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ARTIGO ORIGINAL

Analysis of durability of hamstring stretching effect in two forms of intervention

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ABSTRACT

One of the biggest causes of movement dysfunction is the lack of muscle flexibility, what can interfere in the individual's functionality. Flexibility can be altered through stretching but the training effects are, in general, transitory – durable increases results of adaptative remodeling and not only for mechanical deformation. OBJECTIVE: To analyze the durability of the effects of a stretching training program of the hamstrings and verify if it has difference when associated with an electric treadmill (deep warming) before. METHODS: Thirteen women and seven men between 18 and 39 years, divided into two groups: stretching (A) and treadmill and stretching (EA), was submitted to a six weeks, five times/week, of active static stretching of the hamstrings with four series of 30s and electric treadmill, only at EA, before the stretching. Measurement of the popliteal angle was made through goniometry in the pre and post training for one month. RESULTS: The groups obtained significant gains (p=0.000), but no have significant difference between them. The decreased of the gains in both groups occurred in the first day post training, returning to the initial measurement in 72 hours. DISCUSSION: The finds suggest that the benefits of the long-term training exists, however when interrupted they stop, and it was impossible to affirm if they occurred because an adaptative remodeling or mechanical deformation. CONCLUSIONS: The obtained gain was transitory, but it is necessary to consider that wasn't functional demand for it remained.

KEY-WORDS

stretching, flexibility, training, durability

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Introduction

Alterations in muscle length and extensibility are the main causes of movement dysfunctions[1]. Physical therapists frequently evaluate their patients' tissue flexibility, by measuring the range of movement (ROM), and use stretching techniques to restore normal mobility, as mobility deficits can occur as the result of different types of pathology[2-4].

Stretching techniques can be used as a means of ROM recovery[5-8], enabling the re-establishment of normal mobility and improving total function5. There are several types of stretching techniques, and among them, the static stretching[5]. This is a technique of isometric tension applied slowly to a muscle at its highest extension and maintained in such position for a period of time[9,10]. Defenders of this technique report that the stretching reflexes are minimized by the slow movement and absence of pain, and so, recommend it as it is easy to perform and carry low risk of injury[4,5,11].

In some clinical practices, the stretching techniques are associated to heat in an attempt to obtain a greater gain of flexibility. It is expected that the heat will increase blood supply and the oxygen release from myoglobin and hemoglobin to the muscles[4]. These changes prepare the body for the physical activities, by accelerating the metabolism of muscle fibers and decreasing the intra-muscular resistance, thus increasing the variety of movement and the mechanical efficiency[4]. There are several types of heat that can be utilized, such as moist hot packs, paraffin, ultrasound, whirlpools, and short wave diathermy[7,12], as well as aerobic exercises[4,12,13].

The analysis of the muscle behavior at different lengths must take into account its structure, considering its elastic and viscous properties[6,12,14]. Elasticity is defined as a property of the tissue to tolerate a deformation by an external force and return to its initial form and volume after the force has ceased to act upon it[5,14]. The viscous property is characterized as being time-dependent and rate of change-dependent, where the deformation is directly proportional to the applied force, i.e., the greater the force applied, the bigger the muscle deformation[5,12].

Most biological tissues work with both the viscous and the elastic properties, and are, therefore, considered viscoelastic models[5]. At the analysis of the muscle behavior, a mechanic model related to the elastic elements of the muscle can be observed, which has three interconnected components: the contractile element, the series elastic element and parallel elastic element[2,12,14].

Deyne affirms that the biomechanical models cannot wholly explain a constant increase in the motor variation; such changes can only be applied if the muscle added new sarcomeres in series, becoming larger. When kept for several days, a stretching would cause an accommodation of the size of the sarcomeres and would stimulate the addition of new sarcomeres[3]. According to Herbert, a large part of viscous deformations is responsible for the immediate increase in muscle length and it is lost with time[1].

