IJMSR

Original Article

Comparison of Flexibility in University Students Before and After the Application of Isometric Contractions for Different Functional Lines

Amanda Soares Lacerda [1], Loys Lene Sinthia Gomes Lacerda [1], Hellen Chystina Silva Duarte [1], Missany Shigueta Coelho [1], William Alves Lima [1] *

[1] Universidade Evangélica de Goiás - UniEVANGÉLICA
* Correspondence: williamfef@hotmail.com

Abstract

Objective: To investigate the acute effects of an adapted Muscle Energy Technique protocol on flexibility in university students, considering different functional lines and shoulder mobility. **Methods:** This study included 32 university students of both sexes, all aged between 19 and 28 years and regularly engaged in resistance training for at least six months. Participants were allocated into an experimental group (n = 20) and a control group (n = 12). Flexibility was assessed before and after the intervention using the bilateral sit-and-reach test, unilateral sit-and-reach test for the right and left lower limbs, trunk extension test, and right and left shoulder mobility tests. The experimental group performed an acute adapted MET protocol consisting of voluntary isometric contractions directed toward different functional lines, repeated over approximately 10 minutes. The control group remained at rest for the same duration. Data were analyzed using descriptive statistics, the Shapiro–Wilk normality test, Wilcoxon test for within-group comparisons, and Mann–Whitney U test for between-group comparisons, adopting a significance level of $p \leq 0.05$. **Results:** At baseline, no significant differences were observed between groups for most anthropometric characteristics and flexibility tests, except for right shoulder mobility. After the intervention, the experimental group showed significant improvements in all flexibility outcomes. The bilateral sit-and-reach test increased from 22.03 ± 8.78 cm to 28.15 ± 8.14 cm, corresponding to a mean gain of 6.13 cm ($p = 0.01$). Improvements were also observed in the unilateral sit-and-reach test for the right limb (+4.60 cm; $p = 0.01$) and left limb (+2.73 cm; $p = 0.01$), as well as in trunk extension (+3.40 cm; $p = 0.01$). Shoulder mobility also improved bilaterally, as indicated by reduced distances between the hands in the right shoulder mobility test (-4.55 cm; $p = 0.01$) and left shoulder mobility test (-4.45 cm; $p = 0.01$). The control group did not show significant changes in any measured variable. In addition, training experience did not significantly influence the magnitude of flexibility gains. **Conclusion:** An acute adapted MET protocol based on voluntary isometric contractions improved flexibility across different functional lines and enhanced shoulder mobility in university students engaged in resistance training. These findings suggest that this strategy may be a practical and time-efficient option to acutely improve flexibility before exercise sessions or activities requiring greater range of motion.

Keywords: Stretching; Flexibility; Isometric Contractions; Muscle Energy Technique; Functional Lines.

---

1. Introduction

Individuals who do not regularly perform stretching exercises or movements requiring large joint ranges of motion tend to present greater limitations in flexibility. These limitations may be associated with reduced angular flexibility, decreased joint mobility, lower muscle elasticity, and the accumulation of myofascial tension [1–4].

Flexibility is considered an important component of physical fitness, as it contributes not only to better performance in daily and occupational activities, but also to athletic performance, allowing movements to be performed with greater efficiency, power, and lower accumulation of musculoskeletal tension [2]. Therefore, maintaining adequate flexibility may be relevant for both health-related and performance-related outcomes.

However, stretching does not occur in an isolated muscle. Instead, movement and tension are distributed along interconnected myofascial chains. Thus, when a specific region is stretched or contracted, mechanical tension may be transmitted throughout a functional chain [4]. This concept supports the idea of functional lines, among which the superficial anterior line and the superficial posterior line are among the most commonly described and investigated [3,4].

Flexibility training may be performed using different strategies, depending on the objective, technical ability, and training level of the individual. Stretching may be active, when performed without external assistance, or passive, when external tension is imposed. It may also be performed using static or dynamic methods [2], as well as through isometric contractions [5]. The use of sustained isometric contractions, performed through voluntary activation of the target segment without external overload, has been described by some authors as a form of Muscle Energy Technique (MET) [5,6].

