

Acute imagery resistance exercise improves subsequent muscle power performance in teenage futsal athletes

Exercício resistido imaginário agudo melhora o desempenho subsequente da potência muscular em atletas adolescentes de futsal

El ejercicio de resistencia con imágenes agudas mejora el rendimiento de la potencia muscular posterior en atletas adolescentes de fútbol sala

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Abstract

Background: Futsal is one of the most popular sport in Brazil with millions of players worldwide. It is characterized by intermittent stimuli of high intensity anaerobic actions. Recently, studies have shown that imagery resistance training (IRT), like conventional strength training, can increase muscle strength, making it reasonable to think that this effect can also be transferred to muscle power. **Purposes:** we aimed to verify the acute responses of IRT on muscle power in teenage Futsal players. **Methods:** fifteen Futsal athletes were enrolled and underwent three visits to the laboratory: 1) familiarization with the resistance exercise they would undergo; 2) one them for vertical jump test after the IRT session and the other one for control session, without any intervention before vertical jump test. Sessions 2 and 3 being applied in random order. **Results:** the results indicate that acute IRT improved muscle performance, since it produced higher power output [3134.5 Watts (2744 - 3796.3)] than control session [2952.4 Watts (2637.55 - 3433.45)] ($Z=3.4078$; $p=0.0007$). In addition, all participants in IRT group showed some improvement after the IRT session. **Conclusions:** a single imagery resistance exercise session can increase acute muscle power output in teenage Futsal athletes.

Keywords: Athletic performance; Performance enhancing effect; Vertical jump; Strength training.

Resumo

Introdução: O futsal é um dos esportes mais populares do Brasil com milhões de jogadores em todo o mundo. Caracteriza-se por estímulos intermitentes de ações anaeróbicas de alta intensidade. Recentemente, estudos têm demonstrado que o Treinamento Resistido Imaginário (TRI), como o treinamento de força convencional, pode aumentar a força muscular, tornando razoável inferir que esse efeito também pode ser transferido para a potência muscular. **Objetivos:** buscamos verificar as respostas agudas do TRI sobre a potência muscular em jogadores adolescentes de Futsal. **Métodos:** quinze atletas de futsal foram inscritos e passaram por três visitas ao laboratório: 1) familiarização ao exercício resistido que eles seriam submetidos; 2) teste de salto vertical após a sessão de TRI e; 3) para sessão de controle, sem qualquer intervenção antes do teste de salto vertical. Sendo as sessões 2 e 3, aplicadas em ordem randômica. **Resultados:** os resultados indicam que o TRI agudo melhorou o desempenho muscular, uma vez que produziu maior potência de potência [3134,5 Watts (2744 - 3796,3)] do que a sessão de controle [2952,4 Watts (2637,55 - 3433,45)] ($Z=3,4078$; $p=0,0007$). Além disso, todos os participantes do grupo TRI apresentaram alguma melhora após a sessão de TRI. **Conclusões:** uma única sessão de exercício resistido imaginário pode aumentar a produção aguda de potência muscular em atletas adolescentes de Futsal.

Palavras-chave: Desempenho atlético; Efeito de aumento de desempenho; Salto vertical; Treinamento de força.

Resumen

Introducción: El fútbol sala es uno de los deportes más populares en Brasil con millones de jugadores en todo el mundo. Se caracteriza por estímulos intermitentes de acciones anaeróbicas de alta intensidad. Recientemente, los estudios han demostrado que el entrenamiento de resistencia imaginario (IRT), al igual que el entrenamiento de fuerza convencional, puede aumentar la fuerza muscular, por lo que es razonable inferir que este efecto también se puede transferir a la potencia muscular. **Objetivos:** buscamos verificar las respuestas agudas del TRI sobre la potencia muscular en jugadores adolescentes de Futsal. **Métodos:** quince atletas de futsal fueron inscritos y realizaron tres visitas al laboratorio: 1) familiarización con el ejercicio de resistencia que realizarían; 2) prueba de salto vertical después de la sesión de IRT y; 3) para la sesión de control, sin ninguna intervención antes de la prueba de salto vertical. Las sesiones 2 y 3 se aplicaron en orden aleatorio. **Resultados:** Los resultados indican que la IRT aguda mejoró el rendimiento muscular, ya que produjo una mayor producción de potencia [3134,5 Watts (2744 - 3796,3)] que la sesión control [2952,4 Watts (2637,55 - 3433,45)] ($Z=3,4078$; $p=0,0007$). Además, todos los participantes del grupo IRT mostraron alguna mejora después de la sesión IRT. **Conclusiones:** una sola sesión de ejercicio de resistencia imaginaria puede aumentar la producción aguda de potencia muscular en deportistas adolescentes de fútbol sala.

