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ARE TRAINED MEN REALLY STRONGER? A COMPARISON OF RELATIVE STRENGTH IN UPPER AND LOWER LIMBS

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ABSTRACT

This study compared the relative strength of the upper and lower limbs in trained and untrained men. Twenty-four healthy adult men participated, divided by training experience into Trained (TR) and Untrained (UNTR) groups. Participants performed one-repetition maximum tests in the bench press and 45º leg press in two sessions separated by 24 hours. The weight lifted was normalized by body mass as an indicator of relative strength. According to the results, TR showed higher relative strength in the bench press than UNTR, while no difference was observed in the leg press. The relative strength ratio (leg press/bench press) was higher in the UNTR. In conclusion, although TR men showed greater relative strength in the bench press than UNTR men, there was equivalence in relative strength for the leg press. This suggests that TR individuals focus more on training their upper limbs than their lower limbs over time.

Key words: Muscle Strength. Resistance Training. Physical Performance. Health.

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RESUMO

Homens treinados são realmente mais fortes? Comparação de força relativa nos membros superiores e inferiores

Este estudo comparou a força relativa nos membros superiores e inferiores de homens treinados e não treinados. Participaram 24 homens adultos saudáveis divididos pelo tempo de treinamento entre Treinados (TR) e Não Treinados (UNTR). Os participantes realizaram testes de 1 repetição máxima no supino reto e leg press 45º em 2 sessões separadas por 24 horas. O valor de peso encontrado foi normalizado pela massa corporal, como indicador de força relativa. De acordo com os resultados, os TR apresentaram maior força relativa no supino do que os UNTR, enquanto não houve diferença no leg press. A razão de força relativa (leg press/supino) foi maior nos UNTR. Concluindo, apesar dos homens TR apresentem maior força relativa no supino do que os UNTR, houve uma equivalência na força relativa no leg press, sugerindo que os TR dedicam maior treinamento nos membros superiores que inferiores ao longo do tempo.

Palavras-chave: Força muscular. Treinamento Resistido. Desempenho Físico. Saúde.

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INTRODUCTION

Resistance training is a method that involves muscle contractions performed against resistance, either by one's body weight or through the use of weights and machines (Winett, Carpinelli, 2001).

This training method is widely recognized for its significant contributions to overall health, including preventing hypertension, diabetes, and mental disorders (Barahona-Fuentes and collaborators, 2020).

In addition to the overall health benefits, RT promotes several neuromuscular adaptations, such as increased aerobic capacity, muscle hypertrophy, and maximum strength gain (Maestroni and collaborators, 2020), enhancing both sports performance and everyday motor actions (Chaabene and collaborators, 2020; Lacio and collaborators, 2021).

In this context, individuals who engage in RT can lift significantly greater weights than untrained (UNTR) individuals (Ahtiainen and collaborators, 2003; Pedrosa and collaborators, 2024).

The difference in weightlifting ability between trained (TR) and UNTR individuals results from the neuromuscular adaptations developed by those who practice RT regularly (Carroll, Carson, 2001; Lacio and collaborators, 2021).

These adaptations include, among other aspects, changes in muscle architecture, an increase in the level of voluntary muscle activation (Duchateau and collaborators, 2021), enhanced muscle synchronization, and an increase in motor unit firing rates (Schoenfeld and collaborators, 2015).

Muscle hypertrophy is another adaptation associated with RT, characterized by an increase in the size of muscle fibers and, consequently, in the volume and number of myofibrils (Schoenfeld and collaborators, 2021).

This characteristic contributes to the superior capacity of RT to generate more force compared to UNTR due to the greater availability of muscle mass in the first group. In addition, studies indicate that TR has a smaller spacing between myofibrils, suggesting a structural compaction that allows the presence of more contractile filaments in a given area.

This results in an increase in the capacity to produce tension (Maeo and collaborators, 2023). Together, it is observed that morphological adaptations and changes in the central nervous system promote significant advantages to TR in strength performance when compared to UNTR.

However, total muscle strength, or absolute strength (defined as the most significant amount of weight lifted in one repetition), can be influenced by several variables, such as gender, age, training history, and body size, which makes direct comparisons between different groups complex (Jacobson and collaborators, 2013).

Strength values can be normalized about body mass to overcome these differences, resulting in relative strength. This strategy seeks to minimize the effects of initial variations in the independent variable. For example, comparing absolute strength between two groups can lead to different conclusions than those obtained through relative strength (Thei and collaborators, 2019).

Thus, considering that TR tends to have greater muscle mass and, consequently, greater body mass and that muscle mass is directly related to strength performance (Suchomel and collaborators, 2018), it is plausible that these individuals demonstrate higher relative strength values than UNTR.