MET was originally developed by Fred Mitchell in 1948 and is commonly described as a therapeutic procedure designed to improve musculoskeletal function through joint mobilization and the release of myofascial tension. In addition, it has been used with the purpose of reducing pain and improving circulation and lymphatic flow [7,8].

Traditionally, MET is applied by positioning the individual against a physical barrier and asking them to perform a controlled muscle contraction against resistance. For this reason, the technique is considered a form of proprioceptive neuromuscular facilitation and is widely used by physiotherapists [8]. However, an important question remains: could an adapted form of MET, performed without external counter-resistance and based only on voluntary isometric contraction, produce similar acute gains in flexibility? From a theoretical perspective, this approach could still promote changes in circulation, lymphatic flow, neuromuscular inhibition, and myofascial tension, which may contribute to increased range of motion.

Therefore, the objective of the present study was to investigate the acute effects of an adapted Muscle Energy Technique protocol on flexibility in university students, considering different functional lines..

2. Methods

2.1 Study Design

This was a controlled, pre–post intervention study designed to investigate the acute effects of an adapted Muscle Energy Technique (MET) protocol on flexibility in university students. Participants were allocated into either an experimental group, which performed the adapted MET protocol, or a control group, which remained at rest for the same period. All assessments were conducted before and immediately after the intervention or rest period.

2.2 Participants

A convenience sample of 32 volunteers of both sexes was recruited. Of these, 20 participants were allocated to the experimental group and 12 to the control group. Participants were university students enrolled in the Physical Education program at the Evangelical University of Goiás (UniEVANGÉLICA), Brazil. All volunteers were between 19 and 28 years of age. Participants were approached on the university campus and invited to participate in the study. Data collection was performed between 6:30 p.m. and 7:00 p.m., corresponding to the period when students were arriving on campus for academic activities.

2.3 Anthropometric Assessment

Initially, participants provided basic information for sample characterization. Body mass was measured using a mechanical scale (Welmy®, Brazil), and height was measured using a wall-mounted stadiometer (WCS®, Brazil). Sitting height was assessed using the same stadiometer and a rigid 40-cm chair.

Upper-limb length was measured from the lateral acromial border to the distal end of the middle finger using a metallic anthropometric tape (Cescorf®, Brazil). Abdominal circumference was measured at the level of the umbilical scar using the same anthropometric tape. All measurements were recorded in centimeters, except for body mass, which was recorded in kilograms.

2.4 Flexibility and Mobility Assessments

Flexibility was assessed using tests directed toward different functional lines. The first test applied was the bilateral sit-and-reach test using the Wells and Dillon bench, following the Canadian Standardized Test of Fitness procedures [9,10]. The same test was also performed unilaterally for the right and left lower limbs [11].

Anterior-chain flexibility was assessed using the trunk hyperextension test without hand support [12]. In this test, participants were positioned in the prone position and instructed to elevate the trunk by performing spinal hyperextension without using the hands. The evaluator measured the vertical distance from the chin to the floor. Higher values were interpreted as greater anterior-chain flexibility and/or thoracic extension mobility. Although trunk extensor strength may influence performance in this test, the pre–post design allowed the assessment of acute changes after the intervention.

Shoulder mobility was assessed using the shoulder mobility test [12]. Participants stood with their back facing the evaluator, closed both fists with the thumbs inside the fingers, and attempted to bring both hands as close together as possible behind the back. One arm was positioned over the shoulder and behind the head, while the opposite arm was positioned from below. The distance between the closed fists was measured using a ruler. When the right arm was positioned above the shoulder, the test was classified as right shoulder mobility; when the left arm was positioned above the shoulder, it was classified as left shoulder mobility. Lower values indicated better shoulder mobility.

2.5 Intervention Protocol

Immediately after the baseline flexibility assessments, the experimental group performed the adapted MET protocol. The protocol consisted of voluntary isometric contractions performed in different body positions and planes of movement, without the use of external manual resistance.

