term retention of gains following these interventions remain unclear.** Aim of Study. **This study aimed to investigate the immediate and short-term effects of warm-up, static and dynamic stretching on hamstring flexibility in college students.** Material and Methods. **A crossover study was carried out among forty college students with clinically confirmed hamstring tightness. The subjects underwent three interventions - warm-up, static stretching, and dynamic stretching in random order. Hamstrings flexibility was evaluated with passive knee extension range of motion (PKE ROM) test.** Results. **A two-way repeated measures ANOVA examined the effects of static vs. dynamic stretching and time. The average ROM across all time points did not differ significantly between the two stretches [F(1,312) = 0.291, $p = 0.590$, partial $\eta^2 = 0.0009$] and produced comparable overall ROM values. ROM changes across the 4 time points approached significance [F(3,312) = 2.275, $p = 0.080$, partial $\eta^2 = 0.0214$], indicating small but observable variations across the measurement timeline. The Condition × Time interaction was not significant [F(3,312) = 0.767, $p = 0.513$, partial $\eta^2 = 0.0073$], demonstrating that the pattern of ROM change over time was similar for both stretches. Effect sizes were estimated using Cohen's d, which revealed greater within-condition ROM improvement following static stretching, while post-stretch differences between stretching types were small. Warm-up alone accounted for approximately 3.5° and 5.8° of ROM improvement. Static stretching produced a larger additional increase than dynamic stretching, while both conditions showed high short-term retention.** Conclusions. **Warm-up, static and dynamic stretching techniques are effective in improving hamstring flexibility in the short term. However, flexibility gains may diminish slightly after 15 minutes.**

KEYWORDS: static stretching, dynamic stretching, flexibility, warm-up, hamstrings.

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Introduction

Located in posterior aspect of the lower limb, the hamstrings are a collection of three different muscles, namely the semitendinosus, semimembranosus and biceps femoris [1]. These are primarily fast-twitch muscles and respond to low repetitions and powerful movements and are the most common muscle group to undergo shortening and injury [2, 3]. Hamstring tightness is prevalent among healthy individuals, particularly males (91.8%) compared to females (78.7%), and is commonly associated with a sedentary lifestyle [4]. People with tight hamstrings have higher chances of suffering recurrent severe hamstring strains or experiencing problems such as low back pain due to exaggerated posterior pelvic tilt. This muscle tightness can greatly affect the athlete's performance in sports. A study conducted at the National Sports Institute Clinic in Kuala Lumpur, Malaysia reported that approximately 60% of injuries occurred in athletes under the age of 20 and knee is the most common injured part of the body involving hamstrings muscle strain [5]. Hamstring injuries can happen when hamstrings are stretched with a greater force and the muscle fibers end up tearing. Activities that involve excessive use of the hamstrings such as sudden sprint or other fast twisting legs movements, excessive running or improper stretching – can predispose a person to hamstring injury during sports activities [6, 7]. A study by the Union of European Football Association showed that the proportion of hamstring injuries in European men's professional football increased from 12% to 24% of all injuries between 2001 and 2022 [8]. Sometimes hamstring injuries may result from inadequate preparation and warm-up before the start of certain exercises or sporting activities.

Stretching involves the application of manual or mechanical force to elongate soft tissue structures that are adaptively shortened. The stretching methods widely used in clinical practice are static and dynamic stretching. Static stretching involves elongating the tissue to the point of resistance and holding it for a sustained duration. It is considered safe and effective in increasing flexibility, with minimal tissue trauma and post-exercise soreness [9]. However, aggressive static stretching may impair muscle function by reducing strength and power, and potentially causing microscopic damage [10]. In contrast, dynamic stretching involves controlled, rhythmic movements and is believed to enhance neuromuscular control and motor function, making it suitable for athletic performance enhancement [11, 12]. While static stretching has been associated with reduced injury rates and improved recovery, some studies suggest it may negatively affect immediate performance parameters such as isometric strength, power output, and sprint or jump performance [8, 12]. On the other hand, dynamic stretching appears to benefit performance without impairing strength, although it may be less effective than static stretching in improving muscle flexibility [12]. There is ongoing debate over how long the effect of these stretching procedures last, although the flexibility gains are known to decrease relatively quickly. Therefore, it is important to investigate not only the effectiveness of warm-up, static, and dynamic stretching techniques but also the retention of flexibility after a short rest period.

