ACUTE AND CHRONIC EFFECTS OF A STATIC AND DYNAMIC STRETCHING PROGRAM IN THE PERFORMANCE OF YOUNG SOCCER ATHLETES

LOCOMOTOR APPARATUS IN EXERCISE AND SPORTS

ORIGINAL ARTICLE

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ABSTRACT

Introduction: Stretching is a therapeutic technique and may be used as a form of warm-up to increase flexibility or decrease pain throughout the movement, with objective to improve performance and reduce the risk of injury. Objective: To verify the acute and chronic effects of a program of static stretching compared with the dynamic one in performance of young soccer athletes. Methods: Randomized clinical study of equivalence carried out between August and November, 2010 with the under-17 category of the Grêmio Torrense club. After fulfilling the inclusion criteria, the athletes were randomly allocated into two groups: static stretching or dynamic stretching. All of them underwent an initial evaluation and were submitted to the first intervention. They were evaluated once again and at the end of 12 training sessions as well. Flexibility, impulse, speed, strength and muscle recruitment valences were evaluated. Results: The long jump has significantly improved in the two study groups; however, this improvement persisted in the chronic phase only in the static stretching group ($p = 0.02$). Flexibility increased significantly in both groups in the acute phase, but it only occurred in the static group following this improvement in the chronic phase ($p = 0.03$). The two examples of stretching led to decrease in performance in the velocity test. No improvement was observed in the hamstrings muscle strength throughout the study period in the two groups. Electric activity of hamstrings significantly decreased in the acute phase for the static stretching group ($p = 0.035$), while it significantly increased in the chronic phase in the dynamic stretching group ($p = 0.038$). Conclusion: It could be concluded that static stretching improves flexibility and long jump, while dynamic stretching improves muscular activation.

Keywords: muscle stretching exercises, wounds and injuries, soccer.

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INTRODUCTION

Soccer is one of the most admired sports around the world and is able to raise interest for its practice in millions of people from both sexes. The *Fédération Internationale de Football Association* – FIFA congregates 203 countries and about 200 million practitioners, being 40 million of them women[1]. It has faced many changes over the last years, especially due to its increasing physical demands which make it necessary that training and performance levels close to the maximum exhaustion thresholds are developed, increasing hence predisposition to injury[2].

Injuries of the musculoskeletal system represent over 30% of the injuries observed in sports medicine. Among their prevention, countless stretching protocols present positive results in the prevention of muscular injuries as well as the ones of soft tissues[3]. Stretching is a therapeutic technique and can be used as warm-up to increase flexibility or decrease pain during the movement, in order to improve performance[4,5] and reduce risk of injuries [6-10]. Although stretching techniques have been widely used prior to physical exercises, there is still a lot of controversy and little scientific evidence which supports this idea[11,12]. Epidemiological investigation studies cite decrease in flexibility as an etiological factor in acute muscular injury[13-16]. Another study concluded that improvement in flexibility by stretching may reduce the risk of injury[17].

Among the many stretching techniques, we can mention dynamic stretching. It has been studied both due to its effect on improving flexibility and due to its integration effect of the movement[3,18]. On the other hand, we should mention that excessive range of motion may be as harmful as lack of flexibility, due to laxity which increases probability to injury[19]. Static stretching on the other hand, it is the mostly used technique in rehabilitation or training programs. It allows better settlement of the viscoelastic properties of the musculotendon unit, besides being a technique which offers low risk for the muscular tissue[20].

The aim of the study was to verify the acute and chronic effects of a static stretching program compared with the dynamic one in performance of young soccer athletes.

MATERIALS AND METHODS

Outlining

A random clinical assay of equivalence held between August and November, 2010, with the under-17 category of the Grêmio Torrense Club.

Sample

Eighteen athletes from the under-17 category of the Grêmio Torrense Club were randomly separated in two groups: group I, with static stretching and group II, with dynamic stretching.

Ethical aspects

The study was approved by the Ethics and Research Committee of the Lutheran University of Brazil under the number 2010-220H.

