Manuscript Title: The influence of music genre on explosive power, repetitions to failure and mood responses during resistance exercise

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Abstract

Objectives: To investigate the influence of different music genres on the psychological, psychophysical and psychophysiological responses during power-based and strength-based resistance exercises.

Design: Repeated-measures counterbalanced design.

Method: Sixteen resistance-trained participants completed an explosive power test in the squat and bench exercises at 30% 1RM across no music, electronic dance music, metal and self-selected conditions. Peak and mean values were recorded for power and velocity. A progressive loading protocol assessed the impact of condition on repetitions to failure at 60, 70 and 80% 1RM in the squat and bench exercises. For all tests, recording of heart rate and rating of perceived exertion were completed after every set, blood lactate after protocol completion, and mood states before and after.

Results: Using magnitude-based inferences, music either had no effect or a small detrimental effect on power and velocity, depending on the exercise. Repetitions to failure increased by a small to moderate amount for all music conditions compared to no music at low but not high intensities. Self-selected music provided additional small benefits in repetitions than other music conditions. Rating of perceived exertion was similar between self-selected, metal and no music conditions, whereas electronic dance music revealed higher responses. Vigour increased after all music conditions but remained unchanged in no music.

Conclusions: Explosive power exercises either remain unchanged or are disadvantaged when completed to music. Various music genres could improve repetition to failure training at low to moderate intensities, although individuals might expect greatest improvements using self-selected music, without concomitant increases in perceived effort.

Introduction

The popularity of resistance training (RT) has increased significantly over the last 30 years, with numerous research articles demonstrating that appropriately prescribed RT is effective for improving neuromuscular function in a range of populations (i.e. clinical, children, adults, and athletes) (Feigenbaum & Pollock, 1999). Resistance training is commonly used to promote an individual's health status and quality of life (Cruz-Jentoft et al., 2014) and to enhance physical performance for athletes (Soriano, Suchomel & Marin, 2017). The design of any RT programme requires careful consideration of several acute programme variables and key training principles (Bird, Tarpenning, & Marino, 2005). In this regard, a number of training recommendations are available within the literature. For example, training at intensities ~30% 1 repetition maximum (1RM) for 3-4 repetitions and 3-6 sets with maximal explosive intent, has been recommended for improving maximal rate of force development (Soriano et al., 2017). To increase maximal force output, 6-10 repetitions for 3-5 sets at 60% to 70% of 1RM has been advised for novice/intermediates and 3-5 sets of 4-6 repetitions at ≥80% of 1RM for experienced athletes (American College of Sports Medicine, 2009). Moreover, repetition to failure training has also been endorsed in recent years, pertaining to maximise motor recruitment and provide optimal stimuli for muscular strength development (Fisher, Steele, & Bruce-Low, 2011; Smith & Rutherford, 1995).

Irrespective of the programme objectives (e.g. to enhance power, strength or hypertrophy), it is typical for individuals to use a range of ergogenic aids during training (Hackett, Johnson, & Chow, 2013). Ergogenic aids relate to anything that improves energy production, use, or recovery and can be mechanical, nutritional, physiologic or psychologic in nature (Levy, Cabrera, Thomas & Brennan, 2008). For individuals partaking in RT, the effects of pscyhologic aids such as music have received limited attention within the literature (Biagini et al., 2012). This is surprising considering that music has been shown to improve work capacity, mood, arousal and lower perceived exertion in a range of other exercise contexts (for reviews see Karageoghis & Priest, 2012a, 2012b). However, as these effects have largely been derived from studies using aerobic exercise models (e.g. running and cycling), it is not yet clear if they transfer to resistance exercise (Arazi, Asadi, & Purabed, 2015; Bartolomei, Di Michele, & Merni, 2015; Biagini et al., 2012). Of the limited studies to investigate the effects of music on RT, Biagini et al. (2012) evidenced improved work capacity via greater peak muscle force and velocity when self-selected music accompanied maximal squat jump exercise. This same study reported no improvements in the number of repetitions when participants performed a bench press test to failure (at 75% of 1RM) with music. This is in conflict with Bartolomei and colleagues, (2015), who reported a 5.8% improvement in repetitions to failure in the bench press exercise (at 60% of 1RM) when self-selected music was played (compared to a no music control). Without a clear consensus between studies, it is difficult to ascertain whether music can positively influence an individual's ability to produce higher RT work capacity and therefore warrants further investigation.

At present, it is not clear if the beneficial effects of music are dependent upon the exercise intensity (Karegeoghis & Priest, 2012b). Research in aerobic studies suggest that exercising above the ventilatory threshold represents the critical point whereby any potential ergogenic effect is overridden by negative sensations associated with metabolic acidosis (Bharani, Sahu, & Mathew, 2004; Boutcher & Trenske, 1990). However, more recent findings contend that it is possible to maintain positive affective responses and motivation beyond this critical threshold, providing that the music is appropriately selected (Hutchinson, Karageorghis & Jones, 2015; Hutchinson et al., 2011; Karageorghis et al., 2013). As these observations have been derived from aerobic studies, it is not currently known whether intensity-dependent effects (e.g. as a percentage of 1RM) are apparent in resistance exercise. Understanding how participants respond to musical accompaniment at a variety of exercise intensities (e.g. at 30, 60, 70 and 80% of 1RM) could help researchers better understand how to utilise music in a RT setting. Moreover, assessing the ergogenic potential of self-selected options in comparison to different genres of music such as metal (M) and electronic dance music (EDM) at different intensities might offer further insight into whether an optimal musical accompaniment exists. This information could assist both practitioners and individuals completing resistance training who wish to maximise performance by alerting them to how music can be best utilised during sessions in conjunction with their individualised objectives.

Therefore, the aim of this study was to investigate the influence of different music genres during a power-based (30% 1RM) and strength-based (60, 70 and 80% 1RM) repetition to failure exercise protocol in the bench press and back squat exercises. The psychological (mood), psychophysical (RPE, power, velocity, number of repetitions) and psychophysiological (heart rate, blood lactate) responses to music were assessed as the dependent variables.

Methods

Music Selection

The music selection procedure was conducted to select 10 tracks (~40 min) from each genre to be played in the main experimental testing. Forty-nine students (19.6 ± 2.2 years) from a Sport and Exercise Sciences undergraduate course in North England participated in the music selection procedure. To ensure that the methodological guidelines of Karageorghis and Terry (1997) were adhered to, participants were similar in age and socio-cultural background to those who took part in the main experimental conditions. All music tracks were evaluated using the Brunel Music Rating Inventory-2 (BMRI-2; see Karageorghis, Priest, Terry, Chatzisarantis, & Lane, 2006). The instructions provided to participants highlighted that the word, "motivate" meant music that would make you want to exercise harder and/ or longer in a resistance training session. A total of 40 music tracks were generated in total, including 20 from both EDM and M. Tracks for each genre were initially selected based on their ranking (most played) in a popular online streaming service provided they fulfilled the criteria (>120 BPM). After being randomly allocated into two groups, participants were asked to listen to 90 s of baseline calm instrumental music (75 BPM; Improv #10 - One last thought, The Daydreamers Club) and then rate alternate EDM and M tracks within 90 s using the BMRI-2. The same calm instrumental music was also played between each music track for 30 s as a control. The two separate groups each listened to 20 tracks in total, including 10 from the genre of EDM and 10 from M. The 20 tracks listened to by group one were different to the 20 tracks listened to by group two. The reason for using two groups was to reduce the possibility of respondent fatigue that can occur during lengthy surveys (Elrod, Lowier, & Davey, 1992). Room conditions and testing time were standardised for both groups. Music was delivered through speakers (Storm, Azatom, UK) which were positioned at the front of the room with volume standardised to 75 dBA.

