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THE EFFECT OF SELF-SELECTED MUSIC ON BACK SQUAT PERFORMANCE

by

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of

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Approved:

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ABSTRACT

Over the past several years, the use of music has become increasingly popular among athletes of various performance levels as a means to provide prework-out relaxation, focus, and motivation. Extensive research has examined music's effects on aerobic exercise performance, and the results generally show positive outcomes (e.g., music can increase endurance, performance in running). Research on anaerobic exercise has provided mixed results as to music's effectiveness. However, previous research has not investigated the use of music to augment performance under the conditions of a high intensity, dynamic strength-based movement such as the free weight squat in an elite strength trained athletic population. **Purpose:** The purpose of the present study is to examine the effects of self-selected music on power-based performance, using the back squat exercise, with it being performed in a familiar weight room setting in NCAA Division I football players. **Methods:** Sixteen NCAA Division I football players performed a set of 15 repetitions on a squat exercise on separate days under three conditions: no music (control), music beforehand during a warm-up, and music during the warm-up and testing. During the exercise, a computer-interfaced dynamometer was secured to the barbell and provided measures of power and velocity for each repetition and across the duration of the test. Participants also filled out the Situational Motivation Scale (SIMS) which represents a self-report measure of situational intrinsic motivation, identified regulation, external regulation, and amotivation. **Results:** There were no significant differences among the three conditions for power, velocity, or SIMS responses. **Conclusion:** Music may not be a beneficial aid to performance during high intensity activities in elite strength trained athletes. Music's distracting effect may only be productive at lower force requiring activities and/or in populations less accustomed to the demands of high intensity lower body resistance exercises.

INTRODUCTION

The modern sports era has evolved to incorporate more advanced ergogenic techniques in an effort to improve sports performance, both in training and during competition. With training regimens becoming increasingly difficult and competition becoming more elite, it is common for athletes to take it upon themselves to employ mental relaxation and focusing techniques. Music is one particular mode that has increased in popularity and has more recently become empirically recognized to influence motivation and arousal levels. For example, athletes commonly use music during training and prior to competition as a method to attain higher levels of arousal (Karageorghis & Terry, 1997; Edworthy & Waring, 2006), and thus, higher levels of performance to a certain extent. Whether it be fast, upbeat music to help synchronize movements to (Karageorghis & Terry, 1997) or slow, relaxing music to relax physiological processes and promote endurance (Copeland & Franks, 1991), music can be used to attain many goals and research in this area has shown that music may have a positive effect on athletic performance and can be used to regulate emotion during activity (e.g., Brooks & Brooks, 2010; Edworthy & Waring, 2006; Koc & Curtseit, 2009; Lane, Davis, & Devonport, 2011; Mohammadzadeh, Tartibiyan, & Ahmadi, 2008; Potteiger, Schroeder, & Goff, 2000; Stork, Kwan, Gibala, & Ginis, 2015; Yamashita, Iwai, Akimoto, Sugawara, & Kono, 2006).

It has been suggested that athletes require a narrow, internal focus prior to competition in order to avoid "spiraling down" from pregame anxiety (Klavora & Daniel, 1984). In theory, by shifting his focus to a nonstressful, external cue, like music, the athlete is able to keep himself focused on the game ahead, which may draw his focus away from the anxiety of competition (Klavora & Daniel, 1984). It is thought that if athletes employ this same distraction during exercise, they may be able to shift their attention from the fatigue and exertion of the activity just long enough to increase their performance (Edworthy & Waring, 2006; Mohammadzadeh et al., 2008; Potteiger et al., 2000). However, as the body is only capable of focusing on a limited number of incoming stimuli at one time, this may only be applicable to lower intensity activities (Hardy & Rejeski, 1989; Koc & Curtseit, 2009; Yamashita et al., 2006). Evidence suggests that eventually the intensity of exercise will outweigh the distracting effect that music has (Karageorghis & Terry, 1997).