The under-17 athletes from the soccer school of the Grêmio Torrense Club were invited to participate in the study and they and their parents or legal tutors received information about the research and signed the Free and Clarified Consent Form (TCLE).

Eligibility criterion

Exclusion criteria were: presence of any injury previous or during the study, any kind of hereditary or acquired orthopedic dysfunction on the lower limbs which could limit the applicability of the training program, practice of any type of sport or training in other modality or institution and three or more absences during the training program.

Evaluation protocol

The athletes received explanation about the evaluation protocol at the first moment. The evaluations were held at the physiotherapy school clinic of the Ulbra Torres before and immediately after the first training (acute effect), and at the end of the training protocol (chronic effect) (figure 1).

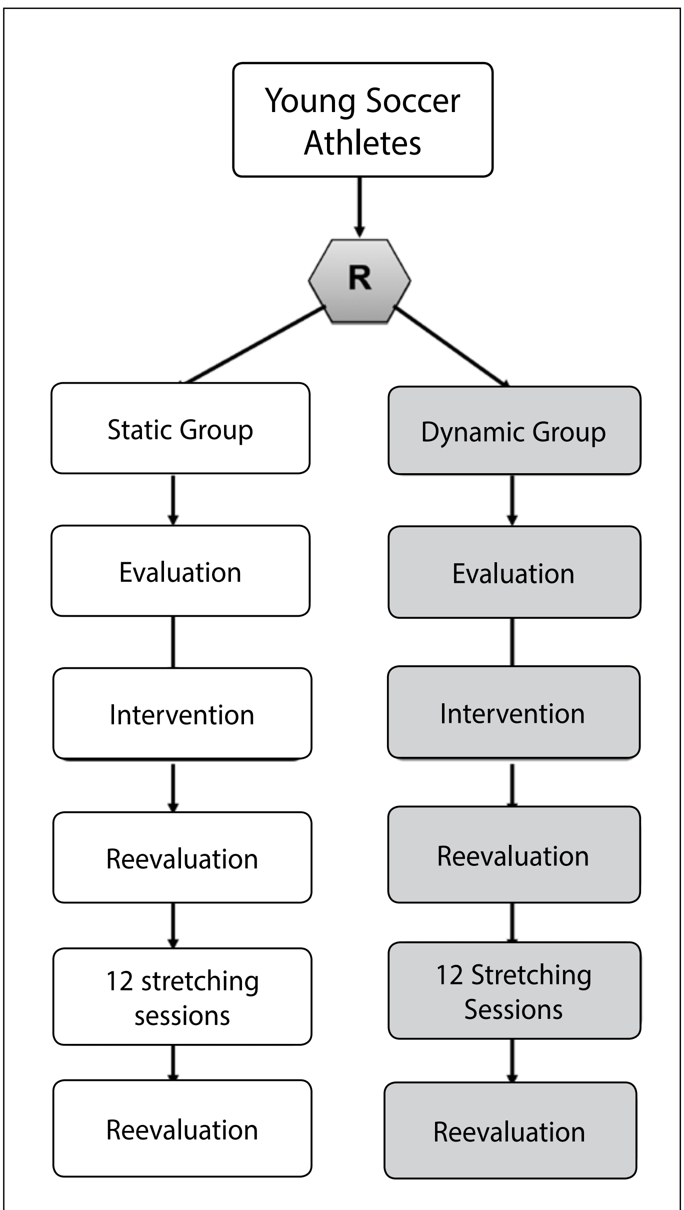


Figure 1. Study's organizational chart.

The evaluation consisted of the following items:

1. Velocity: The 50-m running test was used, according to description by Pitanga[21]. Individual at standing position, with anteroposterior leg space and trunk inclined at five meters away from the mark zero line. The athlete started the running test when the signal was given, and when he reached the mark zero line, the timer was started with the aim to set the time spent by the individual to complete the 50 meters, when the timer was stopped. Positioning at 5 meters away from the initial line is recommended so that the individual can perform the test starting from previous acceleration in a trial to avoid that reaction time interferes on the performance of the dislocation velocity.