Aim of Study

The objective of this study was to examine the effectiveness of warm-up exercises, static stretching and dynamic stretching on hamstring flexibility and to determine whether the flexibility gained after the stretch was maintained 15 minutes after each stretching maneuver.

Material and Methods

Study design and participants

This study employed a crossover study design with simple random sampling. A total of 40 college students (both male and female), aged 18 to 28 years, from Rathinam College of Physiotherapy, Coimbatore, were recruited. All participants had clinically confirmed hamstring inflexibility, defined as a lack of 15° of terminal active knee extension [8]. Written informed consent was obtained from all participants before they took part in this study. Ethical approval was obtained from the Institutional Ethics Committee of Rathinam College of Physiotherapy (approval code: RCP/IEC/2025-26/017). Subjects with any history of traumatic and degenerative changes in the knee joint, low back disorders, recent knee surgeries and active practitioners of yoga were excluded from this study.

Procedure

Participants were randomly allocated using sealed envelopes to Group A and Group B, with 20 participants in each group (Figure 1). Demographic data were collected (Table 1). Hamstring flexibility was assessed using the passive knee extension range of motion (PKE ROM) test with a goniometer. Participants were positioned in the supine position with the dominant leg passively moved into 90° of hip flexion and maintained using a crossbar. The tested knee was then passively extended to its maximal range. The non-tested limb was strapped to the couch with the knee in extension. The procedure was repeated twice and the mean value was recorded [13]. Participants received both static and dynamic stretching interventions across two days. On day 1, Group A performed static stretching, while Group B performed dynamic stretching. After 48 hours of washout period, the interventions were reversed. Two physiotherapists demonstrated the stretching procedures for both groups. An independent assessor, who was blinded to the subject allocation, conducted the testing procedure and collected data for both the groups. To reduce variability, all testing procedures were performed at the same time of day for each participant by the same assessor. The values of PKE ROM were measured at baseline, after warm-up, post-stretches and 15 minutes after the stretches. The 15-minute duration was chosen to investigate the short-term effect of the stretches on hamstring flexibility. The intra-rater reliability of assessing hamstring flexibility using the PKE ROM was excellent and showed lack of bias and test-retest repeatability [13]. The PKE tool can also be readily replicated in the clinical settings and is a reliable and effective indirect test for assessing hamstring muscle length [14].

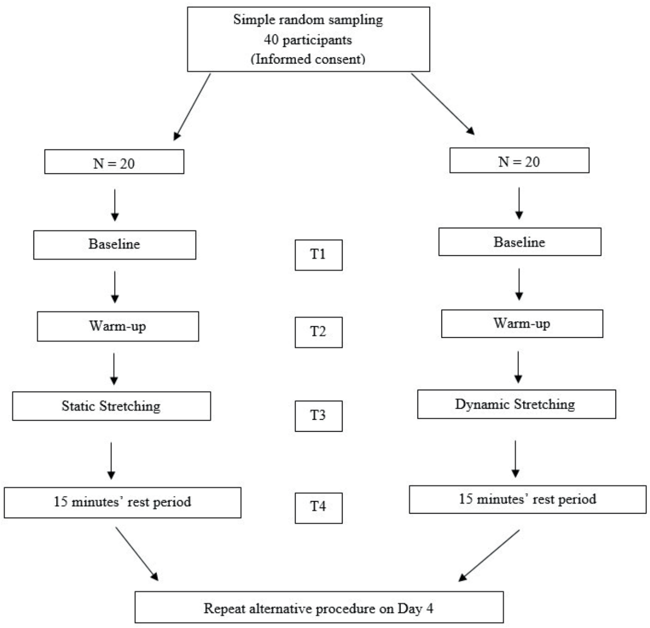

Figure 1. Study design and protocol

Table 1. Demographics

Variable	Values
Total participants	40
Male	22
Female	18
Mean age (years)	23.3 ± 0.5
Group A (static → dynamic)	20
Group B (dynamic → static)	20

Warm-up protocol

Before the stretching interventions, all participants performed a standardized general warm-up consisting of 5-minute brisk walking followed by two minutes of spot marching. The warm-up aimed to increase core body temperature and blood flow to the lower limb musculature. Immediately after this warm-up, PKE ROM measurements were recorded to assess the effect of warming up alone on hamstring flexibility.