Among the few studies found in literature, there was no consensus regarding the durability of the stretching effect, with the permanence of the effect varying from 1 hour to 4 weeks after the end of the training. Therefore, it would seem that the increase in muscular flexibility seen immediately after stretching is mostly, if not all, a transient phenomenon that has a necessary therapeutic value for short periods of time, such as physical activities[1]. As for the durable increases in muscular length, they will be the result of an adaptive remodeling and not simply caused by viscoelastic deformation[1,4]. This adaptive remodeling would result from the existence of a functional demand.

Physical therapists often need to effectuate the durable increases in muscular length in order to achieve the objectives intended for their patients[1]. Thus, the importance of the knowledge on the durability of the flexibility increase obtained through a training based on long-term stretching techniques is demonstrated.

The objective of this study was to analyze the durability of flexibility gains after six weeks of stretching techniques applied alone or in association with muscular warming-up, provided by the physical activity on a treadmill before the stretching and to observe which of the two techniques was more effective in maintaining this flexibility and for how long.

Methods

Patients

The following inclusion criteria were used in this study: to be considered sedentary or insufficiently active for at least six months prior to the study (classification was achieved through the International Physical Activity Questionnaire (IPAQ)[15] translated and validated into the Portuguese language, which the participants were asked to answer) and agree to not participate in any physical exercise program during the training, present the popliteal angle $\leq 150^o$, be 18 to 39 years of age, and sign the free informed consent form. Those individuals who presented joint hypermobility, evaluated through the criteria of Carter and Wilkinson for generalized joint laxity (hypermobility)[16]; incapacity to perform the necessary movements at the test; diabetes; difficulty of understanding; decompensated cardiopathy; recent trauma and/or surgical intervention in the lower limbs (LLLL) ; were undergoing physical therapy treatment; presented congenital or pathological alterations of the LLLL and/or did not meet the inclusion criteria, were excluded.

Study design

This quasi-experimental study had an initial convenience sample of 33 subjects. The volunteers, both male and female, were divided into two groups: static stretching (S-13 women and 3 men) and treadmill plus static stretching (TS-7 women and 10 men). According to the literature, there seems to be no alterations between men and women regarding stretching gain[17] and within the age range of 18-39 years, there seems to be no physiological alterations that could change the performance of the subjects[18]. Both LLLL were used for the study.

The sample had signed an informed consent form before any measurements were performed. The consent form was handed together with the IPAQ15, to evaluate the level of physical activity of the volunteers.

The measurement of the popliteal angle was performed before and after the training protocol and at the end of the training, the analysis of the maintenance of flexibility gains.

Material and equipment

Goniometer: A universal goniometer with two 20-cm arms and a fulcrum with a 2-degree measurement precision was used to determine the shortening of hamstrings. It is a joint angle measurement equipment of which validity and reliability has been described in literature and is frequently used by physical therapists[14].

Support rail for positioning the LLLL: To measure the popliteal angle, a support was used to define and standardize the correct positioning of the LLLL (90º of hip flexion) in relation to the evaluation table. This rail has two PVC parallel arms, with a perpendicular arm in relation to them (Fig. 1a).

Treadmill: To promote deep warming-up of the musculature, through aerobic exercise, the YOZDA MODEL 9500 PLUS electric treadmill was used.

PROCEDURES

Initial Evaluation

An individual interview was carried out to collect demographic and physical assessment data. The evaluation of the popliteal angle was performed through anatomical reference marks (trochanter major, lateral femoral epicondyle and lateral malleolus). To assure the reliability in the alignment between the references in relation to goniometer arms, a dermographic pen was used to make straight lines in the proximal and distal limbs of the assessed joint. For the measurement, the hip was positioned and maintained at 90º of flexion with the help of the rail (Fig. 1b). The measurements of the popliteal angle were obtained by three investigators who were divided among the following tasks: depiction of the anatomical references, passive elevation of the leg until the tactile perception of the muscular tension to knee extension could be felt and goniometer analysis. These measurements were performed at the same time of day before and after the intervention at all measurements.

Group randomization

The first evaluated individual drew lots for the training group to which he or she would belong, and the remaining individuals were distributed between the groups until the sample was finished. There was no randomization by gender. Both groups started the training protocol simultaneously.

Training protocol

All the participants wore appropriate clothes that did not prevent the adequate hip flexion movement and allowed the visualization

Figure 1a
Support rail for correct positioning of the LLLL for test procedures. - Support rail coupled to the stretcher.

