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The Effect of Music Tempo on Muscular Endurance During the Bench Press

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Purpose: Music is often utilized in athletic and recreational settings. Many athletes believe it is motivating and improves their performance. The purpose of the current study was to determine the effects of high (>120 bpm) and low (<90 bpm) tempo self-selected music on repetitions to failure (RTF) on the bench press, as well as perceived effort, heart rate, and blood lactate. **Methods:** Five male and four female recreationally trained athletes (M_{age} = 21.7 ± 1.1 years, M_{height} = 173.8 ± 8.0 cm, M_{weight} = 77.8 ± 10.0 kg, $M_{\%\ body\ fat}$ = 22.7 ± 8.5%) with at least one year of experience in resistance training participated in the study. One-repetition maximum (1-RM) was measured on the bench press using the National Strength and Conditioning Association (NSCA) guidelines. In the following sessions, individuals were asked to bench press 70% of their 1-RM to volitional failure while listening to one of the three music conditions in a counterbalanced design. The number of RTF was used as their performance measure. The music conditions included control (white noise), low tempo (<90 bpm), and high tempo (>120 bpm), which were played on wireless headphones. Participants selected music from a playlist the day of their trials to control for genre preference. RTF was compared between trials, while heart rate (HR), blood lactate, and rating of perceived exertion (RPE) were assessed immediately post-exercise. Repeated-measure ANOVAs were used to explore differences between music conditions. **Results:** There were no significant differences between conditions (control, low tempo, high tempo) for RTF (p = .38), blood lactate (p = .18), peak HR (p = .57), or RPE (p = .38). **Conclusion:** Music tempo did not significantly impact RTF during the bench press in a resistance-trained population. **Clinical Implications:** Neither self-selected high or low tempo music impacts muscular endurance performance in resistance-trained individuals, suggesting that music does not positively or negatively impact resistance training performance.

Introduction

Music is played at many athletic venues, such as sporting events and gyms to motivate people during physical activity. Thus, it has received attention as a potential legal ergogenic aid regarding exercise performance.[1-11,17,18,20] The technological advancement and improved portability of personal music devices, such as cell phones and MP3 players, have made this potential ergogenic aid more accessible and convenient. It has been suggested that music can improve peak and mean power during high-intensity exercise when played before or during the activity, likely by motivating and arousing athletes.[2,5,13,14,17] Research has also indicated that high music tempo or synchronous music may benefit athletes, such as cyclists or runners, who perform rhythmic contractions because it allows a person to pace their movements to the tempo of the song.[10,18,20] During asynchronous tasks, music may serve as an ergogenic aid by altering a participant's mood state or serving as a distractor from the fatigue and pain associated with the exercise task .[3,13,20] Boutcher and Treneske proposed that dissociation is load-dependent when discussing music's psychological effects.[4]

The specific exercise task (e.g., aerobic versus strength), participant experience (e.g., trained versus untrained), mode of exercise (e.g., running

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versus cycling), music structure (e.g., type and tempo), the timing of the music (e.g., beginning of warmup versus during event), and exercise history have been shown to impact the ergogenic effect of music.[1,8,11,13,15,17,20] For example, adjusting the tempo of a song has been shown to elicit a self-selected alteration in cadence during cycling, likely due to matching of cadence.[20] This may elicit a benefit to rhythmic aerobic exercise. With resistance exercise, Abreu et al.[1] found an increase in the number of repetitions for leg extension and barbell curls at 80% of 10 repetition-maximum (RM) with the presence of self-selected music. Kose[11] also found an increased number of RTF at 60% 1-RM of the bench press while listening to self-selected high tempo music (>120 bpm) before and during the attempt but found no impact on maximal strength as assessed by a 1-RM protocol. Karageorghis et al. found that loud high tempo music (126 bpm/80 weighted decibels) yielded the highest grip strength compared to the high tempo/quiet, low tempo/loud, and low tempo/quiet music.[9] This suggests that simple strength tasks, such as handgrip, benefit from high tempo music. In addition, music has been found to impact anaerobic performance. For example, Maddigan et al.[13] demonstrated that music elicited a 10.7% increase in exercise duration, slightly increased heart rate (HR), and blood lactate, with no difference in ratings of perceived exertion (RPE) during high-intensity cycling activity consisting of four-minute intervals repeated until volitional fatigue. These studies indicate that music may have a psychological effect on participants, perhaps by serving as a distraction from the exercise and associated discomfort, in addition to influencing cadence during rhythmic, aerobic exercise.[1,7,9]