Palabras clave: Rendimiento deportivo; Efecto potenciador del rendimiento; Salto vertical; Entrenamiento de fuerza.

1. Introduction

Futsal is practiced in more than 100 countries with a growing popularity and millions of players worldwide (Berdejo-del-Fresno et al., 2014). Data suggest that futsal is the most practiced sport in Brazil, especially during school ages (Moura & Salles, 2005). This sport is characterized by explosiveness and sprints, usually lasting from one to four seconds and performed at supra-maximum, maximum or sub-maximal intensities with short rest intervals, getting through it with actions at low intensity or even with none action, as during breaks (Naser et al., 2017). Most of game's actions last (75%) from one to eighteen seconds, indicating that muscle power is relevant for success in this sport (Barbero Álvarez et al., 2003). The literature evidenced positive effects of strength training on muscle power in any population, but especially in athletes who play sports, which muscle power is more required, such as basketball (Marques et al., 2005) and Futsal (Araujo et al., 2014).

More recently, studies have shown that imagery resistance training (IRT) can increase muscle strength (Lebon et al., 2010; Ranganathan et al., 2004; Reiser, 2011). IRT consists of a cognitive review of a physical skill in the absence of explicit physical movements (Tonello, 2009). In other words, is also understood as thinking or imagining certain aspects of the skill being practiced, without doing any movement (Marques et al., 1992).

Therefore, it is reasonable to infer that imagery strength training can favour neuromuscular performance, such as power, which is extremely important aspect for Futsal players. However, for the best our knowledge, there are no studies that investigated the responses of IRT on muscle power. Given this scientific context, the aim of the present study was to verify the responses of acute IRT on muscle power in teenage Futsal players. We hypothesize that IRT could increase the subsequent vertical jump performance.

2. Methodology

The present study used as a reference the assumptions described by the "International Committee of Medical Journal Editors" and respected all the items proposed in the recommendations "Consolidated Standards of Reporting Trials". The study was approved by University Ethics Committee in Research (protocol no. 0183/2010), following Helsinki Declaration and Brazil National Health Council Resolution No. 466/2012.

Subjects

Fifteen male amateur Futsal athletes, aged 14 to 17 years, participated in the study. The subjects were invited by public call at the club where they acted as futsal players. Inclusion criteria's were: aged between 14 and 17 years; did not had any kind of bone, muscle, or joint injury; registered member of the local Brazilian athlete's Futsal Federation; and had had state-level competitions participation. Were excluded from the study, individuals with some kind of musculoskeletal injuries, use of any drug substance that might affect the performance. The subjects were informed of the benefits and risk of the investigation, later, consent and assent forms were given and signed by the parents (or guardians) and participants, respectively.

The sample size calculation, a priori statistical power was used, considering the Wilcoxon signed-rank test, an effect size of $d=0.68$ (moderate), mean and standard deviation of both sessions, a correlation between sessions of 0.80 and $\alpha=0.05$. The statistical power conferred to this sample was 80% ($1-\beta = 0.80$).

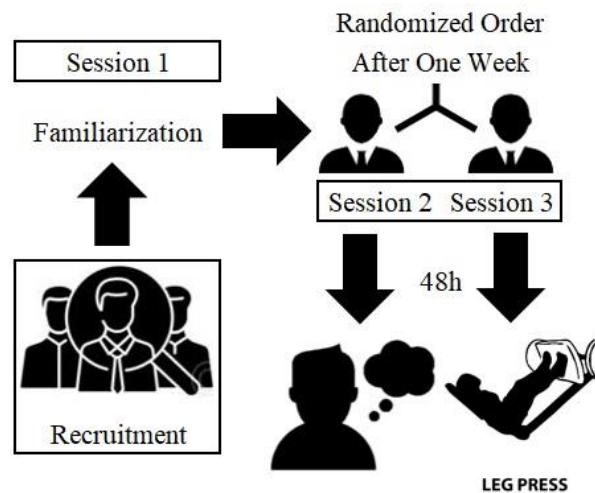
Design of Study

The experiment consisted of three test sessions: a) familiarization; b) control; and c) IRT, performed in a randomized order at the same time of day with an interval of 48 hours apart. Initially, the subjects' familiarization with the procedures was performed one week before the beginning of the experiment, all individuals went to the laboratory and performed an exercise