Considerable research has been conducted in regards to the effects of music on aerobic activities (e.g., running/cycling to exertion) and the consensus is generally positive showing that music can help increase performance by decreasing unpleasant physiological feedback and athlete's rating of perceived exertion (e.g., Edworthy & Waring, 2006; Koc & Curtseit, 2009; Mohammadzadeh et al., 2008; Potteiger et al., 2000; Yamashita et al., 2006). However, humans have a predisposition to rhythmical movement and naturally synch up with the rhythm of music (Karageorghis & Terry, 1997). Consequently, it is easier for athletes to select a fast-paced track while running because they can keep pace simply by using the rhythm. Real-world scenarios of various sports activities exhibit high intensity, time-dependent characteristics (e.g., sprinting, jumping, etc.). These types of activities are mostly anaerobically-based, explosive power movements that feature key differences compared to endurance-based activities. Research performed on music's impact on anaerobic activities is limited and less extensive when compared to aerobic-based activities, and the results are mixed as to whether it is beneficial or not. This could be, in part, due to the wide array of research designs that have been employed to study the topic (Karageorghis & Terry, 1997). Stork et al. (2014) investigated the impact of either listening to music, or not, on anaerobic Wingate (WaNT) performance (four 30-second WaNT tests), while allowing a 4-minute break between sets. They found that both peak and mean power were higher in the music condition than the control (Stork et al., 2014). In agreement with these findings, Brooks and Brooks (2010) examined the effects of listening to music, or going without, on the WaNT (two WaNTs, two weeks apart) and found a higher peak and average power in the music group. Conversely, Pujol and Langenfeld (1999) tested music's effect on power output and time to fatigue using the WaNT and found no significant difference between the music and control conditions. Atan (2013) used both the WaNT and the running-based anaerobic sprint test (RAST) to examine music's effect on anaerobic performance and physiological response to supramaximal exercise; both tests showed no significant difference of listening to fast, slow, or no music during testing. Furthermore, heart rate and blood lactate levels remained unchanged, indicating that the same effort was expended under each condition (Atan, 2013). While these studies contribute to the discussion of music's effect on anaerobic-based activities, there are some shortcomings. These studies have examined recreationally active individuals, but not high level college athletes. Secondly, many of these studies selected the music for their subjects, taking away the familiarity for listeners, which has been suggested by some to be equally as beneficial to performance (Karageorghis & Terry, 1997; Lin & Lu, 2013). Lastly, the tests performed are not easily applied to real-life work-outs and activities performed on a regular basis by athletes.

Although extensive research has been done on the effects of music on exercise and performance. The majority of research has involved aerobic tasks (e.g., running on a treadmill) and is not representative of many other sports and explosive movement-based activities. There is limited research based on anaerobic tasks, such as sprinting or jumping, and the most commonly used test in those cases, the WaNT, is not relevantly applied to sports other than cycling. No previous research has examined the performance effect of music on a high-intensity, high-load exercise activity that is commonly performed in the exercise routines of power-based athletes (e.g., free weight resistance exercise). One such exercise, which serves as a prime model, would be the free weight back squat because it is a popular high-intensity resistance exercise that is performed by various types of power athletes. Also, few studies have examined these effects in a more realistic environment (e.g., weight room where athletes typically train versus a laboratory). Given that athletes are listening to music in many training and pregame environments (e.g., buses, locker rooms, weight rooms, pregame warm-ups), it is less applicable to test the influence that music elicits increased performance by testing participants in a lab setting and with music they are unfamiliar with. Therefore, to address these research gaps, the purpose of the present study is to examine the effects of self-selected music on power-based performance, using the back squat exercise, with it being performed in a familiar weight room setting in NCAA Division I football players.

