Bilateral deficit in leg flexion and extension and elbow flexion movements

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ABSTRACT

Endurance exercises (EE) may be performed unilaterally and bilaterally. The objective was to compare the maximum load (ML) in leg flexion and extension and elbow flexion alone and between the sum of these two results with that developed simultaneously by both legs and arms, respectively. Sixty individuals were submitted to leg flexion and extension and elbow flexion exercises at 1 RM. The results for left and right leg flexion and extension and left and right elbow flexion at ML were of 31.6 (± 7.9), 32.0 (± 8.0), 20.2 (± 9.2), 20.2 (± 9.8), 29.3 (± 13.9) and 29.8 (± 14.1) kg, respectively and seemed to be similar ($p > 0.05$) and strongly associated ($r = 0.96$, 0.96 and 0,98). When the sum of the unilateral values was compared with the bilateral values, the ML presented significant difference for the leg extension movements ($p = 0.04$) and elbow flexion ($p = 0.03$). The same behavior was not observed in the leg flexion movement ($p = 0.75$). This result may be explained due to the lower load increment – two kilos and a half – in this last movement in relation to the previous movements – five kilos. Despite most subjects were right-handed, no unilateral differences were observed in ML, although not all subjects were trained. The sum of the unilateral results was higher in 9.8% and 4.0% for leg extension and elbow flexion movements, respectively, when compared with that previously obtained, showing a probable central limitation on the motor coordination of a complex movement performed at maximal speed and with high load. However, in the leg flexion movement, the sum of the unilateral results was lower that the sum of the bilateral results (–0.6%), indicating a possible learning of the movement and adaptation to training with weights from twelve weeks on.

Key words: Muscular strength. Unilateral and bilateral exercises. Endurance training. Muscular strengthening. Bilateral deficit.

INTRODUCTION

The posture of the American College of Sports Medicine[1] (ACSM) demonstrates the importance of strength and muscular power. The training of these variables seems to be effective in the improvement of several functional capacities and in the increase on strength and muscular hypertrophy. Thus, the training prescription becomes vital for distinct populations such as athletes, individuals with orthopedic lesions, old-aged individuals or even for healthy individuals who practice exercises aimed at health promotion[2,3].

The conduction of the endurance exercises training (EE) may be performed unilaterally or bilaterally. The load developed during bilateral actions is lower than the sum of loads developed by each limb[4-8]. According to some authors[4-8], this difference, also called as bilateral deficit is associated with the reduced stimulation of motor units, what could be caused by the inhibition of protective mechanisms, resulting in lower strength production[9,10]. Although bilateral activities reduce the deficit[4,9,11], the performance in unilateral exercises may constitute an important strategy with regard to maintaining strength[11,12], especially in important asymmetry situations.

Thus, this study has as objectives: a) to compare the maximum load (ML) obtained in leg flexion and extension and elbow flexion through unilateral work; b) to compare the sum of ML obtained in each limb alone with that obtained in the simultaneous bilateral work in the same previous movements.

MATERIAL AND METHODS

Sixty individuals divided into three groups were evaluated. The anthropometrical data of each group are found in table 1.

TABLE 1
Anthropometrical data of groups alone per movements

Movements	N	Gender	Age (years) average ± SD	Weight (kg) average ± SD	Height (cm) average ± SD
Leg flexion	20	10 M	21-38 (27.6 ± 5.7)	47-94 (72.1 ± 15.8)	156-190 (170.7 ± 9.6)
Leg extension	20	20 F	18-35 (26.3 ± 5)	50-70 (60 ± 7)	155-170 (160 ± 8)
Elbow flexion	20	10 F	18-37 (26.5 ± 5.9)	50-91 (71.5 ± 9)	157-187 (171.8 ± 8.3)

M = Male; F = Female; SD = Standard deviation

All individuals were physically active, with regular practice of exercises at least three times a week and experienced on EE. In the elbow flexion group, the 20 subjects evaluated had never practiced EE.

Before data collecting, all participants responded negatively to items of the PAR-Q questionnaire[13] and signed a consent form. The data collecting was composed of the following stages: a) body mass and height measurements; b) application of the maximum repetition test (1RM)[14] with the objective of determining ML in

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leg flexion and extension and elbow flexion unilaterally and bilaterally. All volunteers signed a consent form, according to resolution 196/96 of the Brazilian Health National Council.