Stretches

Since crossover design was used to find out the short-term and reversible effects of the treatment, on day 1 subjects in Group A completed static stretching exercises, whereas Group B did dynamic stretches and the same was reversed on day 4, when Group A subjects performed dynamic stretches and Group B completed static stretches. For each participant, testing procedures on days 1 and 4 were carried out at the same time of day by the same assessor. Subjects who completed static stretching performed 3 types of static stretches, each done for 5 repetitions and held for 15 seconds. The stretch was performed to the end range where the participant felt a mild discomfort in their posterior thigh. In dynamic stretching, 3 dynamic stretches were taught and each movement was repeated 7 times during 15 seconds for 5 sets and 10-second rest interval was provided between each set. Stretches were initiated at a low velocity and progressed gradually to achieve at least 75% of maximum velocity through a particular ROM [15]. The static and dynamic stretching routines were timed appropriately so that the amount of time spent during stretching was the same for each group, enabling comparison between the two groups.

Static stretches: (i) Standing toe-touch: Subjects assumed a standing position, bent their trunk forward to touch their toes with both knees fully extended; (ii) Forward swing static stretch: Subjects placed their leg on an elevated surface with the knee extended and the ankle plantar flexed, leaned their trunk forward from the hips keeping the spine in neutral position until a stretch was felt in the posterior thigh; (iii) Passive supine sling stretch: Subjects lay in the supine position on a couch with a towel placed around the sole of the foot to assist hip flexion and stretch the hamstrings.

Dynamic Stretches: (i) Deep lunges with rotation: Subjects stood straight, assumed a forward lunge position by placing their dominant leg in front of their body positioning the knee over the toes and rotated their upper body away from the front leg. Then they returned to the standing position; (ii) Dipping birds: Subjects stood straight and stepped forward with their dominant leg and bent forward at the waist. With their left hand, they touched their right foot without bending the dominant leg, then returned to the standing position; (iii) Cross-body leg swings: In a standing position, the dominant leg was flexed and taken across the midline of the body towards the opposite shoulder to stretch the biceps femoris, the lateral muscle of the hamstrings [8].

A priori power analysis

An a priori sample size calculation was performed using G*Power software version 3.1.9.7 to determine the required number of participants for detecting the Condition × Time interaction in a repeated-measures ANOVA design. This study employed a cross-over design with two groups, two within-subject conditions and four repeated time points. The sample size estimation was based on a moderate effect size (Cohen's $f = 0.25$, corresponding to partial $\eta^2 \approx 0.06$), an alpha level of 0.05 and a statistical power of 80% ($1 - \beta = 0.80$). A within-subject correlation of 0.5 among repeated measures and a nonsphericity correction of $\varepsilon = 1$ were assumed. The analysis indicated that a minimum total sample size of 56 participants was required to detect a moderate Condition × Time interaction effect with adequate statistical power.

Results

Participant characteristics

A total of 40 college students (22 males, 18 females; mean age 23.3 ± 0.5 years) presenting with self-reported hamstring muscle tightness were enrolled and completed this randomized two-period crossover study. Participants were stratified into two groups based on intervention sequence: Group A ($n = 20$) performed static stretching first followed by dynamic stretching, while Group B ($n = 20$) completed the counterbalanced sequence. All participants completed both intervention periods, separated by a 48-hour washout interval, with full adherence and retention. Data analysis was done using the statistical software SPSS 17.0 and Microsoft Excel, ensuring a thorough examination of the results.

Validation of crossover assumptions

Tests for potential period and carryover effects indicated that the crossover design was appropriate. The period effect was non-significant [$F(1,310) = 1.123$, $p = 0.290$] indicating that the order of interventions did not influence the outcomes. The carryover effect was similarly non-significant [$F(1,310) = 0.234$, $p = 0.629$] as shown in Table 2, suggesting that the 48-hour washout adequately prevented residual effects. Thus, treatment effects were not confounded by sequence or insufficient washout.

Table 2. Period and carryover effects (crossover validation)

Effect	*df*	*F*	*p*-value
Period (Order)	1,310	1.123	0.290
Carryover (Group × Period)	1,310	0.234	0.629

Two-way repeated measures ANOVA

A two-way repeated measures ANOVA examined the effects of Condition (static vs. dynamic stretching) and Time (baseline, post-warm-up, post-stretch, 15-minute post-stretch).

