Original Article

Musical and biofeedback stimulus increased performance during upper limb resistance exercises

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Abstract:

Introduction: Regular practice of resistance training offer positive results on muscular and physical performance. Thus, some strategies have been developed to influence the increase of performance results. Therefore, the objective of this study was to verify the influence of music, placebo supplementation and biofeedback on the number of executions and total volume, as well as the myoelectric activity of the pectoralis major muscles and triceps brachii. **Methods:** Men between 18 and 40 years of age, practicing and not practicing bodybuilding, were selected for convenience. Data recording was performed in four different conditions: a. Without intervention, b. Placebo intervention, c. Music and d. Biofeedback. As for the variables, the number of repetitions, total load and myoelectric activity of the evaluated muscles were measured. **Results:** A significant increase in the number of repetitions ($p = 0.008$) and total load ($p = 0.001$) with music application was observed, although the condition biofeedback also significantly influenced ($p < 0.05$) the total load ($p = 0.005$). **Conclusion:** It was verified with this study that music and biofeedback increased the total load and only the music increased the number of repetitions. However, there was no change in myoelectric activity.

Keywords: Resistance training; Music; Athletic Performance; Biofeedback..

Introduction

Regular practice of resistance exercise promotes positive results in muscle performance, contributing for improvements in strength, hypertrophy and resistance (Heiestad, Rustaden, Bø, & Haakstad, 2016). Are generally observed by practitioners an improvement of sport performance, quality of life and health, therefore, resistance exercise stands out like modality commonly chosen for athletes and non-athletes of both sexes and ages groups (Howe & Waldron, 2017). However, in view of the characteristics from practice such as monotony and the difficulty in obtaining results over time of practice, both point of view temporal and in terms of load adjustment, strategies are necessary to increase of results (Heiestad et al., 2016).

Some strategies, such as the use of placebo, have been adopted with the intention of causing positive effects in the subjects. Implementation of this type of resource in the research area has grown and aroused great interest due to its psychophysiological effects (Bystad, Bystad, & Wynn, 2015). In turn, music also stood out as a valuable instrument during the training process, as well as during competitions. According to some authors, music can contribute to the reduction of monotony, reduction of the subjective perception of effort and increase of motivation in the practice of exercise (Silva et al., 2016; Stork, Kwan, Gibala, & Ginis, 2015). In the same way, biofeedback, a commonly used approach in rehabilitation situations, is a technique that allows to increase the sensitivity and control of the physiological process through the use of instruments that measure and inform the individual with information about autonomic activities and / or disorders neuromuscular the form of auditory and visual signals. Biofeedback has proven to be a great motivational tool (Hernandez N, Martinez K, 2018; Huang, Lin, Guo, Wang, & Chen, 2013; Sturma et al., 2018). However, although studies have investigated the effect of different strategies on performance in resistance training (M. Marocolo, Da Mota, Pelegrini, & Appell Coriolano, 2015; Saunders et al., 2017), there are still few comparisons between them.

Thus, the aim of this study was to compare the effects of different strategies on resistance exercise performance of bench press.

Material & methods

Participants

Seven healthy men recreationally trained were selected for participation in this study (table 1). The exclusion criteria adopted were: a. history of chronic non communicable diseases (e.g., hypertension, diabetes mellitus, metabolic syndrome); b. use of medications that could interfere with the manifestation of the strength during the collection period; d. presence of neuromusculoskeletal diseases at least in the last six months. All subjects signed the consent form and answered they responded to Physical Activity Readiness Questionnaire (PAR-Q)(Shephard, 2015) and presented a medical document attesting full physical conditioning to perform the tests.

Table 1: characteristics of subjects.

Participants	Age	Weight (kg)	BMI	Height (cm)	1-RM (kg)
1	22	66	21,6	175	72
2	26	68	24,09	168	82
3	21	70	23,94	171	88
4	25	80	27,68	170	60
5	24	108	33,71	173	74
6	21	80	24,97	179	58
7	22	70	22,9	175	90

Legends: BMI = Body Mass Index; 1-RM = One-Repetition Maximum.