session, conventional resistance training, as proposed in the experimental session (3 sets of 15 repetitions with a 3-second cadence for both phases, concentric and eccentric), with a self-related comfortable intensity load. This session had the purpose of making the individuals capable of perceiving the sensation of effort, making the imagery training session close to the real one. Subsequently, in random order, the control and imaginary sessions were performed according to the procedure described in Figure 1.

All subjects were instructed to maintain their eating habits throughout the study and do not perform any exhaustive physical activities within 48 hours prior to the test sessions. All tests were carried out in the Laboratory of Translational Exercise Physiology (LAFET) at the State University of Goiás, Câmpus Sudoeste-Quirinópolis, Brazil.

Figure 1. Experimental procedures: control and imaginary sessions.



Source: Authors.

Anthropometric Measurements

Anthropometric measurements (height and body mass) were carried out before the first test session. Height was obtained using a wall stadiometer (Sanny®, Brazil) and body mass was obtained using a digital scale (Welmy®, Brazil), according to the technique suggested by ISAK (International Society for the Advancement of Kinanthropometry).

Vertical Jump Test

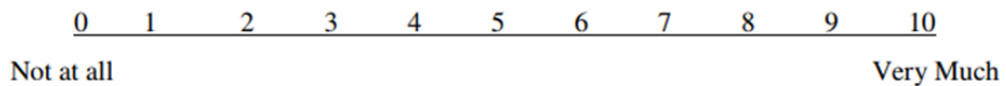
The test consisted of jumping as high as possible, performing the total extension of the knees, with the balance of the upper limbs for the execution of the jump (Laffaye et al., 2006). At the time of the jump, volunteers could freely flex the lower limbs as well as move the upper limbs to provide the greatest possible vertical thrust. Each individual performed three jumps and the highest jump was considered for peak power calculation (Bosco et al., 1983).

The height of the vertical jump was obtained using a smartphone application previously validated (Carlos-Vivas et al., 2018), called “My Jump”. This application makes it possible to measure height, speed, as well as identify the best jump. The Sayers power equation [peak power (W) = $60.7 \times (\text{cm}) + 45.3 \times \text{body mass (kg)} - 2055$] was used to estimate the total power output in Watts (Sayers et al., 1999). The reliability of the measurements was very high (intra-class correlation coefficient [ICC] = 0.977–0.989). According to Arteaga et al. (2000) the measurement error observed for the countermovement vertical jump for trained subjects is 6.3%. We applied the vertical jump due to it is strongly correlated with maximal strength and sprinting in soccer player (Sales et al., 2018; Wisloff, 2004).

Perceived Exertion during the Imagery Scene

The scale consisted of 10 items aimed at evaluating the perceived level of involvement with the mental images, adapted (Razon et al., 2010). The scale (Figure 2) consisted of assigning a value from zero to 10 to the following question: “to what extent did you perceived the exertion during the imagery scene?”

Figure 2. Perceived Exertion Scale



Source: Authors.

Control Session

Participants remained seated, at rest, for 10 minutes. Afterwards, they were placed on the Leg Press machine apparatus and instructed to keep on resting. The subjects were allowed to use their Smartphones while waiting for six minutes and 30 seconds, the approximate time spent for IRT session. Subsequently, the individuals were kept at rest for another seven minutes, since the literature advocates a post-activation potentiation response (PAP) (Bird et al., 2005), when the individuals are submitted to a set of strength exercises with certain characteristics and with a rest interval between five and eight minutes (Bird et al., 2005). Thus, the seven minutes proposed here, fitted the recommended time span for visualizing the physiological event in question (PAP). Finally, the athletes were positioned in the vertical jump area, where they performed three consecutive jumps and the best result was used to calculate muscle power output.