Existing evidence highlights that men tend to allocate more time to training upper body muscles (upper limbs: UL), with no significant gender differences in the time spent on lower body muscles (lower limbs: LL) (Nuzzo, 2023).

Among individuals of the same sex, those with a trained status are generally expected to show greater strength in UL and LL exercises compared to UNTR.

However, the magnitude of these differences may vary depending on adherence to training and focus on specific muscle groups. For instance, TR men often emphasize UL training at the expense of LL, potentially limiting lower body adaptations (Nuzzo, 2023).

Thus, we hypothesize that relative strength differences between TR and UNTR men will be more pronounced in UL exercises. To test this hypothesis, this study aims to compare the relative strength of TR and UNTR men in the barbell bench press (UL) and 45º leg press (LL).

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MATERIALS AND METHODS

Sample

Twenty-four healthy adult men with previous experience in RT and no history of injuries were selected for the present study. Participants were divided into TR and UNTR groups, with twelve individuals each.

Participants in the TR group were required to have a minimum of three years of continuous RT, allowing interruptions of no more than 30 days within this period. In contrast, individuals with resistance training experience of at least three months but no more than six months were categorized into the UNTR group.

All participants were informed about the objectives and methods of the study and provided written consent. The Federal University of Minas Gerais Ethics Committee previously approved the research protocol under number 39917714.8.0000.5149.

Study design

Participants were randomly assigned to perform the one-repetition maximum (1RM) test on the barbell bench press and the 45º leg press in two randomized sessions, separated by 24 hours.

These two exercises were chosen because they are commonly used in sports or recreational settings and, in the present study, represent the strength of the upper and lower limbs, respectively. Then, the maximum weight lifted in each 1RM test was normalized by body mass, reporting the relative strength in each test.

Procedures

First session: Anthropometric record and 1RM protocol for the bench press or leg press. The anthropometric record included the assessment of body mass, height, age, and seven-point skinfolds to measure fat percentage and training history (Jackson, Pollock, 1985).

For the 1RM test of both exercises, participants could perform up to five attempts to determine the maximum weight lifted. All attempts strictly adhered to standardized execution protocols, including the prescribed range of motion and movement patterns. A rest interval of between 3 and 5 minutes was offered between attempts, according to each participant's perception of recovery. During the test, a minimum weight of 1 kg was added for the bench press and 10 kg for the 45º leg press.

The 1RM testing protocol began with a warm-up consisting of ten repetitions at 40% of the estimated 1RM value, followed by one minute of rest and then six repetitions at 60% of the estimated 1RM value. The estimated 1RM value was determined based on the participants' judgment. After the warm-up, there was a three-minute rest interval before the start of the test.

To standardize the bench press exercise, participants were instructed to hold the bar as they usually do in their regular training routines, a familiar and comfortable task for them. To standardize the range of motion during the eccentric phase, a smooth rubber device (2 cm in height, 4 cm in length, and 4 cm in width) was positioned on the participant's chest. Upon making contact with the device, participants were instructed to lift the bar vertically to full extension, completing one repetition. The exercise was performed with a traditional bench press (Vitally®, Brazil), which had a vertical adjustment for positioning the bar. The bar weighed 10 kg and measured 200 cm in length, with all weights previously checked on a three-digit digital scale.

Second session: The second session was performed 24 hours after the first and maintained the criteria and procedures previously described. In this session, the individual performed the 1RM test in the 45º leg press exercise. The participants positioned their feet on the platform per their regular training routines to standardize the exercise. The location of the feet was documented to ensure reproducibility in subsequent phases. In the starting position, the volunteers kept their knees extended. The platform was lowered until it formed a 90º angle of knee flexion (0º = knee extended), determining the end of the eccentric phase. Then, the participant pushed the platform until full knee extension was reached, ending the concentric phase. To monitor the movement angles, a goniometer was placed on the knee joint, and two tape marks were individually attached to the machine to indicate the 90º and 0º angles of knee flexion to facilitate visualization of the exercise phases.

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Statistical analysis

Initially, the maximum weight lifted in each 1RM test was individually divided by the participant's body mass to determine relative strength. Then, the normality of the relative strength values of the upper and lower limbs was confirmed by the Shapiro-Wilk test. A t-test for independent samples was conducted to compare the relative strength of the upper and lower limbs between the TR and UNTR groups. In a complementary manner, the weight value found in the 1RM test of the lower limbs was divided by the weight value found in the 1RM test of the upper limbs and compared between the groups by the t-test. In addition, the effect size values (ES – Cohen's d) were reported to reflect the magnitude of the differences between the groups (small: 0.01; medium: 0.06; large: 0.14) (Cohen, 1998). All statistical procedures were performed using SPSS software (IBM SPSS 22.0; IBM, Armonk, USA).