Experimental Design

This study is characterized as experimental and was approved by the Local Research Ethics Committee with Humans (n ° 2.767.698).

The collections happened in five separate days (with intervals of seven days), Always in the same period of the day (12:00 – 15:00 h) to minimize circadian influence(Casarini, Lopes-silva, Arita, Bishop, & Lima-silva, 2014), as described in figure 1:

First day: Anthropometric measurements and the one repetition maximum (1-RM);

Second day: Maximum performance test (repetition maximum test) and delivery of the bottle labeled “herbal remedy” containing seven wheat flour capsule (ingestion of a capsule per/day);

Third day: Maximum performance test considering only as resource of increase performance the possible use of the wheat flour capsules during the previous seven days (placebo strategy);

Fourth day: Maximum performance test using the music as strategy to performance improvement;

Fifth day: Maximum performance test with applied of the biofeedback.

Fig. 1: Experimental design of the protocol. 1-RM: maximum repetition test.

Maximum Repetition Test

Maximum repetition test (1-RM) followed the protocol of Baechle and Earle(Richens & Cleather, 2014), with the objective to measure the maximum individual load of participants. The protocol consisted in the maximum of four trials per day, if the 1-RM load was not found, were expected 48 hours for a new attempt(Abdessemed, Duche, Hautier, Poumarat, & Bedu, 1999). A horizontal Physicus® bench was used, a standard bar (weight 12kg, length 1.80 cm) and standard weight plates scanned on an analog scale with precision of 100 grams was used.

Maximum Performance Test

After warming with 50% of the load obtained in the 1-RM test and 15-20 repetitions, volunteers performed the maximum repetitions as possible until the concentric failure was reached, using 80% of the load obtained in the 1-RM test (Do Nascimento et al., 2007).

Total Load

To evaluate the total load (TL) of interventions, the following formula was used (J. McBride, G. McCauley, P Cormie, J. Nuzzo, M. Cavill, 2009):

$$\text{Total load} = \text{number of repetitions} \times \text{number of series} \times \text{load}$$

Applied Strategies

Placebo: prepared by a handling pharmacy, a bottle labeled "herbal remedy" containing seven capsules of wheat flour was delivery to the volunteers, who should have been ingested one capsule/day for seven consecutive days. The participants were informed that the capsules were a natural component to increase muscle strength and power. After ingesting the last capsule, the volunteers repeated the muscle performance test.

Music: each subject chose a song of your preference. On the day of maximum performance test (musical stimulus) a folding external headset (Mdr-Zx110, Sony®) coupled to a smartphone (Motorola G3) was used. The volume was individually standardized and referred to as comfortable with the music chosen by each subject. In relation to performing the performance rest, the participants only allowed to start executing from 30 seconds of the beginning of the song.

Biofeedback: the subjects performed the maximum performance test with a laptop (Sony vaio®, 14inches) in your visual field with the graphic image of the raw EMG signal reading. The graph showed in real time the record of the signal of two studied muscle (pectoralis major and triceps brachii).

Electromyographic Activity

To record myoelectric activity in each of the maximum performance tests, an EMG System of Brazil electromyograph was used (Model EMG-800C, 16 channels, USB communication, gain 2000x; Butterworth bandpass filter 20-1000 Hz 4th order) and disposable electrodes (3M®, model 2223BR; Ag-AgCl). Before placing the electrodes on the pectoralis major and brachial triceps muscles, the regions of interest were trichotomy, followed was rubbed with cotton and alcohol 70%, to reduce skin impedance and minimize noise and interference (Hermens, Freriks, Disselhorst-Klug, & Rau, 2000). The EMG signals were acquired in resting condition (sampling frequency 2kHz) and in concentric and eccentric isotonic voluntary contraction during the execution of movements in the free-form bench press exercise (Attebrant, Mathiassen, & Winkel, 1995).

