Flexibility behavior after 10 weeks of resistance training*

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ABSTRACT

The objective of this study was to analyze the flexibility behavior of different articulations after 10 weeks of resistance training (RT). That is why, 16 inactive men (23.0 ± 2.1 years; 68.0 ± 7.0 kg; 178.8 ± 8.7 cm) apparently healthy were randomly divided into training group (TG, n = 8) and control group (CG, n = 8). The group TG was submitted to 10 consecutive weeks of RT (three weekly sessions in alternated days), whereas for group CG, no systematized program of physical activities was developed in this period. The 11 exercised that composed the RT program were performed in three series of 8-12 RM. The shoulder flexion and extension, trunk flexion, lateral flexion and extension, hip extension and flexion, elbow extension and flexion and knee flexion were used for the analysis of the flexibility behavior. The ANOVA and ANCOVA for repeated measures, followed by the Tukey *post hoc* test for $P \leq 0.05$ were used for data treatment. Significant increase on flexibility between pre and post experiment were found in TG in shoulder flexion movements (right hemisphere, $P < 0.05$), hip extension (left hemisphere, $P < 0.05$), trunk extension ($P < 0.05$), trunk flexion ($P < 0.05$) and trunk lateral flexion (right hemisphere, $P < 0.05$; left hemisphere, $P < 0.01$). Although, the effect of the interaction group vs time was only identified in elbow flexion movements (right and left hemisphere, $P < 0.05$), hip extension (left hemisphere, $P < 0.05$) and trunk lateral flexion (left hemisphere, $P < 0.01$). Thus, the results of the present study suggest that the 10 first weeks of RT practice may contribute effectively for the maintenance or improvement of the flexibility levels observed in the pre-training period, in different articulations.

Key words: Flexibility. Resistance training. Physical fitness. Fleximeter.

INTRODUCTION

Adequate levels of muscular strength and flexibility are essential for the good muscle-skeletal functioning, also contributing for the maintenance of healthy muscles and joints during life time[1]. On the other hand, the decline on both the muscular strength and the flexibility levels is progressively impairing the performance of different daily tasks, many times leading to the early lose of autonomy[2,3].

Thus, the regular practice of physical exercise programs aimed at the development or maintenance of the muscular strength and flexibility or even of other important components of the physical fitness related to health may play extremely important role during life time.

Considering this, among the different types of physical exercises, the systematized regular practice of resistance exercises has been encouraged by some of the most important international organizations involved in studies about populational health[2-5].

This fact is fully justified based on countless positive information related to this type of physical exercise that has been published by the literature in the last years such as: reduction of risk factors associated to cardiovascular diseases and to the diabetes mellitus non-insulin dependent; osteoporosis prevention; reduction or maintenance of the body mass; improvement of the dynamic stability and preservation of the functional capacity[6]. Thus, the number of participants of resistance exercise programs among young people, adults and aged from both gender and with different levels of physical fitness has increased significantly.

There is still much controversy related to the isolated practice of resistance training (RT). One of these controversies is related to possible negative modifications that, apparently, may be caused by RT during the time on the flexibility levels, once the information available in literature in this regard is not conclusive.

In this context, the hypotheses are supported by studies involving the analysis of the acute effect of RT on the flexibility or yet, by transversal studies, which there is an attempt of extrapolating the information found at a given moment, above all, in athletes with large experience on RT, however, without a more detailed follow-up of other variables supposedly involved in the process.

Although some of these studies point to a reduction on the flexibility levels shortly after the practice of the resistance training[7,8], some relevant methodological limitations such as the lack of standardization of the training programs performed by the subjects, the measure instrument used, the reduced number exercises performed, among others, impair a more detailed analysis of the information produced. Besides, a possible explanation for the range of motion reduction verified in these studies based on the relaxation stress was not confirmed with the use of a more sophisticated technique such as the electromyography[8], what suggests that other factors yet unknown may be involved in this process.

