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Using auditory stimulation to enhance athletes' strength: An experimental study in weightlifting

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In the last fifteen years sport psychology researchers have developed different perceptual strategies based on auditory stimulation in order to improve athletes' skills. Most of these strategies focused on providing athletes with the correct timing of action, in order to make this information available for motor production setting. However, it has also been demonstrated that some sounds can be a useful tool to modulate the physiological arousal in order to optimize sport performances. In our study we propose a protocol of intervention based on the stimulation with an auditory track whose intensity varies in correspondence with the physical effort of each phase of a bench press exercise. Eighteen participants performed three bench press lifts, both in experimental condition (with the auditory stimulus) and in control condition (without any stimulation). We measured the power exerted during the lifting. The results show that athletes can take advantage of the stimulus we provided, evidencing a higher average exertion of power in the experimental condition, compared to the control condition. Concluding, the results suggest that auditory perception can be a productive field of research in developing experimental strategies to improve athletes' skills.

Key words: auditory perception, motor control, sport, strength

Developing techniques to improve performances is one of the fundamental aims of sport psychology research. A consistent part of research in this field explored modeling strategies, most of them based on visual information, only a few based on auditory information (McCullagh, Ste-Marie, & Law, in press). Indeed, the potential of auditory stimulation in sports has been only partially explored, as what has been investigated almost exclusively are its effects on the timing of movements (Agostini, Righi, Galmonte, & Bruno, 2004; Effenberg, 1996, 2005; Murgia, Bresolin, Righi, Galmonte, & Agostini, 2011). We assume that acoustic stimulation may positively affect performance not only in sports where optimal movements reproduction in terms of timing is essential, but also in sports where psychophysiological arousal is required. This hypothesis stems from two well established observations: The first one is that high levels of psychophysiological arousal facilitate muscular power output, and the second one is that acoustic stimulation can modulate this arousal.

The former assertion is confirmed by a study of Schmidt and colleagues (2009). The authors presented pictures with different emotional impact to their participants. Some of this pictures were defined as arousing, others as neutral. They measured the muscular power output in response to these stimuli. Results confirmed that arousing pictures lead participants to produce more force. Neuroimaging analysis revealed a bilateral activation of ventrolateral prefrontal cortex, region which would be responsible for facilitating effort tasks. Similar results were found by Perkins, Wilson, and Kerr (2001) after inducing high arousal motivational states in elite athletes. In this study as well, participants produced more force when they were in high arousal motivational states, if compared with a control condition.

The fact that acoustic stimulation can modulate psychophysiological arousal has received empirical support too. Many authors detected variations in physiological parameters and behavioral responses as a consequence of different kinds of acoustic stimulation (Bach et al., 2008; Bradley

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& Lang, 2000). Beyond their great empirical and theoretical value, these studies have very little to do with applied sport psychology. One of the first attempts to investigate the effects of acoustic stimulations on psychophysiological arousal in a sport-related situation was made by Brownley, McMurray, and Hackney (1995). These authors measured some physiological parameters during different intensities of treadmill exercises as a consequence of listening to fast music, compared to a sedative music, and a no-music condition. The results evidenced a significant difference in both respiratory frequency and plasma cortisol levels for the fast music condition compared to the other conditions.

Other studies demonstrated a direct relationship between auditory stimulation and force exerted. For instance, Jaskowski, Rybarczyk, Jaroszyk, and Lemanski (1995), using a reaction time paradigm in response to different intensities of auditory or visual stimuli, measured the force exerted in pressing the buttons. They found that the force increased as a function of the intensity only for the auditory condition, but not for the visual condition. The results concerning the relationship between the intensity of auditory stimulation and the force exerted have been confirmed even in a more recent study, in which participants were required to squeeze a force dynamometer during listening to a loud sound (Anzak, Tan, Pogosyan, & Brown, 2011). Similar results were obtained using verbal encouragement (Andreacci et al., 2004; McNair, Depledge, Brettkelly, & Stanley, 1996). These studies evidenced that significant increments in muscular power output can be produced when participants are orally encouraged, further confirming the association between auditory stimulation and force exerted.

