



Impact of an eight-week weight training program on the muscular strength of men and women*

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ABSTRACT

The objective of the present study was to verify the impact of an eight-week weight training program (WT) on the muscular strength. To do so, 23 men (20.7 ± 1.7 years) and 15 women (20.9 ± 2.1 years), apparently healthy and moderately active (regular physical activity < 2 times a week) were submitted to a WT program composed of 10 exercises for the different muscular groups during eight consecutive weeks. Three series of 8-12 RM were performed in each exercise in three weekly sessions with intervals each 48 hours. The pre and post-training muscular strength was determined by means of 1-RM tests in bench press, squat and arm curl exercises after five familiarization sessions. Increases on the muscular strength were verified in both genders in all exercises investigated as well as in the total amount of load lifted ($P < 0.01$). Although men presented higher absolute strength when compared to women in all exercises evaluated, the gains observed along time were higher for women (14.7 vs. 7.6% in squat; 17.2 vs. 11.0% bench press; 20.4 vs. 14.0% in arm curl). The results suggest that the eight-week WT period seems to be sufficient to promote significant modifications in the muscular strength of men and women in different body segments (lower limbs, trunk and upper limbs).

INTRODUCTION

Weight training (WT) is one of the physical exercise modalities most practiced by individuals from different age ranges, both genders and with diverse physical fitness levels. This fact may be easily explained by the several benefits this practice brings that includes since important morphological, neuromuscular and physiological modifications up to social and behavioral alterations.

One of the main alterations associated the practice of WT reported in literature has been the increase on the muscular strength levels, both in children and adults as well as in older people from both genders⁽¹⁻³⁾. This adaptation seems to be associated with at least two factors called as neural adaptations and muscular hypertrophy.

In this context, in untrained individuals, the increase on the muscular strength levels apparently occurs more intensely during the first training weeks, fact that has been attributed to neural adaptations by many authors. Thus, there are evidences that most part of the muscular strength gains in initial periods of a WT program are due to the increase on the total muscular activation, increase on the shot frequency and synchronization of the motor units or even due to the reduction on the co-activation of the antagonistic muscles during exercise⁽⁴⁻⁶⁾.

Key words: Weight training. Muscular strength. Neural adaptations. Motor performance. 1-RM tests.

On the other hand, the muscular hypertrophy seems to occur more intensely later on, in other words, after some weeks of training⁽⁷⁾. Although there is a tendency to associate muscular strength levels with the size of the muscle cross-sectional area, this relation seems to be true only when most of the neural adaptations have already been shown⁽⁸⁾.

Despite the existence of an extensive literature indicating relevant modifications induced by the practice of WT programs, the magnitude of these alterations are not yet fully cleared when men and women are submitted to the same type of training program, once most studies have included subjects from only one gender, besides the fact that the protocols used have been quite differentiated.

Therefore, it seems to exist a great difficulty to compare results obtained from different studies, once most protocols designed for women have emphasized volume rather than intensity, and these protocols have been characterized, above all, by the high number of repetitions (15-20 RM). Moreover, the lack of standardization in the other training variables (frequency, intensity, recovery period, intervals between sessions, exercises used, muscular strength evaluation means, among others) makes the comparison between information produced by literature even more difficult.

Thus, one believes that investigations with most of these variables under control involving individuals from both genders and similar physical fitness levels will be able to support the comprehension of the effectiveness of WT programs and the possible differences of behavior between men and women as response to this type of physical exercise.

Thus, the objective of this study was to analyze the behavior of muscular strength indicatives in men and women after a standardized eight-week weight training.

METHODOLOGY

Subjects

Thirty-eight university students (23 men and 15 women) apparently healthy participated as volunteers in this study. As initial inclusion criteria, the individuals should be moderately active (regular physical activity < 2 time a week) and not being enrolled in any physical activity program in the last six months before the experiment. Furthermore, each participant responded to a questionnaire on the health history before the study and no metabolic or musculoskeletal dysfunction was reported.

After being previously cleared about the objectives of the investigation and procedures they would be submitted to, the individuals signed a free and cleared consent term. This study was previously approved by the Ethics Committee in Researches of the Londrina State University, according to norms of the resolution 196/96 of the National Health Council on researches involving human beings.

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Anthropometry

The body mass was measured in a digital reading scale label *Urano*, model *PS180 A*, with accuracy of 100 g and maximum load of 180 kg, whereas the stature was determined using a wooden stadiometer with accuracy of 1 mm, according to procedures recommended by Gordon *et al.*⁽⁹⁾. Based on these measures, the body mass index (BMI) was calculated by means of the relation between body mass and the squared stature, where weight was expressed in kilograms (kg) and stature in meters (m).

1-RM tests

The muscular strength was determined by means of the repetition maximum test (1-RM) in three exercises involving trunk, upper limbs and lower limbs segments. The execution order of the exercises tested was the following: bench press, squat and arm curl, respectively. The minimum interval between exercises was of five minutes. These exercises were selected for being quite popular in weight training programs of individuals with different trainability levels.

