Effects of number of stretch series on hamstring muscle flexibility in young women

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Abstract

The aim of this study was to look at the influence of five different sets of passive stretching on hamstring muscle flexibility in young women. The sample consisted of 45 university students of physiotherapy. The range of motion of the hip and the knee was evaluated with a manual goniometer, using two tests: Straight Leg Raise test and Knee Extension modified test, before and after stretching. The stretching was performed once a week, with different numbers of series: one, two, three, four and five 30-second sets, the order established by lot. The data relating to pre and post- test were compared using the t test for paired samples. One-Way ANOVA was used for comparison between the number of runs; in the presence of post-hoc differences Bonferroni was used ($\alpha = 0.05$). The results demonstrate that the post-test had a significant increase in range of motion compared to the pre all tests. Comparing the series showed a marked increase in range of motion of the hip when there were three, four and five series of stretching in the Straight Leg Raise test and in four and five series in the Knee Extension modified test. The data show that the stretching exercises, regardless of the number of series, increase joint range of motion. However, the application of the four for range of motion gains because the results are better.

Keywords: Passive stretching; Flexibility; Range of motion.

Introduction

The performance of occupational, recreational, sports and daily life activities requires adequate flexibility without restrictions and without joint pain. Stretching is effective to maintain proper mobility of the soft tissues and joints, and can also be used to increase muscle and periarticular connective tissue extensibility. It contributes to greater flexibility, in other words, to an increased range of motion[1].

According to Marshall et al.,[2], flexibility is physical capacity of muscle tissue to lengthen or stretch beyond resting length. It is important in rehabilitation, postural balance, maintaining full range of motion, injury prevention and optimization of musculoskeletal function, such as strength and power[3].

According to Kisner and Colby[1] flexibility can be affected by soft tissues such as muscle and connective tissue. Tissue deformations occur as a force is applied to maintain the maximum range of motion until thereby tension is decreased in the muscle, fascia and tendon. Increasing the length of the tissue influences the range of motion and is proportional to the applied tension[4].

Several types of stretching were developed aiming to increase flexibility, including active, passive and ballistic stretching and proprioceptive neuromuscular facilitation[5]. Passive stretching consists of passively stretching a segment to the maximum extent possible, using mechanical or manual force and keeping it up for a specific period of time[1].

The results of stretching on flexibility are influenced by the technique of stretching, the number of sets, the duration of each stretch, the point of discomfort, daily dose and the length program[6-7]. However, there is no consensus on how to perform the stretches to ensure maximum efficiency, due to the uncertainties generated by the variety of techniques, series, frequency, duration and intensity on the voltage that must be applied during stretching[8].

Regarding the number of series, there are a variety of studies such as Bandy *et al.*[9] who looked at the difference between one and three 30-second sets. DePino *et al.*[10] verified the efficacy of four 30-second sets in hamstring flexibility. Ayala *et al.*[11] investigated the effectiveness of six 30-second series in individuals with and without shortening hamstrings. Ford et al.[12] looked at the difference between two 30-second sets, three of 60-seconds, and four of 90-second passive stretching.

The variability of the studies in relation to the number of series used in the stretching exercise does not show what is the most appropriate number of series to improve flexibility. Therefore, this study is justified because it proposes to clarify and identify how many series of stretches provide increased gain in range of motion of the hip and knee. Hence, the study aims to investigate the influence of five different sets of passive static stretching on flexibility of the hamstrings of young women.

Methods

Experimental Approach to the Problem

This was a quantitative experimental study, with a semi-experimental design and it will be conducted at the Laboratory of Exercise Research (LAPEX), ESEF/UFRGS.

Subject

The study population consisted of female physiotherapy students at Federal University of Rio Grande do Sul (*n*= 84).

The sample was intentional and limited. The number of study subjects was determined from the sample calculation for populations with a finite *n* (number of subjects). For a sample, drawn from the population of 84 female physioterapy students of UFRGS, we adopted a confidence level of 95 % and accepting an error of 10%. The *n* calculated for the sample size of this study, representative of the population of female physiotherapy students UFRGS, was 45.

Inclusion criteria were the subject being female students duly enrolled in the Physiotherapy Course at the Federal University of Rio Grande do Sul and being sedentary. And the exclusion criteria adopted for the subjects in the study were a prior history of musculoskeletal, bone or neurological injury in the lower limbs, use of analgesics and/or relaxants, pregnancy, practicing activities that build flexibility and ligament hyperlaxitude.

The study was approved by the Research Ethics Committee (REC) of the Federal University of Rio Grande do Sul, under number 376 600. Prior to participation in the study, all subjects were asked to read the Statement of Informed Consent and agree to participate in the study.

