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Impact of Music Selection on Motivation and Performance during Cardiopulmonary Exercise Testing

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Abstract: Background: The aim of this study was to examine the effect of applying synchronized music and appropriate music selection on motivation for exercise and achieving better results in individuals of different fitness levels. Methods: The study included a total of 20 female participants, who for certain analyses were divided into two groups with slightly different levels of aerobic fitness: students from the Faculty of Sport and Physical Education (n = 10, age 23.0 ± 2.8), and middle-aged adult women exercising recreationally (n = 10, age 38.3 ± 11.6). Cardiopulmonary exercise testing (CPET) was conducted using a treadmill and gas analysis equipment, and motivational music qualities were assessed using the BMRI-2 questionnaire. The procedure included an initial maximal CPET test, echocardiography, and spirometric tests, followed by an interview to select preferred music tracks. A second CPET test was then performed with the chosen motivational music. The Borg Rating of Perceived Exertion (RPE) scale was used in both tests. Results: The internal consistency of the questionnaire was confirmed with a Cronbach's Alpha of 0.982. The synchronized motivational music significantly improved cardiopulmonary parameters such as peak oxygen consumption (peak VO_2), oxygen consumption (VO_2) at the second ventilatory threshold (VT2), peak heart rate (peak HR), test duration, and reduced perceived exertion (RPE) at the beginning of the test and at the intensity level corresponding to the VT2. Negligible differences were noted between students and recreational athletes, so it can be assumed that music had an equal impact on these two groups of subjects. Conclusions: The study concluded that synchronous motivational music significantly enhances cardiopulmonary performance and reduces perceived fatigue during physical exertion by serving as a key motivational element and facilitating more economical movement.

Keywords: synchronized music; aerobic fitness; peak VO_2; endurance training; exercise performance; perceived fatigue

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Citation: Labudović, D.; Stojiljković, S.; Orlić, A.; Matić, M.; Uzunović, S.; Bubanj, S.; Dobrescu, T.; Macura, M.; Popović, D. Impact of Music Selection on Motivation and Performance during Cardiopulmonary Exercise Testing. *Appl. Sci.* **2024**, *14*, 6751. https://doi.org/10.3390/app14156751

Academic Editors: Elena Amaricai, Roxana Ramona Onofrei, Oana Suciu and Alexandru Florian Crisan

Received: 5 July 2024
Revised: 29 July 2024
Accepted: 31 July 2024
Published: 2 August 2024

1. Introduction

Cardiopulmonary exercise testing (CPET) is the most widely used assessment to examine the dynamic relationship between exercise and integrated physiological systems. The information from CPET can be applied across the spectrum of sport performance, occupational safety screening, research, and clinical diagnostics [1]. Exercise testing in medicine is used to examine the hemodynamic status of an individual, as well as the tolerance to effort, i.e., aerobic capacity, and to diagnose and assess the severity of ischemic heart disease [2]. Aerobic capacity, aerobic endurance, aerobic fitness, or cardiorespiratory endurance are synonyms for the same component of physical fitness [3], which represents the ability of the respiratory and cardiovascular system to deliver oxygen to the muscles and to utilize this oxygen to generate energy during exercises involving large muscles and the entire body at a moderate to high intensity for a prolonged period [4,5].

The best measure, or "gold standard", of aerobic capacity is maximal oxygen consumption (VO_2max), the upper limit of the body's aerobic functioning, the most widely used parameter characterizing the effective integration of the central nervous, cardiopulmonary, and metabolic systems [6]. VO_2max is achieved during large muscle mass exercise and represents the integrative ability of the heart to generate a high cardiac output, total body hemoglobin, high muscle blood flow, and muscle oxygen extraction, and in some cases, the ability of the lungs to oxygenate the blood [7]. Although the difference exists between VO_2max and peak VO_2 and these terms are often used interchangeably in the literature [1], the peak VO_2 attained on a maximum-effort incremental test is likely to be a valid index of VO_2max [6]. Peak VO_2, the highest rate at which an individual can consume oxygen during exercise, was used in this study.

During testing, to measure peak VO_2, a second ventilatory threshold (VT2) was also determined. In a three-zone model of the exercise [8], the training zones (low, medium, and high intensity) are separated by thresholds, which can be either determined through the ventilatory exchange—ventilatory thresholds (VT1, VT2) [9]—or the lactate concentration—lactate thresholds (LT1, LT2) [10]. VT2 was initially determined in order to dose the exercise intensity of cardiac patients [11], but today it is widely used to determine intensity zones in endurance sports. VT2 is a marker of higher exercise intensity, when lactate builds up in the bloodstream faster than the body can remove it, the exerciser breathes very heavily and can no longer speak [12]. VT2 is often called the anaerobic threshold (AnT)—usually estimated to be around 85–90% of the HRmax [13].

In addition to muscle strength, aerobic capacity is one of the most important capacities of an individual from a fitness perspective but also from a medical standpoint, as this parameter is directly related to health and longevity [14]. Promoting health-related fitness—particularly cardiovascular and muscular fitness—are the primary focus of the latest Guidelines of U.S. Department of Health and Human Services. For substantial health benefits, adults should perform at least 150 min to 300 min a week of moderate-intensity—or 75 min to 150 min a week of vigorous-intensity—aerobic physical activity and muscle-strengthening activities of moderate or greater intensity and that involve all major muscle groups on 2 or more days a week [15]. Oxygen consumption increases with aerobic physical activity, which helps in combating chronic non-communicable diseases by preventing them or alleviating symptoms through immune system enhancement [14,16], and subsequently contributes to improving the quality of life in older age by increasing physical and mental well-being [16,17].