To establish the weight the ML generated in the 1RM test in the leg flexion movement, the equipment flexor chair label *Technogym* was used and the load accessories followed the overload of the own device (two and a half kilos). In the leg extension, the equipment extensor chair (Life Fitness) was used and the load increment also followed the overload of the own device (five kilos). In the elbow extension, the equipment cross-over label Life Fitness model 2000 was used, where the movement was performed in its low pulley and the load increment performed for the attainment of the ML was of two kilos. For a better distinguishing of exercises, the following execution stages were established: initial position and concentric phase. The eccentric phase was the return to initial position. The detailed description of exercises in both phases of the movement is presented as follows:

1) Leg flexion (bilateral and unilateral).

a) Initial position – Individual sat down with arms along the body and holding the device's support with trunk inclination at 70°, knees extended at 170° and head positioned according to the Frankfurt plan[15].

b) Concentric phase – From initial position, leg flexion exercises were performed up to 90°.

2) Leg extension (bilateral and unilateral).

a) Initial position – Individual sat down with arms along the body and holding the device's support with trunk inclination at 70°, knees inflected at 90° and head positioned according to the Frankfurt plan[15].

b) Concentric phase – From initial position, full leg flexion exercises were performed.

3) Elbow flexion in standing position (bilateral and unilateral).

a) Initial position – Individual standing up with parallel legs with small lateral spacing, keeping knees extended, hips at anatomic position, arms along the body with hands in supine position holding bar and head positioned according to the Frankfurt plan[15].

b) Concentric phase – From initial position, full elbow flexion exercises were performed.

For the conduction of tests, 20 individuals were divided into two groups of ten subjects, randomly selected for the 1RM test. The first group performed exercises at the following sequence: right limb, left limb and both limbs. The second group performed the following sequence: both limbs, left limb and right limb. This procedure allowed individual to be evaluated in both limbs simultaneously and unilaterally at the same day.

In the beginning of the 1RM test[14], the individuals performed one maximal execution as fast as possible up to the attainment of maximum load. At each new attempt, progressive increments were performed considering the loads of the own devices. A 3-5 minutes interval was given between each attempt. After the attainment of the maximum load in 1RM test according to the sequence adopted, a 10-20 minutes rest interval was given for the following of tests. The procedure adopted in the 1 RM test had the objective of obtaining the maximum load and when the individual could no longer perform the entire movement, the test was interrupted. Thus, the maximum load obtained in the last correct execution was adopted as valid.

The statistical analysis was performed through the paired t-test with the objective of verifying the possible existence of significant difference between right and left limbs as well as difference of the sum of both limbs in relation to work performed bilaterally. The significance level of 5% was adopted for all procedures.

RESULTS

Table 2 provides the descriptive statistics in the comparison of loads obtained in right and left legs in the legs flexion and extension and in right and left arms in the elbow flexion movements. Table 3 shows the lack of significant difference between right and left limbs in all movements and the high correlation between them. Figure 1 illustrates the results of three movements alone comparing the averages of the maximum loads between right and left limbs.

TABLE 2
Comparison of maximum load between right and left limbs

Movement	Group	N	Average	SD	Median	Minimum	Maximum	EPM
Leg	R	20	32.0	8.0	33.8	17.5	40.0	2.13
flexion	L	20	31.6	7.9	33.8	17.5	42.5	2.12
Leg	R	20	20.2	9.8	20.0	5	50	1.73
extension	L	20	20.2	9.2	20.0	5	45	1.63
Elbow	R	20	29.8	14.1	29.0	12	55	2.88
flexion	L	20	29.3	13.9	30.0	11	54	2.83

SD = Standard deviation; EPM = Average standard error; R = right limb; L = left limb. Average value, SD, median, minimum, maximum and EPM expressed in kg.