Figure 1a
Support rail for correct positioning of the LLLL for test procedures. - Individual being evaluated with goniometer.

of the knee joint.

A warm-up period of 10 minutes on a horizontal treadmill was determined, which is described in literature as being sufficient[19] for the participants of group TS. The individuals were asked to walk at a self-selected velocity.

Regarding the static stretching, four series of 30s were performed for each limb, with a 10-second interval between the series. The individual was kept in dorsal decubitus on a stretcher, with the limb to be stretched in knee extension and hip flexion without rotation supported by a strip and the other in semi-flexion of the knee and hip with the foot resting on the stretcher.

The participants followed the training protocol for six weeks, 5 times per week. When the training was missed, an extra day of stretching was added. The individual was excluded from the study after missing three consecutive training days.

Evaluation of Durability

After the six-week training was completed, the individuals were re-evaluated, regarding the popliteal angle, on the 1st, 2nd, 3rd, 4th, 10th, 15th and 31st days post-training, following the same procedures described before.

Statistical analysis

Data analysis was carried out by the SPSS (*Statistical Package for the Social Sciences*) software program for Windows, Release 13.0. Initially, the analysis of the intra-examiner Interclass Correlation Coefficient (ICC) for the measurement of the popliteal angle was performed, which was considered appropriate for the reliability of measurements in this study.

Five volunteers (3 women and 2 men) agreed to participate in this reliability evaluation. The first and the second measurements were carried out with a one-week interval between them. The established confidence interval was 95%, and a reliability of 0.92 was obtained. Descriptive statistics were used for all variables. Analysis of variance (ANOVA) for repeated measures with pre-planned contrasts was carried out to determine if there were any statistically significant differences between the measurements of each group (pre, post-intervention, 2nd, 3rd, 4th, 10th, 15th and 31st days) and between the groups. The level of significance was set at $\alpha = 0.05$.

Results

Thirty-three individuals were evaluated. Of these, 3 were excluded right after the evaluation, eight withdrew from training and 2 did not come back for the re-evaluations. Six belonged to the stretching group (4 women and 2 men) and seven to the treadmill and stretching group (3 women and four men).

The statistical analysis used data from the measurement of the popliteal angle of 20 individuals whose mean age was 26.87 ± 5.17 (S group 25.58 ± 4.88; TS group 28.16 ± 5.37). Thirteen were females (S: 9, TS: 4) and 7 were males (S: 1, TS: 6). As both LLLL were measured, a total of 40 limbs were studied.

According to the statistical analysis, there was a significant stretching increase between the pre and post-training in both groups and a return to the baseline value on the 4th day after the end of the protocol, also in both groups (approximately 72 hrs) (Table 1).

Group A showed a statistically significant difference among all measurements up to the 10th day (SPre to S10), with no statistically significant difference between the two last measurements (Figure 2).

Regarding the TS group, the initial gain between TSPre and TSPost, and the loss of this gain remained significant in all measurements, except between the 4th and the 10th day (Figure 3). It was observed that, in this last group, there was a smaller stretching gain when compared to the S group (S=22.2 and TS=19.2), although it was not significant (p=0.062) (Table 2).

Table 1
P values for comparison of pre-training measurements with the others in both groups

Measurements	Group S	Group TS
Pre-Post	0,000*	0,000*
Pre-2	0,000*	0,000*
Pre-3	0,002*	0,000*
Pre-4	0,234	0,148
Pre-10	0,359	0,371
Pre-15	0,192	0,639
Pre-31	0,126	0,035*

*statistical significance – p< 0.05; Measurements – comparison of the measurement obtained at Pre– pre-training with all the other measurements after training: Post – on the first, 2 - second, 3 - third, 4 - fourth, 10 - tenth, 15 - fifteenth, and 31 – thirty-first days of training; S – stretching; TS – treadmill and stretching

When comparing the two groups, the difference of flexibility loss measurements was observed only from the 2nd to the 3rd day post-training, when a more gradual loss was verified in the TS group; however, this group presented a statistically significant decrease in the popliteal angle in relation to the baseline measure, i.e., the last measurement was smaller than the initial one (Tables 1 and 2).