Although scientific research demonstrates the positive effects of exercise, the percentage of inactive people worldwide ranges from 20 to 80% [14], with approximately 50% of individuals giving up on exercise [17]. The main reason for quitting sports is lack of motivation [18]. For these reasons, many techniques used to promote physical activity and change exercise-related habits have emerged from psychological theories of motivation and behavior change [19]. From a motivational standpoint, music represents a significant element suitable for combining with physical exercise [20–23], as it stimulates or inspires physical activity [24]. Music has been postulated to influence exercise performance through three main types of mechanisms: psychological (affect, mood, subjective fatigue), psychophysiological (arousal, dissociation, autonomic control), and physiological (VO_2, cardiac output/blood flow, hormonal response, lactate clearance) [25]. Research has shown that music of different styles leads to cardiovascular and respiratory responses in subjects that are associated with the tempo of the music [26].

The conceptual framework for predicting the psychophysical effects of asynchronous music (background music, where there is no attempt by the exerciser to synchronize their movements with the music's tempo or rhythm) in exercise and sports [27,28] provides the starting point for investigating the motivational role of music during exercise, the framework on which this study is based. It answers the question of whether certain melodies, which have a satisfactory motivational score for the participants, lead to better results in physical load testing compared to testing without music at the same level of ability. Within this framework, four factors contributing to the motivational qualities of the musical stimulus were identified: (1) reaction to rhythm, which represents a natural response to musical rhythm and tempo (beats per minute—bpm); (2) musicality, which encompasses harmony (the consonance of tone combinations) and melodic line (theme); (3) cultural influence, which represents the penetration of music in society or a particular subcultural group; and (4) associations relating to non-musical experiences that a particular melody can evoke [24,27–29]. These factors are hierarchical in nature and divided into internal, which relate to how the music is composed (reaction to rhythm and musicality), and external, which are associated with the personal experience of a specific musical piece (cultural influence and associations), with internal factors being much more important in predicting how a person will respond to the musical stimulus [27,28]. Another conceptual framework, derived from the framework for predicting the psychophysical effects of asynchronous music, focuses on the sports context, postulating that the main benefits for an athlete from listening to music will be: (1) increase in positive and decrease in negative mood; (2) arousal control; (3) dissociation from unpleasant sensations such as pain and fatigue; (4) decrease in RPE; (5) increased work output due to synchronization of movement and music tempo; (6) enhanced acquisition of motor skills when rhythm or associations match the required movement patterns; (7) increased likelihood of achieving a state of flow; and (8) increased performance levels [28–30]. Music can be used in various ways during exercise, sports training, and competition: as a stimulant or sedative before performing a task, as asynchronous (background) music, or as synchronous music that is synchronized with movements in physical exercise and sports [28], which is the focus of this study. Synchronous music can be applied in aerobic and anaerobic activities, as well as with all participants, whether competitive athletes or recreational exercisers.

Synchronous music can increase neuromuscular or metabolic efficiency in cyclic activities. Participants performing a submaximal test on a cycle ergometer were able to maintain the prescribed intensity (60% of maximal heart rate) while consuming 7.4% less oxygen when listening to selected synchronous music during the test, compared to the same task while listening to asynchronous music [28], justifying its use for motivational purposes. The greatest effect is certainly exerted by melodies that meet the exercisers' needs in terms of internal and external characteristics of music. Music should be selected according to specific criteria if we want it to provide a source of motivation during physical activity. Motivational music has a fast tempo (>120 beats/min) and a strong rhythm to generate energy and cause bodily action [27,31]. In order to select exercise music with satisfactory motivational qualities, it was necessary to construct an instrument for selecting musical tracks. For this purpose, the Brunel Music Rating Inventory—BMRI for music exercise experts [27] and the Brunel Music Rating Inventory–2 (BMRI-2) adapted for all levels of trainers and exercisers [24] were constructed, and the validity and reliability of the instrument were tested and confirmed. This questionnaire, as an instrument, can provide more precise information about the motivational qualities of music applied as asynchronous or synchronous music during exercise of all intensities. Its application can be in two directions—before training so that the exerciser can choose the musical tracks that motivate him or after exercise in order to evaluate the motivational qualities of the music chosen by the coach. Some results suggest that females may respond more positively than males to exercise-induced fatigue while listening to self-selected music during repeated bouts of high-intensity exercise [32].

The subject of this study was to examine the effect of applying synchronized music and appropriate music selection on motivation for exercise and achieving better results in females.

The main aim of this study was to examine the response of cardiorespiratory parameters as well as RPE during CPET in 20 female participants, in two different testing conditions: without music and with the use of selected synchronized music. An additional purpose was to assess the significance of differences in responses between two groups of participants with slightly different levels of aerobic fitness and age.

We hypothesized that: H1: the BMRI-2 scale is reliable; H2: music will affect the values of cardiorespiratory parameters during the load test; H3: greater effect of music on cardiorespiratory parameters during the CPET will be shown in recreational athletes compared to students; H4: RPE will show a lower value in the music testing condition than in the non-music condition.

2. Materials and Methods

2.1. Subjects

A total of 20 female participants, who for certain analyzes were divided into two groups with slightly different levels of aerobic fitness, participated in this study. The first group consisted of students from the University of Belgrade—Faculty of Sport and Physical Education, majoring in recreation (n = 10; age 23.0 ± 2.8; body height 169.7 ± 5.0 cm; body weight 63.7 ± 5.9 kg; body mass index 22.1 ± 1.4 kg/m^2). The second group consisted of middle-aged adult women (n = 10; age 38.3 ± 11.6; body height 168.5 ± 5.1 cm; body weight 67.5 ± 9.5 kg; body mass index 23.8 ± 3.1 kg/m^2), whose exercise frequency was at a recreational level, not more than 2 to 3 times a week. To be included in the study, participants had to be healthy and free of musculoskeletal injuries or other conditions that could hinder their participation. All participants were informed of the study procedures, benefits, and potential risks and provided written informed consent.

