

Music Tempo Influences Perception but not Performance of Exercise

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ABSTRACT

Music is an ergogenic aid often used in exercise and has been shown to have positive impacts on performance. Six male recreational (REC) (Age: 20.5 ± 1.2 yr, Ht: 177.5 ± 1.3 cm, Mass: 75.0 ± 6.9 kg, BF: $15.3 \pm 4.8\%$) and 6 competitive (CMP) female swimmers (Age: 20.0 ± 1.4 yr, Ht: 165.9 ± 7.0 cm, Mass: 66.6 ± 4.9 kg, BF: $28.0 \pm 7.7\%$) completed a self-directed warmup of up to 10 minutes, followed by four 200-yd swims during which they were exposed to 4 conditions: fast-tempo music (FT;160 bpm), slow-tempo music (ST;80 bpm), control (C; no music), and metronome (M;160 bpm). Subjects were exposed to each for 4 minutes before and during each 200-yd trial. Swim times, RPE, exercise enjoyment (EE), and the musical qualities (MQ) impact on the exercise bout were collected after each trial. No significant differences were found in times (FT: 3.3 ± 1.0 , ST: 3.3 ± 1.1 , C: 3.3 ± 1.0 , M: 3.3 ± 1.0 ; $p = 0.685$) or RPE (FT: 14.2 ± 2.5 , ST: 13.2 ± 3.0 , C: 13.9 ± 2.8 , M: 14.6 ± 3.4 ; $p = 0.132$); an interaction effect was found between competition status and RPE ($F(3,30) = 4.373$; $p = .013$). CMP swimmers had higher RPE (FT: 13.8 ± 3.3 , ST: 12.3 ± 3.7 , C: 13.5 ± 3.5 , M: 12.7 ± 4.0) for FT compared to ST ($p = .017$), and higher RPE for FT compared to M ($p = .013$). There was a significant difference in EE (FT: 4.6 ± 1.3 , ST: 4.7 ± 1.1 , C: 1.8 ± 1.6 , M: 4.1 ± 1.5 , $p = 0.022$). There were higher MQ scores for FT and ST ($p < .001$, $p = 0.001$) compared to C and M ($p < .001$, $p < .001$), indicating higher motivation in FT and ST conditions. In conclusion, different music conditions impacted perception of exercise but not performance.

Introduction

Music is a psychological ergogenic aid used during exercise and has been seen to positively impact exercise. It is used by elite athletes and recreationally active people. Different aspects of music (musicality, tempo, rhythm, association, and motivational qualities) have potential to impact performance (5). These impacts have mainly been researched in running and cycling. Music has many potential effects on exercise, including increasing enjoyment, reducing perceived effort, and improving performance (5). It is suggested that different musical aspects (rhythm, tempo, melody, etc.) may contribute differently to the effect of music on exercise modes such as running, swimming, and cycling (5).

One benefit of playing music during exercise is higher reported enjoyment (8). The distraction ability of music allows subjects to dissociate from negative aspects of exercise, such as exertion. Hume and Grossman et al. (1993) found that 75% of swimmers in their study reported that listening to music made it feel like warming up was easier, increasing exercise enjoyment (3). Another ergogenic effect of using music during exercise is reduced perceived effort. Studies have shown that music can delay fatigue onset and provide a distraction from fatigue (11). Greco et al. (2022), found that music had several impacts on the perception of effort (RPE) during exercise; it was found that RPE decreased with medium to high-tempo music compared to no music in a high-intensity treadmill protocol, and all music conditions resulted in a lower RPE than the non-music condition (2). RPE differences vary between different conditions and between persons, but Karageorghis and Priest et al. (2012) found that RPE reduction between music and non-music-conditions between subjects was 10% while running at a moderate intensity (5). Preferred music may contribute to even larger decreases in RPE, while non-preferred music may have the opposite effect and be perceived as annoying.

In swimming, the two variables that determine swimming speed are stroke distance and frequency. Evidence indicates that music may lead to synchronization, potentially making both stroke distance and frequency more efficient, but only with fast-tempo music (1). Sensorimotor synchronization refers to coordination of rhythmic movement to external rhythm (9). In cases of responding to tempo from external rhythm, such as responding to a metronome, movements synchronized close “motion gaps” between beats, measured by quantity, known as tau, allowing predictability about when the next beat will occur. Aburto-Corona et al. (2023), found that faster-tempo music (140 bpm) caused both increased stroke distance and frequency compared to slow-tempo music (120 bpm) (1). Hume and Grossman (1993) reported that their subjects found it easier to endure the given task when music was playing, especially when the music was synchronized to movement (3).