RESULTS

The descriptive information of each group associated with the anthropometric profile and the performance of each group in the 1RM tests are shown in Table 1.

Table 1 - Characteristics of individuals in each studied group.

Group	Body Mass (kg)	Height (cm)	Age (years)	Body Fat (%)	Training History (months)	1 RM Bench Press (kg)	1 RM Leg Press 45º (kg)
TR	84,0 ± 5,0*	178,2 ± 7,1	28,0 ± 3,0	12,6 ± 4,0	96 ± 24*	109,5 ± 15,19*	348,1 ± 52,6*
UNTR	69,0 ± 6,0	174,7 ± 5,0	23,7 ± 5,1	8,4 ± 5,0	5 ± 1,0	74,3 ± 10,4	283,1 ± 44,0

Data are presented as means and standard deviations (±). TR: trained individuals; UNTR: untrained individuals. *Significant difference from UNRT (p<0.05).

Considering the comparison of the relative strength of the upper limbs, the t-test indicated that the TR presented a higher value than the UNTR (t = -3.3552; p = 0.003; ES = 1.33). However, there was no significant difference between the relative strength of the lower limbs of the TR and the UNTR (t = -0.1822; p = 0.857; ES = 0.07). Figures I and II illustrate, respectively, the results of the comparison between groups regarding the relative strength of the upper limbs and lower limbs.

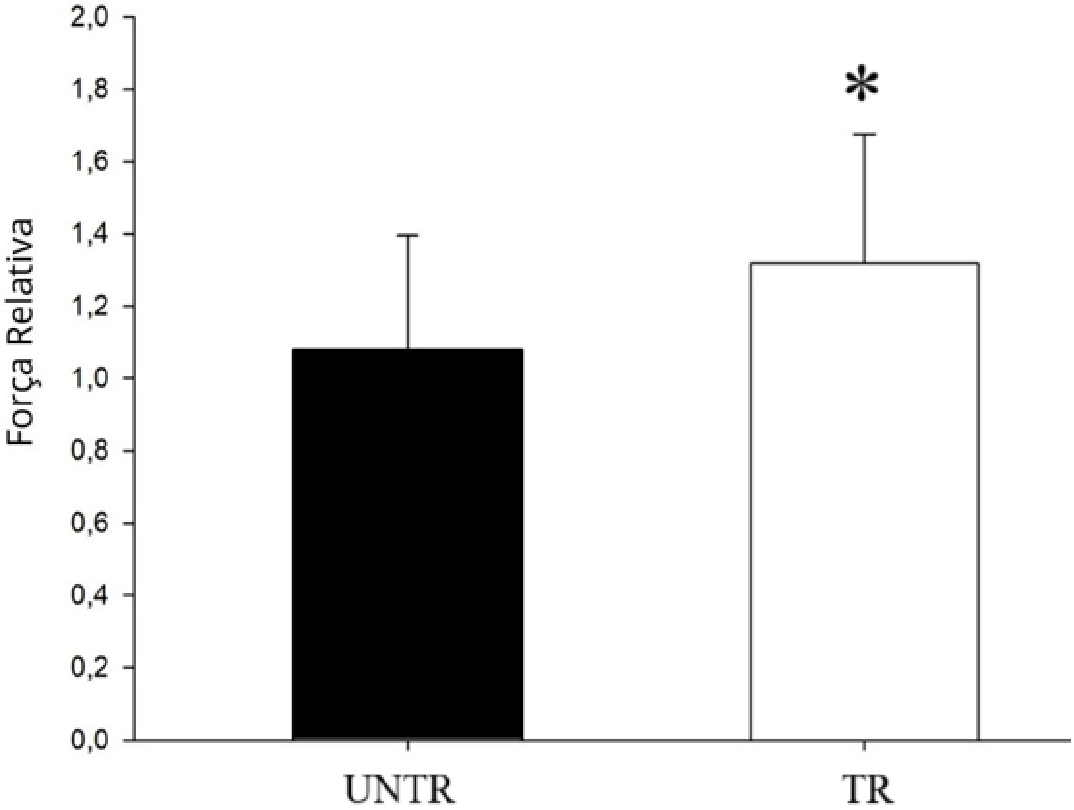

Figure 1 - Comparison of the relative strength of upper limbs between trained (TR) and untrained (UNTR) individuals. * = greater than UNTR. $p<0.05$

