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# Bilateral Deficit in Maximal Isometric Knee Extension in Trained Men

André Luiz S. Teixeira, Júlio Cézar A. Narciso, Ibrahim Taroco Salomão, Marcelo Ricardo C. Dias

Granbery Methodist Institute, Laboratory of Exercise Physiology, Juiz de Fora, MG, Brazil

## ABSTRACT

**Teixeira ALS, Narciso JCA, Salomão IT, Dias MRC**. Bilateral Deficit in Maximal Isometric Knee Extension in Trained Men. **JEPonline** 2013;16(1):28-35. Bilateral deficit occurs when the sum of unilateral strengths is greater than the bilateral strength. The purpose of this study was to test the hypothesis that bilateral deficit occurs in maximal isometric knee extension in trained men. For this, 27 healthy men with previous experience in resistance training (RT) were enrolled (25.1 ± 8.6 yrs, 74.9 ± 10.9 kg, 178.1 ± 5.2 cm; 23.5 ± 2.8 kg·m$^{-2}$). The evaluations were made randomly in 1 day. For analysis of maximal isometric strength, a mechanical dynamometer with 1 Newton (N) of resolution was fixed to the RT machine (extension chair) and was connected to a computer that transfers data to specific software. The 120º of knee extension was determined by goniometry. For the unilateral contraction, subjects made 5 sec of maximal voluntary contraction with the dominant leg and immediately after with the non-dominant leg. For the bilateral contraction, subjects made 5 sec of maximal voluntary contraction with both legs. Five minutes of rest interval between the tests was respected (unilateral x bilateral). Student's paired *t* test showed that the sum of values obtained unilaterally (718.4 ± 106.3 N) was greater than the bilateral values (663.2 ± 97.7 N) (P=0.0012). These results confirm our initial hypothesis that bilateral deficit occurs in maximal isometric knee extension in trained men.

**Key Words**: Resistance Training, Muscle Strength, Bilateral Deficit

## INTRODUCTION

The American College of Sports Medicine (2) recommends a program of regular exercise that includes cardiorespiratory, resistance, flexibility, and neuromotor exercise training. The organization believes the training program goes beyond activities of daily life, and that it is essential for most adults if they are to improve and maintain physical fitness and health. When included in a physical activity program, the resistance training (RT) part promotes increase in strength, muscle hypertrophy, and flexibility. The program assists in the maintenance of body composition and cardiovascular function, and it decreases the risks associated with coronary diseases (3,4). For the RT prescription, some variables can be manipulated as the volume of training (6), the number of sets (5), the number of repetitions (7), the load of training (1,21), the rest interval between sets (19), the exercise order (23), and the form of execution (10,18).

Thus, RT can be carried out unilaterally or in bilaterally form. Previous studies have shown that the sum of unilateral strength is greater than bilateral strength. It is reported as bilateral deficit (12,13,17). However, when the sum of the unilateral strength is lower than the bilateral strength, it is reported as bilateral facilitation (8,14,22). According to some research findings (14,16,22), such difference called bilateral deficit resulting in a lower production of strength, can be associated with reduced stimulation of motor units, neural recruiting differentiated by the crossed effect in the extra-pyramidal tract, fiber differences in the limbs, and predominance of use of one limb over the other.

Many studies have been conducted with the purpose to investigate the bilateral deficit and facilitation during RT. Some authors reported bilateral deficit in RT (8,17), while others have reported bilateral facilitation in RT (14). Interestingly, Simão and colleagues (22) reported elbow flexion bilateral deficit for muscle power, but bilateral facilitation for maximum load on one repetition maximum (1 RM). These discrepancies can be explained due to the different methodological designs of studies that were used: trained (8) and untrained subjects (12); isometric (17) and isotonic muscle contractions (8); upper limbs (22) and lower limbs exercises (12); subjects of both genders (9); and only males (13) and only females (14). Given the inconsistency in the literature, the purpose of this study was to test the hypothesis that bilateral deficit occurs in maximal isometric knee extension in trained men.

## METHODS

### Subjects

For convenience, 27 healthy men (25.1 ± 8.6 yrs) participated in this study. The inclusion criterion was physically active subjects with previous experience in RT for 6 months. We excluded from the sample subjects with any limitation that could interfere in the experimental procedures and/or who had positively answered one of the questions on the Physical Activity Readiness Questionnaire - PAR-Q (20). All subjects were instructed to keep their daily habits and not to practice physical exercises 24 hrs prior to the tests. Each subject read and signed a specific informed consent form after being informed of the study protocol. The university institutional review board approved all the study procedures.

### Procedures

#### *Anthropometry*

The subjects' body weight was assessed using a digital weighing scale (Fillizola®, Brazil). Height was determined using a stadiometer with mm precision (Sanny®, Brazil). Then, body mass index (BMI) was calculated.