Results revealed that the motivational qualities for EDM tracks (31 ± 1.14) were higher than M (14 ± 1.5); $t(18)=-27.99$, $p<0.05$, indicating that participants rated the tracks within each genre as moderate and low, respectively. The selected tracks were scored significantly higher than the non-selected tracks in EDM; $t(18)=6.54$, $p<0.05$ and M; $t(18)=6.79$, $p<0.05$.

Experimental testing

Participants

A power analysis (G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2009) was used to establish an appropriate sample size based on the effect size (partial η_2 = .24) of Simpson and

Karageorghis (2006) for the impact of synchronous music on anaerobic endurance. This indicated that a sample of 12 participants was needed to detect an effect in a repeated measures design. To ensure protection against participant dropout, a total of 16 resistance trained males (who were different to participants in the music selection phase) were recruited and completed experimental testing (age 22 ± 3.4 years, stature 181.8 ± 7.1 cm, body mass 78.4 ± 11.1 kg, 1RM back squat 114.5 ± 21.5 kg, 1RM bench press 90.3 ± 18.6 kg). Inclusion criteria required participants to be resistance trained for a minimum of two sessions per week for the last two years, with no more than 4 consecutive weeks away from training. All participants were of Caucasian heritage and brought up in the United Kingdom in similar socio-cultural backgrounds. All participants provided written informed consent and the study was approved by the institute's Research Ethics Committee and was carried out in accordance with the declaration of Helsinki.

Design

Using a repeated-measures design, participants were required to attend the laboratory on five separate occasions, with each visit separated by at least 48 h. After the initial familiarisation session, participants repeated the same exercise protocol across four conditions (no music control; C, SS, EDM and M) in a randomised order at the same time of day (±1 h), with each participant completing testing within a 2 week period. Throughout the duration of the study, participants were asked to refrain from completing heavy exercise between visits (i.e. up to 48 h before), omit consumption of supplements (e.g. caffeine) and arrive in a hydrated state. All participants confirmed that they had adhered to instructions throughout the study. Temperature and humidity were regulated so that environmental conditions were matched between all experimental trials (22 ± 1 °C ± ; 46.5 ± 4.5%, respectively).

Apparatus and Measurements

All experimental trials took place within a Strength and Conditioning laboratory at a University. A ‘Smith machine’ (Perform Better, UK) was used for both lower body (jump squat; back squat) and upper body (bench press throw; bench press) exercises as it allows the smooth, vertical movement of the bar along a fixed track. During each music condition, the tracks were played via ‘noise-isolation’ Bluetooth headphones (S204, iDeaUSA, USA), with volume standardised to 75 dBA. This volume is deemed safe from an audiological perspective (Alessio & Hutchinson, 1991).

Measures

Power and velocity: During each trial a rotary encoder (tendo power analyser-WL, Tendo Sport Machines, Trencin, Slovak Republic) was attached on the left-hand side of the barbell so that it did not hamper the participant’s grip or stance. Data were recorded during each repetition and subsequently used to calculate peak power/velocity and mean power/velocity. This method has shown an intraclass correlation (ICC) of 0.71 - 0.81 at these intensities (Stock, Beck, DeFreitas & Dillon, 2011) and has previously been established as a valid measure for velocity and power (Garnacho-Castaño, López-Lastra & Maté-Muñoz, 2015).

Internal and perceptual responses: Participants wore an adjustable strap around their chest to monitor heart rate (HR; FS1, Polar Electro, Oy, Finland 2006) via telemetry throughout each session. Heart rate values were recorded after completion of each exercise set. Using the rating of perceived exertion (RPE) scale (Borg, 1998) participants were also asked to rate their perceptual responses after completion of each exercise set using methods similar to Loenneke et al. (2015). Blood lactate concentration ([Bla]; Lactate Pro, Akray, Kyoto, Japan) was sampled ~ 2 min post completion of the entire protocol from the finger, which was initially cleaned with a mediwipe and dried with a gauze swab. Using a softclix lancet device, the site was punctured and the first drop of blood wiped away. Light pressure around the site was applied to the ~15 uL lactate strips for automatic analysis. The same device was used throughout testing (coefficient of variation; CV = 5.7%) (Tanner et al., 2010).

Mood: Measurement of mood profile was taken using the Brunel Mood Scale (BRUMS) immediately before and after each condition. In brief, this 24-item questionnaire asks participants to quantify individual levels of anger, confusion, depression, fatigue, tension and vigour “right now” on a 5-point Likert scale (0 “not at all” to 4 “extremely”). Two validation studies have revealed satisfactory psychometric characteristics of this questionnaire (Terry et al., 1999; Terry, Lane, & Fogarty, 2003).

Pre-test and habituation trials

On the first visit to the laboratory, participants completed a health screen and were measured for their stature (Holtain, UK) and body mass (Tanita, Medical Scales, USA). Participants then received instructions regarding how to use the RPE scale and practiced this at different stages of the subsequent maximal testing procedure. Specifically, they were told to provide an accurate measure of the exertion they felt at that specific time. The exercise session began with a standardised 10 minute dynamic warm up followed by 5 minutes of additional independent activities. To individualise loading for exercises in the experimental conditions, participants completed the following protocol for both back squat and bench press. This comprised 10 reps of a squat movement on an unloaded (20 kg) Smith machine, followed by loads of 30, 50 and 80% of a self-estimated 1RM for 6, 4 and 1 reps, respectively. After this, the load was progressively increased from 90% of self-estimated 1RM by 2.5 or 5 kg for 1 rep based on perceived effort, in line with the recommendations from McMaster, Gill, Cronin and McGuigan (2014) until a maximum effort was reached using a full range of motion. A minimum of three minutes were given for participants to rest, with an additional 2 minutes if required. Following a 10 minute upper-body mobility warm up and stretching (e.g. press ups with a rotation and resistance band shoulder openers), the same protocol was repeated for the bench press.

Final maximal values informed the calculation of individualised loads corresponding to 30% 1RM for power-based exercises (jump squat, bench press throw) and 60, 70 and 80% 1RM for strength-based repetition to failure tests. Habituation to both power-based exercises (jump squat and bench press throw) took place following adequate rest (~10 min) from the maximal testing protocol. For the jump squat, participants were asked to adopt a comfortable stance and grip width with the bar resting across the upper trapezius, lower the bar under control to a self-selected depth and complete an explosive movement to produce the highest jump possible, stopping and re-starting between each repetition (Hori, Newton, Andrews, Kawamori, McGuigan & Nosaka, 2007). The bench press was performed on a flat bench, where participants were asked to hold the bar at arm's length at a comfortable grip width, with their feet flat on the floor and hips, shoulders and head placed on the bench. They lowered the bar towards their chest to the lowest point without touching, then produced an explosive upward arm push, releasing the bar at the top of the movement to produce the highest possible throw. Trained spotters were used during each attempt to catch the bar and return it to the hands of the participant (West, Cunningham, Crewther, Blair, Christian &

Kilduff, 2013). After completion of this initial visit, the full experimental procedures were reiterated to participants and an opportunity for any further habituation was offered.