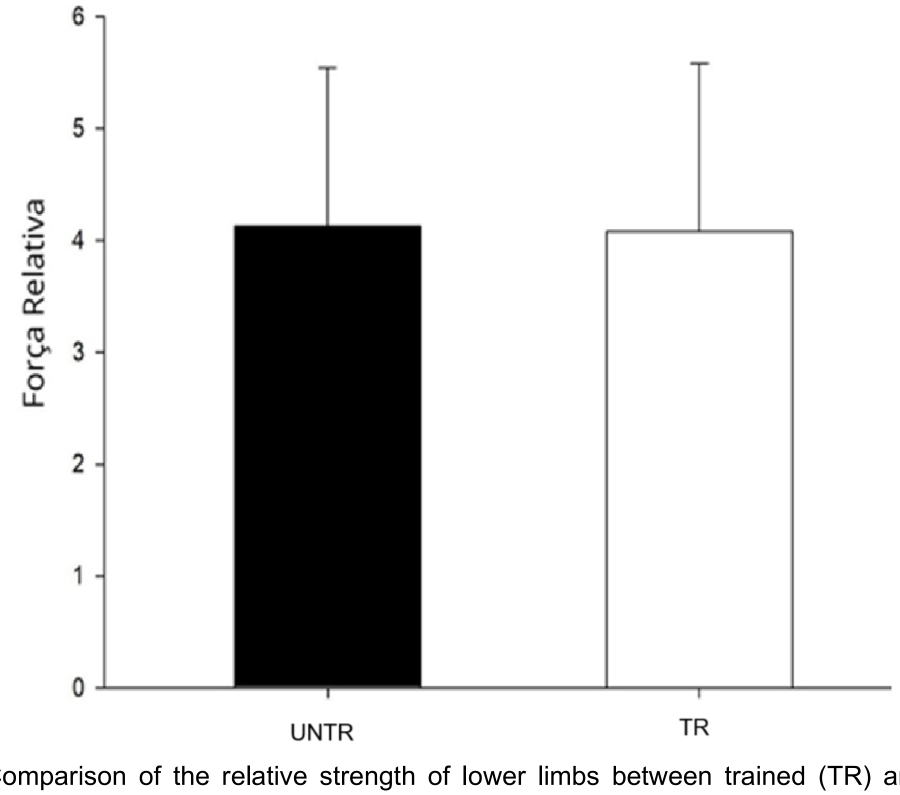

Figure 2 - Comparison of the relative strength of lower limbs between trained (TR) and untrained (UNTR) individuals.

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Additionally, the t-test indicated that the relative strength ratio (1RM leg press / 1RM bench press) was significantly different between the groups (t = 2.8574; p = 0.005; ES = 0.16), in which the UNTR presented a higher value than the TR.

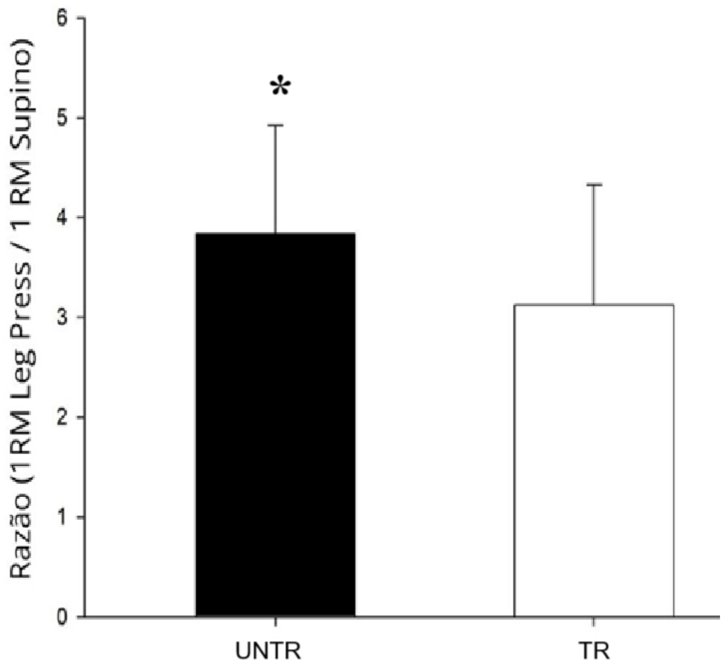

Figure 3 - Absolute Strength Ratio (1RM leg press / 1RM bench press) between trained (TR) and untrained (UNTR) individuals. 1RM: one repetition maximum. * = greater than TR. $p<0.05$

DISCUSSION

The study aimed to compare the relative strength of TR and UNTR men in the barbell bench press (UL exercise) and 45º leg press (LL exercise). The results indicate that the relative strength of the UL in TR was more significant than that of UNTR. However, this pattern was not repeated in the LL, where no significant differences in relative strength were observed between the TR and UNTR groups. Furthermore, the ratio between performance in the LL and UP was higher in untrained individuals.