2. Vertical impulse: The ruler test was used[21]. After the ruler was attached to the wall, the individuals was placed standing laterally to the graded surface, with extended arm above his head as high as possible. Total height of the individual was recorded and later his fingertips were marked with chalk. Subsequently, the athlete laterally moved away from the wall a bit to be able to perform the jump. Three jumps with three-minute intervals between them were performed, not preceded by gait, run, another jump or even arm move, or else the test would be considered invalid. The aim of the jump was to previously touch the digital pulps of the dominant hand at the highest point of the grading in centimeters. The difference between the initial and final marks was recorded as vertical impulse.

3. Horizontal impulse: It was performed as thee test described by Pitanga[21]. Athletes positioned with parallel feet at starting point. At the evaluator's signal, the individuals performed the horizontal jump, trying to reach as far as possible. Free move of arms and trunk was allowed. Threes attempts were performed and the mark at the posterior part of the foot was recorded and the furthest distance was considered.

4. Flexibility: The Wells bench was used[21]. The athlete was at sitting position, with feet resting at the machine and with extended legs. Afterwards, trunk and hip flexion was performed keeping knees at complete extension, with hands overlapped and resting on the measuring tape placed on the upper part of the Wells bench. Flexibility reading was performed by the evaluator, when the athlete reached the maximum forward point of trunk and hip flexion.

5. Agility: Agility was evaluated through a curved running test[21]. The athlete ran a curved path, marked with five cones, 1.50 m away from each other, and the first one was three meters away from the starting line. The athlete completed the distance running within the cones back and forth at the shortest time as possible.

6. Muscular strength evaluation of the thigh posterior muscle group: The muscular activity of the hamstring muscle was measured through hand dynamometry with a Chattanooga Group® push-pull dynamometer, performed on the lower dominant limb. Three isometric contractions of knee flexion at 60 degrees were performed, and that with the highest activity measured was recorded.

7. Electromyographic evaluation of the posterior muscular chain of the thigh: The electromyographic exam was performed with the athlete at prone position, according to Ling *et al.*[22]. Surface electromyographer, model EMG Retrainer, Chattanooga Group® with two channels and bipolar electrodes placed on the motor point of the biceps femoris and semitendinosus muscles on the dominant lower limb was used. The basic approach was the data collection, expressed in microvolts, with surface electrode attached to the skin, while the subjects performed isometric contraction kept at the hand dynamometer. Prior to the signals collection, skin was cleaned with alcohol with alcohol 70%, followed by the electrodes attachment, guided by the disposition of the muscle fibers and proof of function of the analyzed muscles.

Stretching protocols

Each athlete was submitted to a stretching protocol which consisted of four different types of stretching in each group during the period of 12 interventions.

1. Protocol of passive stretching

Exercise 1 – Athlete at standing position, with posterior musculature relaxed and feet united. The evaluator asks him to perform trunk flexion over the hip with knee steady at extension until maximum comfortable range of motion. The evaluator holds the limb and asks the athlete to take his extended arms trying to "reach" his feet.
Exercise 2 – Athlete at sitting position on the ground with lower limbs extended and relaxed. Contralateral lower limb performs light adbuction, hip flexion and knee flexion, keeping the stretching limb at extension. He performs then trunk flexion over the hip with extended arms trying to "reach" his foot, keeping this position statically.
Exercise 3 – Athlete at dorsal decubitus, relaxed. Contralateral limb remains extended. The evaluator performs hip flexion of the limb which was treated with the knee extended over the trunk, leading up to maximum range of motion and keeping it statically.
Exercise 4 – Athlete at dorsal decubitus, relaxed. Contralateral limb extended. The evaluator performs hip flexion with knee flexed over trunk and leading up to maximum range of motion. After that, the athlete "holds" his knee by the popliteal region, at the same time the evaluator performs its passive extension until maximum range of motion, keeping it statically.