Main effect of condition and effect on time

The average ROM across all time points did not differ significantly between static and dynamic stretching [$F(1,312) = 0.291$, $p = 0.590$, partial $\eta^2 = 0.0009$]. Both interventions produced comparable overall ROM values. ROM changes across the four time points approached significance [$F(3,312) = 2.275$, $p = 0.080$, partial $\eta^2 = 0.0214$], indicating small but observable variations over the measurement timeline as seen in Table 3.

Condition × Time interaction

The Condition × Time interaction was not significant [$F(3,312) = 0.767$, $p = 0.513$, partial $\eta^2 = 0.0073$], demonstrating that the pattern of ROM change over time was similar for static and dynamic stretching.

Table 3. Two-way repeated measure ANOVA results

Effect	Degrees of freedom	*F* value	*p* value	Partial η2
Condition	1,312	0.291	0.590	0.0009
Time	3,312	2.275	0.080	0.0214
Condition × Time	3,312	0.767	0.513	0.0073

Estimated marginal means

Static stretching

ROM increased from 136.11° at baseline to 139.67° post-warm-up and reached 142.22° post-stretch, a total improvement of 6.11°. At the 15-minute follow-up, ROM measured 140.5°, representing 99% retention of the acute increase.

Dynamic stretching

Baseline ROM was 129.95°, increasing to 135.82° post-warm-up, post-stretch ROM was 138.59°, reflecting a total improvement of 3.50° from baseline. At the 15-minute assessment, ROM was 134.68°, which maintained 97% of the initial change (Table 4).

Comparative pattern
Warm-up alone accounted for approximately 3.5° and 5.8° of ROM improvement in both conditions. Static stretching produced a larger additional increase than dynamic stretching, while both conditions showed high short-term retention.

Table 4. Estimated marginal means of passive knee extension ROM (°) across conditions and time points

Group	Time point	Mean ROM (B°)	SD	95% CI Lower	95% CI Upper
A	Baseline	136.11	9.4	129.97	142.25
A	Post-WU	139.67	8.32	134.23	145.1
A	Post-stretch	142.22	8.57	136.62	147.82
A	15 minutes	140.5	9.41	134.35	146.65
B	Baseline	129.95	6.37	126.19	133.72
B	Post-WU	135.82	5.86	132.36	139.28
B	Post-stretch	138.59	5.34	135.44	141.75
B	15 minutes	134.68	4.93	131.77	137.6

Note: WU – warm-up; ROM – range of motion; SD – standard deviation; CI – confidence interval.

Effect size analysis (Cohen's d*)*
Within-condition changes
(i) Static stretching: baseline vs. post-stretch: $d = -1.014$ (large effect);
(ii) Dynamic stretching: baseline vs. post-stretch: $d = -0.441$ (small effect).
Between-condition comparison
(i) Static vs. dynamic at post-stretch: $d = 0.250$ (small effect) (Table 5).
These standardized effects indicate greater within-condition ROM improvement following static stretching, while post-stretch differences between stretching types were small.

Table 5. Cohen's *d* effect sizes

Comparison	Cohen's *d*	Effect
Static: baseline vs. post-stretch	–1.014	Large
Dynamic: baseline vs. post-stretch	–0.441	Small
Static vs. dynamic at post-stretch	0.250	Small