METHODS

Participants

NCAA Division I football players were recruited from the Utah State University (USU) football roster with the approval of by the Head Strength and Conditioning coach. Participants were excluded if they had been deemed medically unfit by a physician to participate in NCAA Division I Football, had an injury within the last thirty days or surgery within the last twelve months, or had any restrictions placed on them by the USU Sports Medicine staff that would not allow them to complete the required testing. Twenty athletes were recruited and formally started the study, but due to injury and schedule conflicts, only sixteen participants completed the study. The participant demographics of those who completed the study were as follows: (mean (SD)) age 21 (±1.5) years, body mass 98.54 (±5.9) kg, height was 184.63 (±5.9) cm. The study procedures were approved by the Internal Review Board (IRB) at USU and all participants read and signed an informed consent document prior to the beginning of testing.

Experimental Design

Procedures

Participants were approached about participation in the study after the study received IRB approval and the list of participants was approved by the Head Strength and Conditioning coach. Prior to the start of testing, participants attended a familiarization day. During this time, participants completed a brief demographics and health history questionnaire and height and weight were collected. Participants also received an explanation of the test to be conducted and were familiarized with the test and equipment.

Participants completed three different testing sessions, each one week apart. This schedule was designed to avoid any overlap or fatigue from the participants' offseason lifting and conditioning program. On the day of testing, participants were asked to refrain from ingesting caffeinated substances (e.g., beverages, prework-out supplements, etc.) at least two hours before testing. They were also asked to refrain from eating or listening to any music at least one hour before testing. They were sent a text message reminder in the morning of their report day, which indicated their report time and cut-off times for the above restrictions. Participants were asked to create a playlist, lasting at least forty-five minutes, consisting of music they would listen to prior to an intense work-out or competition. They were informed that they would be unable to "shuffle" the playlist, so the order of the songs should be satisfactory to them.

Upon arrival, participants were randomly assigned to one of three test conditions: no music (CON), music beforehand (MB), or music during (MD) the warm-up and exercise test. The CON consisted of no music available throughout the testing session; participants also did not wear headphones so they were able to hear ambient noises in the weight room. The MB condition consisted of listening to music for at least 20 minutes while completing a dynamic warm-up, but not while performing the test. Finally, the MD condition consisted of listening to music both during the dynamic warm-up and during the test. Participants completed a dynamic warm-up prior to each testing session, consisting of dynamic stretches and sport specific movements, as well as a test specific warm-up as suggested by Luebbers and Fry (2015). The dynamic warm-up includes knee to chest stretch, walking glute stretch, walking over/under stretch, walking quad stretch, walking calf stretch, walking hamstring stretch, A-skips, A-runs, straight leg run, and lateral shuffles.

Testing Protocols

Participants were asked to complete the Kansas Squat Test (KST), which has been developed and used to determine lower body, anaerobic power with the use of a velocity transducer. Previous studies have found significant relationships between the KST and WaNT when measuring peak and mean power (Fry et al., 2014; Luebbers & Fry, 2015). However, the KST may be more practical than the WaNT as it can be performed in the weight room, with little education needed for individuals who are familiar with the squat and it is also less expensive to perform (Luebbers & Fry, 2015). Participants also completed the test using a free weight barbell, rather than a Smith machine, to simulate the conditions of a work-out performed during typical training. The free weight squat has shown to be a valid and feasible alternative to the Smith machine squat (Luebbers & Fry, 2016). Prior to testing, each participant completed a dynamic warm-up provided by the strength staff, as well as a test specific warm-up of 1 x 5 at 30% 1 RM, 2 x 5 at 50% 1 RM (Luebbers & Fry, 2015). The one repetition maximums (1RM) were acquired by the strength staff during preseason training. For the testing, participants lifted a load equal to 70% of their systemic mass (systemic mass = 1RM + body mass), per the protocol of Luebbers and Fry (2015). Because power is the primary purpose of the test, the concentric phase of the squat was to be performed as explosively as possible. A valid repetition consisted of the participant squatting to a position where the thigh was parallel to the ground. The test consisted of 15 repetitions, with one repetition being completed every six seconds. In order to maintain cadence, a large timer was placed visibly in front of the participant as an indicator of when to begin the next repetition. Repetitions were counted out loud by the investigator and a signal was given with one repetition remaining.