2. Protocol of dynamics stretching

Exercise 1 – Athlete at orthostatism and with feet united. The evaluator asks for trunk flexion over the hip until maximum comfortable range of motion keeping knee extended. After 10 seconds, the evaluator asks the athlete to perform trunk extension against a resistance (isometric contraction) for five seconds. Subsequently, the athlete performed again stretching beyond the previous range of motion, trying to "reach" his feet and keeping this new stretching position steady.
Exercise 2 – Athlete at sitting position, relaxed. The contralateral limb performs a light flexion, hip abduction and knee flexion, keeping the limb which elongates in extension. He performs trunk flexion over the hip with extended arms, trying to "reach" the foot of the limb at stretching. He remains still for 10 seconds, and after that, the evaluator asks the athlete to perform trunk isometric extension strength against a resistance applied on the dorsal column for five seconds. Later, he performs another passive trunk flexion, repeating this process four times.
Exercise 3 – Athlete at dorsal decubitus, relaxed. The contralateral limb remains extended. The evaluator performs hip flexion with knee extended over the athlete's trunk, taking up to maximum comfortable range of motion, keeping it static for 10 seconds. Afterwards, the evaluator asks for an isometric contraction of hip extension against the evaluator's resistance. The evaluator then stretches the limb beyond its previous range of motion and repeats the process four times.
Exercise 4 – Athlete at dorsal decubitus, relaxed. Contralateral limb at extension. The evaluator performs passive flexion of the athlete's hip of the stretching limb leading up to maximum comfortable range of motion. The athlete then "holds" the knee by the popliteal region. The evaluator performs then passive knee extension until maximum range of motion, maintaining it statically. The athlete performs an isometric contraction for simultaneous hip extension and knee flexion for five seconds against resistance imposed by the evaluator. Subsequently, the evaluator stretches the limb again beyond the previous range of motion and repeats the process four times.

Statistical analysis

The SPSS program (*Statistical Package for the Social Sciences*) version 17.0 was used as statistical package. Data were expressed in frequency, mean and standard deviation, and statistically analyzed by analysis of variance (one-way ANOVA) for repeated measures, followed by Bonferroni *post-hoc* test for comparison of pre, partial and post-treatment means within the same group. Non-paired Student's *t* test was used for analysis between the two groups. The significance level for the statistical test was set at $p < 0.05$.

RESULTS

18 soccer athletes of the under-17 school from the Grêmio Torrense Club, mean age of 15.78 ± 0.81 (static stretching group 15.89 ± 0.92; dynamic stretching group 15.89 ± 0.92), were assessed between August and November, 2010. No statistically significant differences have been found in any of the variables between the two groups (table 1).

The group of assessed athletes presented two goalkeepers, three wingers, three defenders, three central midfielders, three midfielders and four forwards (table 1).

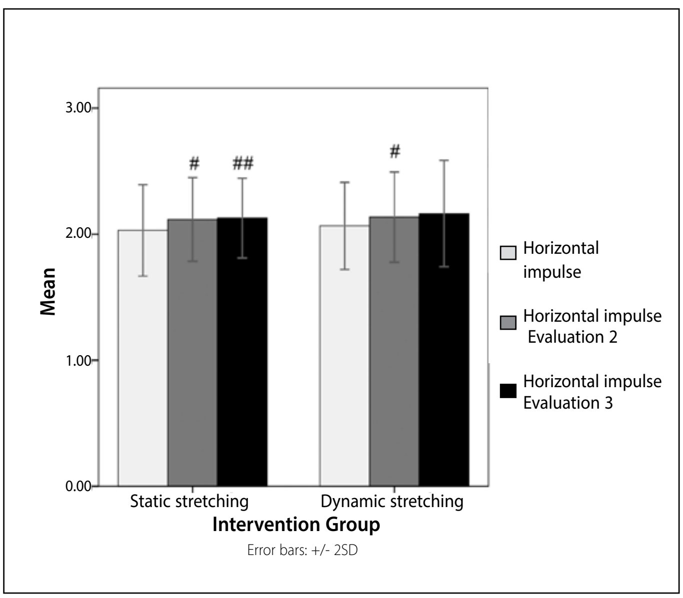
Significant differences have not been found after acute or chronic intervention in the vertical impulse and agility valences.