These results corroborate previous findings (Shimano and collaborators, 2006; Pedrosa and collaborators, 2020) and confirm the hypothesis that TR have greater relative strength in the UL than UNTR. In the study by Shimano and collaborators (2006), TR men outperformed UNTR men in the 1RM barbell bench press strength test, lifting on average 45.5% more weight.

Additionally, Pedrosa and collaborators (2020) found an average difference of 31% in the result of the bench press 1RM test between TR and UNTR, a difference close to that of the present study (32.2%).

These findings with those of the present study indicate that TR can lift more weight in the 1RM test than UNTR. Possible biomechanical and physiological adaptations occurred over the training time in TR, benefiting the force production capacity (Maestroni and collaborators, 2020).

However, these studies did not normalize strength by body mass to better understand the relationship between TR and UNTR. Although we did not find studies that compared the relative strength between TR and UNTR, our findings reinforce the reasoning that TR is relatively stronger than UNTR, even after normalization by body mass.

Considering the LL, no differences were found in relative strength between TR and UNTR, corroborating the initial hypothesis formulated. This hypothesis was supported by the narrative review by Nuzzo (2023), who reported that TR men are more likely to select strength exercises for the UL to the detriment of LL exercises. This reasoning opens the possibility for the assumption that TR men neglect LL training. This neglect impacts the overload principle and adaptation resulting in

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strength adaptations of lesser magnitude in the less-trained regions.

Another point of view was presented by Santos and collaborators (2022), who reported that men underestimate the intensity of training for the LL, impairing the magnitude of the adaptations expected for the development of muscular strength.

The reasoning presented by Nuzzo (2023) and Santos and collaborators (2022) is reinforced by the present study's findings, given the lack of statistical differences in the relative strength between TR and UNTR in the leg press. Hoeger and collaborators (1990) found a difference of 21.2% in the 1RM test in the leg press between TR and UNTR, a value close to the difference found in the present study (18.6%).

Considering the percentage difference between TR and UNTR in the 1RM test in the bench press from previous studies and the finding in the present study (~30 - 32%) (Shimano and collaborators, 2006) and in the leg press (~18 - 21%) (Hoeger and collaborators, 1990), it is noted that the difference in the strength of TR vs UNTR in the UL and LL is not similar and in favor of the UL, suggesting that some factor influenced this aspect. We speculate that a combination of underestimation of LL training intensity (Santos and collaborators, 2022) and low selectivity for LL exercises (Nuzzo, 2023) in the composition of the training routine justifies the result of the equivalence in relative strength between TR and UNTR.

In addition, the ratio of the absolute values of the 1RM test in the leg press and bench press was analyzed, in which UNTR men presented a higher value than TR. The explanation for this finding is based on the availability and dedication of each group to train in each exercise. Possibly, the more extraordinary dedication to UL training compared to LL training in TR increased performance more in the bench press than in the leg press over time.

These findings reinforce a possible neglect of LL training by TR, which could, among other things, cause harm to the physical health of the practitioner. Malone and collaborators (2019) demonstrated that athletes with greater relative strength in the LL have a reduced risk of injury compared to those with less strength. Ditroilo and collaborators (2010) observed that the male quadriceps present a more pronounced decline in strength than other muscle groups over training time. In the elderly, this loss of strength is associated with reduced LL function (Latham, Liu, 2010), with LL weakness being one of the leading independent intrinsic factors for falls (Pizzigalli and collaborators, 2011).

These findings highlight the need for a balanced approach to RT, prioritizing both the UP and LL. This serves as a warning to trained men, highlighting the importance of maintaining interest in LL training to achieve a proportional level of strength and promote overall health. It is noteworthy that, to the best of our knowledge, no study has been found that compares the strength ratio between TR and UNTR using the leg press and bench press exercises to support the perspective identified in the present study.

Finally, TR participants demonstrated significantly superior performance in the bench press, leg press, and relative strength in the bench press.

Conversely, the UNTR group showed a higher leg press/bench press ratio, reflecting a greater proportion of relative strength in the LL. These findings highlight the importance of prescribing balanced training for both UL and LL, ensuring no neglect of specific segments, such as the LL. In conclusion, while relative strength in the bench press was higher in TR, no significant differences were observed in the leg press relative strength between the groups.

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