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Short Communication

Music in CrossFit®—Influence on Performance, Physiological, and Psychological Parameters

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Abstract: Gaining increasing popularity within the fitness sector, CrossFit® serves as an appealing and efficient high intensity training approach to develop strength and endurance on a functional level; and music is often utilized to produce ergogenic effects. The present randomized, controlled, crossover study aimed at investigating the effects of music *vs.* non-music on performance, physiological and psychological outcomes. Thirteen (age: 27.5, standard deviation (SD) 6.2 years), healthy, moderately trained subjects performed four identical workouts over two weeks. The order of the four workouts (two with, and two without music, 20 min each) was randomly assigned for each individual. Acute responses in work output, heart rate, blood lactate, rate of perceived exertion, perceived pain, and affective reaction were measured at the 5th, 10th, 15th, and 20th min during the training sessions. Training with music resulted in a significantly lower work output (460.3 repetitions, SD 98.1 *vs.* 497.8 repetitions, SD 103.7; $p = 0.03$). All other parameters did not differ between both music conditions. This is partly in line with previous findings that instead of providing ergogenic effects, applying music during CrossFit® may serve as a more distractive stimulus. Future studies should separate the influence of music on a more individual basis with larger sample sizes.

Keywords: music; performance; psychological state; pain; RPE; crossfit

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1. Introduction

Traditional resistance training (RT) has been proven to provide beneficial effects on cardiovascular risk factors (e.g., blood pressure, arterial stiffness, and total body fat mass) [1] and enhance quality of life while reducing disability in young, middle-aged and elderly adults [2]. These findings are valid irrespective of age, health status, body mass index, cigarette smoking, and cardiorespiratory fitness, thus, the all-cause mortality risk for individuals with a moderately well-developed muscular fitness is considerably lower[3].

Compared to traditional RT, high-intensity RT (≥80% of 1RM) has been shown to be more effective in young healthy adults [4] and elderly people [5,6] in enhancing strength and functional movement, and in order to counteract sarcopenia. Also, aerobic high-intensity interval training (HIIT) has been proven to provide supplemental effects to enhance physical fitness, such as oxygen uptake, in comparison to standard aerobic training [7]. As it combines the benefits of HIIT and high intensity RT, it seems reasonable that high-intensity circuit training (HICT) has grown in popularity [8].

CrossFit® as a novel and nontraditional training approach, includes elements of high intensity power training as well as high intensity strength endurance training [9,10]. Despite its growing popularity, this training modality has received very little attention in research. Interestingly, CrossFit® workouts are frequently accompanied by music.

In the last two decades, a variety of research questions have been addressed in order to understand the effects of music being played during exercise. Experimental designs include (amongst others): movement performed synchronously *vs.* asynchronously to music, the choice of motivational *vs.* oudeterous (neutral) music *vs.* metronome (as a control condition) and the effect of self-selected *vs.* non-self-selected music. The review of Karageorghis and Priest (2012) on music used during exercise states that "During repetitive, endurance-type activities, self-selected, motivational and stimulative music has been shown to enhance affect, reduce ratings of perceived exertion, improve energy efficiency and lead to increased work output". However, "it appears to be ineffective in reducing perceptions of exertion beyond the anaerobic threshold." [11].

There is, however, only one study in the aforementioned review pertaining to the effects music has during strength-endurance exercises. That investigation examined whether performing strength-endurance exercises synchronously to motivational music, oudeterous music or metronome would alter work output and feeling states. Results showed that both sexes performed best with motivational music. While men performed better with a metronome than with oudeterous music, women performed worse with the metronome condition [12].

Two studies have shown that less trained individuals benefit more from music than those who are trained. It appears to be likely that highly trained participants employ an associative attention strategy, *i.e.*, they pay attention to the signs of perceived effort [13,14]. For these individuals, music might be a distractive stimulus and may thereby adversely affect physical performance. This will be particularly the case if the individuals have to pace themselves, as this demands an associative attention style. Interestingly, age also seems to be an important factor when considering the reactivity to music during exercise. With increasing age, the presence of music during exercise becomes less important and there is a shift in preference to less stimulative music [15]. Other factors such as socio-economic background and the resulting music preferences are also important factors to be taken into account.