Procedures

The study was conducted in five stages. Each step occurred in one day with a one-week interval between them. Each stage consisted of three steps: (1) Pre-test, evaluation of range motion of hip and knee; (2) Passive static stretching of hamstrings muscle, and (3) Post-test, evaluation of range motion of hip and knee immediately after the intervention.

Two tests were performed to evaluate the range motion of the hip and knee, the Straight Leg Raise test (SLR) and the modified Knee Extension Test (mKET), respectively.

In the Straight Leg Raise test, the subject was positioned supine on a stretcher with the lumbar region and sacrum flat on the stretcher. Then the evaluator performed hip flexion with the knee extended and the foot relaxed until the angle at which the volunteer complained of discomfort while the contralateral limb remained in extension[13] (FIGURE 1).

In the Knee Extension modified test, the subject was positioned supine on a stretcher. The evaluator positioned the hip to be evaluated at 90º flexion and the position was secured by an iron structure where the popliteal fossa was sustained (FIGURE 3). The test began with the knee flexed at 90° and the evaluator then performed the knee extension without allowing the hip to move (FIGURE 2). The contralateral limb remained in extension[14].

The order of execution of the tests was determined by lot. And the range of hip flexion and

FIGURE 1 - Straight Leg Raise Test.

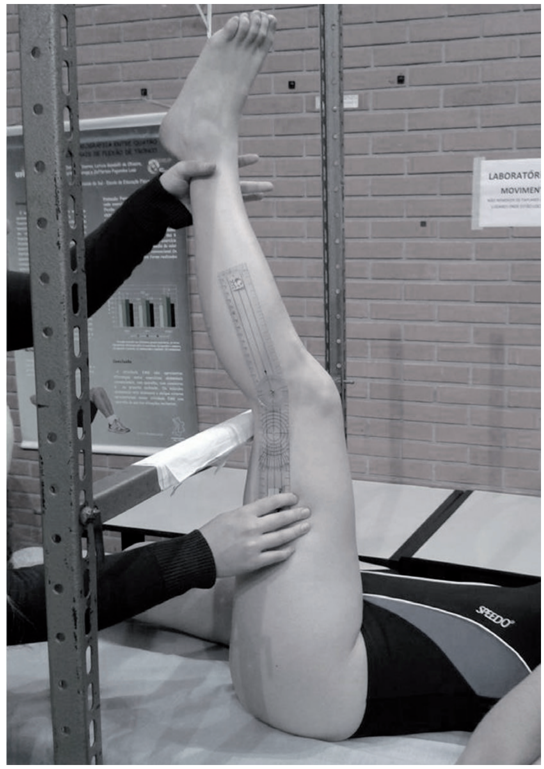

FIGURE 2 - Knee Extension Test modified.

FIGURE 3 - Equipment used for maintenance of the hip at 90° during the Extension Knee modified test.

knee extension achieved in the two tests were measured using an acrylic manual goniometer manufactured by Trident (Itapuí, São Paulo, Brazil). The start and end of the hip or knee angles of each subject were measured with a goniometer and recorded in a table. The difference between the two angles was used as the range of motion of each individual. The same procedures were performed for both flexibility tests and recorded before and after each test week.

For the SLR test the fixed shaft of the goniometer was positioned at the mid-axillary line of the trunk, the spindle was positioned parallel to the femur towards the lateral condyle of the femur and the shaft was positioned near the greater trochanter[15] (FIGURE 1). For the mKET the fixed shaft of the goniometer was placed parallel to the femur, directed to the greater trochanter, and the parallel spindle directed toward the lateral malleolus, the shaft was on the joint line of the knee joint[15] (FIGURE 2). Tests were applied, every week, in the same way, before and after the intervention.

The intervention was carried out by the same participants in five different times, each time a number of repetitions of passive static stretching varied: a set of 30 seconds, two sets of 30 seconds, three sets of 30 seconds, four sets of 30 seconds and five sets of 30 seconds. The passive stretching was done once a week and each week the number of sets run varied according to lottery.

To perform the passive static stretching exercise the subject was positioned in the supine position and the evaluator performed hip flexion with the knee extended and relaxed foot until the angle at which the volunteer complained of discomfort, remaining in that position for 30 seconds, can be performed 1, 2, 3, 4 or 5 sets according to lottery. The interval between sets, when necessary, was given between 20-30 seconds.

Statistical Analysis

Statistical analysis was performed with the Statistical Package for Social Science (SPSS) 18.0. The level of significance for all tests was 0.05.