Discussion

The intention of this study was to compare the effectiveness of warm-up, static stretching and dynamic stretching in improving hamstring muscle flexibility and to find out if the flexibility gained through the interventions were maintained after 15 minutes. Decreased hamstring flexibility is supposed to be one of the predisposing factors for hamstring strains [12] and is the main reason for choosing this study. The findings of this study state that warm-up, static stretching and dynamic stretching are effective to improve hamstring flexibility in normal subjects, with the baseline values improved when compared with the post-intervention values. A similar study showed that combined warm-up exercise and static stretch significantly increased hamstring flexibility [13]. In our study, the warm-up exercises could have enhanced the tolerance and muscle compliance during static stretch resulting in improvement. Evidence suggests that static stretching results in short-term increases in flexibility and our results are in agreement with this. Static stretching increased hamstring flexibility significantly more than dynamic stretching [16]. One study that compared modified hold-relax technique with static stretching found that the improved hamstring flexibility that occurred during static stretching may be due to autogenic inhibition [17]. Static stretching and Swiss massages are effective techniques for enhancing hip ROM by reducing stiffness of the muscles [18]. Hamstring flexibility can be improved by prolonged static stretching which allows the muscle spindle to adapt over time bringing about an increase in muscle length [16]. According to a study that provided insights regarding the current concepts in muscle stretching, both static and dynamic stretching are effective methods of increasing flexibility and muscle extensibility and static stretching is most helpful for athletes who require sport-specific flexibility, whereas dynamic stretching is more beneficial for athletes who perform more running and jumping activities during their sport. It was also summarized that static stretching was more effective for individuals recovering from hamstring muscle strain. Moreover, it has been suggested that dynamic stretching can be recommended in warm-up sessions to avoid a decrease in strength and performance that may occur due to performing a static stretch before commencing any sport activity. It has also been noted that static stretching is best performed at the end of a workout during the cool-down phase, as it can improve muscle flexibility when the muscles are properly warmed and more pliable [19]. In our study, the pattern of reduction in flexibility after stretching was remarkably alike to a study done by O'Sullivan et al. [13] who found that the increased flexibility obtained through stretching interventions reduced significantly after 15 minutes, but remained greater than baseline values. It has to be noted that the value they obtained 15 minutes post-stretching remained consistent when reassessed even after 24 hours. However, DePino et al. [20] pointed out that flexibility after static stretching lasted significantly greater from baseline for only 3 minutes. This is in contrast with our study, where after 15 minutes the flexibility was still greater than baseline. It appears, therefore that the effect of both types of stretching maneuvers decreases quickly, but remains higher than baseline. There is strong evidence from previous research suggesting that dynamic stretching improves sport-specific performance measures such as agility, speed and strength, whereas static stretching may actually decrease performance [8, 11, 19]. In a systematic review, Amiri-Khorasani et al. [21] examined the effects of both types of stretching on the dynamic ROM of the hip joint during kicking movements in professional soccer players. The results indicated that active hip ROM during kicking improved after performing dynamic stretches before sport, which may be related to changes in angular velocity occurring in the athlete's lower limbs during the kicking movement. However, static stretch failed to achieve a similar effect in that sample, so dynamic stretch seems to be more valuable and superior to static stretch when performing dynamic movements. Therefore, the choice of stretching may vary depending on the aims of rehabilitation. Muscle flexibility can be improved drastically with static stretching, whereas boosting immediate physical performance with improved flexibility can be done with dynamic stretching as recommended by previous trials [8, 11, 19, 22]. It is suggested that warm-up and stretching immediately before sport participation should prioritize performance-related outcomes rather than flexibility development; therefore, static stretching should be performed at times other than the pre-participation phase.

Limitations

This study had certain limitations. Control group was not included. Hamstring flexibility was measured only 15 minutes after stretching; however, it could also be assessed at additional time points such as 30 minutes, 60 minutes or even 24 hours post-stretch. In the current study, during the 15-minute rest interval, all subjects were allowed to sit in a chair with their feet on the floor after stretching and this might have influenced the result that was obtained after 15 minutes. This study can be conducted with a larger sample of individuals who are actively involved in competitive sports. Gender-based differences in hamstring flexibility can also be examined. Further studies are needed to investigate other techniques for increasing hamstring flexibility, such as eccentric training and additional stretching methods including ballistic or proprioceptive neuromuscular facilitation (PNF) techniques.

Conclusions

An active aerobic warm-up exercise significantly increased hamstring flexibility in all subjects. After the warm-up, both stretching procedures produced further increases in hamstring flexibility. The flexibility gained decreased after the 15-minute rest interval, although it remained higher than baseline values. Aerobic warm-up exercise, static stretching and dynamic stretching can be recommended to individuals with hamstring tightness to improve flexibility.

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Conflict of Interest

The authors declare no conflict of interest.