Thus, the objective of the present study was to analyze the flexibility behavior after 10 weeks of a TP systematized program in untrained young adults.

METHODOLOGY

Subjects

Sixteen men (23.0 ± 2.1 years; 68.0 ± 7.0 kg; 178.8 ± 8.7 cm), apparently healthy voluntarily participated in this study. As initial inclusion criterion, the participants should be inactive or moderately active (regular physical activity < 2 times per weeks) as well as not having participated regularly of any physical exercise program in the last six months prior to the beginning of the experiment. Furthermore, each participant previously answered a questionnaire about the health history and no metabolic or muscle-skeletal dysfunction was reported.

From this point on, the subjects were randomly divided into two groups, each of them composed of eight individuals. The first group, called training group (TG) was submitted to 10 weeks of standardized resistance training practice, whereas the second group had no involvement in any regular physical exercise program.

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The individuals, after being informed about the investigation objectives and the procedures to which they would be submitted, signed a consent form. This study was approved by the Ethics Research Committee of the Londrina State University, according to norms of the resolution 196/96 of the National Health Council on researches involving human beings.

Resistance training program

The RT program was performed during 10 consecutive weeks, three times a week, performed in alternated days. The frequency to the training sessions was above 86% (26 to 30 sessions).

The individuals from group TG were previously submitted to a period of two adaptation weeks before the beginning of the RT program with the objective of learning the motive tasks and familiarizing with the technical aspects (movement performance speed, repetitions counting, control of the recovery and respiration intervals during exercises), performing a total of six training sessions in this period.

Considering that participants of this study were not involved with the systematized practice of physical exercises for several months, it was opted to structure the RT program as a circuit (simple or alternated segment assemblage).

Thus, the training program was composed of 11 exercises for different muscular groups named: bench press and flat dumbbells fly (pectoral); lat pull down, seated row and barbell curve row (back); knee curls and squat (thigh); shoulder press (shoulder), arm curls and elbow extension with barbell in supine position in horizontal bench (biceps and triceps, respectively), sit up (abdomen).

All exercises were performed in three series of 8 to 12 maximal repetitions (RM), except for the exercise for the abdomen muscular group, which was performed in three fixed series of 50 repetitions with the own body overload. A warm-up series of 15 repetitions with approximately 50% of the load to be used in each exercise was arbitrarily added to the first three exercises of the sequence in the attempt of furthering the physiological and neural responses to the subsequent efforts. The recovery interval established between series was approximately 1:3 (execution time per recovery time), equivalent to 60-90 seconds. On the other hand, the transition interval between exercises was of 90 to 120 seconds. Although the movements' performance speed had not been controlled, the subjects were oriented to try to perform each movement in the concentric phase in the time of 1 to 2 seconds and in the eccentric phase in the time of 2 to 4 seconds.

Both the initial loads and the periodic readjustments in loads used in the different exercises were established based on results obtained by means of the application of maximal repetitions tests[9]. The individuals were oriented so that the training loads were readjusted every time the repetitions upper limit preestablished for each exercise was reached in all series so that the initial intensity could be preserved.

The subjects were also oriented not to perform any flexibility specific activity during the study period, so that the impact of the weigh training on this physical capacity could be evaluated isolated.

Flexibility

Based on the biomechanical analysis of the exercises selected to compose the resistance training program and correlating them to movements possible to be performed, 10 articular movements were adopted for the analysis of the flexibility behavior (shoulder extension and flexion; elbow extension and flexion; hip extension and flexion; trunk lateral flexion, flexion and extension and knee flexion). Except for the trunk extension and flexion movements, all measures were collected bilaterally.

It is important to know that only the elbow extension and flexion movements and the trunk flexion and lateral flexion were performed in the orthostatic position. For the other movement, it was opted to maintain subjects laid on a stretcher in order to neutralize possible compensatory movements.

Flexibility was actively measured and the subjects executed each articular movement three times without previous warm-up. During the performance of measures, the individuals were oriented to remain at the final position until the appraiser could perform the reading. The highest score obtained among the three measures in each articular movement was adopted as the reference value.