Considering that research on strength-endurance exercise is very limited, it was decided to choose a preexisting setting and to alter as little as possible, so as to most adequately depict the real-life situation in which music is used. Therefore, the presented investigation examined the use of asynchronous music during a self-paced, CrossFit® workout; a multiple joint, high-intensity strength-endurance exercise bout. The study aimed at investigating the effects of music application on CrossFit®-specific performance (number of repetitions within a given time) and physiological (heart rate, blood lactate), and psychological parameters (rate of perceived exertion, perceived pain level, and affect) during several maximal and randomly assigned bouts of strength endurance exercise with and without music. The derived hypotheses were that music may increase CrossFit®-specific performance, heart rate, and blood lactate, while the rate of perceived exertion, pain, and affect remain unchanged.

2. Method

2.1. Study Design

The present study was conducted as a randomized, controlled, crossover trial. Thereby, the order of single training bouts with and without music was randomly assigned. Due to assumed biological day-to-day variability, four CrossFit® training sessions (2 with and 2 without music) of 20 min each had to be completed. 96% of the workouts were performed in the afternoon (only two participants had to perform one session each in the morning). The average intra-individual time difference between workouts was 3.6 h (standard deviation (SD) 3.0). In order to stratify participants' overall fitness and ensure that the group of participants is relatively homogenous, a Multistage Shuttle Run Test (MSSRT) was performed. The MSSRT is a valid and reliable test to predict VO2max in female and male adults [16]. Although the MSSRT does not assess strength, VO2max is an important parameter for CrossFit®-specific performance as workouts can also last longer than 20 min. After receiving all relevant study information, the participants signed an informed consent. The participants did not receive any information on the purpose of the study.

2.2. Subjects

Thirteen (age: 27.5 (SD 6.2) years; 6 females; BMI: 23.9 (2.7) kg/m²) healthy, moderately trained (completed stages in MSSRT: 9.1 (1.75)) participants were enrolled in the study. Participants fulfilled eligibility criteria if they had at least three months of CrossFit® experience. Exclusion criteria were any type of cardiac disease, hypertension, diabetes, use of medication, and total endoprosthesis. Subjects were asked to refrain from any other activity 24 h prior to the exercise sessions.

2.3. Training Sessions and Testing Procedure

The total number of four training sessions was completed within two weeks. Training sessions took place at least 24 h apart. Each training session consisted of a so-called "Cindy" CrossFit® workout. The purpose of this workout approach is to complete as many rounds as possible (AMRAP) in 20 min. One round consists of 5 pull-ups, 10 push-ups, and 15 air squats. Participants could perform at their own pace and take breaks if they needed. A digital stopwatch (visible at all times) counted down from 20 min. At the 5th, 10th, 15th, and 20th min the workout was interrupted for a maximum of 30 s to draw a blood sample. During this time participants filled out the questionnaire.

2.4. Music

In order to provide an authentic training setting, the chosen music corresponded to a typical selection played during workouts in the CrossFit® Basel gym. The playlist was standardized in terms of titles, order of titles, and volume. The chosen volume corresponded to the one, which is usually chosen when music is played in that gym. The genre was rock and roll. The following titles of the band AC/DC were played during the sessions with music: Shoot to Thrill (141 bpm), Rock N' Roll Damnation (133 bpm), Guns for Hire (128 bpm), Cold Hearted Man (121), and Back in Black (94 bpm). The chosen playlist was amongst those typically played in that particular CrossFit® gym at the time. It was chosen, as it reduces the risk of participants understanding the true nature of the investigation and reflects the real-life situation most adequately.

2.5. Outcome Measures

The total work output served as the primary outcome and was measured as the number of repetitions completed within 20 min. Work output was only measured once, *i.e.*, as the total number of repetitions, because it is the CrossFit®-specific aim of this workout. Physiological parameters included heart rate (averaged over the last 30 s; Polar Electro, Oy, Kempele, Finland) and bloodlactate (Super GL ambulance, Dr. Müller Gerätebau, Freital, Germany). Additionally, a questionnaire with five items was used. Perceived exertion was assessed using the 10-point rate of perceived exertion scale. Perceived pain intensity was measured using a 10-point numeric scale. In order to examine the affective reaction, the self-assessment-manakin (SAM) was used. Affect, unlike mood, which is less specific and intense, is the instant emotional reaction to a stimulus. SAM is comprised of non-verbal graphic representations measuring the "three fundamental emotional dimensions": affective valence, arousal, and dominance. Although it includes only three items, SAM has been shown to be a valid instrument to measure affective reactions [17].