2.2. Procedure

The study was approved by the Ethical Committee of the University of Belgrade—Faculty of Sport and Physical Education (approval number 02-1986/21-2). All procedures were conducted following the standards established by the Declaration of Helsinki and its later amendments. The study was conducted in three phases from June to August 2021.

In Phase I, the participants performed an initial CPET according to the ramp protocol with a constant increase in load until reaching the peak respiratory exchange ratio (peak RER) ≥ 1.1 and peak heart rate (peak HR) at a value ≥ 90% of the theoretical maximum HR, according to current guidelines [33,34]. Participants were advised not to exercise at least 48 h before the test and to eat only a light breakfast and not to consume caffeine at least 2 h before testing. CPET was performed in the morning under controlled conditions (temperature and humidity in the room) for all subjects. Test was performed on an h.p. Cosmos treadmill, while gas analysis was measured using the "breath by breath" method on a Cardiovit CS 200 ergospirometer (Schiller, Baar, Switzerland) and printed at 10 s intervals. Before the first testing, echocardiography was performed, while spirometric tests were performed before the start of both CPET. Numerous cardiopulmonary variables were measured by testing, and among the most important were peak VO_2 and VO_2 at VT2. VO_2max represented the mean of peak VO_2 (mL/kg/min) and was calculated using the highest VO_2 measurement average in 30 s [35]. The VT2 was determined, using the ventilation/carbon dioxide production (VE/VCO_2) plot at the point where VE increases out of proportion to the VCO_2 [10].

During the CPET, the Borg's Rating of Perceived Exertion (RPE) Scale$_{6\text{-}20}$ was used to assess the level of perceived exertion [36,37]. Before the test, the subjects were familiarized with the Borg's scale. The verbal descriptions of the numbers (from 6 to 20) on the exertion scale were translated from English to Serbian by a certified expert. Before the test, during the test (in the second half of every even minute), and at the end of the test, the subject indicated with his index finger on a large board (held near the subject by one of the researchers), the number that best corresponds to the current subjective feeling of exertion. After that, the researcher would repeat out loud the number that the subject showed, the subject would nod his head affirmatively, and only then would that number be entered into the corresponding field in relation to the elapsed time of the test. Later, gas analysis determined when the subject reached the VT2 and what was her subjective assessment of effort at that intensity. A short interview was conducted with each subject after the test, with questions regarding their overall impression of the test. The main purpose of the interview was for the researchers to make sure that everything was fine with the subject after the test.

In Phase II, an interview was conducted with the participants regarding their favorite music, including questions such as (1) what type of music they like to listen to, (2) which music genre they prefer, and (3) who their favorite band/artist is, and then they were asked to send several faster tempo songs that they would like to listen to while walking on the treadmill, meaning songs that would make them want to exercise longer and harder. Based on the responses, a list of music tracks was created specifically for each participant, where each track had to have a tempo > 120 beats per minute (120 bpm). Afterwards, all participants were asked to complete the BMRI-2 questionnaire for each song from their list. The BMRI-2 questionnaire, constructed by Karageorghis et al. [24], was used to examine the motivational qualities of music. For the purposes of this study, the BMRI-2 questionnaire was translated and adapted to the musical terminology in the Serbian language. The questionnaire consists of six statements that examine the motivational qualities of music related to rhythm, melody, and harmony and is constructed on seven levels of assessment, from 1 (strongly disagree) to 7 (strongly agree) (Table 1). The total score for each song ranges from 6 to 42, representing the motivation score (MS) for the applied music. Based on this score, Karageorghis [28] stratifies the musical stimulus into highly motivational (score 36–42), moderately motivational (score 24–35), and neutral (score $\leq$ 24). For each subject separately, the songs with the highest motivation scores were selected for the final playlist for the second CPET. The mean motivation score of all songs on the playlists of all participants was 39 $\pm$ 2, which belongs to the category highly motivational music, according to Karageorghis [28]. The playlist was formed from the slowest to the fastest tempo and according to the increasing motivation score, if that was possible.

Table 1. BMRI-2 questionnaire [24].

		Strongly Disagree			**In-Between**			**Strongly Agree**
1	The rhythm of this music would motivate me during exercise	1	2	3	4	5	6	7
2	The style of this music (i.e., rock, dance, jazz, hip-hop, etc.) would motivate me during exercise	1	2	3	4	5	6	7
3	The melody (tune) of this music would motivate me during exercise	1	2	3	4	5	6	7
4	The tempo (speed) of this music would motivate me during exercise	1	2	3	4	5	6	7
5	The sound of the instruments used (i.e., guitar, synthesizer, saxophone, etc.) would motivate me during exercise	1	2	3	4	5	6	7
6	The beat of this music would motivate me during exercise	1	2	3	4	5	6	7

In Phase III, the participants performed the same CPET again, but this time with the selected motivational music. During testing, they listened to their own playlist of motivational songs using headphones. In all other details, the procedure and test conditions was identical to the first test. The interval between tests was at least 48 h, and participants were advised not to exercise between tests.

2.3. Variables

The dependent variables in this study were: peak oxygen consumption—peak VO_2 (mL/kg/min), percentage of predicted peak oxygen consumption—pred. peak VO_2 (%), oxygen consumption at second ventilatory threshold—VO_2 at VT2 (mL/kg/min), ventilatory efficiency during exercise i.e., the slope of the minute ventilation and carbon dioxide production curve—VE/VCO_2 slope, ventilatory equivalent for oxygen—peak VE/VO_2, end-tidal carbon dioxide pressure at rest—$PETCO_2$ (mmHg), increase in end-tidal carbon dioxide pressure during exercise—$\Delta PETCO_2$ (mmHg), peak heart rate during exercise—HR peak (bpm), percentage of predicted maximum heart rate—pred. HR max (%), resting systolic blood pressure—SBP rest (mmHg), resting diastolic blood pressure—DBP rest (mmHg), peak systolic blood pressure during exercise—peak SBP (mmHg), peak diastolic blood pressure during exercise—peak DBP (mmHg), test duration (s), rating of perceived exertion at three time points, at the beginning, at VT2, and at the end of the test—RPE start, RPE VT2, peak RPE. Peak VO_2 were expressed as the highest 10 s average sample obtained during the last 20 s of the test. The VE/VCO_2 slope was calculated using tabular calculation (Microsoft Excel version 2023, Microsoft Corp., Bellevue, WA, USA) with the help of least squares linear regression (y = mx + b, m = slope).

