ORIGINAL INVESTIGATION (ARTIGO ORIGINAL)

TRAINING LEVEL, PERCEPTION AND BILATERAL ASYMMETRY DURING MULTI-JOINT LEG-PRESS EXERCISE

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Abstract

CARPES, F. P.; BINI, R. R.; MOTA, C. B. Training level, perception and bilateral asymmetry during multi-joint leg-press exercise. Brazilian Journal of Biomotricity, v. 2, n. 1, p. 51-62, 2008. This study was designed to investigate the training level, perception and bilateral asymmetry of force applied on the pedals of a leg-press machine during multi-joint leg-press exercise. Force data were acquired throughout the exercise by means of an FSCAN system with sensitive insoles adapted to the right and left pedals of a leg-press device and used to determine the bilateral asymmetry. Perception of bilateral asymmetry was evaluated by means of an inventory including two closed questions. Two groups according to their training experience were considered: subjects adapted (n=8), and trained (n=8). The results suggest that trained subjects present a smaller asymmetry index and a better perception of bilateral asymmetries. Trained subjects presented better perception of bilateral asymmetries, when it occurs during the exercise, than adapted subjects. The training seems to influence the perception and reduce the bilateral asymmetries during the leg-press multi-joint exercise.

Key Words: Bilateral asymmetry, strength, perception, interlimb coordination, lower limb.

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Introduction

It is reported that when bilateral actions exhibit mirror symmetry, e.g., a really strong similarity between the sides, they are produced more easily than movements that are asymmetrical (WOODWORTH,1903). It is also observed that when the movements are accomplished in the same direction in external space, they have a propensity to be performed more reliably than those in which the limbs are moving for opposite directions (for a review, see SWINNEN,2002). Even so Swinnen's paper considers mainly actions of upper limbs, if transferring the theories to the lower limb the leg-press exercise should be accomplished with a reliable symmetry when the lower limbs are compared among then.

Considering the lower limbs involvement on cyclic rhythmic movements such as running and cycling, studies that investigate inter-limb differences reported bilateral asymmetries for the ground reaction force that may vary as much as from 35% to 45% between the lower limbs (HAMILL et al., 1984; HERZOG et al., 1989; CHAVET et al., 1997; MAUPAS et al., 2002). When pedaling movement was investigated, there were evidences of differences that may vary from 0.5% (SMAK et al., 1999) to 42% (CAVANAGH et al., 1974), which are also reported as frequently (GREGOR, 2002; SANDERSON et al., 2000).

During walking for example, the bilateral asymmetry of ground reaction forces can be employed as an indicator of clinical abnormality (CHARNLEY & PUSSO, 1968). These asymmetries may have physiological effects affecting the exercise responses (HUGHES et al., 1976). Even so, the physiological effects of bilateral asymmetries on the task performance seems to be not fully explained, as well as there is a lack of a plausible conclusions about how long an bilateral asymmetry index can be considered as "slight" (RILEY et al., 1977; CHAO et al., 1983).

During the execution of multi-joint exercises such as the "leg-press", the subject must produce force concentric and eccentrically to overcome and to resist, respectively, to the external load imposed by the machine. They must execute the movement with control of the movement velocity and the range of motion throughout the hip, knee and ankle flexion and extension. During the movement, it could be supposed that some bilateral asymmetry exists between the lower limbs when considering the force, mainly due differences in muscle strength between limbs. Even so hypothetical, this situation could be lead to a reduction in eventual bilateral asymmetry indexes as force is improved throughout a training regimen. Perhaps this situation of asymmetry or symmetry can be not perceived by the executants during the exercise.

A previous study has been investigated the bilateral deficit during the leg-press exercise (HAY et al, 2006). The bilateral deficit is defined as the decrement of the maximum force elicited by two limbs working simultaneously when compared to the sum of each limb working independently(SALE, 1992). The authors reported bilateral force deficit range from 16.7% to 16.5%, but the muscles activation and joint kinematics were not equally affected. The Hay's study (HAY et al, 2006) suggests that differences in movement strategies

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between subjects can difficult the bilateral deficit investigation. For the present research we suppose that different movement strategies between subjects can also result on different perception capacity among these subjects. The perception can be affected by main characteristics of training, like intensity and volume of training, which are basic principles of training prescription (DANTAS, 1998; WEINECK, 1999; BOMPA, 2000). The perception is recognized to be related to motor and sensitive pathways (THOMAS et al, 2006) being characterized by somatic information from joints and muscle receptors during the movements (BOAS PINTO et al, 1997). The relationship between perception capacity and exercise intensity has been reported (MOURA, 2003), but the relationship between force output and the capacity of perceived differences in the force between the lower limbs (bilateral asymmetry) seems to be not yet investigated. In this regard, there is a lack of studies addressing the capacity of force perception related to bilateral asymmetries during dynamic tasks involving lower limbs.