Discussion

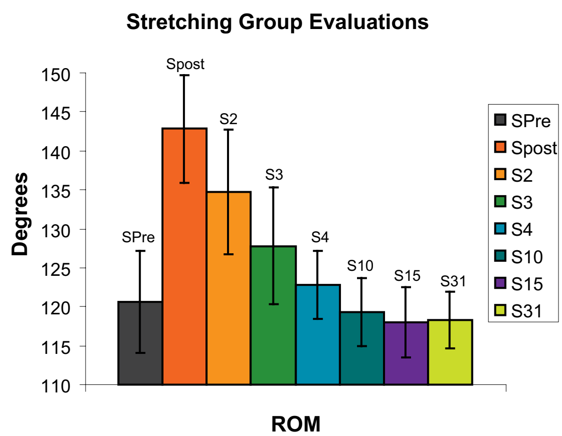
The present study demonstrated that the static stretching pro-

Table 2
P values of the comparison of subsequent measurements between the two groups

Measurements	S x TS
Pre – Post	0,062
Post – 2	0,555
2 – 3	0,049*
3 – 4	0,806
4 – 10	0,071
10 – 15	0,489
15 – 31	0,082

*statistical significance – p< 0.05; Measurements – Pre-Post – comparison of the measurement obtained at the pre- with the post-training, Post-2 - post and second day, 2-3 – second with third, 3-4 – third with fourth, 4-10 – fourth with tenth, 10-15 – tenth with fifteenth, and 15-31 – fifteenth with thirty-first days; S – stretching; TS – treadmill and stretching.

gram resulted in a gain of joint ROM, but when associated to deep warming-up, it did not present a statistically different gain when compared to stretching alone. The regression of the post-training flexibility, when compared to the first measurement, occurred within 72 hrs in both groups and regarding the TS group, this return on the 31st day post-training was higher than the baseline measurement.

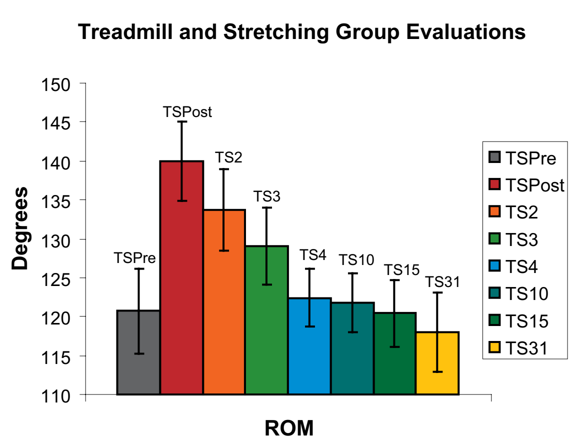


SPre – measurement obtained before training, SPost – on the first day after training, S2 – on the second, S3 – on the third, S4 – on the fourth, S10 – on the tenth, S15 – on the fifteenth, and S31 – on the thirty-first; * - statistical significance, p< 0.05.

Figure 2

Measurements of the popliteal angle obtained in the Stretching group – means and standard deviation..

According to the study by Bandy and Irion, intended to verify the necessary time for the musculature to be supported in the stretching position in order to achieve a maximum flexibility increase using a goniometer to measure the gain, it was observed that 30s was enough time to attain an effective stretching of the hamstring musculature. In this study, 57 individuals (40 men, 17 women) aged 20 to 40 years, were selected and divided into 4 groups: group 1, static stretching sustained for 15s; group 2, for 30s; group 3, for 60s and group 4 was the control group. The training was carried out for six weeks, 5 times a week, with one series per day10.



TSPre – measurement obtained before training, TSPost – on the first day after training, TS2 – on the second, TS3 – on the third, TS4 – on the fourth, TS10 – on the tenth, TS15 – on the fifteenth, and TS31 – on the thirty-first; * - statistical significance, p< 0.05).