Outcome measures obtained during the squat were acquired using a computer interfaced dynamometer (Tendo Power Analyzer, Trencin, Slovak Republic). The device uses a nylon cord tethered to the barbell to determine the linear velocity (sampled at 100 Hz). The computer calculates force by computing the first derivative of velocity across time (acceleration), adding to it the acceleration of gravity, and multiplying this by the systemic mass (barbell load + body mass) (Fry et al., 2014). Power is then calculated as the product of the calculated force and measured velocity (Fry et al., 2014). Mean power and mean velocity were computed and retained for each of the 15 repetitions. Finally, the overall mean power and velocity for the combined 15 repetitions was calculated and reported as the mean power and mean velocity for the entire test (Fry et al., 2014).

Following the warm-up and prior to beginning with the test, participants were also asked to fill out the Situational Motivation Scale (SIMS; Guay, Vallerant, & Blanchard, 2000). Findings in the sport and exercise psychology literature suggest that the SIMS represents a brief and versatile self-report measure of situational intrinsic motivation, identified regulation, external regulation, and amotivation (see Deci & Ryan, 1985). Participants were asked questions about their reasoning for engaging in testing, and the SIMS identifies participants' responses to determine their intrinsic motivation (behaviors engaged in for one's own sake; "Because I think that this activity is interesting"), external regulation (behavior regulated by reward; "Because it is something I have to do"), identified regulation (behavior that is valued or chosen; "Because I believe that this activity is important for me"), and amotivation (behavior has no sense of purpose; "I do this activity but I am not sure if it is worth it") (Guay, et al., 2000). Past research using this measure demonstrated internal consistency of scores (Chronbach's Alpha) ranging from .74 to .91.

Statistical Analysis

Descriptive data is reported as mean ± standard deviation (SD). Two one-way repeated measures ANOVA's were used to analyze the mean power and mean velocity data across the three conditions (CON x MB x MD) and, where appropriate, follow-up analyses included Bonferroni corrected post hoc comparisons. A MANOVA was used to analyze the individual components of the SIMS responses across the three conditions. A significance level of $\alpha < 0.05$ was established to determine statistical significance and partial eta squared values were examined to determine effect sizes.

RESULTS

The mean (SD) values of the power and velocity measures for each condition are reported in Table 1. For mean power, there was no significant difference between the music conditions (P = .947). Also, for mean velocity, there was no significant difference between the music conditions (P = .449).

Table 1. Mean (SD) values for mean power and mean velocity variables for the control, music beforehand (MB), and music during (MD) conditions during the squat test.

	Control	MB	MD
Mean Power	558.35 (90.89)	557.35 (90.14)	560.65 (92.35
Mean Velocity	.88 (.10)	.90 (.12)	.91 (.11)

No significant differences were found between conditions at the P < .05 level

The mean (SD) values of the intrinsic motivation, identified regulation, external regulation, and amotivation are reported in Table 2. For intrinsic motivation, there was no significant difference between any of the music conditions (P = .987). For identified regulation, there was no significant difference between any of the music conditions (P = .992). For external regulation, there was no significant difference between any of the music conditions (P = .659). Finally, for amotivation, there was no significant difference between any of the music conditions (P = .822).

Table 2. Mean (SD) values for intrinsic motivation, identified regulation, external regulation, and amotivation for the control, music beforehand (MB), and music during (MD) conditions during the squat test.