Experimental Session

Similar to the control session, participants remained seated, at rest, for 10 minutes. Then were properly positioned on the Leg Press machine apparatus, and instructed to imagine performing the exercise session, which consisted of three sets of 15 repetitions. Each repetition should have a three-second cadence for Imagery concentric phase and three seconds for Imagery eccentric phase, and one-minute recovery interval between sets, totaling six minutes and 30 seconds of Imagery training. The subjects were encouraged to mentally replicate the same level of effort in which they performed in conventional strength training performed during familiarization. After the IRT, individuals answered the perceived exertion scale (Figure 1) adapted (Razon et al., 2010) for imagery scene. At the end of the IRT, individuals had a seven-minute rest interval, before performing the vertical jump test. Same as the control session, the athletes were positioned in the vertical jump area where they performed three consecutive jumps and the best result was used to calculate muscle power output.

Statistical Analyses

The normality of the data was evaluated using the Shapiro-Wilk test. For the variables that presented Gaussian distribution (age, body mass, height and perceived exertion during the imagery scene), the results were presented as mean and standard deviation. For variables that did not have a normal distribution (body mass index and power of the vertical jump), data were expressed as medians and their respective interquartile ranges (25th and 75th percentiles). In addition, muscle power results were also expressed in individual values (spaghetti plot). The comparison of muscle power between the sessions, control and IRT, was carried out using the Wilcoxon test. The level of statistical significance was ≤ 0.05 . All procedures were performed using the Statistical Package for the Social Sciences 21.0 software for Windows (SPSS 21.0) and G*Power 3.9.1.7.

3. Results and Discussion

The characteristics of the sample are displayed in Table 1.

Table 1. Characteristics of adolescent futsal athletes.

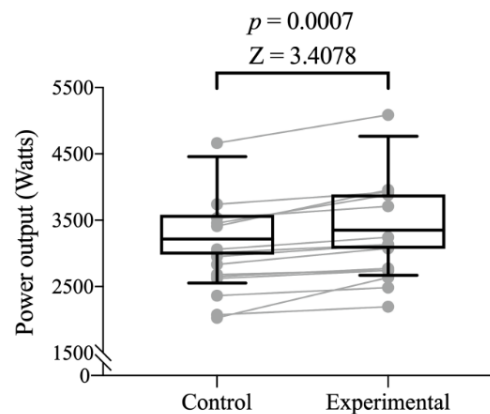
Variables	Position and dispersion measures
Age(years)	15.4 ±1.2
Body mass(kg)	59.2 ±9.3
Height (cm)	172 ±0.1
BMI (kg·m ⁻²)	19.5 (18.95 – 22.8)

BMI – body mass index. Source: Authors.

Although the height of the vertical jump is often presented as a variable of normal distribution, due to the BMI having presented a considerable variation, although within the same stratum (eutrophic), thus reverberating, in the violation of normality ($p < 0.05$). This, in turn, affected the variation of estimated muscle power, as the equation to estimate muscle power has body mass as a variable.

Muscle power showed significant differences ($Z = 3.4078$; $p = 0.0007$) between control [2952.4 Watts (2637.55 - 3433.45)] and IRT [3134.5 Watts (2744 - 3796.3)]. It is noteworthy that 100% of the participants showed some improvement after IRT session, with an average improvement of 8.3% (Figure 3). Additionally, IRT elicited some effort, with an average of perceived exertion score of 4.7 ± 1.6 , on a scale ranging from zero to 10.

Figure 3. Power output in teenage futsal athletes.



Source: Authors.

The main finding of the present study indicates that a single session of IRT can increase subsequent muscle power in youth Futsal athletes. This finding can be partly explained by the increase in muscle strength produced by IRT (Lebon et al., 2010; Ranganathan et al., 2004; Reiser, 2011).