Experimental conditions

On visits 2-5, participants filled out a pre-exercise BRUMS mood scale and then put on the over-ear bluetooth headphones. Participants were exposed to one of four conditions in a randomised order (1) no music/ control (C), whereby no music was played, although headphones were still worn (2) metal (M, 159 ± 24 bpm) (3) Electronic Dance Music (EDM, 128 ± 1 bpm) and (4) self-selected (SS, 129 ± 9 bpm). For the SS condition, each participant was instructed to compile a list of 10 songs which they would normally listen to for motivation during resistance training. Music tracks specific to each condition were played from the beginning of the warm-up to the end of the last exercise set, totalling approximately 40 min and equivalent to 10 music tracks.

To begin the protocol, participants completed the previously described standardised 10 min lower body warm up and 6 back squat repetitions at 30% 1RM. After a 3 min rest period, participants completed 3 explosive jump squat repetitions at 30% 1RM with peak power and velocity in addition to mean power and velocity recorded on a rotary encoder.

Participants then completed three back squat sets to failure, defined to participants as “until you can no longer lift another full repetition” at 60, 70 and 80% 1RM with three minutes recovery between sets. One complete repetition was defined as the inguinal crease falling in line with the proximal patella to create a parallel squat (Fry, Aro, Bauer & Kraemer, 1993), with any incomplete repetitions above this angle not included for analysis. The number of complete repetitions were recorded alongside HR and RPE after each set.

After a further 3 min rest, the same protocol was repeated for the upper body (i.e. upper body warm-up, 3 explosive bench throws, bench press sets to failure at 60, 70 and 80% 1RM) with completed reps defined as the bar touching the midline of the chest, but not resting on it (Brennecke, et al., 2009). Two trained spotters were present at all times for safety reasons and no encouragement was offered during or between exercises to ensure that the environment remained consistent between conditions. After all sets had been performed, participants removed the headphones, completed a post-session BRUMS mood scale and BLa was sampled.

Insert figure 1 about here *

Statistical analysis

Inferences about the true (population) values of the effect of music genre on the dependent variables were assessed using magnitude-based inferences (MBI). This analysis type was selected instead of traditional null hypothesis testing due to its merits in informing practical decisions based on the efficacy of an intervention (Batterham & Hopkins, 2005). This approach enables the practical significance of any observed differences to be established based on the magnitude and likelihood of an effect (Hopkins, Marshall, Batterham, & Hanin, 2009), which was deemed necessary considering the applied nature of the investigation. Based on the 90% confidence limits, threshold probabilities for a substantial effect were 0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, and 99.5% most likely. The threshold for the smallest important change for each variable was determined as the within-participant SD multiplied by 0.2, with the following thresholds: < 0.2 trivial; 0.2–0.6 small; 0.6–1.2 moderate; 1.2 large; ≥ 2.0 very large effects, respectively (Hopkins, Marshall, Batterham, & Hanin, 2009). Effects were deemed unclear if confidence intervals overlapped the thresholds for substantiveness, such as if the effect was substantially positive and negative (Hopkins et al., 2009). Relative (%) changes in performance were expressed as the transformed (natural logarithm) % change:

+90% confidence limits. A predesigned spreadsheet (Hopkins, 2006) was used for all calculations.

Results

Power-based jump squat and bench press throw at 30% 1RM

Power and velocity

Jump squat: Peak and mean power and peak and mean velocity did not differ between conditions, revealing *unclear* or *trivial* changes (Table 1).

Bench press throw: Peak power was *possibly* lower by a small difference in the EDM compared to the M condition, while peak velocity was *possibly* higher by a small difference in C compared to EDM, M, and SS. While there were no differences in mean power for the bench throw, mean velocity was *possibly* higher in C when compared to the EDM condition and *likely* higher when compared to the M condition. Mean velocity was also *likely* higher in SS compared to EDM and M (Table 1).

Rating of perceived exertion

Jump squat: There were no differences between C and any music condition, although RPE was *possibly* higher in SS compared to M by a small difference.

Bench press throw: RPE was *likely* higher by a small difference in EDM and SS compared to C, and by a *possibly* small difference in M when compared to C.

Insert Table 1 about here

Heart rate

Jump squat: HR was *likely* higher in SS compared to C and EDM by a moderate and small difference, respectively. HR was also *possibly* higher in M than C and EDM by a small difference (Table 2).

Bench press throw: In the SS condition, HR was *most likely* higher than C and *likely* higher than EDM and M by a moderate and small difference, respectively. In comparison to C, HR in EDM was *likely higher* and M was very likely higher by a small and moderate difference (Table 2).

Strength-based repetitions to failure protocol in back squat and bench press at 60, 70 and 80% 1RM

Number of repetitions

Back squat at 60% 1RM: All music conditions resulted in higher repetitions to failure, with SS showing a *very likely* moderate effect, M showing a *likely* small effect and EDM showing a *possibly* small effect. There was also a *very likely* small benefit of SS compared to EDM and a *likely* small benefit of SS compared to M (Figure 2). Back squat at 70% 1RM: All music conditions resulted in higher repetitions to failure, with SS, M and EDM showing a *likely* small benefit and SS also showing a *possibly* small benefit compared to EDM. Back squat at 80% 1RM: There was no beneficial effect of any music condition compared to C, although repetitions in the SS condition were *possibly* higher by a small difference compared to EDM.

Bench press at 60% 1RM: A *very likely* small benefit in the number of repetitions was shown in SS compared to C. Bench press at 70% 1RM: There were no differences in repetitions to failure. Bench press at 80% 1RM: There was a *possibly* small benefit in M compared to C.

Insert Figure 2 about here

Internal and perceptual responses

Rating of perceived exertion

Back squat at 60% 1RM: RPE was *likely* higher in EDM compared to C and was also *possibly* higher EDM than M and SS, all by a small difference. Back squat at 70% 1RM: RPE was *likely* higher in EDM compared to C and SS and was *possibly* higher in EDM than M, all by a small difference. Back squat at 80% 1RM: RPE was higher in EDM than C by a *likely* small difference, and also *possibly* higher than M. The RPE for SS was also *possibly* higher than C by a small difference.

Bench press at 60% 1RM: RPE was higher in EDM than C by a *likely* small difference, and higher in EDM than SS by a *possibly* small difference. Bench press at 70% 1RM: RPE was higher in EDM than C and SS by a *possibly* small difference. Bench press at 80% 1RM: RPE was *possibly* higher in SS compared to C by a small difference.

Heart rate

Back squat at 60% 1RM: Compared to C, HR was *possibly* higher in EDM and M and *likely* higher in SS, all by a small difference. Back squat at 70% 1RM: Compared to C, HR was *possibly* higher in EDM and *likely* higher in SS by a small difference. HR was also *possibly* and *likely* higher in SS compared to EDM and M, respectively. Back squat at 80% 1RM: Compared to C, HR was *possibly* higher in EDM and SS by a small difference. HR was also *possibly* higher in EDM and SS compared to M by a small difference.

Bench press at 60% 1RM: Compared to C, HR was *likely higher* in EDM, *possibly higher* in M and *very likely* higher in SS by small, small and moderate differences, respectively. Bench press at 70% 1RM: There were no differences in HR between conditions at this intensity. Bench press at 80% 1RM: Compared to C, HR was *possibly* higher in EDM and M and *likely* higher in SS by a small difference. HR was also higher *possibly* higher by a small difference in SS compared to EDM. Heart rate results are presented in Table 2.