Figure 3

Measurements of the popliteal angle obtained in the Treadmill and Stretching group - means and standard deviation

Malliaropoulos et al. also reported that 30s of stretching was enough for healthy individuals; however, they concluded that a static stretching for 30s repeated four times was more adequate to achieve the maximum benefit[11].

In the present study, a gain of 18.41% was observed in the S group (p=0.000) and 15.91% (p=0.000) in the TS group, with a similar methodology as the one used by Bandy and Irion, but with four series of 30s[10].

Taylor et al reported that, although the literature shows that heat associated to stretching increases the ROM in relation to stretching alone, their results were not statistically significant. Their methodology included 24 individuals (12 men and 12 women) aged 18 to 39 years, who underwent a heat therapy (20 min) followed by a passive static stretching (group 1), cold therapy (20 min) followed by passive static stretching (group 2) and passive static stretching (group 3), with a weekly session[13].

On the other hand, Pinfild, in order to determine the effect of static stretching after short-wave diathermy versus static stretching on the flexibility of hamstrings, acknowledged that the association of stretching with thermal modalities of therapy can alter the visco-elasticity of the conjunctive tissue, resulting in a plastic deformation after the stretching. His study used a universal goniometer as the instrument to measure ROM and included 30 women, who were divided in 3 groups: group 1, the control group; group 2, static stretching for three minutes 3 times a week for a month; and group 3, continuous short-wave diathermy for 20 min and static stretching sustained for 3 min, 3 times a week for a month[20].

Although some authors have reported that the association of stretching with warming-up results in greater flexibility[4,7,13,20], the same result was not observed in the present study. The group that was submitted to muscular warming-up on the treadmill (TS) for 10 min before the stretching did not show any statistically significant difference when compared to the stretching (S) group (p=0.062). This results seems to be related to the duration of the warming-up, as the authors studied used deep warming-up for approximately 20 min. The present study chose to use a 10-min warming up, as this duration has been proposed in literature to achieve increase of body temperature[19].

At the evaluation of the return of flexibility, in relation to the pre-training measurement, the present study showed that both groups presented a total return by the 4th day (72 hrs), with the warming-up group associated to stretching presenting a regression of the measurement that went beyond the initial value, although it happened gradually. These results are in accordance with Youdas et al., who observed, after a six-week static stretching training of the sural triceps, a return to the initial measurement within 60 to 72 hrs after the last training period. The study included 101 individuals, being 38 men and 63 women, aged 21 to 59 years, who were divided in 4 groups: group 1, the control group; groups 2, 3 and 4, who performed a repeated static stretching of the sural triceps, once a day. Group 2 sustained for 30s; group 3 for 1 min and group 4 for 2 min[2].

Nevertheless, Malliaropoulos et al. reported in their study of 80 individuals, of which 52 were males and 28 females, randomly divided in two groups who performed static stretching for 30s repeated 4 times (group A had a daily session whereas group B had four sessions a day) , a return to baseline measurements within a mean time of 7.3 days, which can be due to the fact that, when a muscle is stretched beyond its usual limits, it would be led to a musculotendinous junction tear , creating a plastic deformation. The method of analysis was also through the use of a goniometer[11].

Herbert reported that the durable increases in muscle length would probably result from an adaptive remodeling of the muscle structure, explained by the increase in the number of sarcomeres in series in the muscular tissue. The author also stated that, when there was a decrease in the length of the sarcomeres by adaptive shortening (for instance, immobilization), this would lead to a decrease in their amount, which can be reversed with a long-term stretching technique[1].

As there was a gradual loss of the obtained gains with the protocol stretching training in the present study, with measures returning to the baseline in approximately 72 hrs in both groups, one can suppose that probably there was no structural adaptation, i.e., addition of sarcomeres in series, or, if there was, it was not significant. Unfortunately, it was not possible to measure the actual cause of these gains in the present study (structural adaptation X mechanical deformation). The effects might have been, in their majority, caused by the mechanical deformation created by the stretching 5 times a week for 6 weeks. As the individuals did not have functional complaints despite the fact that they presented hamstring shortening, the gain achieved with the protocol use did not add visible changes to the daily routine of these individuals. Thus, there was no change in the functional demand of these individuals, which might have contributed to a lack of maintenance of the attained gains.