From anthropometric variables, body height—BH (cm), body weight—BW (kg) and body mass index—BMI (kg/m^2) were used for testing. The independent variable was the motivation score of the music tracks—MS.

2.4. Statistical Data Analysis

SPSS software (SPSS version 25.0, SPSS Inc., Chicago, IL, USA) was used for statistical analysis. Descriptive statistics were performed for all variables, as well as testing the normality of distribution using the Kolmogorov-Smirnov test. The reliability of the scale was tested using Cronbach's alpha test. Differences between the test without music and with music were measured using the paired samples *t*-test, while testing between the two groups was conducted using the independent samples *t*-test. Variables that did not have a normal distribution were tested using the non-parametric Wilcoxon signed-rank test. A p value at the level of 0.05 was considered significant.

3. Results

At the beginning of the analysis, a measure of internal consistency was performed to check the compatibility of questions in the questionnaire for the given sample. Cronbach's Alpha has a value of 0.982 (Table 2), indicating excellent internal consistency of the scale. Thus, H1 is accepted: the BMRI-2 scale is very reliable.

Table 2. Reliability statistics.

Cronbach's Alpha	Number of Cases
0.982	4

The average values for relevant cardiopulmonary variables, measured during testing without and with music, are summarized in Figure 1, with only variables that showed a significant difference in the two conditions being shown. There were no differences for other measured variables.

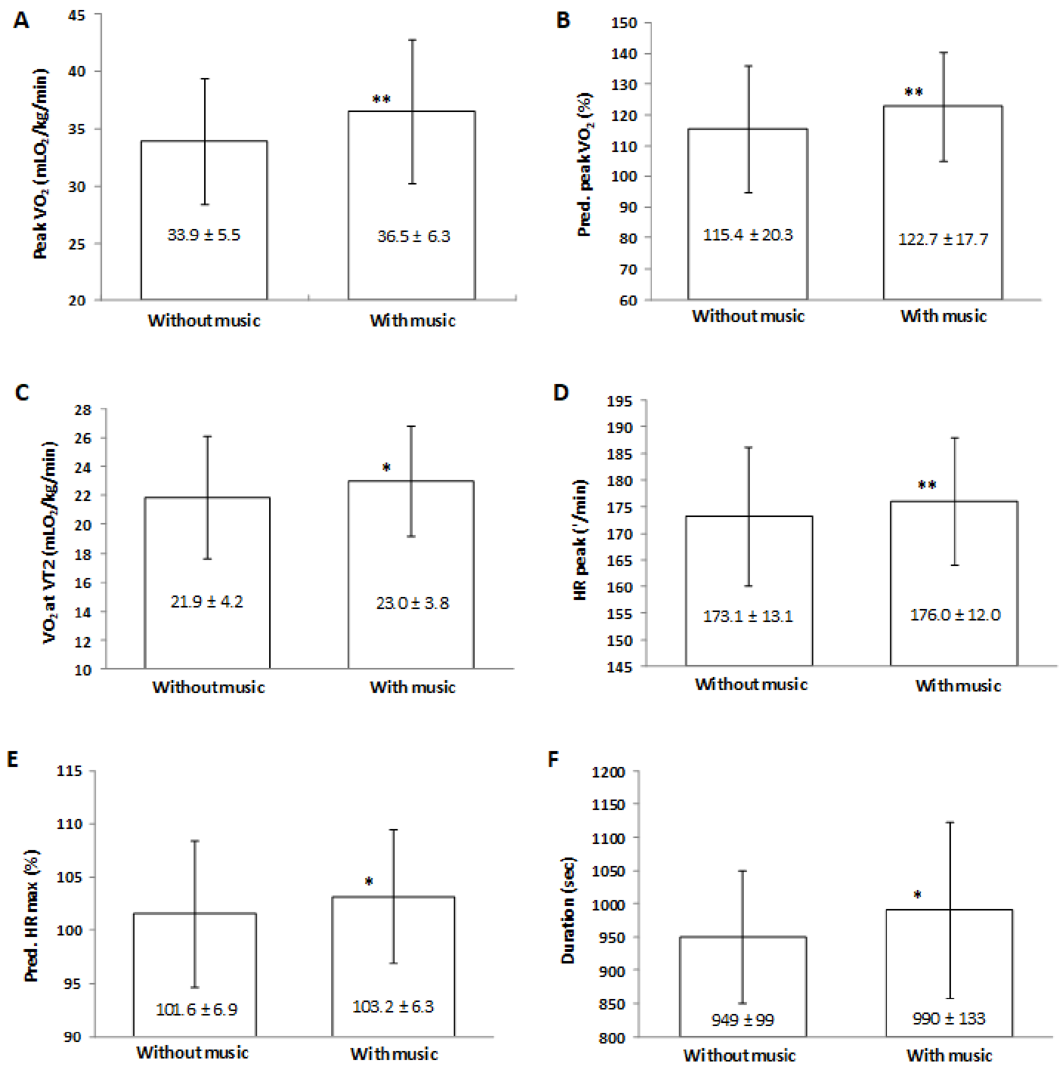

Figure 1. Cardiorespiratory parameters and test duration of CPET without music and while listening to synchronized motivational music. (**A**) Peak oxygen consumption (Peak VO_2), (**B**) predicted peak oxygen consumption (Pred. peak VO_2), (**C**) oxygen consumption at second ventilatory threshold (VO_2 at VT2), (**D**) peak heart rate during exercise (HR peak), (**E**) predicted maximum heart rate (Pred. HR max), (**F**) test duration (Duration). Whiskers extend between ± one standard deviation. * $p < 0.05$; ** $p < 0.01$, significantly different from without music.