***Insert Table 2 about here**

Blood lactate

Blood lactate was *very likely* higher in M (0.94: ± 0.57 mmol·l^{-1}) and SS (1.48: ± 0.78 mmol·l^{-1}) compared to C by a small and moderate difference, respectively. It was also *possibly* higher by a small difference (0.54: ± 0.76 mmol·l^{-1}) in SS compared to M.

Mood

Anger: There were no pre-test differences between conditions in anger. A *possibly* small pre-post trial decrease in anger was apparent in C (-3.56: ± 4.92 AU). All other pre-post changes in anger were deemed *trivial* or *unclear*.

Confusion: Only one pre-test difference between conditions was found for confusion, whereby EDM was *likely* higher than SS (-1.7: ± 1.8 AU). A *likely* small pre-post trial increase in confusion was apparent in SS (2.06: ± 1.77 AU). All other pre-post changes in confusion were deemed *trivial* or *unclear*.

Depression: There were no pre-test differences between conditions in depression. A *possibly* small pre-post trial decrease in depression was apparent in SS (-2.13: ± 2.21 AU). All other pre-post changes in depression were deemed *trivial* or *unclear*.

Fatigue: Only one pre-test difference between conditions was found for fatigue, whereby C conferred *possibly* higher fatigue than M (-3.3: ± 5.0 AU). A *likely* small pre-post trial increase in fatigue was apparent in M (5.38: ± 4.46 AU) and SS (4.56: ± 3.67 AU). All other pre-post changes in fatigue were deemed *trivial* or *unclear*.

Tension: Pre-test tension was *likely* higher in EDM compared to C (3.1: ± 3.1 AU), M (-2.7: ± 2.4 AU) and SS (-2.4: ±2.6 AU), all by a small difference. A *possibly* small pre-post trial decrease in tension was apparent in SS (-1.06: ±1.96 AU). All other pre-post changes in fatigue were deemed *trivial* or *unclear*.

Vigour: Pre-test vigour was *possibly* higher in M compared to C (1.9: ± 2.4 AU) and SS (2.2: ± 3.8 AU) by a small difference. While no pre-post increases in vigour were apparent for C (3.44: ± 5.32 AU), pre-post *likely* increases in vigour were apparent in M (3.50: ± 4.55 AU), *likely* increases were apparent in EDM (6.69: ± 5.13 AU) and *very likely* increases were apparent in SS (7.13: ± 4.91 AU).

***Insert Figure 3 about here ***

Discussion

This study aimed to investigate the effect of exercising to different music genres during an explosive power-based protocol and strength-based repetitions to failure protocol in the squat and bench exercises. In an attempt to better understand the potential mechanisms at play, the psychological (mood), psychophysical (RPE, power, velocity, number of repetitions) and psychophysiological (HR, Bla) effects of music were assessed as dependent variables. The primary findings revealed that music did not benefit mean power output or mean velocity in squat or bench exercises. All music proved disadvantageous to peak velocity production in the bench press, while lower mean velocity was recorded in EDM and M compared to no music. This was coupled with higher RPE in all music conditions compared to the no music control for the bench press throw. For the strength-based repetitions to failure protocol, small to moderate benefits of music compared no music were observed, with participants completing more repetitions to failure with music at low, but not high exercise intensities. A higher number of repetitions occurred without concomitant increases in RPE in the SS and M conditions. However, participants experienced higher RPE in the EDM condition compared to the other music conditions and the no music control. Self-selected music appeared to be the optimal music condition for exercising to failure at low intensities, translating to the highest number of repetitions and conferring small benefits beyond that of EDM and M music. The most notable changes in mood state revealed that vigour improved pre-post all music conditions, although no changes were found in the no music control. There seemed to be no consistent pattern for any single condition to improve negative mood states. Collectively, this study might have applications for exercisers and practitioners seeking to optimise motivation and training outcomes in resistance exercise.

The first aim of this investigation was to assess whether different music genres could be used to enhance power and velocity outcomes in two popular resistance exercises. Compared to no music, results revealed no additional benefit of any music genre on mean power output or mean velocity production during the jump squat or bench press throw. In fact, for the bench exercise, all music types were detrimental to the production of peak velocity compared to no music. Furthermore, mean velocity production was lower in both M and EDM conditions compared to no music. This was coupled with reports of higher RPE in all music conditions compared to the no music control. Together, these results suggest that playing music during acute explosive exercises is of no benefit to performance and is potentially disadvantageous. Our results are in direct contrast to findings reported by Biagini et al. (2012), who revealed that self-selected music improved force and velocity parameters and lowered perceived exertion during the jump squat exercise performed at 30% 1RM. Although this is the only other study known to measure power output during resistance training, inconsistent findings using alternative maximal exercise modalities (e.g. the Wingate anaerobic test) have also been reported (Eliakim, Eliakim, Meckel, & Nemet, 2007; Pujol & Langenfeld, 1999; Yamamoto et al., 2003).

Reasons to explain the absence of any music-related benefit on power or velocity measures are currently unclear but could be somewhat attributed to the nature and relative complexity of the task. It has long been known that complex tasks can exceed the attentional resources of an individual (Kanfer & Ackerman, 1989). In line with the load theory of selective attention (Lavie, 2004; Lavie & Tsal, 1994), when the task requirements are challenging to an individual, the perceptual processing system is required to use all available resources to identify task-relevant information, leaving reduced capacity for processing external information, such as music (Elliot & Giesbrecht, 2010). It is possible that the explosive tasks in this investigation required high component complexity, due to the multiple dimensions being attended to during performance (e.g. to execute the movement quickly and with correct technique while listening to music) and coordinating complexity, requiring sequencing of movement and precision of timing different components (Wood & Locke, 1990). Although speculative, this suggests that under complex task conditions, music was not attended to during the initial jump squat exercise and thus did not influence any power or velocity parameters.

However, while the above justification could be relevant to the jump squat exercise, whereby the addition of music had no influence on the performance parameters, the finding that music had a detrimental impact during the bench press throw exercise warrants further explanation. While there is no definite reason for these between-exercise differences, both cue-utilisation theory (Easterbrooks, 1959) and a wealth of findings posit that the processing of irrelevant stimuli (i.e. information that is not important to task completion) increases as fatigue becomes more pronounced (Thomson, Watt, & Liukkonen, 2009; Boksem, Meijman, & Lorist, 2005). As the bench press throw was performed in the second half of the protocol (after power and strength squat tests), it is possible that fatigue contributed to the disruption of attentional processes, allowing music to interfere and compete with the task-relevant information. This suggestion is complemented by lower RPEs in the bench press throw for the no music condition compared to all other music types. Therefore, during complex tasks performed under fatiguing conditions, it becomes increasingly difficult to focus on task-relevant information. In this case, music could be perceived as an unwanted distractor that does not aid explosive performance.

For the strength-based repetition to failure protocol, music conferred small to moderate benefits in the number of repetitions completed at low and moderate, but not high exercise intensities. This suggests the intensity-dependent relationship reported in aerobic studies (Bharani et al., 2004; Boutcher & Trenske, 1990) also exists in resistance exercise. For example, in the back squat exercise, all music conditions conferred a small or moderate improvement in the number of repetitions at 60% and 70% 1RM compared to the no music control, whereas at 80% 1RM, the total repetitions performed were similar between all music conditions and the no music control. When the same protocol was performed in the bench press exercise, two out of three music types (M and SS) conferred small improvements in the number of repetitions completed compared to no music at 60% 1RM, while no benefit of music was shown at 70% 1RM. Interestingly, at 80% 1RM, exercising to M music conferred a small disadvantage in comparison to the no music control, thus suggesting that certain types of music might be detrimental to exhaustive training as the task demands increase.