First, participants stood in an upright position with the feet hip-width apart and were instructed to generate force as if attempting to bring the legs together in the frontal plane. This contraction was maintained for 30 seconds. Next, participants assumed a staggered stance, with one foot positioned approximately 30 cm in front of the other. In this position, they were instructed to generate force as if attempting to bring the legs together in the sagittal plane. The contraction was maintained for 30 seconds, and the procedure was then repeated with the opposite leg positioned in front. The third exercise consisted of a prone plank maintained for 30 seconds. Finally, participants performed isometric contractions involving the upper limbs. For this procedure, the arms were abducted to 90° in the frontal plane. Participants were instructed to contract as if attempting to adduct the shoulders for 10 seconds, without producing visible movement. They then performed contractions as if attempting to further abduct the shoulders, followed by contractions simulating shoulder flexion in the transverse plane and shoulder extension in the transverse plane. Each contraction was maintained for 10 seconds, totaling 40 seconds for the upper-limb sequence.

The full sequence was repeated three times and lasted approximately 10 minutes. Immediately after completing the protocol, all flexibility and mobility tests were repeated using the same procedures adopted at baseline.

2.6 Control Condition

Participants in the control group remained seated or at rest for approximately 10 minutes after the baseline assessments. No stretching, isometric contraction, or mobility exercise was performed during this period. Immediately afterward, the same flexibility and mobility tests were repeated following the baseline procedures.

2.7 Statistical Analysis

Data were entered into a spreadsheet and analyzed using the Statistical Package for the Social Sciences (SPSS), version 21.0 for Windows. Descriptive statistics were used to characterize the sample, with data presented as mean and standard deviation. The Shapiro–Wilk test was applied to assess the normality of data distribution. As some variables did not present normal distribution, including unilateral sit-and-reach outcomes, non-parametric tests were adopted. The Wilcoxon signed-rank test was used to compare pre- and post-intervention values within each group. The Mann–Whitney U test was used to compare the experimental and control groups. The level of statistical significance was set at 5% ($p \leq 0.05$).

3. Results

3.1 Sample Characteristics

The sample consisted of 32 university students, including 24 women and 8 men. All participants had been engaged in resistance training for more than six months. Regarding self-reported training intensity, 30% of the participants reported training at low intensity, 55% at moderate intensity, and 15% at high intensity. In relation to weekly training frequency, 10% reported training three times per week, whereas the remaining participants reported training four or more times per week.

Table 1. Comparison of the descriptive characteristics of the sample.

Variables	Experimental (n = 20)		Control (n = 12)		p
	Mean	SD	Mean	SD	
Age	23.15	2.66	24.53	2.98	0.31
Body mass	67.83	15.56	69.12	8.85	0.11
Height	1.63	0.07	1.66	0.04	0.09
Body mass index	25.76	6.10	24.22	2.20	0.14
Sitting height	94.70	4.47	95.20	2.83	0.23
Upper-limb length	78.30	4.04	79.90	2.67	0.41
Abdominal circumference	80.40	10.13	80.70	8.14	0.64

Legend: Data are presented as mean and standard deviation (SD). The p-values refer to between-group comparisons at baseline. No statistically significant differences were observed between the experimental and control groups for any descriptive characteristic analyzed. n = sample size; SD = standard deviation; p = probability value.

3.2 Anthropometric Characteristics

The descriptive characteristics of the experimental and control groups are presented in Table 1. In the experimental group, mean body mass was approximately 67 kg, although considerable variability was observed among participants. Mean height was 1.63 m, which may be partially explained by the predominance of women in the sample. Mean body mass index was above 25 kg/m², indicating an average classification compatible with overweight. However, this result should be interpreted with caution, as the presence of one participant with elevated body mass may have influenced the group mean.

Mean sitting height was approximately 94 cm, which is consistent with expected values for young adults. Upper-limb length also showed relevant variability among participants, with differences of up to approximately 15 cm. Mean abdominal circumference was approximately 80 cm; however, as with body mass and body mass index, this variable should be interpreted cautiously due to the influence of individual variability within the sample.