Nevertheless, the evaluation of bilateral asymmetries and performance during lower limb exercise remains generally weakly explored. In fact, it can be assumed that several mechanisms underlying the bilateral deficit remain unclear. This study was designed to evaluate the bilateral asymmetry during the leg-press exercise. The bilateral asymmetry was investigated accompanying evaluation of force perception for subjects classified according to two levels of training. Our primary hypothesis was that trained subjects can present improved perception of force and reduced bilateral asymmetries indexes during the execution of leg-press exercise when compared to subjects beginning a training program.

Material and Methods

- Subjects

The subjects volunteered for this study were younger men recruited from a University gym population. Only men without any neuromuscular disorder reported were considered. All subjects were involved only in weight lifting exercise program and prior to data collection they signed an Informed Consent Term in agreement with the Committee of Ethics in Research with Humans of the Ethical Committee of Federal University of Santa Maria where this study was conducted. A total of 16 subjects were classified in two groups considering their time of practice and number of session accomplished until the moment of the data collection. The sample number was statistically determined considering an error lesser than 2%. Adapted group was composed by 8 subjects with mean age of 17±3 years. Trained group was composed by 8 subjects with mean age of 22±3 years.

Based on the fact that one session of exercise can be sufficient to start the adaptation process (BICKEL et al., 2005), the subjects who had completed, at least six and no more than eight sessions of weight lifting training with the leg-press prescribed in their training routine were classified as adapted. Trained subjects were subjects who had historic of, at least, two and no more than three

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years of continuous practice of weight lifting with the objective of muscular hypertrophy with leg-press exercise in their routine of training.

All testing procedures were fully explained previous to data collection, but the analysis of the bilateral asymmetry which would be examined during the trial was not explained so as not to influence the subject performance (CARPES et al, 2007).

- Bilateral asymmetry evaluation

A horizontal leg-press machine (Inbaf Corporation Inc., Brazil) was used for this investigation. The pedals of the leg-press machine were instrumented with brand-new insoles of a FSCAN system (Tekscan Inc., USA) in attempt to monitor the normal reaction force applied on the pedal. The normal force was obtained from the pressure values measured by the FSCAN system and expressed as kilogram-force (considering 1 kgf as correspondent to 9.80665 N). The signal acquisition was done for three complete leg-press repetitions starting after two first repetitions, and then it was carried out throughout the exercise execution at sample rate of 120 Hz. The mean total force observed for each limb was computed and used to determine the bilateral asymmetry (equation 1) being expressed as percentage (CHAVET et al., 1997). All the subjects were orientated to execute the exercise unshod in attempt to exclude the influence of the type of shoe as well as effects of irregularities of the shoe sole on the measurement.

$$AI_{\%} = \left[\frac{(R - L)}{R} \right] \cdot 100$$

Equation 1

AI is the asymmetry index expressed by the percent difference between limbs; R is the right limb, and L is the left limb.

- Asymmetry perception

The capacity of the subject to perceive some bilateral asymmetry in the force was evaluated by means of two questions that were answered immediately after the finish of the exercise. When the subject finished the exercise, the first question was:

1st question) “During the exercise, did you perceived, in any moment, to be developing more force with one leg than the other?”.

When the answer was “yes”, a secondary question was done:

2nd question) “What was the leg you felt to be producing more force?”. The subject’s answer should be “right” or “left”, or, “neither” for case of not asymmetry perceived.

All answers were registered.