Although this was the first study to use a progressive intensity protocol to investigate any intensity-dependent effect of music in resistance exercise, some previous findings also support its existence (Biagini et al., 2012; Bartolomei et al., 2015). Using the bench press exercise, Bartolomei et al. (2015) revealed a small improvement (5.8%) with self-selected music at 60% 1RM, while no effect was found when Biagini et al. (2012) used the same protocol at 75% 1RM. Based on these collective findings, it could be suggested that the critical point representing the diminished effect of music in resistance training occurs between 70 and 75% of an individual's 1RM. However, further work at different resistance exercise intensities is needed before this can be confirmed.

Potential explanations for these findings are likely to incorporate multiple mechanisms and mediating factors. Firstly, at low exercise intensities the task demands are likely to be interpreted as less complex when compared to high exercise intensities, allowing external information to occupy the attention of an individual. Under the premise of Lavie (2004), the lower task complexity allows all task-relevant information to be processed effectively, subsequently sparing some capacity to also process music. This suggestion also parallels other popular attentional processing theories (see Rejeski, 1985; Tennenbaum, 2001), which by extension emphasise that music is able to override perceptions of exertion and prevent them from reaching focal awareness (Hutchinson & Tennenbaum, 2007). The fact that participants in the current study were able to produce a higher number of repetitions to failure at 60% and 70% 1RM back squat while listening to SS (~23; ~12 repetitions) and M (~20; ~11 repetitions) music compared to no music (~18; ~10 repetitions), without concomitant increases in RPE, further supports that attentional mechanisms are at play. This pattern was also similar in the bench press exercise at 60% 1RM whereby participants completed a higher number of repetitions to failure in M and SS music conditions but did not experience higher levels of perceived exertion. These results highlight that particular music genres are beneficial for reducing perceptions of exertion, despite the completion of more work. While this held true for M and SS choices, EDM often resulted in the highest RPEs at a range of exercise intensities. Therefore, while EDM improves the number of repetitions completed, this occurs at the expense of greater perceived exertion.

When considering the genre most beneficial to accompany repetition to failure training, results best support music that is self-selected. Indeed, alongside its favourable impact on RPE, SS music conferred small benefits over both EDM and M for the number of repetitions in both exercises performed at 60% 1RM. It also benefited the number of repetitions to failure at 70% and 80% 1RM in the back squat exercise by a small difference compared to EDM. The finding that SS music appears to offer further performance benefits beyond other specific music genres, even at high exercise intensities might elucidate a different type of mechanism that works independently of aforementioned attentional processing theories (see Rejeski, 1985; Tennenbaum, 2001). Indeed, Levtin and Tirovolas (2009) suggest that music can cause biologically unconscious movement that is processed via subcortical brain structures. This suggests that certain types of music, such as that which is self-selected, induces responses via systems that are not influenced by fatigue-related feedback (Hutchinson, Karageorghis & Jones, 2015). To this end, this study supports that individuals should be encouraged to select their own music to accompany similar types of resistance training, which could also prove beneficial even at high intensities.

Responses for psychophysiological variables largely corresponded to the number of repetitions produced. Correlations revealed a strong relationship between HR and the number of repetitions at 60 - 70% 1RM (squat: r = 0.82 – 0.94; bench: r = 0.95 - 0.97) but not at 80% 1RM (r = -0.12 – -0.37). This highlights activation of sympathetic neural activity to increase the HR response in line with the exercise demands (Michell, 1990). Higher Bla responses were found in M and SS compared to no music. This was in accord with the greater number of total repetitions in these two conditions (~76 and ~82) compared to no music (~72) and EDM (~75). Enhanced psychophysiological responses contend that participants were better able to tolerate the demands of training under M and SS music conditions, thus manifesting in the production of higher workloads throughout the protocol.

Mood state results revealed increased vigour for all music conditions, with the largest mean change occurring for SS (~20%), followed by EDM (~19%) and M (8%). Feeling states are well known to improve when individuals exercise to motivational music, with a fast tempo (>120 bpm) (Karageorghis, Terry & Lane, 1999) and could help to maintain adherence to an exercise programme (Karageorghis et al., 1999; Miller, Swank, Manire, Robertson, & Wheeler, 2010). These results occurred despite the inclusion of high intensity activity throughout the protocol and thus suggest that music can induce a positive impact on mood regardless of resistance exercise intensity. It is notable that the pre-post change in fatigue was most prominent in those conditions whereby participants completed the most repetitions (SS: 10%; M: 13%). While perhaps not unsurprising, this suggests that perceptions of fatigue are masked during (via lower RPE) but not after exercise. Other negative mood states revealed some pre-post changes between music conditions, although there was no consistent improvement induced by any single music condition. Future studies should consider monitoring other affective outcomes (e.g. enjoyment, pleasure/displeasure) to better understand the influence of music genre on key variables that could help to predict adherence outcomes.

Limitations and recommendations

The music selection process resulted in different mean motivational scores between genres for use in the experimental trials. Although the most popular current tracks from each genre were used within the selection process, the results likely reflect the motivational preferences of the participant group for EDM rather than M music. While this could be deemed a limitation, it is also worthwhile to note that although M scored lower than EDM in motivational qualities, it often resulted in superior outcomes in the strength-based repetition to failure protocol (e.g. higher number of repetitions, lower RPE). This might warrant further investigation into use of the BMRI-2 for selecting appropriate music to accompany resistance exercise, and/ or highlight issues when asking participants to rate tracks at rest for application in an exercise setting.

As the order of tests was dictated by the exercise, this meant that participants could have been experiencing central fatigue when performing the bench press throw (second explosive power exercise). Due to the effect of fatigue on the neuromuscular system (Zają, Chalimoniu, Gołaś, Lngfort & Maszczyk, 2015), it is advised that power-based exercises should be completed at the beginning of an exercise session. Therefore, it is possible that the prior completion of power and strength testing for the squat exercise induced central fatigue and disrupted attentional processes during the bench press throw exercise that followed. Therefore, future studies could ensure that fatigue as a confounding variable is controlled for prior to any explosive power tests. However, it is important to recognise that exercisers and athletes alike often enter training in an under-recovered state and thus it is arguable that the protocol completed in this investigation might better reflect real-world demands.

Conclusions

In conclusion, this study revealed that individuals could use music as an ergogenic aid when trying to increase their work capacity during strength-based repetition to failure training, although specific music choices should be tested to prevent individuals from experiencing pronounced levels of perceived effort. As SS music produced the greatest improvements in repetitions without higher RPEs, practitioners should encourage individuals to create a personalised playlist to accompany exercise with careful consideration of the session demands. Being the first study in resistance exercise to investigate any intensity-dependent effect (using a range of loads), we revealed that music might be best applied at intensities equal to or below ~75% 1RM, although research to assess the potential for carefully selected personal music choices to impact on work capacity at higher intensities is warranted. The finding that all music types increased positive mood after RT supports that individuals can experience psychological benefits, despite working at high intensities. Our results discourage the use of music during explosive power exercises, owing to either unchanged or poorer performance parameters alongside higher perceptions of effort compared to no music. However, further work assessing the influence of playing music prior to such exercises should be conducted. Collectively, the present study suggests that music can be used to influence work capacity and perceived effort during strength-based resistance exercise. This might be important for both practitioners and exercisers who aim to use music to enhance resistance training outcomes.