2.6. Statistics

Data are provided as means and standard deviations (SD) in Table 1. The Kolmogorov-Smirnov test was applied to test for normally distributed data. For each parameter we conducted repeated measures analyses of variance. Thereby, the time points (Time: 5', 10', 15', 20 minutes) were included as time dependent repeated measure variable and music was included also as dependent grouping variable (according to the crossover design). In case of a main effect, Tukey HSD *post hoc* tests were calculated. Significance level was set at $p < 0.05$ *, $p < 0.01$ **, $p < 0.001$ ***. An additional non-parameter Wilcoxon test was tested for the workload variable.

Table 1. Descriptive (means and standard deviations (SD)) and statistical data of work output (total amount of repetitions), heart rate response (beats per minute), rate of perceived exertion level (RPE), pain intensity level (numeric scale), and emotions (valence, arousal, dominance) at the time points with and without music.

Parameters	Minute	With music	SD	Without music	SD	Sig. (asymp., 2-sided)
Work output [n]		460 *	98.12	498	103.68	***0.03***
Heart rate [1/min]	5	173	10	171	10	
[1/min]	10	172	9	173	9	
	15	174	10	174	10	
	20	178	10	178	8	
Bloodlactate	5	8.0	1.8	8.2	1.6	
[mmol/L]	10	10.7	1.8	10.3	2.0	
	15	11.0	2.3	10.7	2.1	
	20	11.9	2.5	11.8	2.5	
RPE	5	4.5	1.4	4.7	1.4	
[0–10]	10	5.5	1.2	5.5	1.3	
	15	6.5	1.2	6.3	1.4	
	20	7.1	1.5	6.9	1.5	
Pain	5	3.0	2.0	3.4	2.1	
[0–10]	10	4.1	1.8	4.2	1.8	
	15	4.7	2.0	4.7	2.2	
	20	5.1	1.9	5.3	2.4	
Valence	5	6.0	1.1	5.9	1.0	
[1–9]	10	5.6	0.9	5.3	1.1	
	15	5.3	0.8	5.2	0.9	
	20	5.6	1.1	5.4	1.5	
Arousal	5	5.7	1.0	5.6	0.9	
[1–9]	10	5.8	1.0	5.7	1.0	
	15	5.9	1.2	6.0	1.2	
	20	6.0	1.3	6.4	1.2	
Dominance	5	5.6	1.0	5.7	1.2	
[1–9]	10	5.3	1.0	5.4	1.1	
	15	5.0	0.7	5.0	1.1	
	20	5.4	0.7	5.2	1.1	

3. Results

The results illustrate that training with music resulted in a significantly (p = 0.03) lower work output whereas all other parameters remain constant. Time × music interactions were found for neither variable ($0.21 < p < 0.71$). Thus, no *post hoc* test could have been computed, Independent of the grouping variable, time effects were found for RPE, pain, lactate and heart rates. SAM values neither revealed time effects nor time x music interactions ($0.60 < p < 0.88$). *Post hoc* tests revealed differences between 5 and 20 min for heart rates ($p < 0.05$). For the other parameters (lactate, pain and RPE, differences were found between the 5th and 15th as well as 10th and 20th min, indicating a meaningful physiological or perceived increase of strain in 10 min intervals.

4. Discussion

The present study aimed at investigating whether the application of music or the absence of music relevantly affects CrossFit® specific work output, cardiac and metabolic response, perceived exertion, and pain level as well as fundamental emotional reactions.

The major finding of the study was that participants completed significantly (p = 0.03) more repetitions in the absence of music. As music is commonly used during CrossFit® workouts in order to increase motivation and performance, this finding appears to be contradictory regarding proven ergogenic effects of music during prolonged high-intensity endurance exercise [11]. However, studies have shown that trained individuals do not profit from music in the same manner untrained individuals do. Highly trained individuals seem to choose an associative attention style focusing on inner perceptions of exertion. Furthermore, according to the exercise intensity attention linkage model [18,19] music may possibly be counterproductive during exercise requiring an associative attention style (*i.e.*, focusing on the performed movement and internal feedback). As the task at hand lasted 20 min and consisted of complex movements at maximal effort, correct technique and pacing was of considerable importance. Therefore, cognitive strain during strength endurance is greater than during standard endurance exercises. For exercise settings in which cognitive processes play a vital role and intensity is high, music might be a distraction. This would explain why work output was greater without music and why all other parameters failed to reach a significant result.