The subjects were previously submitted to a five-minute warm up exercises in cycle ergometer with light load at velocity of 65 rpm. Furthermore, each exercise was preceded of a series of warm up exercises (6-10 RM) with approximately 50% of the load estimated for the first attempt in the 1-RM test. The testing started two minutes after specific warm up exercise. The individuals were told to complete two repetitions. In case two repetitions were completed in the first attempt or even if no repetition was completed at all, a second attempt was performed after a 3-5 minute recovery interval with loads above (first possibility) or below (second possibility) that employed in the previous attempt. Such procedure was performed once again in a third and ultimate attempt in case the load corresponding to a single repetition maximum was not yet determined. Therefore, the load registered as the 1-RM was that in which the individual could complete only one single repetition maximum⁽¹⁰⁾.

A familiarization protocol was previously employed in the attempt of reducing the effects of the apprenticeship and establishing the reproducibility of tests in all exercises. All subjects were tested in situation similar to the protocol adopted in five distinct sessions with intervals of 48 hours. The intra-class coefficients (R) were of 0.98 for bench press and of 0.96 for squat and arm curl.

It is worth emphasizing that the execution form and technique of each exercise were standardized and continuously monitored in the attempt of assuring the test efficiency.

Weight training program

The WT program was performed during eight consecutive weeks including three weekly sessions performed in alternated days. The frequency to the training sessions was above 80% (19 to 24 sessions).

The design of the training program followed the alternated order by body segment and all 10 exercises proposed were performed according to the following order: bench press, leg press at 45°, lat pulldown, leg extension, overhead press, leg curl, triceps press-down, calf in leg press, arm curl and crunch.

All exercises were performed in three series of 8-12 repetition maximums (RM), except for the abdomen muscular group, performed in three fixed series of 50 repetitions with overload of the own body. In the three first exercises of the sequence, a series of warm up exercises of 15 repetitions with approximately 50% of the load to be used in each exercise was arbitrarily added in the attempt of supporting the physiological and neural responses to subsequent efforts. The recovery interval established between series was of 60-90 seconds. On the other hand, the transition interval between exercises was of 120 to 180 seconds. Although the movements execution velocity was not controlled, the sub-

jects were told to try to perform each movement in the concentric phase within one to two seconds and in the eccentric phase within two to four seconds.

Both the initial loads and the periodic adjustments of loads used in the different exercises were established based on results obtained by means of the application weight tests through repetitions maximum⁽¹¹⁾. The individuals were oriented to readjust the training loads whenever the repetitions upper limit pre-established for each exercise was reached in all series with the objective of maintaining the initial intensity.

Statistical treatment

The t-Student test for independent samples with different number of elements was used for comparisons between general characteristics of men and women. The 2 x 2 analysis of covariance (ANCOVA) for repeated measures was used to evaluate possible modifications in the muscular strength of both groups (men and women) along time (pre and post-experiment), once the initial conditions of groups were different with pre-experiment values being used as covariables. The *post hoc* Tukey test was used for the identification of specific differences in variables in which the values of F found were higher than the statistical significance criterion established ($P \leq 0.05$).

RESULTS

The general characteristics of subjects are described in table 1. Men presented values of body mass (-6.1 kg) and stature (-9.4 cm) higher than the women investigated ($P < 0.01$).

TABLE 1
General characteristics of the sample

Variables	Men (n = 23)	Women (n = 15)	P
Age (years)	20.7 ± 1.7	20.9 ± 2.1	0.84
Body mass (kg)	66.4 ± 8.2	58.3 ± 6.3	< 0.01
Stature (cm)	173.0 ± 4.7	163.6 ± 6.5	< 0.01
BMI (kg/m ²)	22.1 ± 2.5	21.6 ± 2.0	0.55

Table 2 presents the results of the pre and post-training 1-RM tests of men and women. An increase statistically significant on the muscular strength was verified after eight weeks of WT both for men and women in all exercises investigated as well as in the total amount of load lifted ($P < 0.05$). Although men presented higher absolute strength when compared to women in all exercises evaluated, the gains observed along time were higher for women (14.7 vs. 7.6% in squat; 17.2 vs. 11.0% bench press; 20.4 vs. 14.0% in arm curl). Thus, the ANCOVA verified no interaction gender x time in variables analyzed ($P > 0.05$).

DISCUSSION

The results found in the present study indicated that the period of eight weeks of WT seems to be sufficient to promote significant muscular strength gains both in men and in women. However, the muscular strength gains observed occurred in different magnitude when men and women were compared. Women presented an increment relatively higher than men in the three exercises investigated.

These results, however, are similar to most results available in literature from studies that investigated possible modifications on muscular strength induced by short WT periods (≤ 12 weeks) in men and women⁽¹²⁻¹⁵⁾.