In the evaluation of the horizontal impulse, significant improvement in an acute manner was verified in both stretching groups ($p < 0.005$) compared with the initial evaluation. Only the static stretching group maintained the result in a chronic effect; that is to say, after the end of the 12 static stretching sessions it maintained significant gain of impulse compared with the initial evaluation ($p = 0.02$) (figure 2).

Flexibility of posterior muscular chain significantly improved in the two stretching groups in an acute effect ($p = 0.01$). After the 12 days of training, only the static stretching group kept the result in a chronic effect ($p = 0.03$). There was a tendency to chronic improvement also in the static group ($p = 0.056$) (figure 3).

Table 1. Characteristics of the sample.

	Static stretching group	Dynamic stretching group	p Value
Age (mean, SD)	15.89 ± 0.92	15.67 ± 0.70	0.435
Color			
White	9	9	
Black	0	0	1.00
Injury			
Yes	3	0	
No	7	10	0.105
Athlete's position			
Goalkeeper	1	1	
Winger	0	3	
Defender	1	2	
Central	2	1	
Midfielder	2	1	
Midfielder	3	1	0.416
Forward			
n Total	9	9	-



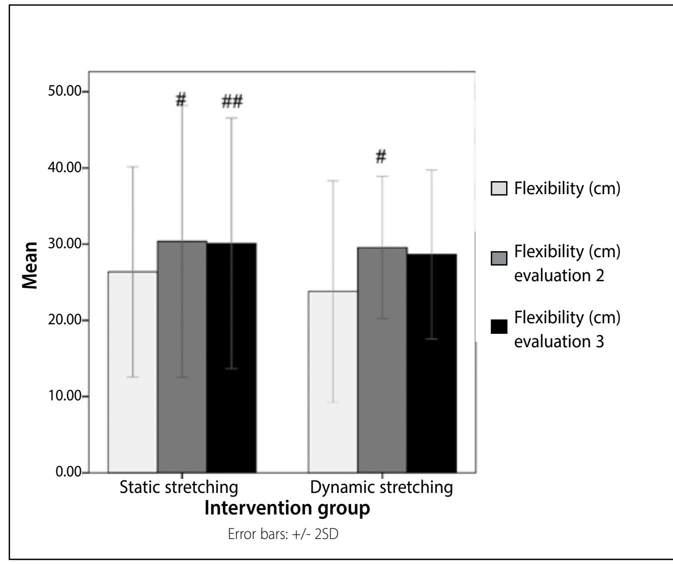
# p<0.005 concerning the initial evaluation. ## p=0.02 concerning the initial evaluation.

Figure 2. Pre and post-treatment horizontal impulse analysis.

Velocity significantly increased in both groups in an acute effect after the first intervention ($p < 0.003$ in the static group and $p = 0.019$ in the dynamics group) compared with the initial evaluation. There was no alteration of this variable at the end of the protocol compared with the initial evaluation in the two groups (figure 4).