All measures were obtained by means of a fleximeter, which patent and register belong to the Code Research Institute (Brazil), with accuracy of one degree, according to procedures and recommendations of Achour Jr.[10]. During evaluations, the equipment was fixed to the limb corresponding to the articulation to be evaluated by means of velcro. It is worthy emphasizing that a single appraiser with experience no shorter than two years performed both measures at both pre and post experiment moments. However, the information previously obtained was not given to the appraiser at the reevaluation moment in the attempt of avoiding any type of interference that could impair the quality of data. The measure technical error found in each movement analyzed at the initial moment of the study is presented in table 1.

TABLE 1
Technical error of measure (degrees) found in the baseline during evaluation of the flexibility levels in 10 joints movements

Movements	Right hemisphere	Left hemisphere	Total
Shoulder flexion	1.03	1.16	–
Shoulder extension	1.02	1.16	–
Elbow flexion	1.20	1.02	–
Elbow extension	1.22	1.12	–
Hip flexion	1.19	1.05	–
Hip extension	0.95	0.88	–
Trunk extension	–	–	0.95
Trunk flexion	–	–	1.24
Trunk lateral flexion	1.03	0.90	–
Knee flexion	1.15	1.10	–

Statistical treatment

The analysis of variance (ANOVA) 2x2 for repeated measures was used to evaluate possible modifications in the flexibility levels of both groups (TG and CG) during the experiment). In movements in which the initial conditions of groups were different, the analysis of covariance (ANCOVA) for repeated measures was used, with the preexperiment values being used as co-variables. The Tukey HSD *post hoc* test was used for the identification of specific differences in variables in which the F values found were higher than the statistical significance criterion established ($P \leq 0.05$).

RESULTS

The flexibility behavior at the shoulder flexion and extension movements in the right and left hemisphere before and after 10 weeks of RT is presented in table 2. No effect that could be attributed to RT was verified in these movements ($P > 0.05$), although the isolated effect of time ($P < 0.01$) has been verified in the shoulder flexion movements in both hemispheres. Despite the lack of statistical significance in the comparisons between groups ($P > 0.05$), the variations observed from pre to post test for group TG (increments of 10-12 degrees and 3-5 degrees in flexion and extension movements, respectively) were higher if compared to group CG (increments of 6-9 degrees in flexion and 2-3 degrees in extension).

An increase on the elbow flexion movement range in group TG (six and four degrees in right and left hemisphere, respectively), associated to a reduction on group CG (three degrees in both hemispheres), resulted in significant interactions (group x time) for both hemispheres ($P < 0.05$), as can be observed in table 3. On the other hand, no isolated effect of time and group was identified in the elbow extension movement ($P < 0.05$).

TABLE 2
Flexibility behavior (degrees) in shoulder flexion and extension movements before and after 10 weeks of resistance training

Movements	TG (n = 8)	CG (n = 8)	Effects	F	P
Shoulder flexion			ANOVA		
(right hemisphere)			Group	0.55	0.47
Pre	167 ± 14	164 ± 17	Time	10.89	< 0.01
Post	177 ± 10*	170 ± 15	Group x Time	0.68	0.42
Shoulder flexion			ANOVA		
(left hemisphere)			Group	0.05	0.83
Pre	164 ± 10	164 ± 16	Time	10.70	< 0.01
Post	176 ± 12	173 ± 15	Group x Time	0.12	0.73
Shoulder extension			ANCOVA		
(right hemisphere)			Group	0.12	0.73
Pre	70 ± 16	58 ± 8	Time	2.79	0.12
Post	75 ± 23	61 ± 12	Group x Time	0.04	0.85
Shoulder extension			ANCOVA		
(left hemisphere)			Group	0.01	0.96
Pre	71 ± 15	60 ± 10	Time	0.77	0.39
Post	74 ± 23	62 ± 9	Group x Time	0.05	0.82

* $P \leq 0.05$ vs Pre.
Note: The results are expressed as average values ± SD.