***Tests***

For the tests of maximal voluntary isometric contraction, a mechanic dynamometer (Cefise®, Brasil), previously calibrated, was fixated to extension chair equipment (Righetto®, High On, Brazil). The 120º of angulation of knee extension was individually adjusted through a metallic goniometer (Cardiomed®, Brazil). The dynamometer was connected to a computer which transferred the data with 1 Newton (N) of resolution to the software N2000PRO® (Cefise®, Brazil).

The tests were conducted randomly in one day (unilateral and bilateral). For the unilateral test, the subjects performed 5 sec of maximal voluntary contraction with the dominant leg and immediately after with the non-dominant leg. For the bilateral test, the subjects performed 5 sec of maximal voluntary contraction with both legs. A period of 5 min of rest interval was required between the tests. To minimize error during the evaluations, the following strategies were adopted (24): (a) standardized instructions concerning the testing procedure were given to the subjects before the tests; (b) the subjects received standardized instructions on specific exercise technique; (c) the RT machine was adjusted individually for each participant; and (d) verbal encouragement was provided during the testing procedure.

**Statistical Analyses**

The Shapiro-Wilk normality test and a homoscedasticity test (Levene's test) were used to analyze the normal distribution of the data. All variables presented a normal distribution and homoscedasticity. The Student's paired *t* test was used to test the difference between the unilateral and bilateral contractions. The significance level adopted was P<0.05. The SPSS statistical package version 19 for Windows (SPSS Inc., Chicago, USA) was used for all statistical analysis.

## RESULTS

Table 1 shows the characteristics of the subjects. No significant differences were obtained between the dominant and non-dominant leg on maximum strength (P=0.600) (Table 2). Figure 1 shows a moderated correlation between the dominant and non-dominant leg strengths ($R^2$=0.74; P<0.001) Figure 2 shows that the sum of unilateral contractions (718.8 ± 106.3 N) was greater than the bilateral contraction (663.2 ± 97.7 N) (P=0.0012).

**Table 1. Descriptive Data of the Subjects (n=27).**

| Variables | Mean ± SD |
|---|---|
| **Age** (yrs) | 25.1 ± 8.6 |
| **Weight** (kg) | 74.9 ± 10.9 |
| **Height** (cm) | 178.1 ± 5.2 |
| **BMI** ($kg \cdot m^{-2}$) | 23.5 ± 2.8 |

**Table 2. Data of Strength of the Dominant and Non-Dominant Legs (**mean ± SD)**.**

| | Dominant | Non-dominant | P-value |
|---|---|---|---|
| **Strength** (N) | 357.7 ± 52.4 | 360.7 ± 57.8 | 0.600 |