TABLE 3
Significance level and correlation coefficient between right and left movements

Movement	P	R
Leg flexion	0.55	0.96
Leg extension	1.00	0.96
Elbow flexion	0.33	0.98

P = significance level; R = correlation coefficient

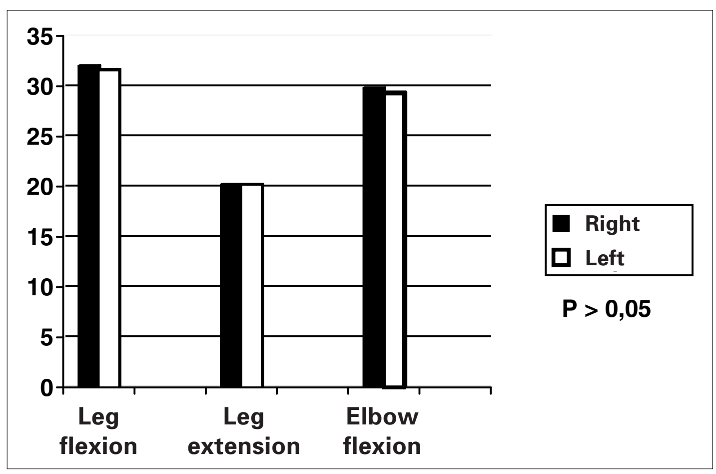

***Fig. 1** – Comparison between averages of maximum loads between right and left limbs*

Table 4 describes the comparison of the sum of maximum loads of limbs with ML bilaterally developed for legs flexion and extension and elbow flexion movements. Table 5 shows the high correlation between the three movements studied and the significant differences between the sum of the unilateral executions and the bilateral work in leg extension and elbow flexion. No significant difference was found between the sum of the unilateral and bilateral movements in the leg flexion movement. Figure 2 presents the difference between the comparison of the averages at maximum loads in the sum of limbs with the bilateral work of leg extension and elbow flexion and the lack of this difference in the leg flexion movement.

TABLE 4
Comparison of maximum loads in the sum of limbs with bilateral work

Movement	Group	N	Average	SD	Median	Minimum	Maximum	EPM
Leg flexion	S	20	63.6	15.8	66.3	35	82.5	4.22
	B	20	63.9	17.3	67.5	35	90	4.63
Leg extension	S	20	40.3	18.8	40.	10	95	3.32
	B	20	36.7	16.2	32.5	10	65	2.87
Elbow flexion	S	20	59.1	27.9	59.0	24	106	5.69
	B	20	56.8	25.5	53.0	23	100	5.22

SD = standard deviation; EPM = average standard error; S = sum of limbs; B = bilateral work. Average value, SD, median, minimum, maximum and EPM expressed in kg.

TABLE 5
Significance level and correlation coefficient between sum of limbs and bilateral movements

Movement	P	R
Leg flexion	0.75	0.97
Leg extension	0.04	0.86
Elbow flexion	0.03	0.99

P = significance level; R = correlation coefficient

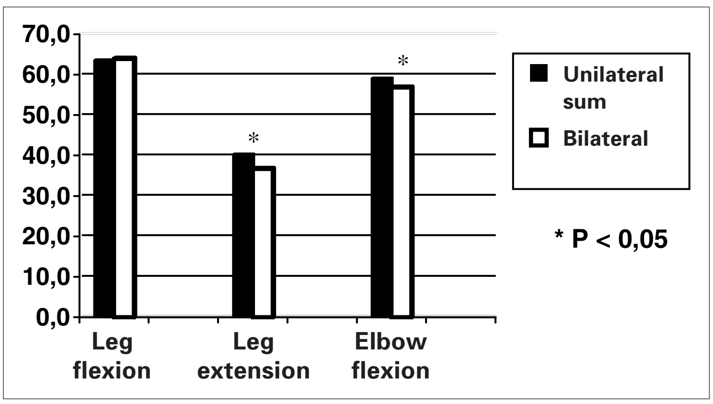

Fig. 2 *– Comparison between averages of maximum loads in the sum of limbs with bilateral work*

DISCUSSION

The bilateral deficit phenomenon is considered as a slight decrease on the neural activation in the recruitment of motor units in the development of bilateral works when compared to the sum of unilateral works[4-8,16].