To test H2, a paired samples *t*-test (dependent *t*-test) was used when researchers tested the same group of subjects twice [38]. According to the data obtained from all participants (n = 20), we can state that there are statistically significant differences between the mean values for the following tested variables in conditions without music and with motivational music: Peak VO_2 ($p = 0.005$), Pred. peak VO_2 ($p = 0.007$), VO_2 at VT2 ($p = 0.041$), Peak HR ($p = 0.006$), Pred. HR max ($p = 0.015$), and test duration ($p = 0.019$). Out of the 14 observed variables, 6 showed significant differences between testing without music and with music, i.e., music significantly influenced the values of 6 cardiopulmonary parameters during the exercise test, while in 8 cases, it did not. Therefore, H2 (music will affect the values of cardiorespiratory parameters during the load test) is rejected as a whole, but the important fact remains that music had a positive effect on a large number of observed variables.

The average values for the relevant variables in the two groups of subjects, measured during testing without and with music, are summarized in Figure 2. Only variables that showed a significant difference between the two groups of subjects are shown. There were no differences between the groups for other measured variables.

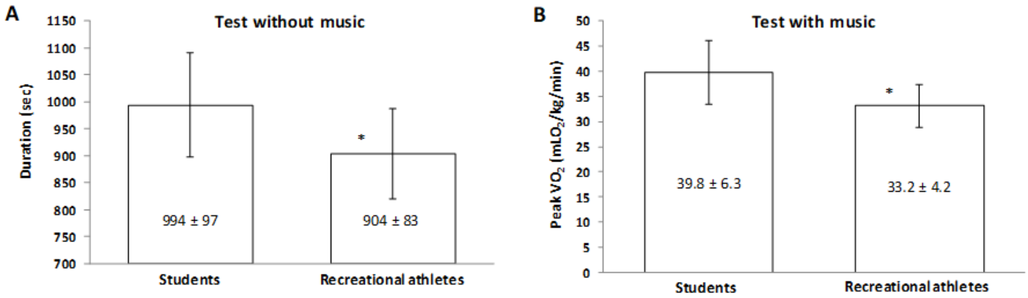

Figure 2. Differences between the group of students and the group of recreational athletes when tested without music and while listening to synchronized motivational music. (**A**) Test duration (Duration) without music, (**B**) peak oxygen consumption (Peak VO_2) with music. Whiskers extend between ± one standard deviation. * $p < 0.05$, significantly different from the group of students.

To test the differences between the two groups of subjects in H3, the independent t test was applied, which is used to compare means between two different samples [38]. The only parameter by which the two groups of subjects differed when tested without music was the duration of the test (Figure 2A)—the test lasted significantly longer ($p = 0.039$) in the group of students compared to the recreational athletes.

The only parameter by which the two groups of subjects differed when tested while listening to synchronized motivational music was the peak VO_2 (Figure 2B): peak VO_2 was significantly higher ($p = 0.013$) in the group of students compared to recreational athletes.

The results showed statistically significant differences in the effect of music between students and recreational athletes only in two of 14 observed variables: duration of the test (slightly greater positive effect in the group of recreational athletes) and peak VO_2 (slightly greater positive effect in the group of students). Thus, H3 (greater effect of music will be shown in recreational athletes compared to students) is rejected.

The average values for RPE at three time points during CPET without music and while listening to synchronized motivational music are summarized in Figure 3.

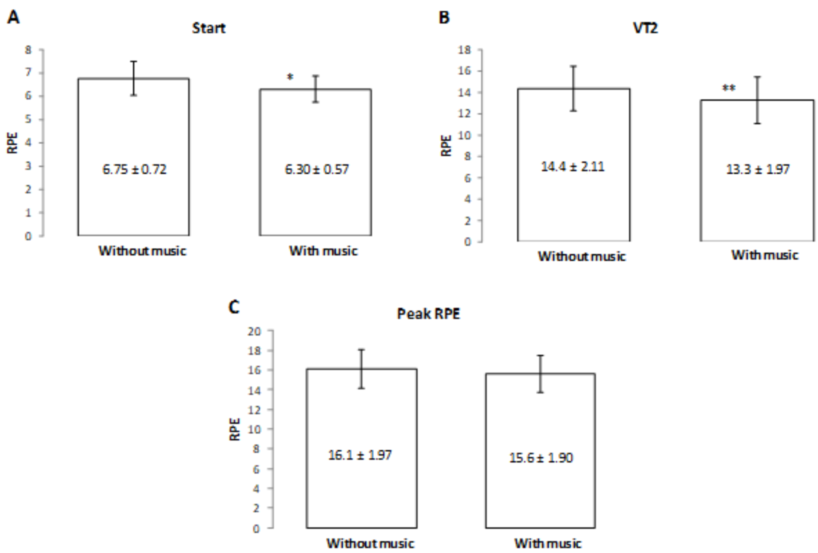

Figure 3. RPE at three time points during CPET without music and while listening to synchronized motivational music. (**A**) RPE at the start of CPET, (**B**) RPE at VT2, (**C**) Peak RPE. * $p < 0.05$; ** $p < 0.01$, significantly different from without music.

The Wilcoxon signed ranks test for nonparametric data was applied to test the differences in perceived exertion, in testing without music and with music at three time points, and the results are shown in Table 3.

Table 3. Comparison of perceived exertion results at three time points during testing.