For the EMG analysis, the first and last portions of each signal were excluded. After that, we selected three stretches for the analysis: IT: Initial stretch (second stretch); TM: middle stretch (middle stretch); and TF: Final stretch (penultimate stretch) totaling 6.000 samples. In each of the stretches of the signal, the midpoint was taken as a reference and from it, 1000 samples were selected upwards and downwards totaling 2000 samples of the stretch for the analysis.

The analysis of the EMG signal stretches occurred in the time domain and through the root mean square amplitude (RMS value). Determined by the equation:

$$RMS = \sqrt{\frac{1}{N} \sum_{n=1}^N EMG[n]^2}$$

Where N represents the number of samples (6000) of the three stretches extracted from the EMG signal.

Statistical analysis

Data were analyzed using Graphpad (PRISM®, 6.0, San Diego, USA). The normality of the data distribution was verified through the Shapiro-Wilk test. According to the results, specific statistical tests were used for analysis of variance (ANOVA) for repeated measures followed by the Tukey post hoc test, and to compare the number of repetitions and the values of RMS, was used the Friedman test followed by Dunn's post hoc test. Given the natural variability of the EMG signal, the RMS values obtained were normalized for comparison purposes between the conditions investigated. Effect size was calculated and the magnitude was classified as: small (0.2), moderate (0.6) and large (1.2) (Hopkins, Marshall, Batterham, & Hanin, 2009). Level of significance was of the ≤ 0.05 .

Results

Compared with the control intervention, the number of repetition (figure 2A) increased significantly with musical intervention (42 %, 3.8 repetitions, ES: 0.92, $p = 0.008$), but not for placebo (23%, 2.1 repetitions, ES: 0.7, $p = 0.99$) and biofeedback (34%, 3 repetitions, ES: 0.83, $p = 0.058$). The total load (Figure 2B) increased significantly for musical intervention (41.7%, 778.3 kg, ES: 0.81, $p = 0.001$) and biofeedback (31.7%, 723% ES: 0.81, $p = 0.005$), but not for placebo (22.3%, 549.4 kg, ES: 0.75, $p = 0.8$).

There was no significant change in RMS values between interventions in the pectoralis major ($p = 0.801$; figure 3A) and brachial triceps ($p = 0.241$; figure 3B).

Fig. 2. Number of repetitions (A) and total load (B) reached in each of the tested interventions presented in median and interquartile interval, and mean $\pm$ standard deviation respectively $p = 0.008$ vs control, $p = 0.001$ vs control, $p = 0.005$ vs control.

Fig.3: Relative variation (%) of RMS values found in all conditions rested for the pectoralis major (A) and triceps brachii (B) muscles. The data are in median $\pm$ interquartile interval.

Dicussion

The present study aimed to verify the influence of different interventions on muscle performance and myoelectric activity in resistance exercise. The main finding was that music and biofeedback increased the total load by 41.7% and 31.7% respectively, and only music increased the number of repetitions by 42%.

Bartolomei et al., found effect of application of music in well-trained men, the study showed a increased of 5.8% on number of repetition in the bench press exercise (Bartolomei, Michele, & Merni, 2015). Maybe this discrepancy in increase of performance in our study can be related with the lack of training of subjects in the resistance exercise, where the most part were practitioners, however, were not trained (Bartolomei et al., 2015). Deferring the results found, a preview study evaluated the influence of self-selected music on performance in squatting exercise followed by vertical jumping and bench press in trained men. It was not find significant difference when compared the control intervention with musical stimulus intervention (Biagini M, Brown L, Coburn J, Judelson D, Statler T, Bottaro M, Tran T, 2012). According to the authors, the music chosen by the participants was not able to motivate them to perform the task investigated.

Music may be able to activate the area of the prefrontal cortex by stimulating pleasure-related emotional responses and, as a consequence, increases the degree of arousal, regulates mood, and decreases vagal tone. Thus helping to prepare for exercise by increasing productive work capacity, decreasing inhibitions and stimulating rhythmic movements (Bartolomei et al., 2015; Biagini M, Brown L, Coburn J, Judelson D, Statler T, Bottaro M, Tran T, 2012; Bigliassi, 2015). According to Archana et al., music has shown positive effects in many physical aspects, highlighting the improvement of motor coordination, reduction the heart rate, muscular strength

and resistance(Thakare, Mehrotra, & Singh, 2017). The increase in performance in our study may have been caused by the motivational effect of music, this motivational effect has been proved in previous work(Silva et al., 2016; Stork et al., 2015).