- Procedures to data acquisition

Prior the data acquisition the subjects where orientated to keep their usual diet

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and avoid any unusual exercise in the day before the test. The subjects were orientated to execute the leg-press exercise as follow: seated on the leg-press machine, the subject must keeps the back resting against the back pad; keeps the abdominal muscles isometrically contracted, knees slightly bent and chest up; under control, the subject rises the weight while keeping your hips stable on the machine bench, and moving the weight throughout the hip, with knee extension. After a knee extension close to the full knee range of motion, the subject returns the weight to the starting position keeping the control of movement and velocity until the knee presents an angle close to 90 degrees of flexion (0 degrees considered as the full-extension).

To a better reproducibility of the training situation that the subjects were usually involved, the adapted group was asked to execute 15 repetitions in the leg-press using the same work load prescribed in their training program (previous prescribed as corresponding to 50-70% of maximal work load). Trained subjects executed 8 repetitions with themselves work load prescribed in their training program (previous prescribed as corresponding to 70-90% of maximal work load). As described follow, five repetitions were evaluated for both groups, after the movement stability (about two first repetitions). Force signals were evaluated from five consecutive repetitions. Bilateral asymmetry index was evaluated considering the training level and the answers for perception questions.

- Statistical procedures

Force data were submitted to descriptive statistics for mean and standard-deviation. From the total force calculated adding up right and left pedals, the percent of force applied by each lower limb was computed and used to determine the bilateral asymmetry index. To characterization of bilateral asymmetry, a reference value of 10% was considered, because differences lower than 10% are usually found (CARPES, 2004; CARPES et al., 2007). Student's t-test was applied to compare right and left pedal force, considering a p-level equal to 0.05. The answers related to perception were registered, and later analyzed together bilateral asymmetries values.

Results

Considering that subjects involved in this study were evaluated using themselves training work load, which was preferred in attempt to keep the proximity of a real situation, the difference in the load between groups is described as the ratio between the force applied on the pedal by each group, as well as the force absolute differences. For right pedal, the ratio of force between the training load of adapted and trained subjects was found to be 1.27±0.04, with a variability of 3%, and an absolute mean difference of 12.16±1.74 kgf. For left pedal the ratio of force between the training load of adapted and trained subjects was found to be 1.32±0.06 with a variability of 4%, and an absolute mean difference of 11.65±1.79 kgf. There were no significant statistical differences for these variables between groups.

Considering the reference value of 10% adopted in the present study for

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significant asymmetry, there was found difference in the force applied between right and left pedal for the subjects classified as adapted. For trained subjects, the bilateral asymmetries did no present results higher than 10%. The figure 1 shows the bilateral asymmetry index calculated as percent for each group.

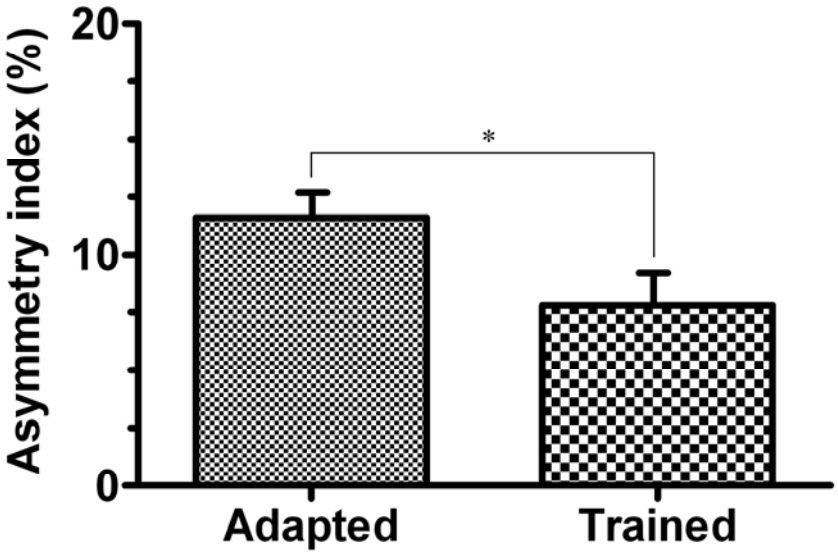

Figure 1 - Mean and standard-deviation of asymmetry index for each group. Adapted subjects present asymmetry index higher than the reference value of 10% (* indicates statistical difference).