TABLE 3
Flexibility behavior (degrees) in elbow flexion and extension movements before and after 10 weeks of resistance training

Movements	GT (n = 8)	GC (n = 8)	Effects	F	P
Elbow flexion			ANOVA		
(right hemisphere)			Group	0.83	0.38
Pre	149 ± 10	156 ± 4	Time	0.76	0.40
Post	155 ± 7	153 ± 6	Group x Time	4.38	0.05
Elbow flexion			ANOVA		
(left hemisphere)			Group	0.13	0.72
Pre	151 ± 11	156 ± 5	Time	0.09	0.77
Post	155 ± 9	153 ± 4	Group x Time	6.05	0.03
Elbow extension			ANOVA		
(right hemisphere)			Group	2.60	0.13
Pre	154 ± 9	160 ± 6	Time	0.17	0.69
Post	155 ± 9	161 ± 8	Group x Time	0.01	0.93
Elbow extension			ANOVA		
(left hemisphere)			Group	0.63	0.44
Pre	155 ± 15	158 ± 5	Time	0.10	0.75
Post	155 ± 9	159 ± 6	Group x Time	0.10	0.75

Note: The results are expressed as average values ± SD.

In table 4, the flexibility behavior in the hip extension and flexion movements is presented for both hemispheres. An interaction group x time was verified only for the hip extension movement in the left hemisphere ($P < 0.05$), with group GT presenting increase of eight degrees and group CG presenting reduction of two degrees after the period of 10 weeks. No modification as result of the RT was found for the other movements. It is important to know that group TG presented non-significant increments in the range of the right (four degrees) and left (two degrees) hip flexion movements as well as in the right hip extension movement (four degrees).

The results presented by table 5 indicate that despite the isolated effect of time being verified in the trunk extension movements, trunk flexion and trunk lateral flexion in the right hemisphere ($P < 0.05$), significant increases of the order of eight, eight and seven degrees, respectively, were identified only for group TG ($P < 0.05$). On the other hand, in the trunk lateral flexion movement in the left hemisphere, the increase of 10 degrees for group TG followed by a decrease of 2 degrees for group CG resulted in an interaction group x time ($P < 0.01$).

TABLE 4
Flexibility behavior (degrees) in hip flexion and extension movements before and after 10 weeks of resistance training

Movements	GT (n = 8)	GC (n = 8)	Effects	F	P
Hip flexion			ANOVA		
(right hemisphere)			Group	0.60	0.45
Pre	71 ± 5	74 ± 10	Time	3.32	0.09
Post	75 ± 7	77 ± 8	Group x Time	0.05	0.83
Hip flexion			ANOVA		
(left hemisphere)			Group	4.30	0.06
Pre	72 ± 5	77 ± 7	Time	0.68	0.42
Post	74 ± 8	79 ± 8	Group x Time	0.03	0.87
Hip extension			ANOVA		
(right hemisphere)			Group	0.02	0.89
Pre	35 ± 7	36 ± 8	Time	2.37	0.15
Post	39 ± 8	36 ± 6	Group x Time	1.41	0.26
Hip extension			ANOVA		
(left hemisphere)			Group	0.21	0.66
Pre	32 ± 7	36 ± 8	Time	2.31	0.15
Post	40 ± 7*	34 ± 5	Group x Time	6.08	0.03

* $P \leq 0.05$ vs Pre.
Note: The results are expressed as average values ± SD.