Stoggl et al., investigated the supplementation in the performance under these condition: a. carbohydrate supplementation in active recovery, b. bicarbonate supplementation in active recovery, c. placebo supplementation in active recovery and d. placebo supplementation in passive recovery, in a protocol of three sprints during a treadmill test. Results showed that the strategies of supplementation when compared to the active (placebo) condition did not present significant differences in the increase of performance; on the contrary, when compared to the two placebo conditions, there was a reduction in placebo (passive) performance(Stöggel, Torres-Peralta, Cetin, & Nagasaki, 2014), which corroborates our findings. Evidence of the significant influence of placebo on performance of number repetition and total load has recently been reported by Marocolo et al. that compared the ischemic preconditioning and the placebo maneuver with control group in thirteen men in the resistance exercise(Moacir Marocolo et al., 2016). These findings contradict our study.

The " Expectation Theory " justifies that this placebo effect occurs due to the belief and the degree of expectation of the individuals influencing their actions and, consequently, the desired results(Lindheimer J, O'Connor P, 2015). However, the expectation that participants placed on the placebo substance may not have been able to influence the results. In addition, the methods of presenting the benefits of placebo have been discussed, and such an approach, which emphasizes positive effects on the individual, may influence the desired results(Li et al., 2018). Thus, a presentation approach with a greater emphasis on the benefits of placebo could have influenced our results.

A recent study compared in performance terms an adapted strength training system using biofeedback-controlled virtual reality games with traditional handgrip training in healthy people. The results showed that palmar compression strength was significantly greater in training with virtual games controlled by biofeedback than traditional training(Hernandez N, Martinez K, 2018). It is possible that the intervention has increased the motivation in terms of pleasure, interest and perception of competence and control of strength. Therefore, these phenomena may explain the improvement of the total load in the recent study(Hernandez N, Martinez K, 2018).

Total volume is an extremely important variable for the increase of the strength, hypertrophy, and improved health(B. Schoenfeld, J. Grgic, D. Ogborn, 2017; Figueiredo, Freitas, & Gabriel, 2017). Our results showed that the use of music and biofeedback, both acutely, were able to increase the total volume of the exercise. Therefore, we suggest that strategies with these two stimuli can serve as ergogenic resource to maximize gains of muscle mass. However, the variables were measured only in a single series of a single exercise, which we consider a limitation of the study.

In addition, non-randomization of the study may have contributed to the learning factor. However, the biofeedback intervention being the last to be performed should have been superior to other interventions and not just to the control situation, case there had been this learning factor. Nevertheless, this does not exclude the importance of randomization.

The task characterized by the use of music as stimulus presented different behavior in RMS compared to the other conditions, although not having significant differences. However, the present time domain analysis was not able to discriminate differences between the conditions tested. Some studies suggest variations in the amplitude of the EMG signal when the muscle begins to show signs of fatigue(Dimitrov, 2008). This variation (increase in RMS amplitude) would be a necessity in the increase of motor units recruited due to a mechanical failure and, therefore, would lead to an increase in the probability of summation of the potentials generated. However, according to some authors the RMS value may not be as sensitive as those extracted from the frequency domain(Garcia et al., 2010) or the speed of conduction of the action potentials of the motor units can influence these values(Garcia, Marco, Magalhães, José, Imbiriba, 2004). Therefore, we suggest that the present parameter (RMS value) was not sufficiently robust for the proposed analysis.

Conclusions

Music and biofeedback increased the total volume and only the music, influenced the increase in the number of repetitions. However, there was no significant change in the myoelectric activity. Therefore, these two strategies can contribute positively to the practice of resistance exercise.

Conflicts of interest - None to declare.

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