It is also suggested that music can affect the autonomic nervous system. Maddigan et al.[13] noted that HR recovery was 13.0% faster for the high tempo (130 bpm) music condition compared to no music, even though the music was removed when the cycling protocol ended. Along these lines, Jarraya et al.[8] investigated the effect of listening to high tempo (120 to 140 bpm) music during a ten-minute warmup before a Wingate anaerobic cycling test, without any music during the test. They found that music during the warmup elicited a higher peak and mean power during the test, without any alteration in RPE.[8] These studies indicate that the impact of music goes beyond the time during which it is played. This is further reflected in research by Arazi et al.,[2] who investigated the impact of listening to high tempo music during different points of a circuit training session, including the warmup only, during the resistance training session only, and both. They found that listening to music in all three trials resulted in a faster circuit completion time compared to no music at all.[2] RPE was significantly higher in the no-music condition compared to the combined warm-up and circuit condition. This suggests that music during both time points (warm-up and circuit) may have had a synergistic effect and resulted in decreased perceived exertion compared to the no music condition.[2] In comparison, Brupacher[6] found that listening to music during CrossFit workouts elicited a lower total work output and suggested that music distracted participants from their tasks, which were longer and more complex than previously studied exercises. Similarly, Dorney et al. showed that participants had higher heart rates before and while performing a sit-up task while listening to music and using an imagery technique compared to an imagery-only condition.[7] However, there was no difference in the number of sit-ups completed during the thirty seconds of testing.[7]

Although there are some discrepancies in the current evidence, it has been shown that music may positively influence performance in aerobic and anaerobic training.[1,2,6,11,13,20] However, the effect of different music tempos on muscular endurance has not been established. Therefore, the purpose of this study was to determine if there was any effect of music tempo while performing RTF on the bench press.

Methods

Using convenience sampling, eleven participants were recruited from Lock Haven University during the Spring semester of 2019 via flyers posted around campus and word of mouth. The participants were healthy, college-aged individuals who had at least one year of resistance-training experience on the bench press and were void of any upper-body extremity injury. They were asked to refrain from consuming alcohol and caffeine for 48 hours before testing. The participants were also asked to not change or manipulate their normal workout routine throughout the research study. All methods were approved by the University's Institutional Review Board (SP19-09). Each participant provided their written informed consent and completed the Physical Activity Readiness Questionnaire+[19] and exercise history questionnaires to confirm prior exercise history and ensure eligibility for the study.

This study utilized a crossover, counterbalanced design with each participant completing four visits. After enrollment, the first visit included collecting demographic data and testing their 1-RM on the bench press. NSCA guidelines[16] were followed for direct measurement of each participant's 1-RM for the bench press. Standing height (to the nearest .1 cm) was measured without shoes using a stadiometer (Detecto, Webb City, MO). Body composition (i.e., fat mass, lean body mass, and relative body fat) was measured to the nearest 0.001 kg and .1% with a BodPod air displacement plethysmography system (Cosmed, Rome, Italy).

In the following three sessions, participants attempted to bench press 70% of their 1-RM for continuous repetitions until volitional failure under three conditions: white noise, high tempo (>120 bpm), and low tempo (≤90 bpm). Upon arrival at the gym, blood lactate and HR were measured. Blood lactate was measured via finger stick and blood lactate analyzer (LactatePlus, Nova Biomedical Corporation, Waltham, MA). HR was measured when the participant was seated with a wireless wrist heart rate monitor (Mio Alpha, Polar, Kemple, Finland). Participants then completed a warm-up run at a self-selected pace for one quarter of a mile on an indoor track followed by a warm-up on the bench press by completing 10 repetitions at 50% of their 1-RM. After the warm-up, participants were informed of their assigned condition for the session and were asked to select their preferred music or white noise from a given playlist, aligning with the required tempo. Each participant played the music for two minutes prior to beginning the set to failure and continued to listen to it during the set on Beats Studio 3 headphones (Culver City, CA, USA). Participants' blood lactate, overall RPE, and HR were measured again immediately after completing their set.[4] Each session was completed three to ten days apart, and at the same time of day between 8:00am and 5:00pm based on participants' schedules. Each participant was tested individually with the same spotter who determined if a repetition was successful. A repetition was considered unsuccessful if the participant was unable to complete the repetition or was unable to maintain the bench press form defined by the NCSA.[12]

Statistical analyses were performed on a PC using the Statistical Package for Social Sciences (SPSS, Version 16). One-way repeated measures ANOVAs were used to determine if there were differences in RPE, blood lactate, RTF, and HR across the three music conditions. Tests of normality (visual inspection of normal Q-Q Plots and Shapiro-Wilks test) and sphericity (Mauchly's test for sphericity) were performed to determine whether the assumptions of normality and equal variances within-groups were satisfied. If the sphericity assumption was violated, a Greenhouse-Geiser correction was applied. The least significant differences were used for follow-up pairwise comparisons. The level of significance was set *a priori* at $p < 0.05$ for all statistical analyses.