	Control	MB	MD
Intrinsic	3.41 (1.43)	3.47 (1.16)	3.47 (1.16)
Identified	3.91 (1.34)	3.95 (1.11)	3.95 (1.11)
External	3.55 (1.22)	3.14 (1.55)	3.14 (1.55)
Amotivation	3.09 (.99)	2.87 (1.21)	2.87 (1.21)

No significant differences were found between conditions at the P < .05 level

DISCUSSION

The present findings revealed that there was no effect of music on lower body power, velocity, and SIMS responses in NCAA Division I football players during the execution of a 15-repetition squat exercise. Furthermore, there was no significant differences in the SIMS responses when given music versus the control condition. These findings agree with the findings of Pujol and Langenfeld (1999) and Atan (2013) but contradict the findings of Brooks and Brooks (2010) and Stork et al. (2014). Similar to the procedures of Pujol and Langenfeld (1999), we allowed participants to select the music they listened to during testing, applied the music via headphones, and allowed the participants to control the volume of the music to their level of comfort. In accord with the present findings, Pujol and Langenfeld (1999) reported that there were no significant differences between music and nonmusic conditions for mean power output, maximum power output, minimum power output, fatigue index, or time to fatigue. Allowing the participants to select their own music was a key feature of the present study as it is believed that the self-selection of music may be as beneficial to performance as the use of music itself (Karageorghis & Terry, 1997; Lin & Lu, 2013). Atan (2013) also found no difference between the use of fast rhythm, slow rhythm, or no (control) music on the running-based anaerobic sprint test (RAST) and Wingate test, which are both predominantly anaerobic measures.

Conversely, Brooks and Brooks (2010) found a significant difference in both peak and mean power in music vs. no music conditions. However, this study examined seventy-one subjects between the ages of 18-38, both male and female. This study also described their participants as "healthy" but gave no indication of activity level. The current study examined active Division I football players, all male between the ages of 18-23. These participants are extremely familiar with supramaximal activity and participate in it on a very regular basis. In the Brooks and Brooks study (2010), the music was also played aloud over the speakers of a laptop at a constant volume. This current study used headphones and allowed the participants to control the volume of the music. Stork et al. (2014) examined participants of similar age as this study, however, they excluded elite athletes from participation. Both the Brooks and Brooks study (2010) and the Stork et al. study (2014) used the Wingate test as their performance test whereas the present study used the Kansas Squat test. Notably, Jarraya et al. (2012) suggested that because athletes aren't allowed to listen to music during competition, music only during warm-up and recovery periods may be a more relevant condition to examine effects on subsequent performance. In their (Jarraya et al., 2012) study used "elite athletes from national and/or regional teams in Tunisia" were used as participants. Their protocol had the participants listen to pre-selected music during a 10-minute warm-up on the Wingate cycle prior to a 30 second maximal sprint on the Wingate cycle, without music. This study found a significant difference in peak power, mean power, and rate of perceived exertion between the music and no music conditions (Jarraya et al., 2012). This study condition coincided with the present study's MB (music beforehand) condition, but with conflicting findings. The collective differences between these previous studies and the present study likely explain the conflicting findings. For example, ours was the only study that investigated the influence of music on a dynamic strength-based squat movement using a population of highly strength trained elite male athletes. It is possible that the combination of the higher load/force requirements of the squat exercise (compared to the more metabolically demanding but relatively lower force characteristics of the Wingate test), coupled with the high strength training experience and skill level of these football players provides a scenario where there is little room for improvement of performance from the use of a motivational-based ergogenic modality such as music.

Since we examined Division I athletes, instead of a nonathlete population, it is possible that the Kansas Squat test was less challenging for the Division I athletes to complete when compared to their normal, very rigorous lower body lifting program. Upon examination of the results of the study, the relatively steady state of power and velocity throughout the conditions suggests that music does not influence these measures as there appeared to be a low level of performance declines across the 15 repetitions, for all of the conditions. It has also been reported that untrained participants derive greater psychophysical benefits from music, while trained participants experienced a disruption of internal focus with music (Edworthy and Waring, 2006). In theory, music could act then, as more of a distraction than an aid to the highly trained individual. As found in the Pujol and Langenfeld study (1999), the distracting effect of music may have limited applicability; because past a certain point of exertion, music tends to lose its distracting effect. Due to the high sustained load and dynamic load balance nature of the squat test used in this study, the distracting effect of music may not have been enough to distract the participants from the high focus requirements of the challenging workload. It is also possible that the Kansas Squat test is not entirely accurate in testing lower body power. This current study was the only one to employ this test as a performance measure instead of the Wingate test when examining the influence of music upon performance. The Wingate is considered the gold standard of anaerobic power testing and is commonly employed. However, the use of a cycle test for examining performance of sprint/running type athletes has been criticized by experts, as being too nonspecific to the sport-based tasks. Thus, the current study aimed to test the impact of music in a more realistic setting, and with a different type of anaerobic test (performed upright and with higher force/lower velocity and more of a balance requirement compared to the seated Wingate cycle test), which are the reasons for why the Kansas Squat test was chosen. Also, one-repetition maximums were collected during participants' summer training session in order to best accommodate the athletes and coaches' schedule. However, due to the availability of the participants to perform the three conditions in a successive manner, scheduling of testing had to be pushed back to a later date. It is possible that the athletes had gained strength in the nearly six months between one-repetitions maximums and the music condition testing.