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Figures

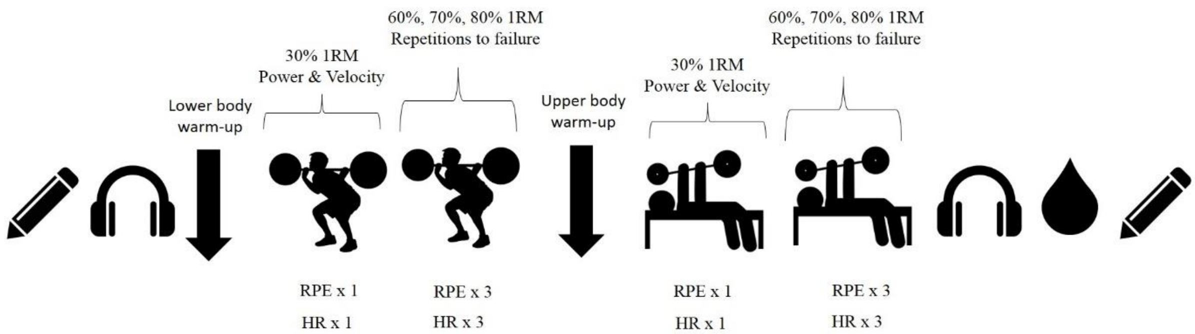

Figure 1. A schematic of the procedures completed during the experimental trials. Key ✎ = BRUMS questionnaire, 🎧 = music initiated/ stopped, [squat icon] and [bench icon] = jump squat/ back squat and bench press throw/ press, respectively in the order presented, 💧 = blood lactate, RPE and HR were taken after the completion of every set (i.e. after 30, 60, 70 and 80% 1RM on all exercises). Rest periods of 3 min between sets and exercises were provided.

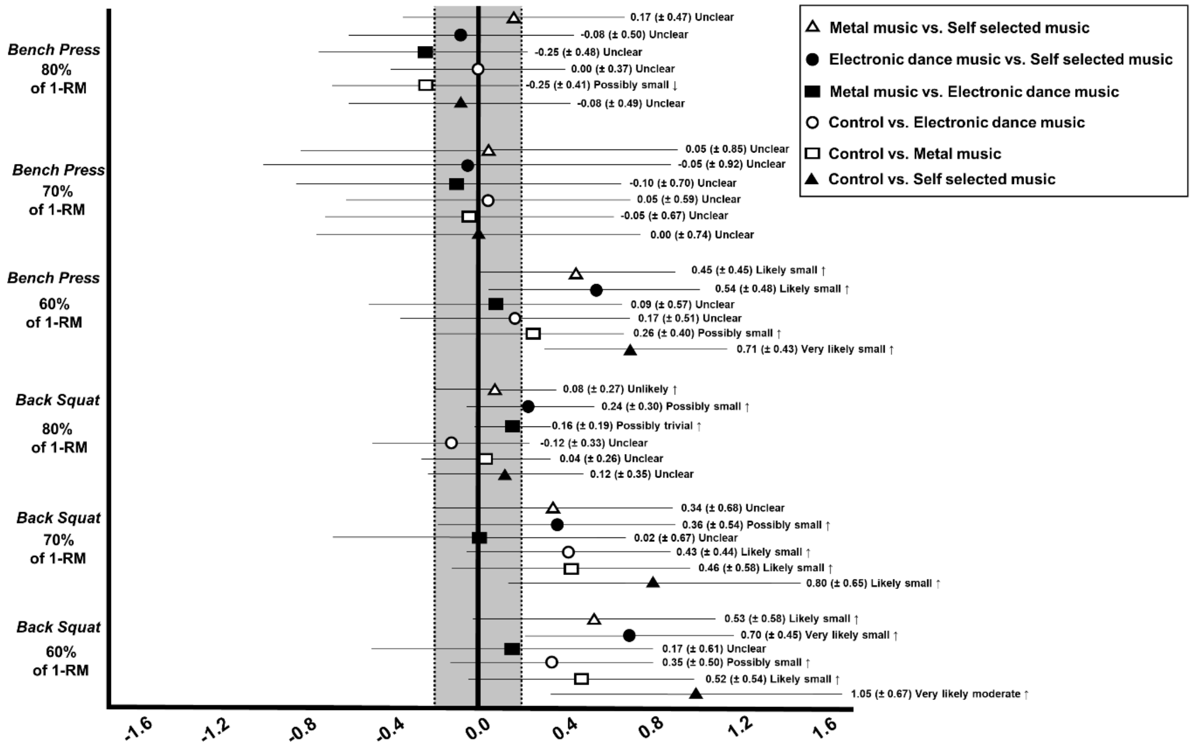

Figure 2. Standard effect size (±90% CI) changes and inferences of between condition comparisons of the bench press and back squat exercises for number of repetitions at different exercise intensities (% of 1RM)

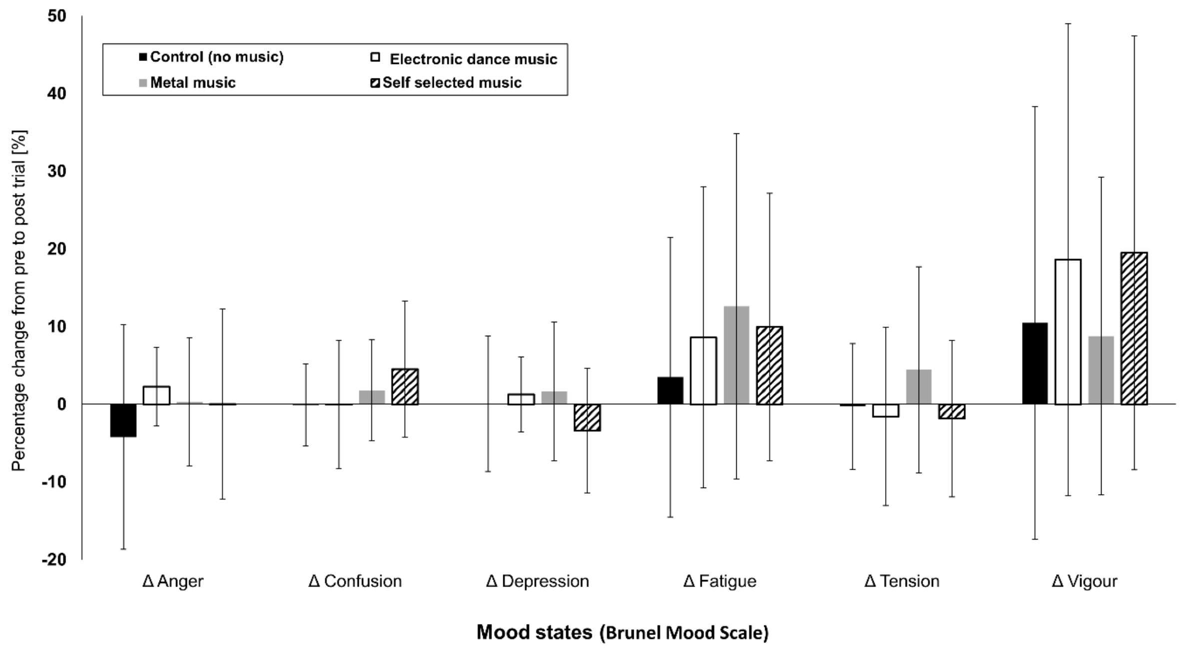

Figure 3. Percentage change from pre to post trials in anger, confusion, depression, fatigue, tension and vigour.