3.3 Comparison Between Experimental and Control Groups at Baseline

No statistically significant differences were observed between the experimental and control groups for the anthropometric variables assessed, including age, body mass, height, body mass index, sitting height, upper-limb length, and abdominal circumference. This indicates that the groups were generally comparable at baseline. This baseline similarity is important because it suggests that neither group had a clear anthropometric advantage or disadvantage that could substantially influence flexibility performance before the intervention. Therefore, subsequent differences observed after the protocol are less likely to be explained by initial differences in body size or anthropometric profile.

In Table 2, according to the CSTF classification [10], both groups were initially classified as having "poor" flexibility based on the internationally established reference values for the bilateral sit-and-reach test: <23 cm for men and <27 cm for women. Although the control group presented slightly higher mean flexibility values at baseline, it was also classified as having poor flexibility.

Table 2. Pre-intervention comparison between the experimental and control groups.

Variables (all measurements in cm)	Mean	SD	p
Bilateral sit-and-reach — experimental	22.03	8.78	0.05
Bilateral sit-and-reach — control	25.22	3.37	
Unilateral right sit-and-reach — experimental	26.95	9.57	0.23
Unilateral right sit-and-reach — control	27.11	3.98	
Unilateral left sit-and-reach — experimental	27.25	8.48	0.88
Unilateral left sit-and-reach — control	27.02	4.06	
Trunk extension — experimental	27.85	6.92	0.14
Trunk extension — control	29.03	3.87	
Right shoulder mobility — experimental	23.20	7.37	0.04
Right shoulder mobility — control	20.04	5.40	
Left shoulder mobility — experimental	23.10	8.27	0.09
Left shoulder mobility — control	22.36	5.90	

Note: SD = standard deviation; p = probability value. All measurements are expressed in centimeters. p-values refer to pre-intervention comparisons between the experimental and control groups.

No significant differences were observed between groups for the unilateral sit-and-reach tests or for the trunk extension test. However, for right shoulder mobility, the control group initially presented better flexibility than the experimental group. In contrast, no significant difference was observed between groups for left shoulder mobility. It is also worth noting that the experimental group consistently showed higher standard deviation values, indicating slightly greater heterogeneity compared with the control group.

In Table 3, the experimental group showed a mean increase of 6.13 cm in the bilateral sit-and-reach test from pre- to post-intervention. However, when compared with the bilateral test, participants presented higher flexibility values in the unilateral sit-and-reach test, both for the right and left sides, at pre- and post-intervention. When comparing both sides in the unilateral sit-and-reach test, the gains were more pronounced on the right side. This finding may be related to limb dominance, as all participants were right-handed.

Table 3. Comparison of flexibility performance before and after the intervention.

Variables (all measurements in cm)	Mean	SD	Δ	p
Bilateral sit-and-reach — pre-intervention	22.03	8.78	6.13	0.01
Bilateral sit-and-reach — post-intervention	28.15	8.14		
Unilateral right sit-and-reach — pre-intervention	26.95	9.57	4.60	0.01
Unilateral right sit-and-reach — post-intervention	31.55	8.31		
Unilateral left sit-and-reach — pre-intervention	27.25	8.48	2.73	0.01
Unilateral left sit-and-reach — post-intervention	29.98	8.87		
Trunk extension — pre-intervention	27.85	6.92	3.40	0.01
Trunk extension — post-intervention	31.25	6.22		
Right shoulder mobility — pre-intervention	23.20	7.37	-4.55	0.01
Right shoulder mobility — post-intervention	18.65	7.35		
Left shoulder mobility — pre-intervention	23.10	8.27	-4.45	0.01
Left shoulder mobility — post-intervention	18.65	7.44		

Note: SD = standard deviation; Δ = mean change from pre- to post-intervention; p = probability value. All measurements are expressed in centimeters. For shoulder mobility, negative Δ values indicate improvement, as lower values represent a shorter distance between the hands.