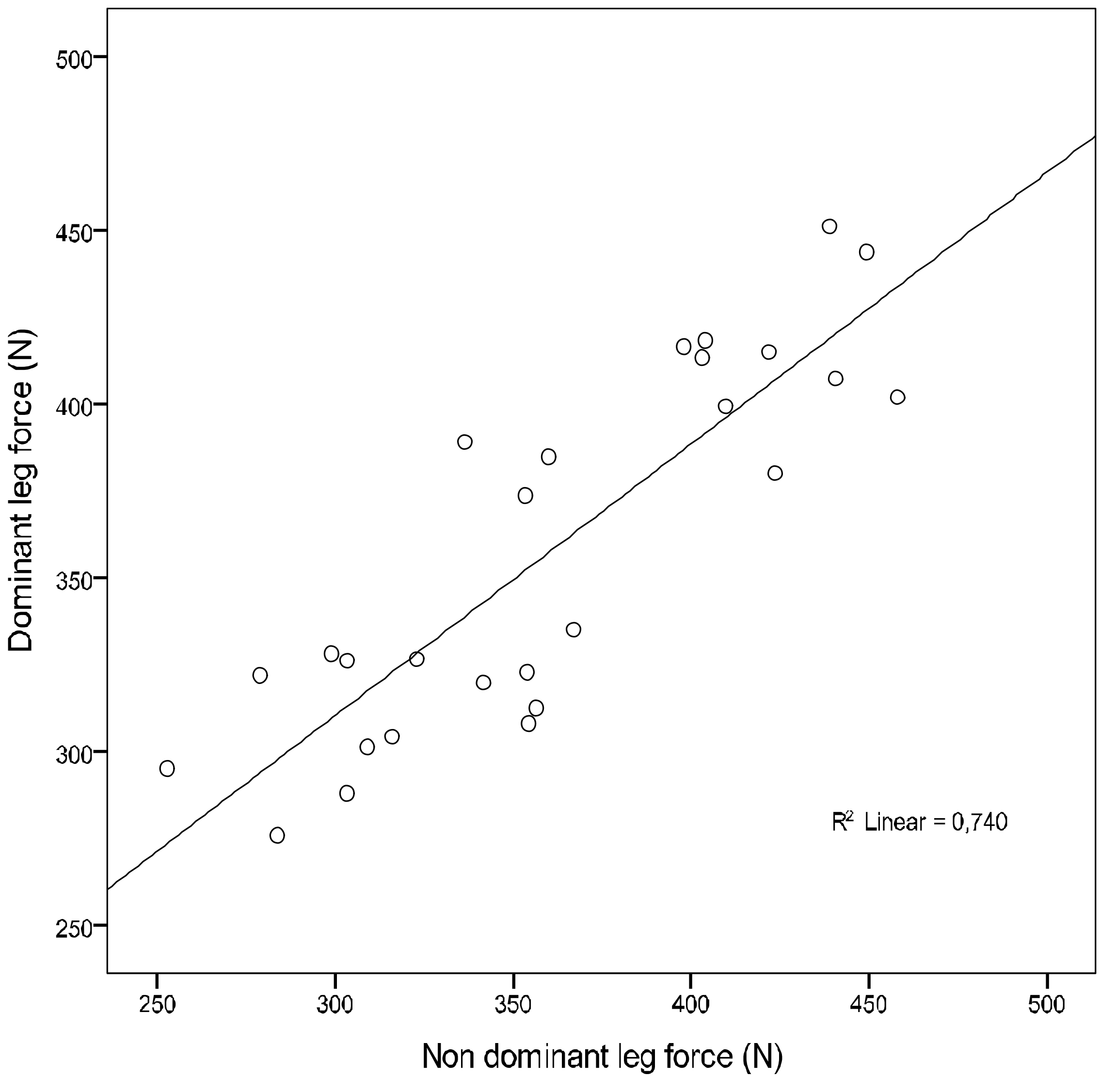


**Figure 1.** Pearson Correlation between Dominant and Non-Dominant Leg Strengths.

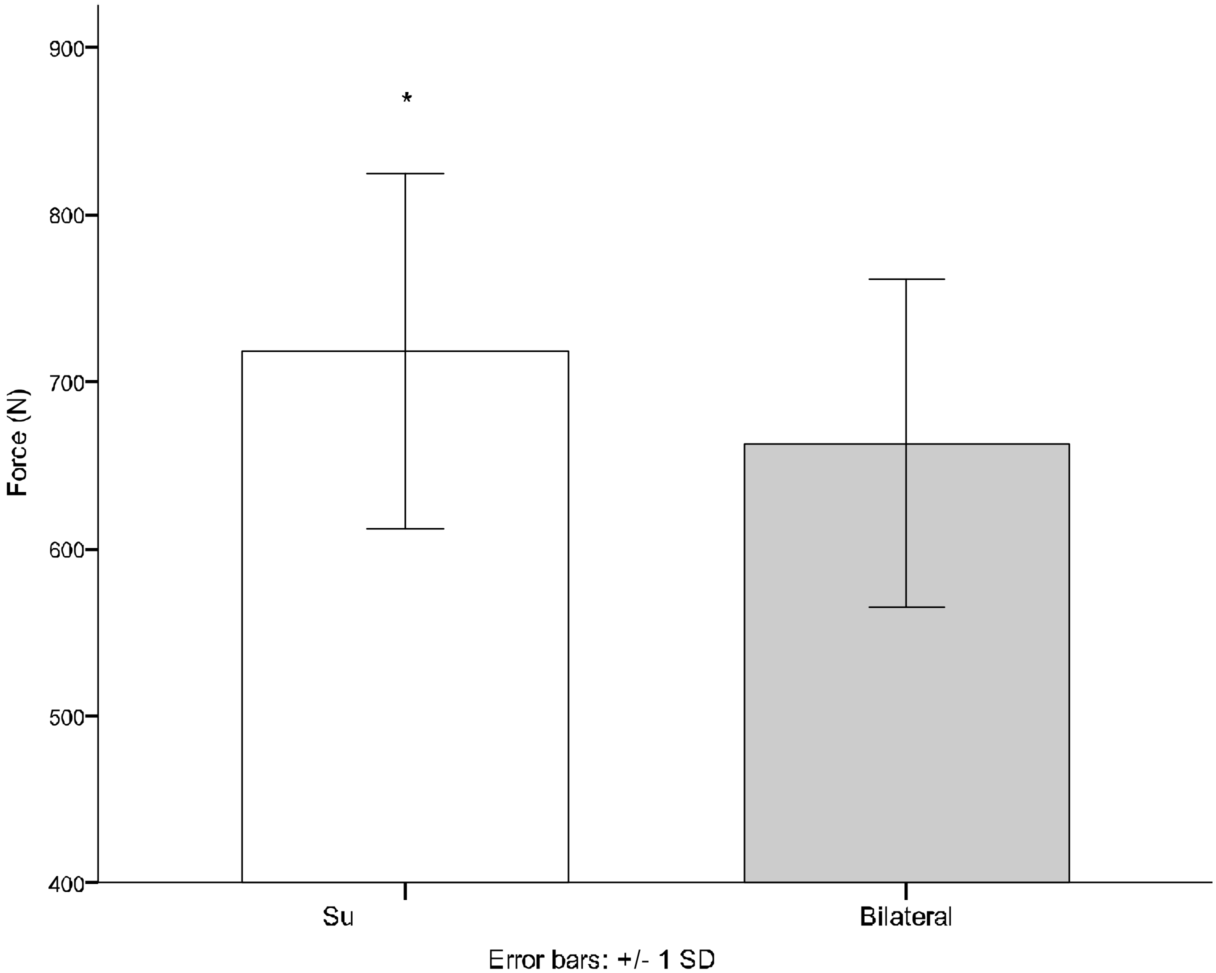


**Figure 2.** Values of the Sum of Unilateral and Bilateral Contractions (*P<0.05).

## DISCUSSION

The purpose of this study was to verify if bilateral deficit occurs during maximal isometric knee extension. The results confirmed our initial hypothesis that the sum of unilateral strength is greater than the bilateral strength at 120º of knee extension in trained men. Several studies are in agreement with our findings. The study that most resembles our research design is that of Pinto et al. (17), in which the authors assessed the maximal isometric knee extension in 10 untrained men. The results showed the existence of bilateral deficit in strength, which corroborates with the results of this study. Other authors also confirmed the existence of bilateral deficit in RT. Vandervoort et al. (25) studied the bilateral deficit in the bench press in three different situations involving isometric and isotonic contractions at low and high speeds using the isokinetic machine. The bilateral performance was lower than the unilateral at high speed. However, at low speeds, as well as in isometric work, the differences were not significant. This indicates that the speed of movement and different angles can also have influence on the bilateral deficit.

Chaves et al. (8) showed through the 1 RM test in elbow flexion and leg extension that the sum of unilateral forces is significantly greater than the bilateral force. However, no significant difference for leg flexion was verified. Simao et al. (22) evaluated 24 untrained subjects of both genders and the authors found that bilateral deficit occurred for 1 RM, but no significant differences were found for muscle power in elbow flexion. Contrary to our results, the study of Monteiro and Simao (14) submitted 20 women (age, 18-30 yrs) to a 10 RM test in knee extension and elbow flexion movement. They showed that the bilateral workload was greater than the unilateral sum in both exercises.

The mechanisms involved in muscle contraction are complex and involve basically the interaction between the sensory receptors, the central command of nervous system and skeletal muscles, in which, through negative feedback, the final product is the sliding of the contractile proteins actin and myosin (11). The right cerebral hemisphere commands the muscular contractions of the left side of the body and *vice-versa*. The literature references the bilateral deficit phenomenon as a consequence of several physiological aspects.