Karageorghis and Priest (2008) suggested that while listening to music during supramaximal exercise may not make the activity easier, it is likely that the participant will find the activity more pleasurable. This is a common thought shared by most athletes. Yeats et al. (2014) found that high school coaches believed that warm-up music improve motivation, mood, and team cohesion, which lead to improved performance. With this belief starting so early in an athlete's career, it is unsurprising that an athlete would think himself incapable of performing once music was taken away from his normal routine. During testing, participants of the current study would verbally state that the testing in the control setting was not pleasurable and that the test itself was perceived as more difficult. Most participants truly believed that they would perform better with the music and were unhappy when randomly assigned the control condition. It could be assumed that since the athletes were allowed to select their own music, they would have reported higher levels of motivation. Helsing et al. (2016) stated that because each individual experiences music differently due to personal preference, allowing the subjects to choose music that is motivating to them personally is the best way to ensure a positive experience. Subjects had verbally reported during testing that they didn't like the control condition and didn't feel motivated. However, the participants were in the middle of their spring strength training program and testing took place later in the day following work-outs and classes as that was the only time the weight room was available for testing. This could have an impact on their motivation compared to if testing was done during offseason. It also may be possible that there was inadequate time prior to testing to listen to the music and allow for it to take effect. Literature on this topic did not provide a duration for listening to music. Twenty minutes was chosen as it was the length of the warm-up done prior to testing. Perhaps if the athletes had begun listening to music much longer before testing, their motivation would have been higher. The participants were also prompted to choose music that they would normally listen to prior to a difficult work-out or a competition, but that doesn't necessarily mean that the music they choose for these situations is appropriate. Lane and colleagues (2011) had their participants choose music using the Brunel Music Rating Inventory (Karageorghis et al., 1997) based on a song's motivational factors and how they wanted to feel during running. They found that, with a goal in mind, music could supplement the work-out by influencing the runner's emotions (Lane et al., 2011).

Perhaps, had the participants of this study been giving the same guidelines when preparing their playlists, they may have developed a more appropriate playlist. Koc and Curtseit (2009) stated in their study that music does not reduce the perception of effort during high intensity work; however, it does improve the experience. It makes hard training seem more like fun, by shaping how the mind interprets symptoms of fatigue (Koc and Curtseit, 2009); this idea reinforces the thought that music just provides enough of a distraction to let the individual complete the exercise without thinking about the fatigue that they are feeling.

In conclusion, the results of this study suggest that music may not be a beneficial aid during high intensity strength-based exercise in a real-world setting. We thus reject our initial hypothesis that music would improve squat performance and induce more motivation. Future studies should examine the influence of music on other real-world performance tasks, such as upper body explosive movements, plyometrics, repeated sprints, agility, etc. in order to better elucidate the characteristics of various exercise types and models which are more or less prone to augmented performance from the use of music. Future studies should also consider the motivational factors of the music and encourage participants to consider those factors when choosing their own music. Coaches, athletes, and practitioners may use these findings to aid in making decisions in regards to the application of music as a potential ergogenic aid when employing maximal effort squat-based performances in their training routines.

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