TABLE 5
Flexibility behavior (degrees) in trunk flexion, extension and lateral flexion movements before and after 10 weeks of resistance training

Movements	GT (n = 8)	GC (n = 8)	Effects	F	P
Trunk extension			ANCOVA		
			Group	0.20	0.66
Pre	29 ± 7	38 ± 13	Time	7.20	0.02
Post	37 ± 9**	41 ± 10	Group x Time	1.64	0.22
Trunk flexion			ANCOVA		
			Group	0.22	0.65
Pre	115 ± 18	126 ± 7	Time	6.94	0.02
Post	123 ± 11**	128 ± 10	Group x Time	2.41	0.14
Trunk lateral flexion			ANOVA		
(right hemisphere)			Group	3.42	0.09
Pre	51 ± 8	50 ± 4	Time	4.97	0.04
Post	58 ± 4**	51 ± 6	Group x Time	3.50	0.08
Trunk lateral flexion			ANOVA		
(left hemisphere)			Group	4.65	0.05
Pre	49 ± 4	51 ± 5	Time	12.08	< 0.01
Post	59 ± 3*	49 ± 4	Group x Time	20.23	< 0.01

* $P \leq 0.01$ or ** $0.01 < P \leq 0.05$ vs Pre.
Note: The results are expressed as average values ± SD.

TABLE 6
Flexibility behavior (degrees) in knee flexion movements before and after 10 weeks of resistance training

Movements	GT (n = 8)	GC (n = 8)	Effects	F	P
Knee flexion			ANOVA		
(right hemisphere)			Group	0.43	0.52
Pre	127 ± 10	131 ± 8	Time	2.93	0.11
Post	133 ± 11	133 ± 7	Group X Time	0.50	0.49
Knee flexion			ANOVA		
(left hemisphere)			Group	0.01	0.99
Pre	129 ± 9	131 ± 9	Time	1.87	0.19
Post	134 ± 10	132 ± 8	Group X Time	1.07	0.32

Note: The results are expressed as average values ± SD.

No effect of time or RT was verified in the knee flexion movement in any hemisphere ($P > 0.05$). However, it is observed in table 6 that an increase of higher range for group TG occurred (six degrees in the right hemisphere and one degree in the left hemisphere) when compared to group CG (two degrees in the right hemisphere and one degree in the left hemisphere), although these differences have not been statistically confirmed ($P > 0.05$).

DISCUSSION

Although there are researchers who support the performance of warm-up exercises before the beginning of the practice of different nature exercises, the probable benefits from this activity (muscle temperature elevation, increase on the nervous impulses, reduction on the muscular and articular stiffness, decrease on the muscle viscosity, prevention of lesion) are yet very controversial in the perspective of improvement of the physical performance, contributing or not, according to the motive task to be performed[11-14].

In addition, for the performance of a warm-up exercise considered as adequate, a combination between activities with general and specific characteristics would be required[14]. Thus, for the warm-up of the five articulations analyzed in the present study, at least 10 minutes of general warm-up exercises and approximately five more minutes of specific warm-up exercises for each articulation would be required, in other words, a time similar to that of each individual evaluation (~35 minutes) without previous warm-up. So, after the analysis of the cost-benefit relation, we have decided for the non-performance of a previous warm-up exercise before the evaluation of the flexibility levels.

Considering that the flexibility in a specific joint depends on its utilization level, the involvement in regular physical exercise programs may further the improvement of the flexibility levels, especially for inactive subjects, once the articulations, so far seldom used and probably shortened, will receive a progressive stimulus that will lead to medium or long-term positive adaptations.

This hypothesis was verified at least in part in the present study, once by means of the stimulus provided along 10 weeks of resistance training, the subjects, initially classified as inactive, achieved maintaining or even improving the flexibility levels in all five articulations analyzed.

The results found in the present study may be considered as very promising, above all in the health perspective, based on the principle that with aging, the reduction on the flexibility levels and muscular strength may affect negatively the quality of life of the human being, once this fact limits the performance of the daily movements, besides increasing the risk of lesions from falls by means of the reduction on the articular stability[15]. However, the application of this type of information may also be of great usefulness for sports, especially for modalities in which the athletes search for optimum levels both in strength and in flexibility.