For trunk extension, a significant difference was observed, with a mean increase of 3.40 cm. This finding may indicate both an improvement in anterior-chain flexibility and an increase in thoracic mobility during hyperextension. Regarding shoulder mobility, lower measured values indicate that the hands were closer to each other behind the back, therefore representing greater mobility. On average, the improvements were highly representative, with gains of approximately 4.5 cm, and these changes were statistically significant compared with the pre-intervention values. The control group did not show significant improvements in any of the measured variables compared with baseline. For this reason, these data were not presented in table or graph format. For the analysis presented in Table 4, the experimental group was divided into two subgroups according to training experience: participants who had been training for more than one year, with a mean training experience of 2.1 years (n = 10), and participants who had been training for less than one year, with a mean training experience of 0.5 years (n = 10). The post-intervention results were then compared between these two subgroups.

Table 4. Comparison of intervention-related gains according to training experience.

Variables (measurements in cm)	Training Experience	Mean	SD	p
Bilateral sit-and-reach	More than 1 year	6.15	4.44	0.97
	Less than 1 year	6.10	1.29	
Unilateral right sit-and-reach	More than 1 year	4.20	2.44	0.62
	Less than 1 year	5.00	4.52	
Unilateral left sit-and-reach	More than 1 year	3.25	2.51	0.33
	Less than 1 year	2.20	2.57	
Trunk extension	More than 1 year	3.80	2.25	0.37
	Less than 1 year	3.00	1.63	
Right shoulder mobility	More than 1 year	-4.80	2.39	0.64
	Less than 1 year	-4.30	2.31	
Left shoulder mobility	More than 1 year	-5.10	2.77	0.31
	Less than 1 year	-3.80	2.74	

Note: SD = standard deviation; p = probability value. All measurements are expressed in centimeters. Negative values for shoulder mobility indicate improvement, as lower values represent a shorter distance between the hands.

Table 4 shows that training experience did not produce significant differences in the flexibility improvements observed after the MET protocol. Both subgroups benefited similarly from the technique, suggesting that the adapted MET protocol was safe and effective for promoting acute improvements in flexibility, regardless of previous resistance training experience.

4. Discussion

Flexibility levels in the Brazilian adult population have long been below those considered adequate for health and functional performance, particularly among university students, including those enrolled in Physical Education programs [13,14]. This is a concerning scenario, as flexibility is directly related to joint mobility, movement efficiency, musculoskeletal function, and the ability to perform daily, occupational, and sports-related tasks. The findings of the present study are consistent with this context, since both groups were initially classified as having poor flexibility according to the sit-and-reach test reference values. Therefore, these results reinforce the importance of investigating practical, low-cost, and time-efficient strategies capable of promoting acute improvements in flexibility, especially in individuals who are about to engage in sports or exercise sessions involving large ranges of motion and moderate-to-high intensity demands.

In this context, Muscle Energy Technique (MET) may represent a useful alternative for acutely improving flexibility, as observed in the present study. Previous evidence suggests that MET may also promote chronic benefits, not only by increasing flexibility, but also by reducing joint pain and improving the individual's tolerance and readiness to perform movements requiring greater amplitudes or higher training intensities [15,16]. Thus, the positive acute responses observed in the present investigation support the potential applicability of adapted MET protocols in exercise and rehabilitation settings.

Several studies have also reported significant acute flexibility gains following self-myofascial release techniques using rigid balls or foam rollers, as well as after dynamic stretching or combined flexibility strategies [17–20]. In general, the increase in sit-and-reach performance reported in these studies ranges from approximately 3 to 4 cm. In the present study, however, the experimental group showed a mean improvement of 6.13 cm in the bilateral sit-and-reach test, which appears to be higher than the gains commonly reported in the literature. This finding suggests that the adapted MET protocol may be particularly effective for promoting acute improvements in posterior-chain flexibility. Nevertheless, future studies should directly compare MET with other flexibility strategies, including static stretching, dynamic stretching, proprioceptive neuromuscular facilitation, and self-myofascial release, in order to determine which technique is more effective under specific exercise, sports, or functional conditions.