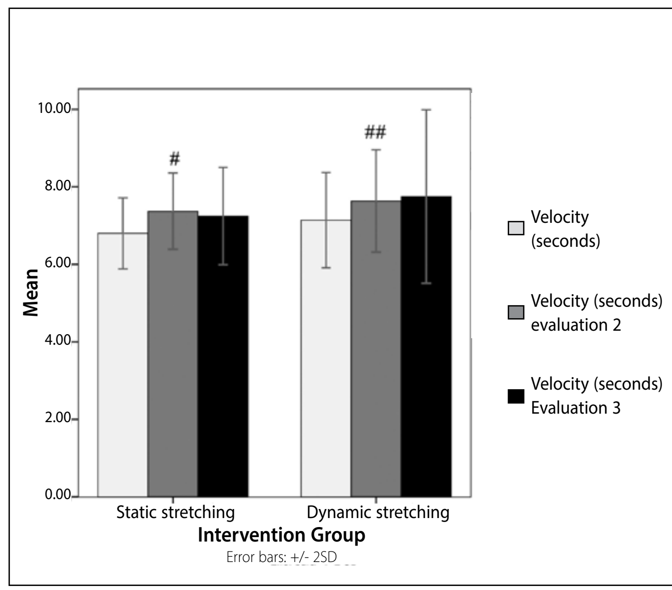
Improvement of muscular strength of hamstrings was not observed during the study in the two groups. Both groups presented tendency to chronic improvement of strength compared with the initial evaluation ($p = 0.08$ for static and $p = 0.09$ for dynamic) (figure 5).

Surface electromyography of hamstrings presented very different results between the two groups. While the static group presented remarkable decrease of electrical signal in the acute phase ($p = 0.035$), the dynamic stretching presented clear increase in the chronic phase compared with the initial evaluation ($p = 0.038$) (figure 6).



p=0.01 concerning the initial evaluation. ## p=0.03 concerning the initial evaluation.

Figure 3. Pre and post-treatment flexibility analysis.



# p<0.003 concerning the initial evaluation. ## p=0.019 concerning the initial evaluation.

Figure 4. Pre and post-treatment velocity analysis.

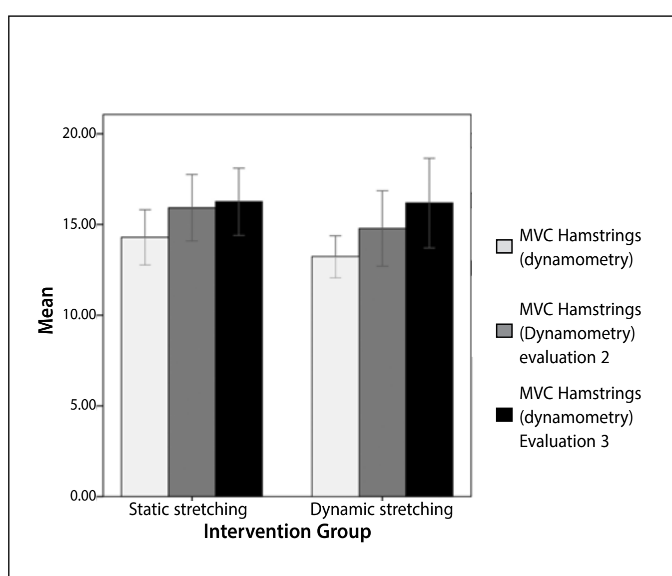
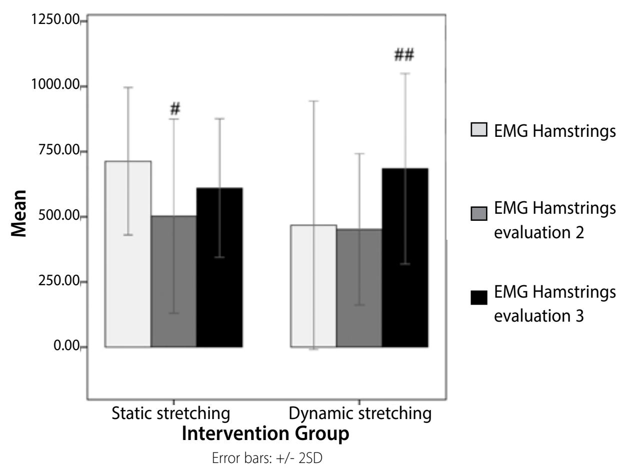


Figure 5. Pre and post-treatment analysis of hamstrings muscular strength.



p=0.035 concerning the initial evaluation. ## p=0.038 concerning the initial evaluation.

Figure 6. Analysis of the eletromyographic activity pre and post-treatment.