Initially we tested the normality and homogeneity of data using the Shapiro-Wilk and Levene tests, respectively. The paired t test was performed to compare the pre and post-test values of the individuals. Analysis of Variance (One-Way ANOVA) was used to compare the number of series, and the Bonferroni post-hoc to determine the differences.

Results

The study was conducted with 45 women who were physiotherapy students at UFRGS, ages between 18 and 26 years (21.77±1.83), weighing between 48 and 115kg (60.73 ±11.79) and height between 1.48 and 1.73m (1.62±0.06).

The results show that in the SLR test, there was no statistically significant difference between one and two series of passive static stretching. Moreover, three, four and five sets showed an increase in ROM of a statistically greater hip (FIGURE 4). In mKET the results were similar to the lifting of the lower limb test, a statistically significant increase in knee ROM with four and five sets of passive static stretching when compared to a single set, and there was no significant difference between two and three series (FIGURE 5).

Using the paired t test a statistically significant difference was found between the pre and post test for all series tested (TABLE 1).

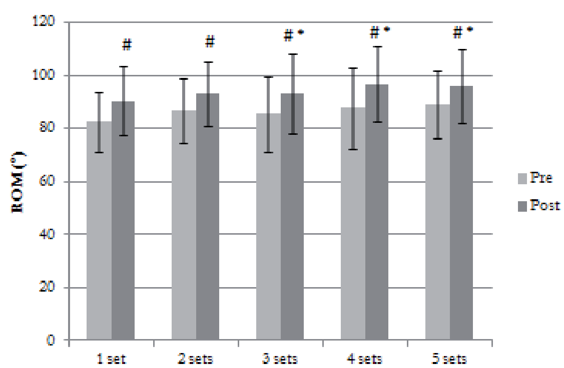

FIGURE 4 - ROM pre and post intervention in the Straight Leg Raise Test.

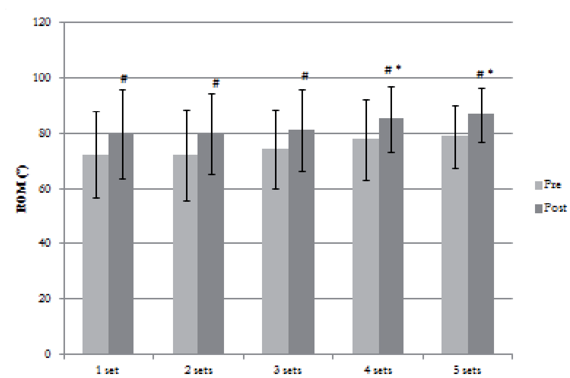

FIGURE 5 - ROM pre and post intervention in the modified Knee Extension Test.

Discussion

The performance of three, four and five sets of 30 seconds showed a significant increase compared to the performance of a series of 30 seconds at SLR test. Already in mkET, there a significant increase in performing three and four sets of 30 seconds. Regarding the comparison between pre and post test, there was a significant increase in post-test for all series in all tests evaluated.

The immediate effect of stretching can be explained by the viscoelastic characteristics of the

TABLE 1 - Average values for pre and post intervention and the angular difference obtained in different sets of stretching (mean values ± standard deviation).

	1 set	2 sets	3 sets	4 sets	5 sets
SLR					
Pre (º)	82.57±11.38	86.81±12.12	85.47±14.26	87.74±15.29	89.14±12.81
Post(º)	90.58±13.15#	93.17±14.27#	93.22±15.04# *	96.95 ±14.26# *	96.14±13.87# *
Δ(%)	9,90±8,20	7,49±8,61	9,52±8,97	11,56±11,14	8,07±6,48
Mket					
Pre (º)	72.29 ±15.51	72.03±16.31	74.30±14.42	77.68±14.27	78.92±11.28
Post(º)	79.71 ±16.10#	79.68±14.61#	81.19 ±14.93#	85.15 ±11.93# *	86.65 ±9.70# *
Δ(%)	11,58 ± 17,35	12,88±17,33	9,86± 8,53	10,89 ± 9,30	10,51± 8,86

# = significant difference from pre to post; * = Significant difference compared with one set ($p < 0.05$);
SLR = Straight Leg Raise Test; mKET = modified Knee Extension Test.

components and the muscle in the short term changes in muscle extensibility[16].

However, according to Halbertsma and Goeken[17] Halbertsma et al.[18] and Ylinen[19] stretching does not make the hamstrings more elongated or less rigid, but rather influences the tolerance to stretching, reducing the generation of tension in the muscle when it is stretched to the same length. In other words, there is only a reduction of the algesic response to increased tension in the muscle, allowing increased ROM.

Regardless of the mechanical and physiological changes that occur in the muscle tissue to gain joint ROM, the manner in which stretching is applied appears to have an influence.