	RPE Start wm—RPE Start m	RPE at VT2 wm—RPE at VT2 m	Peak RPE wm—Peak RPE m
Z	−2.310	−3.660	−1.664
p	0.021	<0.001	0.096

Legend: Variables: RPE start wm—perceived exertion at the beginning of the test without music; RPE start m—perceived exertion at the beginning of the test with music; RPE at VT2 wm—perceived exertion at the VT2 in the test without music; RPE at VT2 m—perceived exertion at the VT2 in the test with music; Peak RPE wm—perceived exertion at the end of the test without music; Peak RPE m—perceived exertion at the end of the test with music.

Analysis of perceived exertion results for all participants (n = 20) showed significance in two time points: at the beginning of the test ($p = 0.021$) and at the VT2 ($p < 0.001$). Perceived exertion is significantly lower when testing with music at two time points: at the beginning of the test (6.3 and 6.8, respectively) and at the intensity level corresponding to the VT2 (13.3 and 14.4, respectively). Thus, H4 (RPE will show a lower value in the music testing condition than in the non-music condition) is partially accepted.

4. Discussion

The study examined the effect of synchronized music as a motivational tool on the results of a CPET in female participants. The assumption was that motivational music would affect changes in cardiopulmonary variables, as well as perceived exertion during maximal exercise testing. In this study, the BMRI-2 scale (Table 1) was used for the first time to determine the motivational characteristics of music in Serbia. Consistent with previous research [30], the scale showed excellent internal consistency (Table 2), making BMRI-2 a valid and consistent tool for selecting music to accompany exercise or training and allowing researchers to standardize music in experimental protocols involving exercise-related tasks [24]. It was also confirmed that music with a tempo > 120 bpm has a pronounced motivational quality, as evidenced by the mean motivation score of all songs on the playlists of all participants (MS = 39 ± 2), which belongs to the category of highly motivational music, according to Karageorghis [28]. These finding is in line with research on the motivational qualities of music for submaximal aerobic exercise in different groups of participants [27] and the claim that motivational music has a fast tempo and strong rhythm to generate energy and induce physical action [31].

Testing the influence of music on cardiopulmonary parameters showed a significant impact on VO_2-related parameters, as expected. Specifically, testing with music compared to testing without music resulted in significantly higher values of peak VO_2, predicted peak VO_2, VO_2 at VT2, peak HR, predicted peak HR, and test duration (Figure 1). Our results are consistent with a study conducted by Vasić et al. [39], which tested the effect of selected music at two levels of exertion in medical school students, showing a significant increase in VO_2max but also a decrease in blood pressure at 90% of VO_2max ($p < 0.05$). Additionally, research on the psychophysical and ergogenic effects of synchronous music during treadmill walking has shown that peak HR remains approximately the same in testing under all three conditions (without music, with neutral, and with motivational music) until very close to physical exhaustion [40]. On the other hand, in a study conducted by Copeland and Franks [41], investigating the effects of different types of music on HR, RPE, and time to exhaustion during treadmill work in three different treatments, the results showed that peak HR and HR in the minute preceding the maximum were higher in testing with soft, slow, and popular music (approximately 100 bpm) than in conditions without music. In a study examining the effects of using motivational music with a video recording on participants, the results showed a significant increase in HR and accumulated lactate during the motivational intervention compared to non-motivational and control conditions [42] as well as an increase in ergogenic effects when using motivational music compared to neutral and control conditions [40].

The comparison between the two groups of participants within the third hypothesis showed that there are significant differences in only two variables (Figure 2). Duration of the test was significantly higher in students than in recreational athletes when tested without music. Considering that there was no difference in the duration of the test between groups when testing while listening to synchronized motivational music, it could be assumed that music had a slightly greater positive effect on duration of the test in the group of recreational athletes. Peak VO_2 was significantly higher in students than in recreational athletes when tested while listening to synchronized motivational music. Considering that there was no difference in peak VO_2 between groups during the test without music, it could be assumed that music had a greater positive effect on peak VO_2 in the group of students. The above two results are contradictory, so it is difficult to explain them. We can assume that music did not have a different effect on the two groups of participants, especially in light of the fact that these are the only two variables in which the two groups of participants differ (out of a total of 28 variables: 14 when tested without music and 14 with music). Thus H3 (greater effect of music will be shown in recreational athletes compared to students) is rejected. Unfortunately, as far as we know, there are no studies that compared groups of subjects similar to this, so we do not have data with which we could compare the results of this study.

RPE testing showed that participants felt significantly less exertion when testing with music at the beginning of the test and especially at the VT2 (Figure 3A,B and Table 3). At the end of the test, at maximum exertion, RPE still had a lower value when testing with music than without (Figure 3C), but statistical significance was not reached. A short interview was conducted with each subject after both tests, with questions regarding their overall impression of the test. Participants reported feeling more pleasant, that time passed more quickly, and that the testing was easier with music. It can be concluded that as the load and fatigue increased, so did the perceived exertion, but participants felt the increase in exertion less and tolerated it more easily under conditions of testing with music. Previous research findings show varying results in subjective exertion. In some studies, RPE remained unchanged in all testing conditions [40,42,43], while in others, it was lower in conditions of exercise with applying motivational music and even in conditions of neutral music [44].

Significantly longer test duration was recorded under motivational music conditions (Figure 1F). Considering test duration as an indirect indicator of fatigue, we can conclude that participants fatigued more slowly and showed greater endurance under conditions of testing with motivational music. The obtained results are consistent with the results of previous research. In the aforementioned studies, the results showed that testing lasted longer, and participants covered a greater distance in motivational conditions compared to non-motivational and control conditions [40,42,44]. Additionally, studies that tested walking speed as a measure of endurance for a certain time or distance showed that participants moved significantly faster when exposed to any music condition compared to the control intervention, with musical conditions also being associated with a higher state of motivation, i.e., they swam faster [45] and cycled 10 km faster with music, even while anticipating its playback [43].