The same connection between auditory stimulation and force exerted has been found in sports. Indeed, a few studies used music to modulate the athlete's physiological arousal in order to improve athletes' performances in sports where explosive power is an important aspect. For instance, Eliakim, Meckel, and Nemet (2005) observed that listening to arousing music during warm-up significantly improved the performance of elite adolescent volleyball players on some parameters of the Wingate Anaerobic Test, compared to a warm-up without any music. Hutchinson and colleagues (2011) obtained improvements in more parameters of the same test when participants performed it while listening to asynchronous music. Finally, Simpson and Karageorghis (2005) demonstrated that synchronous music significantly improves the performance of non-elite athletes on 400 meters sprint.

The majority of these studies examined the consequences of acoustic stimulation on psychophysiological arousal and most of them reported positive effects on subjects' performance. Interestingly, very few studies examined the effect of acoustic stimulation on athletic performance during active competition, suggesting an enhancing effect. To the best of our knowledge, no studies examined the effect of arousing sounds in strength sports. Thus, we hypothesize that a high-intensity sound stimulation during lifting can facilitate the exertion of power during bench press exercises.

METHOD

Participants

Eighteen volunteer lifters (12 males, 6 females) participated in this experiment. They were recruited from the members of the best Sardinia's teams in Italy. Their age varied from 18 to 37 years (M = 26.44, SD = 8.17). Participants had more than 4 years of experience. Their weight ranged between 52 and 95 kg, and their one-repetition maximum ranged between 50 and 130 kg. All participants indicated they had no hearing limitation. Participants did not receive money for their participation, but they were told that they would receive a detailed report about their performances after the end of the experiment. Informed consent was obtained for each participant.

Material and apparatus

We created an auditory stimulus to guide lifters during the exercise execution. The stimulus consisted of an initial countdown, followed by a low-intensity sound (60 db), which corresponds to the down phase of the exercise, and by a high-intensity sound (95 db), which was associated to the pressing phase. In order to create the stimulus, we used the software Goldwave 5.58. An mp3 player Packard Bell Audiokey Premium Fm, connected with headphones Sennheiser HD515 (total harmonic distortion < 0.2%), was used to provide lifters with the stimulus. The apparatus Sensorize FreePower Training and its software for data elaboration were used to measure the power exerted by athletes.

Design and procedure

A within-subject design was employed. We considered the within-subject design more appropriate than the between-subject one because it was important to control the individual differences between the conditions. Before starting the experimental phases, the athletes performed some warming up exercise, according to their normal habits. During this phase, they familiarized themselves with the auditory stimulus and determined their own movement timing according to the countdown, in order to synchronize the down phase and the pressing phase of the stimulus with their normal movement. After athletes sufficiently warmed up and practiced with the stimulus, they started the experimental phase. Subjects were required to perform three trials in a control condition. Each trial consisted of one lift with a load of the 90% of their one-repetition maximum. In the experimental condition, they had to perform exactly the same trials with the assistance of the auditory stimulus. The