The acute improvements observed across the different functional lines may be explained by neuromuscular and mechanical mechanisms. One possible explanation is the reduction in discomfort or pain perception during muscle stretching, which may occur after isometric contractions due to changes in nociceptor sensitivity and stretch tolerance. In addition, the relaxation phase following isometric contraction may reduce muscle spindle activity and favor autogenic and reciprocal inhibitory responses, thereby allowing greater range of motion [21]. Another possible mechanism is related to transient changes in blood flow and muscle tissue behavior induced by sustained isometric tension. These responses may affect the contractile and viscoelastic properties of muscle and connective tissue, increasing tissue extensibility and improving flexibility performance [22]. Taken together, these mechanisms help explain the effectiveness of the adapted MET protocol for producing acute flexibility gains in the present study.

From a practical perspective, these findings suggest that adapted MET may be incorporated as part of a warm-up routine before dynamic or static stretching exercises. Because the technique is based on controlled voluntary isometric contractions and does not require complex equipment, it may be easily applied in academic, recreational, sports, or clinical contexts. In addition, the use of MET before stretching may reduce discomfort, improve tolerance to larger ranges of motion, and potentially increase adherence to flexibility training. Therefore, this strategy may be especially useful for individuals seeking acute improvements in flexibility for sports performance, recreational exercise, functional movement, or activities of daily living.

5. Conclusions

The present study demonstrated that an acute adapted MET protocol, based on voluntary isometric contractions and performed without external manual resistance, significantly improved flexibility and mobility in university students engaged in resistance training. Significant gains were observed in bilateral and unilateral sit-and-reach performance, trunk extension, and shoulder mobility, whereas the control group did not show relevant changes after the same period of rest.

These findings suggest that the adapted MET protocol may be a practical, low-cost, and time-efficient strategy to acutely increase range of motion across different functional lines. In addition, the magnitude of improvement was not influenced by previous resistance training experience, indicating that both less experienced and more experienced participants benefited similarly from the intervention.

Therefore, adapted MET may be considered a useful option to be incorporated into warm-up routines or flexibility-oriented sessions, particularly before exercise or functional activities requiring greater joint mobility. However, future studies with larger samples, randomized allocation, longer follow-up periods, and comparisons with other flexibility methods are needed to confirm these findings and determine whether the observed acute improvements can be maintained or enhanced over time.

Author Contributions: Conceptualization, A.S.L. and W.A.L.; methodology, A.S.L., L.L.S.G.L., H.C.S.D., M.S.C. and W.A.L.; software, W.A.L.; validation, A.S.L., L.L.S.G.L., H.C.S.D., M.S.C. and W.A.L.; formal analysis, W.A.L.; investigation, A.S.L., L.L.S.G.L., H.C.S.D. and M.S.C.; resources, W.A.L.; data curation, A.S.L., L.L.S.G.L., H.C.S.D., M.S.C. and W.A.L.; writing—original draft preparation, A.S.L., L.L.S.G.L., H.C.S.D. and M.S.C.; writing—review and editing, W.A.L.; visualization, A.S.L. and W.A.L.; supervision, W.A.L.; project administration, W.A.L.; funding acquisition, not applicable. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Universidade Evangélica de Goiás.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.
Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Almeida, T. T.; Jabur, N. M.; Mitos e verdades sobre flexibilidade: reflexões sobre o treinamento de flexibilidade na saúde dos seres humanos. Motricidade 3(1): 337-344, 2007.
2. Badaro, A. F. V.; Da Silva, A. H.; Beche, D. Flexibilidade versus alongamento: esclarecendo as diferenças. Saúde (Santa Maria), [S. l.], v. 33, n. 1, p. 32–36, 2007.
3. Schleip R, Müller DG. Training principles for fascial connective tissues: scientific foundation and suggested practical applications. J Bodyw Mov Ther 2013;17:103-15.
4. Myers TW. Anatomy trains. Myofascial meridians for manual and movement therapists. São Paulo: Elsevier; 2014.
5. BRITO CN, TRINDADE K. Efeitos de duas técnicas de alongamentos no ganho de flexibilidade de cadeia posterior em mulheres sedentárias. Fisioterapia Brasil, 21(1): 3-7, 2020.
6. Brosseau L, Balmer S, Tousignant M, O'Sullivan JP, Goudreault C, Goudreault M, Gringras S. Intra- and intertester reliability and criterion validity of the parallelogram and universal goniometers for measuring maximum active knee flexion and extension of patients with knee restrictions. Arch Phys Med Rehabil. 82(3): 396-402, 2001.