Another point to be emphasized is that the resistance training furthered flexibility increases in some joints and maintenance in others, regardless the practice of specific flexibility exercises. Even joints where significant flexibility increases were not verified ($P > 0.05$), most modifications observed in absolute values were higher for group TG than for group CG.

The results of the present study corroborate the findings of Thrash & Kelly[16], who after submitting 13 men (18 to 41 years) to 11 weeks of RT (eight exercises performed in three series of eight repetitions, there times a week in alternated days) verified increases in absolute values in all six movements analyzed (ankle dorsal-flexion and sole flexion, trunk extension and flexion and shoulders extension and flexion). However, increments statistically significant ($P \leq 0.05$) were observed only in the shoulder extension movements (~ seven degrees) and ankle dorsal-flexion (~ six degrees). The main limitations for a more consistent analysis of these information was the inexistence of a control group as well as the lack of information on the initial levels of physical fitness of the subjects investigated. However, the study used the flexometer Leighton for the flexibility measures, approximating to the characteristics of the instrument employed in the present investigation (fleximeter).

In another study, conducted by Fatouros *et al.*[15], eight aged subjects submitted to RT for 16 weeks presented significant increases ($P < 0.05$) in the range of the knee flexion movements (nine degrees); elbow flexion (nine degrees); shoulder flexion and extension (18 and 15 degrees, respectively) and hip flexion and extension (nine and six degrees, respectively). In all movements analyzed, the increments were higher to increments found in the present study, what may probably be explained, at least in part, due to differences in the duration of the protocols (10 vs 16 weeks). It is important to emphasize that in this research, the behavior of groups that received other types of training (cardiovascular alone or combined cardiovascular and RT) was also analyzed, and for the analysis of the possible effects of each training regimen, a control group was used. The results indicated that the practice of RT might increase the flexibility of the aged population, above all, in the hip articulation, thus providing higher stability for the performance of simple daily tasks.

On the other hand, unlike the first weeks of RT where the neural adaptations are considered as determinant factors for the development of the muscular strength, as the training weeks elapsed, the morphological adaptations in the muscular fibres trend to contribute progressively for the changes on the muscular strength[45]. Although the temporal standard in which these modifications occur is not yet well established by literature, the increase on the muscular volume induced by resistance training may limit the range of motion of several joints giving the false impression of reduction on the flexibility levels.

Despite theses important adaptations have not been controlled in the present study, probably this fact could explain the lower levels of flexibility found in bodybuilder athletes in some joints specifically, when compared to untrained subjects or to athletes from other modalities[17,18]. According to these studies, the joint presenting the lowest involvement degree seems to be the shoulder articulation, probably because bodybuilders rather care about the performance of high-volume and intense training in this joints, aiming at higher muscular gains.

It is important to emphasize that at least two out of the three main characteristics of a RT program that might aid on the increase of flexibility are not part of training programs of most bodybuilders, in other words, the inclusion of flexibility exercises and the performance of all weigh exercises making use of the total movement range. The third characteristic would be the balance both in the volume and in the training intensity for antagonistic muscular groups[19].

Unlike what has been observed in studies involving bodybuilders, the subjects from this investigation presented increases on the shoulder flexion movement range after 10 weeks of RT, even without the inclusion of flexibility exercises in the training program. Considering the possible explanations for this distinct behavior, when bodybuilders and inactive individuals are compared, we could mention: the different trainability levels, distinct objectives with regard to training, different program assemblages (alternated by segment vs localized by articulation). Furthermore, the subjects from this study received frequent orientation along training in order to maintain the performance quality of all program's exercises, respecting the complete range of movements.

The possible relations between the modifications on the muscular strength and flexibility were not analyzed in the present study either, once other researchers have indicated low relations between these variables, both in young adults[20] and in older adults[21].

CONCLUSIONS

The RT program employed in this study did not cause reduction on the flexibility values observed before the intervention period. Besides, the results found suggest that the first ten weeks of RT practice may contribute for the maintenance or even improvements on flexibility in several articulations.