Additionally, the lack of maintenance of ROM gain in the groups might have been also influenced by the lack of directions given to the volunteers regarding the most adequate positioning for a better use of the ROM acquired through the stretching, which could have promoted a longer maintenance of the gain.

Although the present study presented a high ICC (0.92) for the use of the goniometer, being considered good for the study reliability, the results must be carefully analyzed, as the technique used to document the pre- and post-intervention process is not very objective. This allows a possible explanation for the statistical difference between the groups from the 2nd to the 3rd day of post-training re-evaluation measurement, as there was no difference regarding the directions given to the individuals, or measurements performed at other times of the day or utilizing a different technique. This difficulty regarding the little objectivity of the techniques used for the documentation of studies has been forcing the professionals from the health areas to seek scientific information to subsidize the choice of interventions, creating discussions on the best functional model that can systematize the practice, helping therapists to look for more relevant evidence. In addition to using a systematized model of objective instrumentation, it is necessary to select instruments that document changes at the three levels of function: structure and function of the body; activity and participation of the individual, for a more general evaluation[21]. It is not guaranteed that a decrease in joint ROM alone (impairment at the structural level and body function) will lead the individual to a functional deficit, although one of the main causes of movement dysfunction is the lack of muscular flexibility, which can interfere with the individuals' functionality. The individual's organism can compensate for the flexibility deficit, with no resulting impairment on the daily and social activities (work, study, leisure). Thus, the evaluation must utilize instruments capable of documenting all three levels. The goniometry must not be used as an isolated parameter of evaluation.

Another limiting factor of the present study was the heterogeneity presented by the stretching group alone, as 90% of its subjects were females, while the treadmill associated to stretching group consisted of 40% of female individuals. This condition of the groups might have influenced the results of flexibility gain, although studies in literature showed no difference between the sexes[22].

According to Chaves, who sought to analyze the behavior of body flexibility through articulation and movement in young adult women, at different phases of the menstrual cycle, there is no difference in flexibility between the phases. The instrument used to evaluate flexibility was the flexitest, handled by the same examiner. Fifteen women, aged from 19 to 25 years, were selected for the study and divided in two groups: experimental group with eumenorrheic women (EG) and control group with women taking oral contraceptives (CG). The volunteers were evaluated for 4 consecutive weeks, always on the same day of the week and approximately at the same time of the day[17].

The study by Blackburn, carried out with 30 individuals (15 women and 15 men) showed a statistically significant difference regarding flexibility due to hormonal alterations, capable of promoting physical and metabolic changes in joint mobility and ligament laxity due to the different levels of relaxin, which showed that the female sex presented results that indicated a significantly greater flexibility in relation to the male sex[23].

Due to the lack of consensus on the proposed subject and insufficient information regarding the stretching maintenance, as well as the importance related to the clinical aspect, further studies in this area of knowledge are greatly necessary.

Conclusions

The results of the present study demonstrated that the static stretching program was effective in increasing joint ROM of the knee, but that its association with deep warming-up did not result in a greater gain of flexibility. As expected, the decrease of the gains in both groups occurred in the first day post-training, returning to the initial measurement within 72 hours. These findings suggest that the benefits of long-term training (six weeks) with hamstring static stretching exercises in insufficiently active individuals with no musculoskeletal pathologies do exist; however, once the training is interrupted, the benefits start to disappear if the individual receives no further directions. Furthermore, as the individuals in this study did not present functional loss due to the initially presented hamstring shortening, the gain obtained was probably lost, as its use was not necessary.