Evidence suggests that music has stimulative effects regardless of synchronization, and this effect may be enhanced depending on perceived motivational qualities of the music (5). Rhythm response, musicality, cultural impact, and association are considered motivational aspects of music. Multiple studies indicate that rhythm response may have the largest influence on performance (2). Different athletes (elite, amateur, recreational), and different people may not always experience the same effects from music and find different types of music more motivational than others. It is difficult to standardize what exactly makes music motivational, and even harder to standardize those aspects across different sports and individuals because of how people may interpret the qualities of music, as well as how certain sports, such as swimming, may make listening to music difficult.

Studies where participants selected both their music and volume appear to have the best performances and the greatest reduction in RPE (6). This supports the idea that motivational qualities of music affect people differently, and people may find different types of music motivational during exercise. There is evidence suggesting that when nonpreferred music was played, reported RPE increased, indicating that non-preferred music may increase RPE (6). This may support the idea that non-preferred music can be seen as a negative auditory stimulus or an annoyance in some instances; this would eliminate the distraction ability of music (6).

Music has the potential to affect exercise in multiple ways. The extent to which music can impact RPE, performance, and enjoyment of the exercise depends on various factors; musicality, rhythm, association, tempo, cultural impact, synchronization, and motivation are the aspects of music that seem most influential. The impact of music can vary widely in exercise; in the cases of trained athletes, it may have little effect, as trained athletes are already intrinsically motivated and have better dissociative skills with exercise; however, in recreationally active athletes, it can have moderate to large effects (especially on RPE), as these athletes are more extrinsically motivated during exhaustive bouts of exercise. Additionally, there are differences between preferred and nonpreferred music, and differences between music that movement can and cannot be synchronized to. Music can impact various modes of exercise, including cycling, running, and swimming. The purpose of this study was to investigate the relationship between music and tempo in swimming performance. Specifically, this study examined the effects of music of varying tempos, performance impacts, RPE, and exercise enjoyment. Different aspects of music (rhythm, tempo, melody, etc.) and their effects were also examined using a motivational quality of music assessment.

Methods

Twelve subjects, six male recreational swimmers and six female competitive swimmers were recruited. Inclusion criteria for competitive swimmers included being female, ages 18-23, and being a current member of the university swim team. Inclusion criteria for the recreational group included the following; male or female, ages 18-23, current students at the university, currently active, and at least six months of structured swimming (i.e. swimming laps or practicing swimming). Exclusion criteria for both groups included not meeting physical activity guidelines, injury, inability to swim, and lack of swimming experience. IRB Approval was received by the University IRB prior to beginning the study (2022-76). Each subject completed informed consent forms, a Physical Activity Readiness Questionnaire (PARQ+), and exercise history questionnaires to indicate prior participation in swimming and to ensure they met current ACSM physical activity guidelines (at least 30 minutes of moderate-intensity exercise five days weekly,

or 20 minutes of vigorous-intensity activity three times weekly). Competitive swimmers were recruited from the university women's swimming team, upon completion of the 2022-2023 swim season.

Table 1. Demographic Data. This table shows the means and standard deviations in demographic data between subjects.

	All Subjects			Female Competitive Swimmers			Male Recreationally Active Swimmers		
Height (cm)	171.7	±	8.5	165.9	±	7.0	177.5	±	5.3
Weight (kg)	70.8	±	7.2	66.6	±	4.9	75.0	±	6.9
Age (yr)	20.3	±	1.3	20	±	1.4	20.5	±	1.2
Body Fat %	21.6	±	9.0	28.0	±	7.7	15.3	±	4.8