During the bilateral contraction there is higher motor complexity and simultaneous activation of both cerebral hemispheres. Thus, it seems that in this situation there is less activation of each hemisphere, which causes a significant reduction in the activation of motor units, allowing for lower force production. Whereas, during the unilateral contraction, where only one cerebral hemisphere is acting, there seems to be greater neural activation and increased recruitment of motor units, mainly type II fibers, which cause increased production of muscle strength (9). This inter-hemispheric inhibition may be a limiting factor of motor performance which would explain the results of this study.

It is important to note the limitations of this study. The sample was composed of only males, which limits the interpretation of the findings. Another limitation is that only one attempt for each contraction (dominant, non-dominant and bilateral) was performed. It is possible that if more attempts were made the subjects may have achieved higher levels of strength.

The load of training is one of the main variables that must be taken into consideration during the RT prescription. According to the results of this study, the sum of unilateral isometric contractions of knee extension is greater than the bilateral contraction. This would make the unilateral training an effective strategy for mobilizing higher loads during the RT, which would entail an important stimulus for the development of strength and muscle hypertrophy.

## CONCLUSIONS

The results of this study confirmed our hypothesis that bilateral deficit occurs at 120º of maximum isometric knee extension in trained men. However, future studies should investigate other angles, other exercises, and the inclusion of untrained subjects and women to compare the results and to present further information about the bilateral deficit during the RT.

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**Address for correspondence:** Marcelo Ricardo C. Dias, Laboratory of Exercise Physiology, Granbery Methodist Institute, Juiz de Fora, MG, Brazil, 36010-532. Phone: 55 (32) 2101-1838; Email: diasmr@gmail.com

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