As the cardiopulmonary exercise test represents a certain stress for the organism and leads to changes in the levels of stress hormones [46], in future research, it would be significant to see if there is a difference in the levels of these hormones under conditions of testing with and without music, precisely because of the different processes, physiological and psychological, that occur in the body, both during exertion and while listening to music. Additionally, there are individual differences in the desired intensity of music and the use of music during the test at certain time points, especially at the anaerobic threshold [47], which could be taken into account in research to tailor the music intensity to create ideal conditions for each participant.

There are also certain limitations in this study. The main limitation is the lack of additional information on other factors that could affect the results, such as days in the menstrual cycle, as well as the hormonal status itself, that can additionally affect the test results in females, which we could not take into account in choosing the test day. The next limitation to the generalizability of this study results is the fact that only healthy females were included in the study. Different results would be obtained if the research included males or participants with health problems, especially cardiorespiratory ones. Another limitation may be the sample size, as generalization would be better with a larger sample. However, studies similar to this one have often been conducted with a similar or even smaller sample of participants [30,39,42–44].

5. Conclusions

This research confirmed the high internal consistency of the BMRI-2 questionnaire for determining the motivational qualities of music, and the validity of its use in this study, as we hypothesized in H1. Adequate selection of motivational music provided the opportunity to investigate its influence on cardiopulmonary parameters during physical exertion. The results of research within H2 on the entire sample showed a significant increase in oxygen consumption and heart rate at maximum exertion as well as in test duration under the conditions of application of motivational music compared to testing without music. Although H2 was not fully confirmed due to the lack of significance in all examined variables, the fact is that there was a significant increase in important cardiopulmonary parameters and test duration while listening to music. Music had a similar positive effect on both groups of participants, so H3 was rejected. The results in supports of H4 on the entire sample showed a decrease in fatigue perception during testing with music in two of the three examined time points, at the beginning of the test and at the VT2, which partially confirmed the hypothesis. Participants reported feeling more pleasant, time passed more quickly, and the testing was easier with music.

We can conclude that music represents a significant element of motivation and that in aerobic exercise conditions, it affects multiple aspects of the results. Its impact is in reducing tension and fatigue and increasing mood. On the other hand, synchronizing movement with the tempo of the melody allows for a constant frequency of movement and more economical movement of the exerciser.