In endurance-type activities, such as running and cycling, the ergogenic effect of music is maintained throughout high intensities. A plausible mechanism through which music can increase work output is by reducing the rate of perceived exertion (RPE) [13]. Alternatively, the same work is performed with a reduced RPE [20,21]. This is especially the case for low-to-moderate intensities, during which music reduces RPE by approximately 10% [11]. However, at intensities above the anaerobic threshold, music becomes ineffective in lowering RPE [22]. The results of the present study support these findings. As to performance, the findings of this study contradict other data. Neither heart rate nor blood lactate differ and most importantly work output decreased when music was played. Studies which showed an increase in work output used simple motor tasks (*i.e.*, endurance exercise) and often applied music synchronous to movement (cf. [11]). Hence, it is possible that the model is not valid for complex movements when music is not used synchronously.

Karageorghis *et al.* (2010) revealed that during *strength* endurance tasks with increased task complexity (multi-joint exercise with heavier loads, e.g., squats) neither oudeterous nor motivational music altered work output or emotional reaction when both genders were considered together [12]. Besides the above-mentioned study, there have been no other experiments carried out analyzing the effect of music on work output in strength training. Therefore, it is possible that the ergogenic effect of music is limited to endurance exercise. Potential mechanisms for this might include the increased complexity of the chosen motor tasks, *i.e.*, degrees of freedom and/or the increased cognitive demand (e.g., pacing and balancing), during strength *vs.* endurance exercise. Additionally, more demanding neuro-muscular tasks with comparable intensities (heart rates) may require more attention in order to successfully perform a high intensity exercise. Consequently, music may lead to a shift of cognitive resources.

The information processing model postulates that during exercise with higher intensities, internal feedback of exertion predominates perception [23]. This model has been challenged by numerous studies [22,24]. The data from this study, however, does not necessarily support this criticism. We did not find a significant difference between any of the items measuring emotional reaction (*i.e.*, affective valence, arousal, and dominance). Music does not seem to relevantly affect feeling states during prolonged, complex neuro-muscular tasks at high-intensities. Future studies investigating information processing and affective states should take varying intensities as well as the cognitive demands of different exercise modes into account.

Furthermore, no significant difference in perceived pain between the two conditions was observed. Pain perception during exercise accompanied by music has received scarce research attention. However, two studies have shown that traditional RT increased pain thresholds in young, healthy subjects [25,26]. Only one study assessed the effects of RT in combination with music on perceived pain. This study reported no difference between music conditions and reported pain levels [27]. It should be noted, however, that this study was conducted with stroke patients. Consequently, these findings may provide limited relevance for the population studied in this trial.

The fact that participants did not classify the music with respect to its motivational quality constitutes a central limitation to the external validity of this study. However, the music was chosen as it is a typical genre and band played during workouts in CrossFit® Basel. Thereby, the choice of music takes the participants' musical preferences and socio-cultural background into consideration. Moreover, during a typical CrossFit® workout many athletes exercise at the same time and are thus exposed to the same music. Therefore, this trial reflects the real-life situation adequately. However, the results suggest that the presence of this music was disadvantageous. Hence, it is possible that the chosen music might indeed not reflect the preferences of the majority. Practitioners who use music during group training sessions should take this into consideration when composing a playlist.

A further limitation of this study is that participants were not asked whether the music played was distractive or not. As participants in CrossFit® gyms often choose to train with music, the authors deemed it superfluous to control for this variable. In light of these results, however, this seems to be an important factor to consider.

Moreover, the music tempo was inhomogeneous (ranging from 94–141 bpm). The slowest song was played at the end of the workout during the last five minutes. Future investigations should include homogenous music in order to separate effects of tiredness (*i.e.*, pacing), characteristics of the music (e.g., bpm) and music as a source of distraction.

Despite the fact that the CrossFit®-specific aim of this workout is AMRAP in 20 min, it would have been interesting to analyze work output every five minutes. This might enable support or refute the presented hypothesis that music impedes participants from pacing themselves in an optimal way.

Lastly, the small sample size constitutes another limitation.

5. Conclusions

The aim of this study was to analyze whether the use of music can evoke ergogenic effects during a CrossFit® workout. The chosen music corresponded to a selection of typical music played in that gym. The data presented suggests that in a CrossFit® workout that is characterized by complex movements, prolonged duration, and maximal effort, music fails to generate ergogenic effects in terms of RPE, pain, and affective reactions and even reduces work output.

Future research should differentiate the effect music has on motor tasks of varying complexities (*i.e.*, intensity of cognitive strain, endurance *vs.* strength exercise,) and intensities (percentage VO2max and percentage of 1RM). Furthermore, varying exercise intensity should be taken into consideration when investigating information processing styles (*i.e.*, associative *vs.* dissociative) and affective states.

Conflicts of Interest

The authors declare no conflict of interest.

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