7. Goodridge JP. Muscle energy technique: definition, explanation, methods of procedure. J Am Osteopath Assoc. Dec; 81(4): 249-54, 1981.
8. Thomas E, Cavallaro AR, Mani D, Bianco A, Palma A. The efficacy of muscle energy techniques in symptomatic and asymptomatic subjects: a systematic review. Chiropr Man Therap. 27: 35, 2019.
9. WELLS, K. F., & DILLON, K. E. The sit and reach - a test of back and leg flexibility.Res Q Exerc Sport, 23(115), 8, 1952.
10. Canadian Standardized Test of Fitness (CSTF) Operations manual, 3rd edn, Fitness and Amateur Sport, Ottawa: Minister of State; 1986.
11. Grabow L, Young JD, Byrne JM, Granacher U, Behm DG. Unilateral Rolling of the Foot did not Affect Non-Local Range of Motion or Balance. J Sports Sci Med. 1;16(2): 209-218, 2017.
12. California Physical Fitness Test. Reference Guide. Department of Education State of California, United States. 2012/13.
13. Silva, L. R., da Silva, F. S., Monteiro, E. R., Neto, V. G. C., & da Silva Triani, F. Comparação entre o efeito agudo do turskish get-up e do alongamento estático sobre o desempenho do teste de sentar e alcançar. RBPFEX-Revista Brasileira de Prescrição e Fisiologia do Exercício, 13(83), 507-513, 2019.
14. Silva, A., Neto, D. D. B. M., da Silva Santos, J. V. L., & da Silva, W. D. B. Análise comparativa de encurtamento dos músculos isquiotibiais em praticantes e não praticantes de musculação. RBPFEX-Revista Brasileira de Prescrição e Fisiologia do Exercício, 14(93), 767-773, 2020.
15. Fátima Hoffmann, C. Uso da técnica de energia muscular em mulheres com cervicalgia. Fisioterapia Brasil, 12(4), 255-260, 2011.
16. Singha, P., Kumar, P., & Chahal, A. Efeito do fortalecimento dos rotadores internos do ombro versus técnica de energia muscular para rotadores externos do ombro na velocidade de boliche entre jogadores rápidos que jogam críquete: um protocolo de estudo. Rev. Pesqui. Fisioter, 561-568, 2021.
17. GODWIN, Mark et al. An acute bout of self-myofascial release does not affect drop jump performance despite an increase in ankle range of motion. Sports, Basel, 8, 37, 2020.
18. YILDIZ, Mehmet. An acute bout of self-myofascial release increases flexibility without a concomitant deficit in muscle performance in football players. Int. J. Physiother, [s. l.], 5(3), 92-97, 2018.
19. BENJAMIN, Mike. The fascia of the limbs and back – a review. J. Anat., London, 214, 1-18, 2009.
20. Sperandio, R. D., Júnior, B. S. S., & Bueno, P. M. Comparação da flexibilidade em atletas do gênero masculino praticantes de futebol, utilizando alongamentos dinâmicos e estáticos. Revista Multidisciplinar da Saúde, 2(4), 37-46, 2020.
21. Brasileiro, J., Faria, A. e Queiroz, L. Influencia do resfriamento e do aquecimento local na flexibilidade dos músculos isquiotibiais. Revista Brasileira de Fisioterapia. 11(1): 57-61, 2007.
22. Harvey, L., Herbert, R. e Crosbie, J. Does stretching induce lasting increases in joint ROM? A systematic review. Physiotherapy Research international. 7(1): 1-13, 2002.