Results

Table 1. Participant Demographics

	M (SD)	P1	P2	P3	P4	P5	P6	P7	P8	P9
Age (years)	21.7 ± 1.1	21	21	22	23	22	21	21	24	21
Sex	55% male	Male	Male	Male	Female	Female	Female	Female	Male	Male
Height (cm)	173.8 ± 8.0	167	174	186.5	164.5	167	176.9	166.4	182.2	180
Weight (kg)	77.8 ± 10.0	76.62	87.43	86.11	65.53	63.55	94.28	76.85	74.84	74.91
Body Fat (%)	22.7 ± 8.5	25.1	14.6	19.5	28.4	19.9	38.3	24.8	12.5	11.1
1-RM (lbs)	162.2 ± 68.5	175	295	175	105	80	95	125	205	205

Table 2. Physiological responses to 70% 1-RM bench press to fatigue

	High Tempo (M ± SD)	Low Tempo (M ± SD)	White Noise (M ± SD)
RTF	18.9 ± 3.4	16.9 ± 3.5	16.8 ± 2.7
Pre-exercise lactate ($mmol \cdot L^{-1}$)	3.8 ± 2.3	3.9 ± 1.5	3.9 ± 1.6
Post-exercise lactate($mmol \cdot L^{-1}$)	6.9 ± 2.7	7.9 ± 3.8	6.5 ± 2.4
Resting HR (bpm)	83.1 ± 14.3	91.0 ± 9.8	82.0 ± 10.5
Post-exercise HR (bpm)	131.2 ± 19.9	136.2 ± 15.4	128.6 ± 13.2
RPE (6-20 scale)	15.2 ± 2.2	14.1 ± 3.4	14.7 ± 2.7

Note. HR = heart rate; RTF = repetitions to failure; RPE = ratings of perceived exertion.
*p < .05

Of the eleven participants recruited, two dropped out due to scheduling conflicts. Nine participants completed all trials with no adverse health outcomes. All participants completed each music condition. Descriptive statistics (means, standard deviations) were used to describe participant characteristics (Table 1) and outcome variables (Table 2). As shown in Table 2, there were no significant differences found between the three music conditions in performance (RTF, $F(2,16) = 1.04$, $p = .38$), physiological (post lactate, $F(2,16) = 1.92$, $p = .18$; post heart rate, $F(2,16) = .90$, $p = .57$), or psychological measures (RPE, $F(2,16) = 1.02$, $p = .38$). In addition, there were no significant differences in pre-exercise blood lactate levels between music conditions ($F(2,16) = .01$, p = .99) or resting heart rate ($F(2,16) = 2.12$, $p = .15$).

Discussion

The main purpose of this study was to determine the effect of music tempo while performing RTF on the bench press. Specifically, this study focused on whether the tempo of self-selected music influenced RTF on the bench press at 70% 1-RM. As mentioned previously, music is commonly played in many training environments to increase performance. Therefore, it is important to determine if the tempo of the music being played could have a positive or detrimental impact on performance.[15] In this study, when accounting for personal music preference by using self-selected music from specified high and low tempo music playlists, the music tempo did not impact performance. Similarly, music compared to white noise did not affect performance.

There was no difference in the number of RTF across music conditions. This is consistent with Biagini et al.,[3] who also found that bench press RTF did not change between self-selected music and no music. Music tempo was not controlled in Biagini et al.,[3] which may indicate that participants could have selected music that was not stimulating enough to overcome the physically taxing demands of this type of exercise.[3] Another explanation could be that the task was too complex for music tempo to elicit an effect, as seen in the previously mentioned study investigating CrossFit participants.[10] Karageorghis et al.[10] found during a handgrip assessment that stimulative music (>130 bpm) improved handgrip strength because the task was simple and required far less total body motor recruitment and coordination. In contrast, Kose[11] reported that motivational music played during warm-up improved RTF at 60% 1-RM on the bench press. Our study's protocol involved music being played two minutes before and during the set to failure, but not during the initial jogging warm-up. The difference in time spent listening to music may account for these differences in study findings. Rivet et al.[15] also investigated the effect of high tempo (>140 bpm) and low tempo (60 to 80 bpm) music compared to no music while performing the bench press, leg press, lateral pull down, lunges, and shoulder press RTF. The results indicated that high tempo music produced the highest mean of total work (6638.1 kg) compared to low tempo music (6372.1 kg), which may suggest that music motivates and stimulates the listener to perform their entire workout.[15] Since our study included only one assessment (RTF on the bench press), it is possible that the length of exercise was not long enough to elicit this impact.