In this context, Hunter⁽¹²⁾ verified increments of 11.9% and 19.5% in bench press exercise in men and women, respectively, after 10

TABLE 2
Values of 1-RM (kg) obtained before and after eight weeks of
WT in bench press, squat and arm curl for men and women

Variables	Men	Women	Effects	F	P
Bench press			ANCOVA		
Pre	61.1 ± 13.0	29.6 ± 5.2	Gender	5.77	< 0.05
Post	67.8 ± 12.3*	34.7 ± 5.6*	Time	112.00	< 0.01
Δ%	+ 11.0	+ 17.2	Gender x Time	2.25	0.14
Squat			ANCOVA		
Pre	125.4 ± 26.6	73.6 ± 14.4	Gender	0.23	0.63
Post	135.0 ± 33.2*	84.4 ± 10.9*	Time	9.33	< 0.01
Δ%	+ 7.6	+ 14.7	Gender x Time	0.03	0.87
Arm curl			ANCOVA		
Pre	39.2 ± 6.6	22.1 ± 4.1	Gender	6.65	< 0.01
Post	44.7 ± 6.4*	26.6 ± 3.5*	Time	96.60	< 0.01
Δ%	+ 14.0	+ 20.4	Gender x Time	0.99	0.32
CTL			ANCOVA		
Pre	225.7 ± 42.7	125.3 ± 22.8	Gender	1.73	0.19
Post	247.5 ± 44.9*	146.7 ± 18.1*	Time	38.35	< 0.01
Δ%	+ 9.4	+ 16.5	Gender x Time	0.30	0.58

*P < 0.05 vs. Pre.

Note: Results are expressed as average values (± SD).

weeks of WT. Wilmore⁽¹⁵⁾ had already reported increments of 28.6% and 16.4% in men and women, respectively, in the same exercise during similar period of WT intervention. In the present study, the muscular strength gains in bench press reached 11.0% in men and 17.0% in women, despite the shorter intervention time.

The modifications on the muscular strength during short WT periods seem to be a result of the improvement on the intra and intermuscular neural adjustment during the performance of the movement. One believes that such adaptations are associated with the increase on the number of motor units recruited, increase on the shot frequency and synchronization of the motor units or even due to reduction on the co-activation of the antagonistic muscles, thus unchaining higher strength output during the initial training phases⁽⁵⁾.

In this context, Hakkinen *et al.*⁽⁴⁾, through electromyographic analyses, verified the muscular activation and the co-activation of antagonistic muscles of men and women followed during six months of WT. The partial results indicated that after two months of WT, a significant increase on the total muscular activation already occurred (iEMG), along with the reduction on the co-activation of antagonistic muscles in both groups, resulting in relevant increase on the muscular strength levels.

Although the initial increments on muscular strength are associated above all with neural adaptations, as previously described, some studies have reported important modifications on the muscular morphology in only two weeks of WT^(14,16), such as the increase on the amount of myosin heavy chain type IIa, demonstrating that the morphological alterations of the muscular tissue may occur since the first WT sessions. However, it was not yet well established whether these short-term adaptations influence the muscular strength development or not.

Despite the mechanisms involved in the different responses found between genders for muscular strength are not yet well defined, it seems that the initial differences in training level may influence strongly the results. Although this variable was not controlled in the present study, one believes that, generally, the physical activity level of most women is below that presented by men. In this context, it would be expected that women presented the highest increases on muscular strength⁽¹⁷⁾, what was actually verified in this study.

Another possible explanation for the differences in increases on muscular strength between men and women would be the better

recruitment standard of motor units in women in relation to men. In this context, Lemmer *et al.*⁽¹³⁾ performed a study where the crossed-education mechanism and the peak isokinetic torque as indicative of the training neural adaptations were evaluated. Thus, men and women submitted to a 12-week training program of unilateral thigh extension presented significant increases on the maximum strength of the untrained limb (crossed-education mechanism). However, an increment on the peak isokinetic torque of the trained limb was only identified among women, suggesting that the neural adaptations are more intense among women than among men.

An interesting finding of this study is that the muscular strength gain of men and women followed a similar order, in other words, arm curl > bench press > squat. Such differences are probably related with the complexity of the motor task required in the different exercises. It seems that the exercises involving the participation of a larger number of muscular groups would require a longer period of time for a plateau on the neural adjustments and on the apprenticeship of the movement motor task to be established⁽⁸⁾.

This hypothesis is reinforced by the findings of Cronin & Henderson⁽¹⁸⁾, who verified temporal differences in the familiarization process to 1-RM test between bench press and squat exercises. While for bench press, only one familiarization session was required for the load stabilization, for squat, two sessions were required. According to the authors, the higher complexity of the motor task required for squat was considered the main explanation for the longer familiarization time required for this exercise.

It is worth emphasizing that among the exercises evaluated, the squat was the only one not included in the WT program performed. This fact probably may have affected the familiarization process for this exercise and hence the neural adjustment of the movement compared with the other exercises tested, which were included in the training program.

CONCLUSIONS

The results of the present study indicated that the eight-week WT period seems to be sufficient to promote significant modifications in the muscular strength of men and women in bench press, squat and arm curl exercises.

However, women presented muscular strength gains proportionally higher than those observed in men in all exercises investi-

gated, what suggests that women seem to present higher potential for the development of the muscular strength when compared with men after short WT periods. One believes that these differences may be attributed, at least in part, to the lower initial training levels of the women analyzed and/or to a higher distribution of the neural factors among women.

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