According to Vandervoot *et al.*[6], the capacity of developing strength during isometric and dynamic exercises at low speed bilaterally performed in straight supine exercises with dumbbells presented similar results when compared to the sum of the unilateral work. Howard and Enoka[9] demonstrated that not all individuals presented bilateral deficit, and some of them presented no difference at all or even bilateral facilitation. In our study, a significant difference in the bilateral deficit was found in relation to the maximum loads in leg extension and elbow flexion movements, unlike studies mentioned[6,9]; however, the same behavior was not verified in the leg flexion movement. In the leg flexion and extension and elbow flexion movements, 25, 36 and 21%, respectively presented bilateral work above the sum of the unilateral work at maximum load.

The group that performed elbow flexion was distinguished from the other groups due to the fact that the 20 subjects evaluated presented no experience on EE. In a study proposed by Simão *et al.*[4], 24 subjects were also inexperienced on EE and the results were similar to ours, in other words, the bilateral deficit was significant. These results seem to corroborate the necessity of bilateral works for untrained individuals when loads are high and the execution speed ranges from moderate to slow.

In another study presented by Simão *et al.*[7], the possibility of the bilateral deficit in lower limbs in the extensor chair was evaluated and the results were significant. Our study suggested the same evaluation line and also found results similar to the study mentioned above[7]. It is interesting to observe that we have adopted the same procedure in the flexor chair but found no significant differences in relation to the bilateral deficit. It is important emphasizing that in our literature reviewing, no study on legs flexion was found.

Other studies[4-7,12,17] on bilateral deficit demonstrate a contraposition in results probably due to the several variables involved. One of the likely causes for such differences would be form of evaluation through electromyography due to its low evaluation sensitiveness in some groups in function of the muscular masses volume[9]. Other factors such as the capacity of neural activation, impulse difusion between cerebral hemispheres, postural stabilization, coordination learning, afferent modulation, reduction on the antagonist's activity, motivation and type of muscular fiber involved[18-21], must be taken into consideration.

The proposal of this study is different from most studies in the references due to the fact of presenting data with regard to the comparison of the bilateral deficit in a muscular evaluation rather than in a training activity. A differential in our study was the use of a load accessory with invariable dynamic strength, unlike most studies where isokinetic devices were used[5,6,22,23]. One of the factors that could explain the bilateral deficit at maximum load in leg extension and elbow flexion movements is the methodology used in the 1RM test in which load increments for the muscular groups above was possibly overestimated, what explains the findings in leg flexion movements where increments were lower – two kilos and a half – and no bilateral deficit was verified. Maybe lower load increments in the 1RM test are important due to the sensitiveness of the musculature involved.

The comparisons of ML between limbs of the same individual are limited in literature[4,7] and data from our study performed among healthy young individuals demonstrated no significant difference in none of the movements tested. Even though most individuals were right-handed in the three movements, 14.3, 9.4 and 20.8% presented lower right maximum load when compared with the left maximum load and 71.4, 78.1 and 33.3% performed the same load for both limbs in the leg flexion and extension and elbow flexion movements, respectively. These differences may be partly explained through differences of fibers in the limbs[24], neural recruitment differentiated due to the cross effect[25,26] or due to the predominance of the use of one limb rather than the other[5,6]. According to Gardiner[16], the mechanisms through which the bilateral deficit occurs still remain unknown. In short, despite most subjects are right-handed, no unilateral differences were verified in the maximum load for none of the movements tested, although not all individuals were trained for the respective movements or training with weights.

The comparison between the average of the unilateral sum with the average of the bilateral execution showed that the first was higher in 9.8 and 4.0% for leg extension and elbow flexion movements, respectively. However, in the leg flexion movement, where 35% of the individuals presented bilateral facilitation, the average of the unilateral sum was lower than the bilateral sum (–0.6%). This fact is probably due to the movement learning and the decrease on central limitation of the motor coordination, once all individuals practiced weight training for at least 3 months up to 96 months, thus characterizing the movement learning and the predominance of other non-neural factors. Depending on the sample characteristics and on the situation-problem analysis, the evaluation strategy could be different as well as the interpretation of the results.

In practical terms of EE prescription with maximum loads and low speeds, one should choose for a bilateral strategy[8]. On the other hand, in the study of Simão *et al.*[4], it was demonstrated that for a better development of muscular power, unilateral works must be performed in order to optimize the limbs' individual speed. Therefore, power athletes may be benefited by unilateral works; however, individuals searching for aesthetics and health must choose for bilateral works.

All the authors declared there is not any potential conflict of interests regarding this article.

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