Despite the interesting results found in the present investigation, it is suggested that new researches be conducted for longer periods of time with individuals from both genders, from different ages and with different levels of physical fitness. The involvement of other articulations as well as the follow-up of different components of the body composition, above all, the muscular mass, will aid on the production of information that will provide a more adequate prescription of training programs that will come to further both the health improvement and the athletic performance.

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REFERENCES

1. Alter MJ. Ciência da flexibilidade. 2nd ed. Porto Alegre: Artes Médicas, 1999.
2. American College of Sports Medicine. Exercise and physical activity for older adults. Med Sci Sports Exerc 1998;30:992-1008.
3. American College of Sports Medicine. Position stand: the recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. Med Sci Sports Exerc 1998; 30:975-91.
4. Pollock ML, Franklin BA, Balady GJ, Chaitman BL, Fleg JL, Fletcher B, et al. AHA Science Advisory. Resistance exercise in individuals with and without cardiovascular disease: benefits, rationale, safety, and prescription: an advisory from the Committee on Exercise, Rehabilitation, and Prevention, Council on Clinical Cardiology, American Heart Association; Position paper endorsed by the American College of Sports Medicine. Circulation 2000;101:828-33.
5. Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML. Exercise standards: a statement for healthcare professionals from the American Heart Association. Circulation 1995;91:580-615.
6. American College of Sports Medicine. Position stand: progression models in resistance training for healthy adults. Med Sci Sports Exerc 2002;34:364-80.
7. Monteiro WD, Farinatti PTV. Efeitos agudos do treinamento de força sobre a flexibilidade em praticantes não atletas em academias. Rev APEF 1996;11:36-42.
8. Wiemann K, Hahn K. Influences of strength, stretching and circulatory exercises on flexibility parameters of the human hamstrings. Int J Sports Med 1997;18: 340-6.
9. Rodrigues CEC, Rocha PECP. Musculação: teoria e prática. Rio de Janeiro: Sprint, 1985.
10. Achour A Jr. Avaliando a flexibilidade: flexímeter. Londrina: Midiograf, 1997.
11. Church JB, Wiggins MS, Moodle FM, Crist R. Effect of warm-up and flexibility treatments on vertical jump performance. J Strength Cond Res 2001;15:332-6.
12. Elam R. Warm-up and athletic performance: a physiological analysis. Natl Strength Cond Assoc J 1986;8:30-2.
13. Gray S, Nimmo M. Effects of active, passive or no warm-up on metabolism and performance during high-intensity exercise. J Sports Sci 2001;19:693-700.
14. Hedrick A. Physiological responses to warm-up. Natl Strength Cond Assoc J 1992;14:25-7.
15. Fatouros IG, Taxildaris K, Tokmakidis SP, Kalapotharakos V, Aggelousis N, Athanasopoulos S, et al. The effects of strength training, cardiovascular training and their combination on flexibility of inactive older adults. Int J Sports Med 2002; 23:112-9.
16. Thrash K, Kelly B. Flexibility and strength training. J Appl Sport Sci Res 1987;1: 74-5.
17. Barlow JC, Benjamin BW, Birt PJ, Hughes CJ. Shoulder strength and range-of-motion characteristics in bodybuilders. J Strength Cond Res 2002;16:367-72.
18. Beedle B, Jessee C, Stone MH. Flexibility characteristics among athletes who weight train. J Appl Sport Sci Res 1991;5:150-4.
19. Stone MH, Fleck SJ, Triplett NT, Kraemer WJ. Health- and performance-related potential of resistance training. Sports Med 1991;11:210-31.
20. Carvalho ACG, Paula KC, Azevedo TMC, Nóbrega ACL. Relação entre flexibilidade e força muscular em adultos jovens de ambos os sexos. Rev Bras Med Esporte 1998;4:2-7.
21. Girouard CK, Hurley BF. Does strength training inhibit gains in range of motion from flexibility training in older adults? Med Sci Sports Exerc 1995;27:1444-9.