Subjects were asked to come to two data collection sessions. During session one, demographic, anthropometric data, and body composition via bioelectrical impedance analysis were collected. During session two, subjects completed a self-selected swimming warmup of up to 10 minutes, then completed four 200-yard swims at approximately 70% to 80% of maximum effort. Subjects were asked to give equal effort in each trial. Subjects could swim any stroke, or any combination of strokes (freestyle, backstroke, sidestroke, combat sidestroke, etc.), but each trial was completed the same way. In each swim, subjects were exposed to a different condition: a nonmusic condition (control), fast-tempo music condition (around 160 bpm), slow tempo condition (around 80 bpm), and a metronome condition (matching the 160 bpm tempo). Subjects listened to the music condition during rest time immediately before and during swim trials. Upon completion, subjects were asked to answer questions on multiple scales. First, they responded to six questions evaluating different musical qualities (rhythm, style, melody, tempo, sounds of the instruments used, and the beat of the music) and their impacts on motivation during the exercise on a 1 to 7 scale, using the Brunel Music Rating Inventory-3 (BMRI-3) (4). Subjects also completed the Exercise Enjoyment Scale (EES) to indicate exercise enjoyment (10). The EES is also a 1 to 7 scale, with 1 indicating no exercise enjoyment and 7 indicating extreme enjoyment. Subjects were asked to rate their perceived exertion (RPE) on the traditional Borg scale. Times for all swims were recorded. Subjects were asked to provide answers on all scales while still being exposed to the condition, and upon completion of all scales by all subjects in the session, the rest interval of four minutes and exposure to the next condition began. After the final trial, subjects were given 10 minutes to complete a self-selected cool-down.

Data were analyzed using SPSS. Repeated measures ANOVAs, and a 2x4 ANOVA were used to investigate differences between competition status and different conditions. Swimming times (performance), RPE, EES, and musical quality questions were compared for all trials and between the different groups to look for any significant differences. Additionally, due to the different groups coincidentally being split by gender, interaction effects were investigated for variables when appropriate.

Results

Table 2 shows the results from all swims and conditions. There was no difference in performance between conditions ($p = 0.685$). There was no difference in RPE between conditions ($p = 0.132$), however, there was a significant interaction effect between competitive status and RPE ($F(3,30) = 4.373$; $p = .013$), and upon further analysis, it was found that competitive swimmers had higher RPE for the fast tempo compared to the slow tempo ($p = .017$), and higher RPE for the fast tempo compared to the metronome ($p = .013$). No other variables were assessed independently within

the categories of competitive status, for lack of other interaction effects. There was a significant difference in EES between trials ($p = 0.022$).

For the BMRI-3, 1 is strongly disagreeing and 7 is strongly agreeing. For Music Q1 (the rhythm of this music motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control and metronome conditions ($p < .001$). For Music Q2 (the style of this music motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control and metronome conditions ($p < .001$). For Music Q3 (the melody or tune motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control and metronome conditions ($p < .001$). For Music Q4 (the tempo of this music motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control and metronome conditions ($p < .001$). For Music Q5 (the sound of the instruments used motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control and metronome conditions ($p < .001$). For Music Q6 (the beat of this music motivates me during exercise), subjects reported higher values for the fast tempo ($p < .001$) and slow tempo conditions ($p = .001$) compared to the control condition and metronome conditions ($p < .001$).

Table 2. Performance & Perception Data for Subjects. This table shows all of the means and standard deviations in trial times, EES, RPE, and music-related questions. *represents a significant difference from the control condition, #represents a significant difference from the metronome condition.

	Control			Fast Tempo			Slow Tempo			Metronome		
Time (min.sec)	3.3	±	1.0	3.3	±	1.0	3.3	±	1.1	3.3	±	1.0
RPE	13.9	±	2.8	14.2	±	2.5	13.2	±	3.0	14.6	±	3.4
EES	1.8	±	1.6	4.6	±	1.3*	4.7	±	1.1*	4.1	±	1.5
MusicQ1	1.7	±	1.1	4.9	±	1.8*#	4.5	±	1.8*#	1.6	±	0.9
MusicQ2	1.4	±	0.8	5.3	±	1.7*#	4.9	±	1.9*#	1.3	±	0.5
MusicQ3	1.5	±	0.9	5.0	±	1.9*#	4.6	±	1.9*#	1.5	±	0.5
MusicQ4	1.4	±	1.0	5.1	±	2.1*#	4.5	±	1.8*#	1.9	±	1.4
MusicQ5	1.4	±	0.8	5.1	±	2.0*#	4.5	±	1.6*#	1.2	±	0.4
MusicQ6	1.4	±	1.0	5.2	±	1.6*#	5.0	±	2.0*#	2.0	±	1.3

Table 3 shows the swim trial data collected for the competitive swimmers. There were no significant differences in performance between trials. There was a significant difference in RPE for the fast tempo compared to the slow tempo, and higher RPE for the fast tempo compared to the metronome ($p = .010$).