References

1. Palastanga NP, Field D, Saomes R. Anatomy and human movement: structure and function. 5th ed. Oxford: Butterworth-Heinemann: Elsevier; 2006.
2. López-Miñarro PA, Muyor JM, Belmonte F, Alacid F. Acute effects of hamstring stretching on sagittal spinal curvatures and pelvic tilt. J Hum Kinet. 2012;31:69-78. https://doi.org/10.2478/v10078-012-0007-7
3. Hoogenboom BJ, Voight ML, Prentice WE. Musculoskeletal interventions: techniques for therapeutic exercise. New York: Mcgraw-Hill; 2007.
4. Khalil E, Tariq R, Arsalan HM, Khalid A, Ayaz S, Javed H. Prevalence of hamstrings tightness and its impact on lower extremity function in asymptomatic individuals with prolonged standing hours. Int J Nat Med Health Sci. 2022;1(4). https://doi.org/10.52461/ijnms.v1i4.1040
5. Shariff AH, George J, Ramlan AA. Musculoskeletal injuries among Malaysian badminton players. Singapore Med J. 2009;50(11):1095-1097.
6. Birch K, McLaren D, George K. BIOS Instant notes in sport and exercise physiology. London: Routledge; 2005.
7. Battinelli T. Physique, fitness and performance. 2nd ed. Boca Raton: CRC Press; 2007.

8. Cai P, Liu L, Li H. Dynamic and static stretching on hamstring flexibility and stiffness: a systematic review and meta-analysis. Heliyon. 2023;9(8):e18795. https://doi.org/10.1016/j.heliyon.2023.e18795
9. Yuichi N, Junya A, Naohiko K, Tetsuya T, Naohisa H, Hirofumi M, et al. Immediate effect of passive and active stretching on hamstring flexibility: a single-blinded randomized control trial. J Phys Ther Sci. 2015;27:3167-3170. https://doi.org/10.1589/jpts.27.3167
10. Knudson DV. The biomechanics of stretching. JESP. 2006;2:3-12.
11. Choi JM, Cho EY, Lee BH. Effects of dynamic stretching combined with manual therapy on pain, ROM, function and quality of life of adhesive capsulitis. Healthcare. 2023;12(1):45. https://doi.org/10.3390/healthcare12010045
12. Costa PB, Herda TJ, Herda AA, Cramer JT. Effects of dynamic stretching on strength, muscle imbalance and muscle activation. Med Sci Sports Exerc. 2014;46(3):586-593. https://doi.org/10.1249/MSS.0000000000000138
13. O'Sullivan K, Murray E, Sainsbury D. The effect of warm-up, static stretching and dynamic stretching on hamstring flexibility in previously injured subjects. BMC Musculoskelet Disord. 2009;1-9. https://doi.org/10.1186/1471-2474-10-37
14. Hopper D, Conneely M, Chromiak F, Canini E, Berggren J, Briffa K. Evaluation of the effect of two massage techniques on hamstring muscle length in competitive female hockey players. Phys Ther Sport. 2005;1;6(3):137-145. https://doi.org/10.1016/j.ptsp.2005.04.003
15. Silveira G, Sayers M, Waddington, G. Effect of dynamic versus static stretching in the warm-up on hamstring flexibility. Sport J. 2011;14.
16. Nelson RT, Bandy WD. Eccentric training and static stretching improve hamstring flexibility of high school males. J Athl Train. 2004;39(3):254-258.
17. Ahmed H, Iqbal A, Anwer S, Alghadir A. Effect of modified hold-relax stretching and static stretching on hamstring muscle flexibility. J Phys Ther Sci. 2015;27(2):535-538. https://doi.org/10.1589/jpts.27.535
18. Arazi H, Asadi A, Hoseini K. Comparison of two different warm-ups (static-stretching and massage): effects on flexibility and explosive power. Acta Kinesiologica. 2012;1:55-59.
19. Page P. Current concepts in muscle stretching for exercise and rehabilitation. Int J Sports Phys Ther. 2012;7(1): 109-119.
20. DePino GM, Webright WG, Arnold BL. Duration of maintained hamstring flexibility after cessation of an acute static stretching protocol. J Athl Train. 2000;35(10): 56-59.
21. Amiri-Khorasani M, Osman NA, Yusof A. Acute effect of static and dynamic stretching on hip dynamic range of motion during instep kicking in professional soccer players. J Strength Cond Res. 2011;25(6):1647-1652.
22. Gunaydin G, Citaker SE, Cobanoglu GA. Effects of different stretching exercises on hamstring flexibility and performance in long term. Sci Sports. 2020; 1;35(6):386-392. https://doi.org/10.1016/j.scispo.2020.04.009