The perception should not be compared between subjects when considering the judgment about the capacity of maximal force generation because each subject will consider of different way the force produced by him (JACKSON and DISHMAN, 2000). In order to eliminate this limitation and make comparison among subjects, the questions regarding perception were done only to verify the capacity of the subjects to judge the existence of bilateral asymmetry and to indicate the leg (considered by the subject) that was producing higher force during the leg-press exercise. The results for answers of perception assessment and the agreement with bilateral force symmetry measured are presented in the table 1. Most of trained subjects were able to perceive the bilateral force generated when compared to the adapted group, e.g., the answers to perception questions were confirmed by the bilateral force evaluation.

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Table 1 – Perception answers compared to bilateral force evaluation.

Subjects	Group	Perception	Bilateral force
1	Adapted (n=8)	Symmetry	Asymmetry (right)
2		Symmetry	Asymmetry (left)
3*		Asymmetry (right)	Asymmetry (right)
4		Symmetry	Asymmetry (right)
5		Symmetry	Asymmetry (right)
6		Symmetry	Asymmetry (right)
7		Symmetry	Asymmetry (right)
8		Symmetry	Asymmetry (right)
1	Trained (n=8)	Symmetry	Asymmetry (right)
2*		Symmetry	Symmetry
3*		Asymmetry (right)	Asymmetry (right)
4*		Asymmetry (right)	Asymmetry (right)
5*		Asymmetry (left)	Asymmetry (left)
6		Symmetry	Asymmetry (right)
7		Asymmetry (left)	Asymmetry (right)
8		Asymmetry (left)	Asymmetry (right)

* Subjects who perceived the bilateral asymmetry.

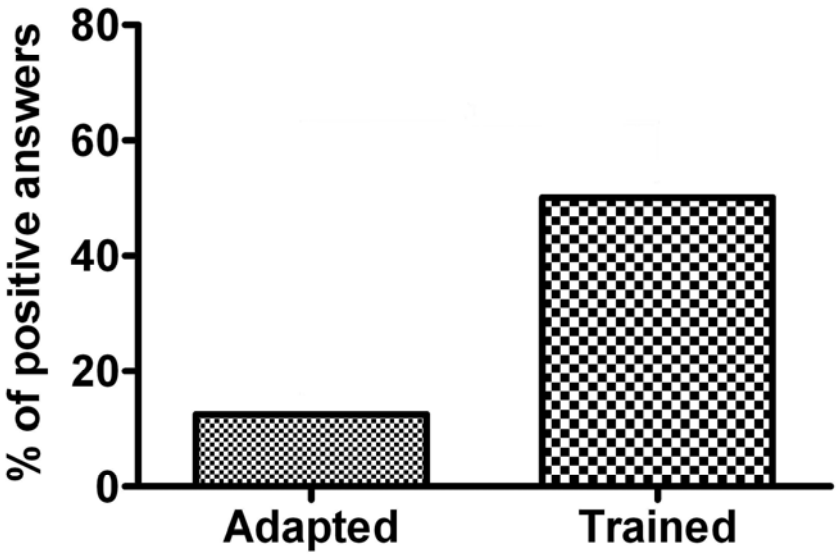

Figure 2. Perception of force produced between legs for each group. Positive answer was considered when the subject had the perception confirmed by the force evaluation.

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Based on the method of assessment employed in the present study, our results suggest that most of adapted subjects present bilateral asymmetry during the execution of a multi-joint leg-press exercise their usual training load. In other hand, trained subjects were able to perform the exercise with significantly lower bilateral asymmetries than adapted subjects, and also they were able to perceive the force production, independently of asymmetries be found or not. Among adapted subjects, 87.5% of the subjects were not able to perceive the development of force asymmetrically during the leg-press exercise whereas 50% of the trained subjects perceived any asymmetry existent.

Discussion

The generation of force with lower difference, e.g. the less asymmetry possible, between the lower limbs can be considered an important factor working to avoid premature fatigue or injuries resultant from repetitive efforts (SMAK et al., 1999; CARPES et al., 2007). However, the relationship between lower limb bilateral asymmetries, level of training and perception seems to be not fully explored in the literature concerning an exercise overview. In this study, the multi-joint leg-press exercise was selected due to its similarity with athletic movements as well as, their characteristic of recruitment of greater muscle groups like the quadriceps and hamstrings. Also, this exercise can be considered as a task requiring coordination of several muscles groups and joints constraining enough for equality when performed bilaterally or unilaterally (HAY et al., 2006).