DISCUSSION

Despite the wide use of stretching techniques before physical exercises as prevention for injuries, there is still massive controversy and little conclusive scientific evidence which supports this idea[11,12]. Epidemiological investigation studies mention flexibility decrease as an etiological in acute muscular injury[13-16]. Another study concludes that flexibility improvement by stretching may reduce the risk to injury[17]. Recent *in vitro*[23,24] and *in vivo* studies[25] have shown relaxation of transitory stress in response to passive stretching.

It was verified that the two stretching examples decreased velocity during the acute 50 m test. These results corroborate the ones found by Fowles *et al.*[26], who assessed the use of static stretching and found out that static stretching before velocity exercises could negatively interfere due to the decrease in activation of the motor units, possibly being responsible for the decrease in maximum strength capacity after stretching exercises. Achour[27] also supports this effect saying that the motor messages could be slowly transmitted due to deformations of the muscular plastic components. Another study showed that the static stretching method with duration between 15 and 30 seconds per muscular group is related to the reduction in the recruiting activity of the motor units[28] and, consecutively, loss of velocity. In our study, we observed that static stretching performed for 30 seconds led to inhibition of electric activity of hamstrings in that group.

If we observe the chronic effect, it is verified that the static stretching maintained the flexibility gain reached in the acute phase, while in the dynamic group, it only presented improvement in the end of the training. The good flexibility results obtained corroborate the ones by Marques *et al.*[29], who stated that passive stretching increases flexibility of the hamstrings musculature. Zakas[30] confirms flexibility improvement when static stretching is used for 30 seconds; however, no results were observed when they were performed for 15 seconds. Additionally, Zenewton *et al.*[31] describe acute flexibility gain of the dynamic stretching three times per week. Nelson and William[32] support the thesis that both the static and dynamic stretching groups increase flexibility of hamstrings compared with the control group. Moreover, they state that there was no significant difference between the static and dynamic stretching groups, with both having performed 30 seconds of stretching. O'Sullivan *et al.*[33] describe that static stretching should be used when the aim is gain in flexibility. They reported that after 15 minutes, stretching slightly decreases its effect; however, it continues with significant difference greater than in the control group.

Better horizontal impulse was verified in both groups as acute effect. In the static group, this improvement was kept as chronic effect. Yuktasir and Kaya[34] evaluated the delayed effect of static stretching and in proprioceptive neuromuscular facilitation (PNF), in which they confirmed that there are not alterations of this valence after the intervention program. Handel *et al.*[35] cite maximal torque improvement compared with the control group, observing increase of concentric work of the flexor and extensor muscles of the knee. The authors also observed increase of the number of sarcomeres in series.

Concerning muscular strength, it was verified that both groups presented tendency to increase in hamstring strength as chronic effect. However, only the dynamic group confirmed significant electric activation of hamstrings on the surface electromyography. It is important to highlight that most of the studies analyzes the acute effect of the many ways of stretching in muscular strength; however, we have not found studies approaching their chronic effect. A study carried out in 2006 suggests that static stretching exercises are put aside when the activity involved later requires great strength production, since loss of strength or increase of possibility for injury is increase is observed[36]. Tricoli and Paulo[37], when investigating the acute effect of static stretching in maximum strength of lower limbs, reported that these were able to significantly reduce strength. Another study stated that both static stretching and PNF stretching reduce strength and the capacity to produce energy, specifically, if the hypothesis that stretching may have altered the length-tension ratio and/or the plastic deformity of the conjunctive tissues, in such a way that maximum strength of production of the musculotendon unit capacity may be limited[38]. In this study a control group was not used since the sample was composed of only 18 eligible subjects. We believe further studies with bigger samples, use of a control group and which analyze delayed effects of a stretching program are necessary to confirm our results.

CONCLUSION

It was concluded in this study that static stretching improves flexibility and horizontal impulse in an acute and chronic way, while both stretching ways improve muscular activation as a chronic result.

All authors have declared there is not any potential conflict of interests concerning this article.

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