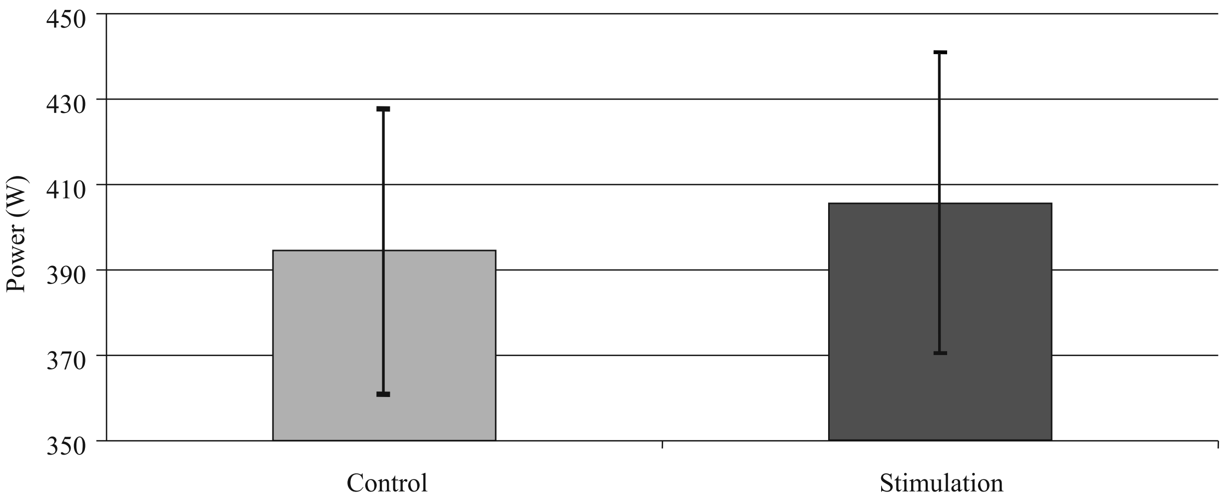

Figure 1. Average power exerted by athletes in control and experimental condition.

trials were performed in an alternate sequence (i.e., control-experimental-control-experimental-control-experimental or experimental-control-experimental-control-experimental-control). The condition of the first trial was counterbalanced. The athletes had five minutes to rest between the trials. The dependent variable was the power exerted during each lift. In particular, we considered the best trial for each condition and the average of the three trials for each condition.

RESULTS

We hypothesized that an intense auditory stimulation during the press phase would facilitate athletes to exert higher levels of power in a bench press task. The results are partially consistent with our hypothesis. In fact, we did not find a significant difference between the best trials in the experimental versus the control condition. However, we found a difference between the average of power measured in the three experimental trials and the average of power measured in the three control trials (Figure 1). A paired-samples t-test analysis revealed a statistically significant difference between experimental and control conditions ($t(17) = 2.046$, $p < .05$).

DISCUSSION AND CONCLUSIONS

Assuming that high-intensity sounds can have an arousing effect on athletes, we hypothesized that an intense auditory stimulation during bench press exercises would facilitate athletes in exerting power. The results of our study partially confirmed our hypothesis. In fact, we did not find differences between the peak power exerted with and without the auditory guidance; however, we found a mean improvement in the experimental trials. It means that athletes could not take advantage of the stimulus to exceed their own limits, but probably they could use it to maintain an adequate level of activation that allowed them to reduce the variability of their performances. In other words, the stimulus we used cannot lead athletes to go beyond their performance standards, but can be a useful tool to facilitate the expression of their potential standards.

The results we found are consistent with previous studies on the arousing effect of auditory stimulation (Karageorghis & Lee, 2001). While previous studies demonstrated the effectiveness of different kinds of music, evidencing the important role of motivational music (Karageorghis et al., 2009), in the present study we extended these findings by using a sound associated to the different phases of the performance, which is supposed to evoke a mental representation of the movement. Karageorghis and Lee (2001) also demonstrated that the combination of imagery with music has an enhancing effect, suggesting that mental representation of movements can have a synergic interaction with arousing music. According to this finding, a crucial point for the strategy we have proposed is the combination of two components: on the one hand, a facilitation of movement mental representation; on the other hand, the arousing effect due to the high-intensity sound.

This study is a preliminary step to validate the efficacy of a new strategy. Our intention was to see if it makes sense to proceed in this direction, and the results seem to support our attempt. However, further studies are necessary in order to improve our method. In fact, we only administered one kind of sound, but it is possible that sounds with other characteristics can have a stronger impact on athletes' strength exertion. Therefore, the present results should encourage researchers to develop new versions of stimuli in order to optimize this effect. Another extension of the present study regards the measured variables. In fact, what would be interesting is the online monitoring of some physiological parameters that can be affected by sounds during the exercise execution. Concluding, this study extends the growing body of empirical evidence which attributes more and more of an important role to the auditory perception in sports.

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