In a systematic review of 28 studies, Decoster et al.[20] found that the time spent in the most used stretching exercises is 30 seconds, however, as to the number of series there is a variety in the studies presented without a consensus regarding the most effective number of repetitions.

Bandy, et al.[21], when comparing a series of 30 seconds with three sets of 30 seconds, in a study of young men and women, did not observe any significant difference between groups. The present study, although it was done only with young women, presented similar results as there was no significant difference between one, two or three sets of 30 seconds in the tests.

The study on young men by DePino et al[10] corroborates the results found in this study, stating that four sets of 30 seconds are effective in gaining ROM of knee and hip. This also occurred in the studies by Ford and McChesney[22] and Chan et al.[23] who evaluated men and women and found significant results in the increase of ROM when when five 30-second sets were performed.

The study by Taylor et al.[16], also examined 10 repetitions of stretching and the goal was to identify how many would be needed to gain more flexibility. Their findings supported the results of this study and found that the best stretch of the muscle-tendon unit occurs after four repetitions, with no significant difference after the seventh repetition. Both the study by Taylor et al.[16], and this study allowed the conclusion that the four series are sufficient to acquire a significant increase in ROM.

However, there are studies such as Bandy and Iron[24], and Ford et al.[12] in which the authors claim that the performance of only a single series of 30 seconds was effective in gaining ROM, indicating its use in clinical practice. That study also compared pre-and post-test, and the intervention group presented a significant difference.

The results of these studies agree with the present study when analyzing the comparison of pre-and post-test, where, regardless of the number of sets, there were significant gains in ROM. This supports the idea that a series of 30 seconds is enough to gain ROM.

However, by increasing the number of sets the gain becomes larger, as demonstrated in this study, on three series in the SLR test and four series in the mKET.

The influence of the number of series can also be discussed in the study by Nelson et al.[25] that compared a series of 30 seconds of static stretching, six repetitions of 30 seconds of excentric stretching and control group using a sample of 75 young athletes, and it was found that eccentric stretching leads to greater gains in ROM than static stretching. However, this result may be related to the number of sets chosen and not to the type of stretching adopted, and as in the present study, the significant increase in ROM may have been achieved by having performed more than four repetitions of 30 seconds.

Another issue that should be considered is the time spent in the stretched position. The study by Cipriani et al.[26], conducted with young men and women, found that performing two sets of 30 seconds, and 6 sets of 10 seconds, is equally effective in gaining ROM. And the study by Johnson et al.,[27] found that realize 9 sets of 10 seconds or 3 sets of 30 seconds, 6 days a week for 6 weeks, is equally effective in gaining ROM. These results show that a larger number of series is not effective to obtain gain of ROM if the residence time is short. In this studys, the residence time was less than the time used in the present study, 30 seconds, suggesting that the time factor also influences the ROM gain.

Therefore, the data show that the stretching exercises, regardless of the number of series, increase joint range of motion. However, the increase in the number of series from four to five provides a more effective gain of range of motion.

Resumo

Efeitos do número de séries de alongamento na flexibilidade do músculo isquiotibial em mulheres jovens

O objetivo foi verificar a influência de cinco diferentes séries de alongamento passivo sobre a flexibilidade dos músculos isquiostibiais de mulheres jovens. A amostra foi constituída de 45 estudantes universitários do Curso de Fisioterapia. A amplitude de movimento do quadril e do joelho foi avaliada com goniômetro manual, através de dois testes: Elevação do Membro Inferior Estendido e Extensão de Joelho modificado, antes a após o alongamento. O alongamento foi realizado uma vez por semana, com número de séries diferente: uma; duas; três;quatro e cinco séries de 30 segundos, sendo a ordem estabelecida por sorteio. Os dados referentes ao pré e pós-teste foram comparados utilizando o teste t para amostras pareadas. Para comparação entre o número de séries foi utilizada a One-Way ANOVA, na presença de diferenças o post hoc de Bonferroni foi utilizado (α= 0,05). Os resultados demonstram que o pós teste teve aumento significativo na amplitude de movimento quando comparado ao pré para todos os testes. Na comparação entre as séries foi encontrado aumento significativo na ADM de quadril quando foram realizadas três, quatro e cinco séries de alongamento no teste Elevação do Membro Inferior Estendido e em quatro e cinco séries no teste de Extensão de Joelho modificado. Os dados permitem concluir que os exercícios de alongamento, independente do número de séries, aumentam a ADM articular. No entanto, a aplicação de quatro séries é o mais adequado para ganhos de ADM por apresentar melhores resultados.

Palavras-chave: Alongamento passivo; Flexibilidade; Amplitude de movimento.

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