Table 3. Performance and Perception Data for Competitive Female Subjects

	Control			Fast Tempo			Slow Tempo			Metronome		
Time (min.sec)	2.5	±	0.1	2.5	±	0.1	2.5	±	0.2	2.5	±	0.1
RPE	13.5	±	3.5	13.8 [#]	±	3.3	12.3 _b	±	3.7	12.7	±	4.0
EES	4.0	±	1.8	4.8	±	1.5	4.7	±	1.4	4.7	±	1.4
MusicQ1	2.0	±	1.3	5.8	±	1.5	4.8	±	1.3	2.0	±	1.1
MusicQ2	1.5	±	0.8	5.8	±	1.9	5.5	±	1.2	1.3	±	0.5
MusicQ3	1.7	±	1.0	5.8	±	1.5	5.3	±	1.2	1.7	±	0.5
MusicQ4	1.8	±	1.3	5.8	±	2.4	5.2	±	1.2	1.5	±	0.5
MusicQ5	1.8	±	1.0	5.5	±	2.3	4.8	±	1.0	1.2	±	0.4
MusicQ6	1.8	±	1.3	5.7	±	1.9	5.8	±	1.2	2.0	±	1.1

Table 3: This table shows all of the means and standard deviations in swimming trial times, EES, RPE, and music-related questions for the competitive female swimmers. *represents a significant difference from the control condition; [#]represents a significant difference from the metronome condition; _brepresents a significant difference from the fast-tempo condition.

Table 4 shows the data collected during swim trials for the recreationally active swimmers. There was no significant difference in RPE or EES between the four trials.

Table 4. Performance and Perception Data for Recreationally Active Male Subjects

	Control			Fast Tempo			Slow Tempo			Metronome		
Time (min.sec)	4.0	±	0.8	4.0	±	0.8	4.1	±	0.8	4.0	±	0.8
RPE	14.3	±	2.3	14.5	±	1.6	14.0	±	2.1	16.5	±	1.0
EES	3.6	±	1.5	4.3	±	1.2	4.6	±	0.8	3.5	±	1.5
MusicQ1	1.3	±	0.8	4.0	±	1.6	4.1	±	2.3	1.1	±	0.4
MusicQ2	1.3	±	0.8	4.8	±	1.4	4.3	±	2.4	1.3	±	0.5
MusicQ3	1.3	±	0.8	4.2	±	1.9	3.8	±	2.2	1.3	±	0.5
MusicQ4	1.0	±	0.0	4.3	±	1.5	3.8	±	2.2	2.3	±	1.8
MusicQ5	1.0	±	0.0	4.6	±	1.8	4.1	±	2.1	1.1	±	0.4
MusicQ6	1.0	±	0.0	4.6	±	1.2	4.1	±	2.4	2.0	±	1.5

Table 4: This table shows all of the means and standard deviations in swimming trial times, EES, RPE, and music-related questions for the male, non-competitive swimmers. *represents a significant difference from the control condition; _brepresents a significant difference from the metronome condition.

Discussion

The purpose of the study was to investigate the relationship between music and swimming performance. This study examined the effects of music of varying tempos and the impacts on performance, RPE, and exercise enjoyment. No differences were seen in performance between conditions, but there were significant differences in exercise enjoyment, RPE, and perception of motivational qualities.

The findings regarding exercise enjoyment are supported by findings by Olson et al. (2015), who found that swimmers reported feeling more pleasant when music was playing during swims (8). Similar findings appeared in this study; average EES values were 1.8 in the control condition compared to 4.7 for slow-tempo and 4.6 for fast-tempo. Interestingly, the metronome condition had a higher reported EES than the control, with a mean of 4.7. Tate et al (2012) found that self-selected music resulted in higher reported motivation and more dissociative thoughts compared to no music (11). It was hypothesized that recreational swimmers would be more impacted by music, however, both groups were affected. The distractionary nature of enjoyable music allows subjects to dissociate from less pleasant aspects of exercise, such as fatigue, therefore increasing exercise enjoyment. One subject verbally expressed that the metronome condition was an annoyance, given the EES scores, most subjects likely thought it served as a distraction.