The current study also found no difference in HR responses between conditions. There was no difference in post-exercise HR when exposed to high tempo, low tempo, or white noise conditions. This is similar to Brupbacher et al.,[6] who found no differences in average HR during CrossFit interval training when comparing music and no music, despite the no music condition resulting in higher total work. Their music selection contained four songs that had a music tempo of more than 120 bpm and one with 94 bpm.[6] The music may have not been motivational enough or was too distracting for participants, or the music and exercise bout was too short to observe a difference.[6] These results were slightly different from those of Moss et al.,[14] who found that participants in the self-selected music condition had a slight increase in mean HR when performing 70% of their 1-RM to failure compared to participants who listened to no music. Self-selected music may have enabled participants to select music that was more personally enjoyable and motivating, therefore resulting in more effort towards the exercise.[14] In the current study, although all genres were available in all playlists provided to participants, there were limitations on self-selection such that participants had to choose music from fixed playlists. Additionally, it may be possible that repetitions involving lower extremity movement may benefit more from high tempo music than upper extremity movements.

During this study, blood lactate was recorded to test for possible differences between music conditions. There were no significant differences in blood lactate pre-exercise or post-exercise between the three conditions. Maddigan et al.[13] found that blood lactate increased due to the longer distances achieved for high-intensity cycling while listening to high tempo music compared to no music. As previously mentioned, participants may have to listen to music for a longer duration of high-intensity exercise to elicit the desired effect, and the level of training of the participants may have allowed for more of a motivational impact in the study by Maddigan et al.[13] Brupbacher et al.[6] found that during Crossfit interval training, there was no significant difference in blood lactate between the music condition (11.9 mmol·L^{-1}) and no music (11.8 mmol·L^{-1}) at the end of the session. These findings demonstrate that music may not influence athletes who already perform their exercises at maximal motivation and effort. This phenomenon may have occurred in the current study as well, considering the study inclusion criteria.

There was no difference in RPE in the current study between music conditions. In a study by Biagini et al.,[3] the authors investigated the effect of self-selected music on the bench press at 75% of their 1-RM to failure using resistance-trained men compared to no music. They reported no differences in RTF or RPE between conditions. Within the same study, self-selected music elicited increased squat jump explosiveness, demonstrated by increased take-off velocity, rate of force development, and rate of velocity development, and decreased RPE related to squat jumps.[3] These results indicate the impact of the specificity of exercise in regard to how music may influence performance.[3] The authors also found significant differences in post-exercise mood state between conditions.[3] The self-selected music condition resulted in increased fatigue, tension, and vigor.[3] The increased vigor and tension may have been a result of the increased effort seen by improved jump squat explosiveness, which may also have increased the feeling of fatigue.[3] Similarly, Kumar et al.[12] found with the Profile of Mood States assessment that high tempo (120 bpm) music demonstrated a decrease in post-exercise mood status in anger, confusion, depression, and tension compared to the low tempo music condition after the participants jumped rope for 15 minutes. These results support a potential explanation that high tempo music could improve concentration by increasing enjoyment, decreasing confusion, and decreasing the chance of anxiety during training.[11] In addition, the mood of an individual could be impacted by music tempo by influencing an athlete's RPE and potentially impact their total performance.

There were some limitations to the current study. Whilst there was a difference in RTF values between white noise and high tempo music condi-

-tions, our sample was small and this difference was not statistically significant. Secondly, although resistance-trained subjects were included to control for the influence of technique, previous research suggests those who already have high intrinsic motivation for exercise may not be influenced by music tempo.[3,4,12,15]

Recommendations for future research include investigating a variety of resistance exercises, as well as expanding the duration of the protocol time. In addition, it would be worthwhile to explore a reduced weight performed to failure (i.e., lower % of 1-RM), as this may increase the number of repetitions and, thus, duration of the exercise. Music tempo may only impact exercises that are more rhythmic, which often include aerobic exercises that involve a cadence performed over a period of time (e.g., running and cycling). Although RPE was assessed, the current study did not collect data regarding participant mood states, which may have provided more insight on the effect of music tempo during the exercise. Therefore, future research should incorporate psychological measures within the study. In addition, comparing songs of various tempos that are not self-selected may provide insight into the tempo of the music itself, while removing any personal feelings towards the specific song. Overall, the authors suggest that more research is needed to discover the possible benefits of music as an ergogenic aid.

Conclusion

This study found no statistically significant evidence that supports the claim that music tempo can alter RTF during the bench press at 70% 1-RM. Listening to self-selected music in this study did not influence HR, blood lactate, or RPE during the bench press. However, it found that listening to low tempo music did not hinder muscular endurance performance on the bench press, which is beneficial for those who may not enjoy high tempo music.

Disclosures

None.

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