Ranganathan et al., carried out a study with 30 individuals divided into four groups, the first group ($n = 8$) being instructed to perform imagery muscle contractions of finger abduction; the second group ($n = 8$), imagery muscle contractions from elbow flexion; and the control group ($n = 8$), without any type of intervention (Ranganathan et al., 2004). Lastly, six volunteers ($n = 6$) performed training of physical maximal finger abductions. The training period lasted 12 weeks (15 min a day, 5 days a week). At the end of training, it was found that the little finger abduction group increased its strength by 35% ($p < 0.005$) and the elbow

flexion group increased its strength by 13.5% ($p < 0.001$). The control group showed no significant changes in strength for finger abduction or elbow flexion tasks.

The improvement in muscle strength of the trained groups was accompanied by significant increases in the cortical potential derived from the electroencephalogram, a measure previously demonstrated directly related to the control of voluntary muscle contractions (C3 region). Moreover, an increase in the electromyographic activity of the related muscles (little finger abductor and biceps brachii) to the joint movement analyzed (abduction of the little finger and flexion of the elbow). Suggesting that imagery training can increase the cortical potential and lead to the excitability of the mentally trained musculature reverberating in a significant increase in strength, and therefore in muscle power.

Another explanation for the increase in muscle power can be attributed to PAP. The physiological mechanism that has been widely studied and accepted is related to phosphorylation of myosin light regulatory chains. This physiological event occurs when a muscle strength exercise is performed prior to a power activity. Thus, a greater release of calcium by the sarcoplasmic reticulum produces an increase in the concentration of this ion in the sarcoplasm, causing an increase in the process of formation of the calcium/calmodulin complex, reverberating in a greater activation of the myosin light chain kinase enzyme, which mediates phosphorylation and is activated by the presence of calcium. This, in turn, makes the actin-myosin interaction more sensitive to the calcium released by the sarcoplasmic reticulum and also makes this interaction last longer. In this way, a greater number of cross bridges is activated, generating a muscle performance higher than that observed without PAP (Bird et al., 2005).

On the other hand, the PAP mechanism that seems to better explain the improvement in performance in the present study may be due to changes in the neural activation pattern, leading to an increase in the recruitment of higher threshold motor units, that is, greater amplitude of the H-reflex, thus improving performance in subsequent activity (Bird et al., 2005). So, as previously mentioned, imagery training seems to provide significant increases in the cortical potential derived from the electroencephalogram, as well as an increase in the electromyographic activity of the muscles related to the analysed joint movement (Ranganathan et al., 2004).

As a practical application, the results of the present study indicate that the IRT, performed previously the activity that requires muscular power, can be an auxiliary or alternative method to the conventional strength exercise to induce effects similar to PAP. Thus, it is suggested that power athletes use IRT or associate it with conventional resistance exercise, before being underwent to the main physical task (activities that require muscle power), in order to benefit from the improvement in physical performance that this maneuver seems to produce.

It is important to mention that, as previously shown (Lebon et al., 2010), the association of IRT with conventional strength training seems to significantly increase muscle strength. Therefore, it becomes reasonable to infer that this improvement in muscle strength can also reverberate in muscle power.

Although, this study is the first to evaluate the acute response IRT, especially when analysing its effect on muscle power output, it is suggested that power athletes perform an IRT session, as proposed here, or associate it with conventional resistance training to improve muscle strength, and, in turn, increase muscle power.

It is important to mention that, as far as is known, this study is also a pioneer in investigating an exercise protocol that best mimics the practice. Since, in a recent systematic review (Paravlic et al., 2018), the meta-regression analysis revealed that at least 25 repetitions and duration of 15 minutes per exercise are necessary, which, in our view, does not necessarily mimic practice.

The fact that we were not able to measure any neural variable, central or peripheral, can be pointed as a limitation. On the other hand, this limitation may have been, at least in part minimized by obtaining the perceived exertion scores during the imagery scene. Furthermore, we do not observe at how long the effect of an IRT session on muscle power output can last. We suggest that further studies should minimizing the limitations raised here, in an attempt to better explain the event in question,

as well as to verify how long it can last.

4. Conclusion

In conclusion, it is known that IRT positively affect muscle strength. This study helps to demonstrate that IRT is beneficial to increase muscle power output as well in teenage Futsal athletes. The application of IRT is recommended during training sessions, as this stimulation can promote an improvement in performance and, consequently, accelerate the appearance of progress resulting from strength training. Therefore, knowledge of these dynamics is exceptional and can have significant applications in sport and rehabilitation sets.

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