Table 1. Mean and peak power and velocity for the jump squat and bench press throw exercises at 30% 1RM.

	Condition				Difference in mean (Cohen) ± 90% CL (Descriptor)											
Variable	C	EDM	M	SS	C vs. EDM	% diff	C vs. M	% diff	C vs. SS	% diff	EDM vs. M	% diff	EDM vs. SS	% diff	M vs SS	% diff
Jump squat at 30% of 1RM																
Peak repetition power [W]	1012 ± 379	1054 ± 391	1048 ± 382	1032 ± 378	0.07 (± 0.36) Unclear	25 ± 43	0.00 (± 0.26) Unclear	17 ± 25	-0.05 (± 0.20) Unclear	12 ± 18	-0.07 (± 0.39) Unclear	22 ± 33	-0.12 (± 0.36) Unclear	16 ± 24	-0.05 (± 0.18) Unlikely Trivial ↓	11 ± 16
Peak repetition velocity [$m \cdot s^{-1}$]	1.92 ± 0.3	1.91 ±0.36	1.92 ± 0.28	1.92 ± 0.29	-0.04 (± 0.33) Unclear	9 ± 14	0.00 (± 0.30) Unclear	9 ± 13	0.01 (± 0.26) Unclear	7 ± 10	0.04 (± 0.38) Unclear	11 ± 19	0.05 (± 0.31) Unclear	9 ± 13	0.00 (± 0.22) Unclear	6 ± 9
Mean power [W]	373 ± 96	385 ±111	372 ± 97	372 ± 108	0.12 (± 0.30) Possibly Trivial ↑	13 ± 21	-0.01 (± 0.19) Likely Trivial	10 ± 13	-0.01 (± 0.18) Likely Trivial ↓	7 ± 11	-0.13 (± 0.30) Unclear	13 ± 20	-0.13 (± 0.30) Possibly Trivial ↓	10 ± 16	-0.01 (± 0.13) Very likely Trivial	7 ± 8
Mean repetition velocity [$m \cdot s^{-1}$]	1.10 ± 0.16	1.10 ±0.19	1.11 ± 0.14	1.10 ± 0.16	-0.02 (± 0.32) Unclear	8 ± 11	0.05 (± 0.28) Unclear	8 ± 11	0.01 (± 0.28) Unclear	7 ± 10	0.07 (± 0.34) Unclear	10 ± 5	0.03 (± 0.26) Unclear	8 ± 10	-0.04 (± 0.20) Unlikely Trivial ↓	5 ± 7
Bench throw at 30% of 1RM																
Peak repetition power [W]	694 ± 193	719 ±181	680 ± 197	695 ± 187	0.12 (± 0.22) Possibly Trivial ↑	14 ± 21	-0.07 (± 0.10) Very likely Trivial ↓	6 ± 8	0.00 (± 0.11) Most likely Trivial ↑	6 ± 7	-0.19 (± 0.21) Possibly Small ↓	11 ± 15	-0.12 (± 0.22) Possibly Trivial ↓	11 ± 16	0.08 (± 0.09) Very likely Trivial ↑	6 ± 7
Peak repetition velocity [$m \cdot s^{-1}$]	1.93 ± 0.13	1.90 ± 0.16	1.89 ±0.14	1.90 ±0.15	-0.22 (± 0.35) Possibly Small l ↓	4 ± 6	-0.26 (± 0.33) Possibly Small ↓	4 ± 6	-0.18 (± 0.29) Possibly Small ↓	4 ± 5	-0.04 (± 0.37) Unclear	5 ± 6	0.04 (± 0.37) Unclear	4 ± 6	0.07 (± 0.29) Unlikely Trivial ↑	4 ± 5
Mean power [W]	313.5 ± 78	326 ± 91	315 ±91	324 ±89	0.15 (± 0.35) Possibly Trivial	18 ± 30	0.02 (± 0.26) Unclear	10 ± 15	0.12 (± 0.23) Possibly Trivial ↑	8 ± 14	-0.13 (± 0.25) Possibly Trivial ↓	9 ± 14	-0.03 (± 0.25) Unclear	8 ± 14	0.11 (± 0.09) Very likely Trivial ↑	5 ± 7
Mean repetition velocity [$m \cdot s^{-1}$]	1.22 ± 0.11	1.18 ±0.15	1.18 ± 0.13	1.22 ± 0.11	-0.32 (± 0.38) Possibly Small ↓	6 ± 9	-0.34 (± 0.31) Likely Small ↓	5 ± 7	Unclear -0.02 (± 0.25)	4 ± 5	-0.02 (± 0.38) Unclear	7 ± 9	0.31 (± 0.30) Possibly Small ↑	5 ± 7	0.32 (± 0.28) Likely Small ↑	5 ± 7

Table key: C; Control [no music], EDM; electronic dance music, M; metal music, SS; self-selected music. Values are presented as means ± standard deviations and percentage differences between conditions. Magnitudes of change were classified as substantial increases (↑) or decreases (↓) when there was a 75% likelihood of the effect being equal or greater than the smallest worthwhile change, calculated as 0.2 * between-subject deviation and classified as small 0.2 to 0.6, moderate 0.6 to 1.2, large 1.2 to 2.0, and very large 2.0 to 4.0 (Hopkins (22)). Threshold probabilities for a substantial effect were <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, and >99.5% most likely.

Table 2. Heart rate and rating of perceived exertion responses for power (30% 1RM) and strength (60, 70 and 80% 1RM) protocols.