According to the literature reviewed, our study was the first to evaluate the bilateral symmetry, level of training and perception during multi-joint leg-press exercise. Only one study considering weight lifting exercise has evaluated different percents of maximal load achieved during one maximal-repetition test, which suggests a relationship between the magnitude of work load and the effort perception (MOURA, 2003). Our study had not evaluated subjective perception of exertion, but the perception of bilateral asymmetries. The experience in multi-joint movements like the movement studied and others (e.g. cycling) can affects load distribution among joints (HOSHIKAWA et al, 2007), and this situation might affects the somatic information from joint and muscle receptors.

The primary hypothesis was that trained subjects could be symmetric (or they can present asymmetry index lesser than only adapted subjects) of force produced based on perception improvement due to training when compared to subjects only adapted to the leg-press exercise. Our hypothesis was based on the fact that trained subjects present a improved perception specific to training process and our results indicate that 50% of the trained subjects were able to identify bilateral asymmetries in the force between the lower limbs during the leg-press performance (DANTAS, 1998; WEINECK, 1999; BOMPA, 2000). The perception ability was confirmed by means of bilateral force evaluation. Among the adapted group, only 12.5% of the subjects were able to identify the bilateral asymmetries, suggesting that subjects starting in a weight lifting training program, after at least six and no more than eight session, remain unable to

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perceive the force produced and to present a capacity to generate force symmetrically between the right and left lower limbs.

Hay et al (2006) reported bilateral deficit range from 16.7% to 16.5%, but the individual muscles activation and joint kinematics were reported as not equally affected during the performance of multi-joint leg-press exercise performed with sequence of jumps. Hay et al (2006) suggest that differences in movement strategies between subjects can difficult the bilateral deficit investigation. We suggest that different movement strategies between subjects can results from different perception capacity of the subjects. When walk and running are considered, it is found that in the majority of studies where the both limbs were evaluated, there were substantial asymmetries found (CHAVET et al., 1997).

Some evidences reported by the literature about bilateral asymmetries in sports suggest that healthy subjects can present between-limbs difference from 5% until 20% considering the force and work produced during pedaling (DALY and CAVANAGH, 1976; SARGEANT, 1977; CARPES et al., 2007), and 35% to 45% of difference for ground reaction force during walking and running (HAMILL et al., 1984; HERZOG et al., 1989; LASSEL et al, 1992). It indicates that the degrees of freedom might affect the symmetry of force production. At this regard, the leg-press exercise is more related to movement of cycling, at which the hip is kept almost fixed and the foot is attached to the pedals with the knee presenting a great movement span. This fact justifies the low asymmetry index observed in the present study, even for the adapted group. Previous studies suggested force asymmetry in sports movements as variable between days, which indicate a need of more evaluation to understand the mechanism of force asymmetry (DALY and CAVANAGH, 1976; DANTAS, 1998; SMAK et al., 1999; GREGOR, 2000; ESCAMILLA et al, 2001).

Our results suggest that the first sessions of training can be important not only for neuromuscular adaptations (TAN, 1999) but also in attempt to improve the force perception ability. The capacity to generate force symmetrically between limbs can be an important ability to be developed during this initial period, mainly because it can be related to premature muscle fatigue (CARPES et al., 2007). The use of leg-press devices with independently pedal could be a good strategy to improve the perception and to minimize force asymmetries during training. The effect of work load is not considered for us because we want to respect the load corresponding to individual training. Using a standard load for both groups we would change the exercise that the subjects were performing and our results would fail.

Conclusion

To the best of our knowledge, this study was the first to describe the bilateral force asymmetry during leg-press exercise and evaluating the training level and perception shows an improvement of perception and minimization of bilateral asymmetries as resultant of training process and progress. Our findings suggest that subjects starting a training regimen involving multi-joint exercises like the leg-press machine can present bilateral force asymmetry more frequently than observed for trained subjects. The perception concerning bilateral asymmetry

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seems to be also improved by the training. Further research is required to investigate whether these asymmetries are related to limb dominance or present repercussion on muscle activity, as well as, to monitor the changes on asymmetry and perception in a group throughout a period of training.

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