References

1. Herbert R. The passive mechanical properties of muscle and their adaptations to altered patterns of use. Aust J Physiother. 1988; 34(3): 141-9.
2. Youdas JW, Krause DA, Egan KS, Therneau TM, Laskowski ER. The effect of static stretching of the calf muscle-tendon unit on active ankle dorsiflexion range of motion. J Orthop Sports Phys Ther. 2003; 33(7): 408-17.
3. De Deyne PG. Application of passive stretch and its implications for muscle fibers. Phys Ther. 2001; 81(2): 819-27.
4. Thacker SB, Gilchrist J, Stroup DF, Kimsey DJr. The impact of stretching on sports injury risk: a systematic review of the literature. Med Sci Sports Exerc. 2004; 36(3):371-8.
5. Taylor DC, Dalton JD, Seaber AV, Garret WE Jr. Viscoelastic properties of muscle-tendon units The biomechanical effects of stretching. Am J Sports Med. 1990; 18(3): 300-09.
6. Halbertsma JP, van Bolhuis AI, Goeken LN. Sport stretching: effect on passive muscle stiffness of short hamstring. Arch Phys Med Rehabil. 1996; 77(7): 688-92.
7. Draper DO, Castro JL, Feland B, Schulthies S, Eggett D. Shortwave diathermy and prolonged stretching increase hamstring flexibility more than prolonged stretching alone. J Orthop Sports Phys Ther. 2004; 34(1): 13-20.
8. Kubo K, Kanehisa H, Fukunaga T. Effect of stretching training on the viscoelastic properties of human tendon structures in vivo. J Appl Physiol. 2002; 92(2): 595-601.
9. Bandy WD, Irion JM, Briggler M. The effect of time and frequency of static stretching on flexibility of the hamstrings muscles. Phys Ther. 1997; 77(10): 1090-6.
10. Bandy WD, Irion JM. The effect of time on static stretch on the flexibility of the hamstrings muscles. Phys Ther. 1994; 74(9): 845-50.
11. Malliaropoulos N, Papalexandris S, Papalada A, Papacostas E. The role of stretching in rehabilitation of hamstring injuries: 80 athletes follow-up. Med Sci Sports Exerc. 2004; 36(5): 756-9.
12. Mcnair P, Stanley SN. Effect of passive stretching and jogging on the series elastic muscle stiffness and range of motion of the ankle joint. Br J Sports Med. 1996; 30(4):313-7.
13. Taylor FB, Waring CA, Brashear TA. The effects of therapeutic application of heat or cold followed by static stretch on hamstring muscle length. J Orthop Sports Phys Ther. 1995; 21(5): 283-6.
14. Bisciotti NG, Vilardi JR, Manfio EF. Lesão traumática e déficit elástico muscular. Fisioter Brás. 2002; 3(4): 242-9.
15. Pardini R, Matsudo S, Araújo T, Matsudo V, Andrade E, Braggioni G, et al. Validação do questionário internacional de nível de atividade física (IPAQ – versão 6): estudo piloto em adultos jovens brasileiros. Rev bras ciênc mov. 2001; 9(3): 45-51.
16. Magge DJ. Avaliação musculoesquelética. 3a ed. São Paulo: Manole; 2002.
17. Feland JB, Myrer JW, Schulthies SS, Fellingham GW, Measom GW. The effect of duration of stretching of the hamstring muscle group for increasing range of motion in people aged 65 years or older. Phys Ther. 2001; 81(5): 1110-7.
18. Powers SK, Howley ET. Fisiologia do exercício: teoria e aplicação ao condicionamento e ao desempenho. 3a ed. São Paulo: Manole; 2000.
19. Pinfild CE, Prado RP, Liebano RE. Efeito do alongamento estático após diatermia de ondas curtas versus alongamento estático nos músculos isquiotibiais em mulheres sedentárias. Fisioter Bras. 2004; 5(2): 119-24.
20. Sampaio RF, Mancini MC, Fonseca ST. Produção científica e atuação profissional: aspectos que limitam essa integração na fisioterapia e na terapia ocupacional. Rev Bras Fisioter. 2002; 6(3): 113-8.
21. Roberts JM, Wilson K. Effect of stretching duration on active and passive range of motion in the lower extremity. Br J Sports Med. 1999; 33(4): 259-63.
22. Blackburn JT, Riemann BL, Padua DA, Guskiewicz KM. Sex comparison of extensibility, passive, and active stiffness of the knee flexors. Clin Biomech (Bristol, Avon). 2004;19(1):36-43.
23. Chaves CPG, Simão R, Araújo CGS. Ausência de variação da flexibilidade durante o ciclo menstrual em universitárias. Rev Bras Med Esporte. 2002; 8(6): 212-8.