It was hypothesized that different musical conditions would affect RPE in subjects in this study. Greco et al. (2022), found that music had a significant impact on RPE (2). In this study, there was no overall effect of music conditions on RPE, but there was a significant interaction effect between competitive status and RPE. It was found that competitive swimmers had higher RPE for the fast tempo compared to the slow tempo, and a higher RPE for the fast tempo compared to the metronome. One possible explanation for this is that most of the competitive swimmers were exposed to the slow-tempo condition first and the fast-tempo last; since these swimmers were past their competitive season, they were likely somewhat deconditioned and the increased RPE can be attributed to fatigue. It is important to note that reported RPE was as high as 18 with the metronome, and only as high as 16 with slow-tempo music (Table 2); while not statistically significant, different conditions might have impacted some swimmers more than others.

It was hypothesized that subjects would swim faster in fast-tempo conditions, based on existing evidence (1, 8). There was no significant difference in swim performance between conditions, however, five of the twelve subjects had their fastest trial during the fast-tempo condition. This may be explained by possible sensorimotor synchronization (1). When the response to music begins, the tempo of the music can assist in setting the pace of exercise; in the case of swimming, faster tempo music can lead to faster stroke rates, leading to increased swimming pace. It was expected that this would occur in the competitive swimmers, but would not occur in the recreational swimmers, as trained athletes are better able to hold a pace throughout exercise. While there were no performance increases in the competitive group, it is important to note that most of the competitive swimmers had similar times throughout the conditions. It was expected that there would be performance increases in the recreational swimmers, as recreational athletes are more susceptible to the motivational or ergogenic effects of music (whereas trained athletes are better at ignoring fatigue), which can lead to increased performance. However, there was no performance increase in any conditions for the recreational swimmers; one possible explanation for this is fatigue. The recreational swimmers were screened for six months of prior swim experience, but many were likely not accustomed to swimming 800 yards in one session, as the experimental design required.

Multiple studies indicate that tempo may be the most influential musical quality impacting performance, however, it is not the only quality that may affect performance (2). Other aspects that were evaluated included rhythm, style (hip-hop, alternative, etc.), melody, instrument sound, and beat of the music. Questions related to qualities of music asked about how these qualities were motivational (4). Question 1 asked if the rhythm was motivating. Question 2 asked if the style was motivating. Question 3 asked if the music's melody, or tune, was motivating. Question 4 asked if the tempo (speed) was motivating. Question 5 asked if the sound of the instruments used (guitar, synthesizer, piano, etc.) was motivating. Question 6 asked if the beat was motivating. Higher scores on any of these questions indicated higher motivation for the subject. For all musical quality-related questions, subjects reported higher values for the fast

and slow tempo conditions compared to the control and metronome conditions; this indicates that the subjects agreed that the fast-tempo music and slow-tempo music had more motivational qualities than the control and metronome conditions. The music played during the conditions included a variety of styles and slow-tempo (80 bpm) songs included *Buy You a Drank (Shawty Snappin)* by T-Pain, *Chasing Pavements* by Adele, *Kashmir* by Led Zeppelin, and *Come Together* by the Beatles. The fast tempo (160 bpm) songs included *Hey Ya!* by Outkast, *The Middle* by Jimmy Eat World, *Shake It Off* by Taylor Swift, and *Paranoid* by Black Sabbath. It was important to include a variety of music varying in styles and genres, as there is evidence to suggest that preferred music may have a greater impact on performance and fatigue than nonpreferred music; evidence from the same studies could indicate that music that is not preferred by subjects may make exercise seem harder, as it negates the dissociative effects that music typically provides (6). Furthermore, if an auditory stimulus is seen as negative, it could be perceived as annoying and affect one's ability to concentrate or enjoy exercise.

Conclusion

In conclusion, the study found that none of the music conditions influenced swimming performance. The competitive swimmers had higher RPE for the fast and slow-tempo compared to the metronome, although the recreational swimmers were not impacted. Music of any tempo increased the enjoyment of the exercise and the motivation of the individuals compared to the metronome and control. Considering the slow-tempo music had no negative impact on swimming performance and still increased motivation among the swimmers, it can be concluded that listening to any music during swimming may be beneficial and lead to improved exercise enjoyment, leading to more motivation during exercise.

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