	Condition				**Difference in mean (Cohen) ± 90% CL (Descriptor)**											
	C	EDM	M	SS	C vs. EDM	% diff	C vs. M	% diff	C vs. SS	% diff	EDM vs. M	% diff	EDM vs. SS	% diff	M vs SS	% diff
Heart rate ***Back squat***					↑											
30% of 1RM	118 ± 23	120 ± 19	126 ± 15	130 ± 16	0.08 (± 0.05) Unclear	0 ± 22	0.34 (± 0.41) Possibly Small ↑	6 ± 18	0.49 (± 0.49) Likely Small ↑	8 ± 21	0.26 (± 0.30) Possibly Trivial ↑	5 ± 13	0.40 (± 0.43) Likely Trivial ↑	6 ± 17	0.14 (± 0.29) Possibly Trivial ↑	2 ± 13
60% of 1RM	160 ± 23	166 ± 21	165 ± 19	167 ± 25	0.25 (± 0.34) Possibly Small ↑	3 ± 12	0.20 (± 0.27) Possibly Small ↑	3 ± 10	0.30 (± 0.23) Likely Small ↑	4 ± 9	-0.04 (± 0.36) Unclear	-1 ± 13	0.05 (± 0.30) Unclear	0 ± 11	0.09 (± 0.33) Unclear	0 ± 13
70% of 1RM	157 ± 21	163 ± 18	160 ± 17	167 ± 20	0.26 (± 0.32) Possibly Small ↑	3 ± 10	0.10 (± 0.30) Possibly Trivial ↑	1 ± 10	0.45 (± 0.27) Likely Small ↑	6 ± 9	-0.16 (± 0.35) Possibly Trivial ↑	-3 ± 12	0.19 (± 0.19) Possibly Trivial ↑	2 ± 6	0.35 (± 0.29) Likely Small ↑	4 ± 10
80% of 1RM	154 ± 20	159 ± 19	154 ± 20	159 ± 23	0.24 (± 0.28) Possibly Small ↑	3 ± 9	0.00 (± 0.24) Unclear	0 ± 8	0.22 (± 0.24) Possibly Small ↑	2 ± 8	-0.24 (± 0.30) Possibly Small ↓	-4 ± 11	-0.02 (± 0.31) Unclear	-1 ± 11	0.22 (± 0.27) Possibly Trivial ↑	2 ± 9
Bench Press																
30% of 1RM	109 ± 12	117 ± 15	119 ± 12	125 ± 15	0.61 (± 0.52) Likely Small ↑	6 ± 13	0.78 (± 0.44) Very likely ↑	8 ± 11	1.13 (± 0.52) Most likely ↑	11 ± 12	0.17 (± 0.40) Unclear	2 ± 10	0.52 (± 0.46) Likely Small ↑	5 ± 11	0.35 (± 0.35) Likely Small ↑	3 ± 9
60% of 1RM	142 ± 18	149 ± 24	147 ± 19	156 ± 17	0.40 (± 0.34) Likely Small ↑	4 ± 11	0.27 (± 0.21) Possibly Small ↑	3 ± 6	0.74 (± 0.33) Very likely ↑	9 ± 9	-0.13 (± 0.37) Unclear	-2 ± 12	0.34 (± 0.32) Likely Small ↑	4 ± 9	0.47 (0.29) Likely Small ↑	6 ± 8
70% of 1RM	146 ± 21	147 ± 20	144 ± 20	146 ± 19	0.01 (± 0.53) Unclear	-2 ± 23	-0.13 (± 0.36) Unclear	-3 ± 13	0.00 (± 0.50) Unclear	-2 ± 20	-0.14 (± 0.34) Unclear	-3 ± 13	-0.01 (± 0.30) Unclear	-1 ± 11	0.12 (± 0.36) Unclear	1 ± 13
80% of 1RM	137 ± 19	141 ± 17	142 ± 16	146 ± 17	0.24 (± 0.36) Possibly Small ↑	3 ± 11	0.26 (± 0.43) Possibly Small ↑	3 ± 13	0.45 (± 0.30) Likely Small ↑	6 ± 9	0.02 (± 0.40) Unclear	0 ± 12	0.21 (± 0.34) Possibly Small ↑	2 ± 10	0.20 (± 0.40) Unclear Small	2 ± 12
Rating of perceived exertion ***Back squat***																
30% of 1RM	9.9 ± 2.6	10.1 ± 1.9	9.2 ± 2.0	10.2 ± 2.0	0.05 (± 0.19) Unclear	2 ± 12	-0.07 (± 0.21) Unclear	-1 ± 15	0.09 (± 0.28) Possibly Trivial ↑	2 ± 18	-0.11 (± 0.16) Unclear	-4 ± 12	0.05 (± 0.26) Unclear	0 ± 19	0.16 (± 0.23) Possibly Trivial ↑	3 ± 14
60% of 1RM	15.0 ± 2.3	15.9 ± 2.3	15.3 ± 2.3	15.3 ± 2.3	0.36 (± 0.27) Likely Small ↑	5 ± 9	0.13 (± 0.24) Possibly Trivial ↑	2 ± 9	0.13 (± 0.32) Possibly Trivial ↑	1 ± 11	-0.23 (± 0.21) Possibly Small ↓	-4 ± 8	-0.23 (± 0.27) Possibly Small↓	-4 ± 10	0.00 (± 0.22) Unclear	0 ± 8
70% of 1RM	16.6 ± 2.0	17.5 ± 1.6	16.9 ± 1.7	16.8 ± 1.9	0.42 (± 0.27) Likely Small ↑	5 ± 7	0.15 (± 0.22) Possibly Trivial ↑	2 ± 6	0.06 (± 0.32) Unclear	0 ± 9	-0.27 (± 0.35) Possibly Small ↓	-4 ± 11	-0.36 (± -0.31) Likely Small↓	-5 ± 9	-0.09 (± 0.31) Unclear	-2 ± 9
80% of 1RM	17.9 ± 1.6	18.6 ± 1.3	18.0 ± 1.7	18.3 ± 1.6	0.44 (± 0.43) Likely Small ↑	4 ± 9	0.07 (± 0.36) Unclear	0 ± 8	0.22 (± 0.41) Possibly Small ↑	2 ± 9	-0.36 (± 0.47) Possibly Small ↓	-4 ± 11	-0.22 (± 0.42) Possibly Small ↓	-3 ± 9	0.15 (± 0.30) Possibly Trivial ↑	1 ± 6
Bench Press																
30% of 1RM	9.1 ± 2.3	10.0 ± 2.0	9.6 ± 2.2	9.9 ± 2.2	0.38 (± 0.22) Likely Small ↑	10 ± 12	0.23 (± 0.30) Possibly Small ↑	5 ± 17	0.33 (± 0.24) Likely Small ↑	8 ± 15	-0.15 (± 0.28) Possibly Trivial ↓	-5 ± 16	-0.05 (± 0.31) Unclear	-4 ± 23	0.10 (± 0.29) Unclear Small	0 ± 22
60% of 1RM	14.7 ± 2.4	15.5 ± 2.6	15.1 ± 2.8	14.8 ± 2.4	0.32 (± 0.29) Likely Small ↑	5 ± 11	0.15 (± 0.28) Possibly Trivial ↑	2 ± 11	0.05 (± 0.29) Unclear	0 ± 12	-0.17 (± 0.28) Possibly Trivial ↓	-4 ± 11	-0.27 (± 0.33) Possibly Small ↓	-5 ± 14	-0.10 (± 0.29) Possibly Trivial ↓	-2 ± 12
70% of 1RM	16.7 ± 1.8	17.1 ± 1.7	16.9 ± 1.9	16.8 ± 1.6	0.23 (± 0.28) Possibly Small ↑	2 ± 7	0.10 (± 0.29) Possibly Trivial ↑	1 ± 8	0.03 (± 0.32) Unclear	0 ± 8	-0.13 (± 0.33) Possibly Trivial ↓	-2 ± 9	-0.20 (± 0.27) Possibly Small ↓	-2 ± 7	-0.07 (± 0.38) Unclear	-1 ± 10
80% of 1RM	17.7 ± 1.7	17.9 ± 1.4	18.0 ± 1.5	18.0 ± 1.5	0.11 (± 0.37) Unclear	1 ± 8	0.18 (± 0.38) Unclear	1 ± 8	0.18 (± 0.28) Possibly Trivial ↑	2 ± 7	0.07 (± 0.38) Unclear	0 ± 8	0.07 (± 0.33) Unclear	0 ± 7	0.00 (± 0.26) Unclear	0 ± 6

Table key: C; Control [no music], EDM; electronic dance music, M; metal music, SS; self-selected music. Values are presented as means ± standard deviations and percentage differences between conditions. Magnitudes of change were classified as substantial increases (↑) or decreases (↓) when there was a 75% likelihood of the effect being equal or greater than the smallest worthwhile change, calculated as 0.2 * between-subject deviation and classified as small 0.2 to 0.6, moderate 0.6 to 1.2, large 1.2 to 2.0, and very large 2.0 to 4.0 (Hopkins (22)). Threshold probabilities for a substantial effect were <0.5% most unlikely, 0.5–5% very unlikely, 5–25% unlikely, 25–75% possibly, 75–95% likely, 95–99.5% very likely, and >99.5% most likely.