Author Contributions: Conceptualization, D.L., S.S., A.O., M.M. (Milan Matić) and D.P.; methodology, D.L., S.S., A.O., M.M. (Milan Matić), S.U., M.M. (Marija Macura) and D.P.; software, D.L., S.S., A.O., S.B. and D.P.; validation, D.L., A.O., M.M. (Milan Matić), M.M. (Marija Macura) and D.P.; formal analysis, D.L., S.S., A.O., S.B., M.M. (Marija Macura) and D.P.; investigation, D.L., S.S., A.O., S.U., M.M. (Marija Macura) and D.P.; resources, D.L., S.S., A.O., M.M. (Milan Matić), S.U., M.M. (Marija Macura) and D.P.; data curation, D.L.; S.S., S.B. and D.P.; writing—original draft preparation, D.L., S.S., A.O., M.M. (Milan Matić), S.U., M.M. (Marija Macura) and D.P.; writing—review and editing, D.L., S.S., S.B., T.D. and D.P.; visualization, S.S., S.B., T.D. and D.P.; supervision, A.O., M.M. (Milan Matić), S.U., S.B., T.D., M.M. (Marija Macura) and D.P.; project administration, D.L., M.M. (Marija Macura) and D.P.; funding acquisition, D.L., M.M. (Milan Matić), S.B., T.D., M.M. (Marija Macura) and D.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of the University of Belgrade—Faculty of Sport and Physical Education (approval number 02-1986/21-2).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Beltz, N.M.; Gibson, A.L.; Janot, J.M.; Kravitz, L.; Mermier, C.M.; Dalleck, L.C. Graded Exercise Testing Protocols for the Determination of VO_2max: Historical Perspectives, Progress, and Future Considerations. *J. Sports Med.* **2016**, *2016*, 3968393. [CrossRef] [PubMed]
2. Nedeljković, I.; Mazić, S.; Žugić, V.; Giga, V.; Dekleva, M.; Popović, D.; Stepanović, J.; Đorđević Dikić, A.; Banović, M.; Beleslin, B. Klinička primena kardiopulmonalnog testa fizičkim opterećenjem u savremenoj kardiologiji i posebnim grupama bolesnika. *Srce Krvni Sudov.* **2012**, *31*, 166–173. [CrossRef]
3. IOM (Institute of Medicine). *Fitness Measures and Health Outcomes in Youth*; The National Academies Press: Washington, DC, USA, 2012.
4. Saltin, B. Oxygen transport by the circulatory system during exercise in man. In *Limiting Factors of Physical Performance*; Keul, J., Ed.; Thieme Publishers: Stuttgart, Germany, 1973; pp. 235–252.
5. Armstrong, N.; Welsman, J.R. Aerobic fitness: What are we measuring? *Med. Sport Sci.* **2007**, *50*, 5–25. [CrossRef] [PubMed]
6. Day, J.R.; Rossiter, H.B.; Coats, E.M.; Skasick, A.; Whipp, B.J. The maximally attainable VO_2 during exercise in humans: The peak vs. maximum issue. *J. Appl. Physiol.* **2003**, *95*, 1901–1907. [CrossRef] [PubMed]
7. Bassett, D.R., Jr.; Howley, E.T. Limiting factors for maximum Oxygen consumption and determinants of endurance performance. *Med. Sci. Sports Exerc.* **2000**, *32*, 70–84. [CrossRef] [PubMed]
8. Stöggl, T.L.; Sperlich, B. Editorial: Training intensity, volume and recovery distribution among elite and recreational endurance athletes. *Front. Physiol.* **2019**, *10*, 592. [CrossRef] [PubMed]
9. Beaver, W.L.; Wasserman, K.; Whipp, B.J. A new method for detecting anaerobic threshold by gas exchange. *J. Appl. Physiol.* **1986**, *60*, 2020–2027. [CrossRef] [PubMed]
10. Binder, R.K.; Wonisch, M.; Corra, U.; Cohen-Solal, A.; Vanhees, L.; Saner, H.; Schmid, J.P. Methodological approach to the first and second lactate threshold in incremental cardiopulmonary exercise testing. *Eur. J. Cardiovasc. Prev. Rehabil.* **2008**, *15*, 726–734. [CrossRef] [PubMed]
11. Wasserman, K.; McIlroy, M.B. Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. *Am. J. Cardiol.* **1964**, *14*, 844–852. [CrossRef]
12. Stojiljković, S.; Gavrilović, L.; Pejić, S.; Pajović, S.B.; Macura, M.; Nikolić, D.; Bubanj, S.; Stojiljković, V. Effects of Endurance Training on Antioxidant and Hormonal Status in Peripheral Blood of Young Healthy Men. *Life* **2024**, *14*, 921. [CrossRef]
13. Kanniainen, M.; Pukkila, T.; Kuisma, J.; Molkkari, M.; Lajunen, K.; Räsänen, E. Estimation of physiological exercise thresholds based on dynamical correlation properties of heart rate variability. *Front. Physiol.* **2023**, *14*, 1299104. [CrossRef] [PubMed]
14. Hardman, A.E.; Stensel, D.J. *Physical Activity and Health: The Evidence Explained*, 2nd ed.; Routledge: London, UK; Taylor & Francis e-Library: Abingdon, UK, 2009.
15. U.S. Department of Health and Human Services. *Physical Activity Guidelines for Americans*, 2nd ed.; U.S. Department of Health and Human Services: Washington, DC, USA, 2018.
16. Mack, D.E.; Wilson, P.M.; Gunnell, K.E. Moving Physical Activity Research: From Quality of Life to Positive Psychological Functioning in Individuals Living with Osteoporosis. In *Handbook of Leisure, Physical Activity, Sports, Recreation and Quality of Life*; Rodriguez de la Vega, L., Toscano, W., Eds.; Universidad de Palermo: Buenos Aires, Argentina, 2018; pp. 391–406.
17. Weinberg, R.S.; Gould, D. *Foundations of Sport and Exercise Psychology*, 5th ed.; Human Kinetics: Champaign, IL, USA, 2011; pp. 397–414.
18. Trbojević, J.; Petrović, J. Effects of motivational climate on the development of amotivation for sport in young handball players. *Teme* **2017**, *41*, 211–226. [CrossRef]
19. Marcus, B.H.; Forsyth, L.H. *Motivating People to Be Physically Active*; Human Kinetics: Champaign, IL, USA, 2003.
20. Spildooren, J.; Speetjens, I.; Abrahams, J.; Feys, P.; Timmermans, A. A physical exercise program using music-supported video-based training in older adults in nursing homes suffering from dementia: A feasibility study. *Aging Clin.Exp. Res.* **2019**, *31*, 279–285. [CrossRef] [PubMed]
21. Van de Winckel, A.; Feys, H.; De Weerdt, W.; Dom, R. Cognitive and behavioural effects of music-based exercises in patients with dementia. *Clin. Rehabil.* **2004**, *18*, 253–260. [CrossRef] [PubMed]
22. Ballmann, C.G. The influence of music preference on exercise responses and performance: A review. *J. Funct. Morphol. Kinesiol.* **2021**, *6*, 33. [CrossRef] [PubMed]
23. Karatrantou, K.; Papavasiliou, T.; Batatolis, C.; Vasilopoulou, T.; Ioakimidis, P.; Gerodimos, V. A chair-based music–kinetic combined exercise program as an alternative approach for increasing health, functional capacity, and physical fitness indices in middle-aged pre-menopausal women. *J. Funct. Morphol. Kinesiol.* **2023**, *8*, 81. [CrossRef] [PubMed]
24. Karageorghis, C.I.; Priest, D.-L.; Chatzisarantis, N.D.; Terry, P.C.; Lane, A.M. Redesign and initial validation of an instrument to assess the motivational qualities of music in exercise: The Brunel Music Rating Inventory-2. *J. Sports Sci.* **2006**, *24*, 899–909. [CrossRef]
25. Terry, P.C.; Karageorghis, C.I.; Curran, M.L.; Martin, O.V.; Parsons-Smith, R.L. Effects of music in exercise and sport: A meta-analytic review. *Psychol. Bull.* **2020**, *146*, 91. [CrossRef] [PubMed]
26. Trappe, H.J. The effects of music on the cardiovascular system and cardiovascular health. *Heart* **2010**, *96*, 1868–1871. [CrossRef]
27. Karageorghis, C.I.; Terry, P.C.; Lane, A.M. Development and initial validation of an instrument to assess the motivational qualities of music in exercise and sport: The Brunel Music Rating Inventory. *J. Sports Sci.* **1999**, *17*, 713–724. [CrossRef]

28. Karageorghis, C.I. The scientific application of music in sport and exercise. In *Sport and Exercise Psychology: Topics in Applied Psychology*; Lane, A.M., Ed.; Hodder Education: London, UK, 2008; pp. 109–138.
29. Terry, P.C.; Karageorghis, C.I. Psychophysical effects of music in sport and exercise: An update on theory, research and application. In *Proceedings Psychology Bridging the Tasman: Science, Culture and Practice of the Joint Conference of the Australian Psychological Society and the New Zealand Psychological Society*; Katsikitis, M., Ed.; Australian Psychological Society: Melbourne, VIC, Australia, 2006; pp. 415–419.
30. Clark, I.N.; Baker, F.A.; Peiris, C.S.; Shoebridge, G.; Taylor, N.F. The Brunel Music Rating Inventory-2 is a reliable and valid instrument for older cardiac rehabilitation patients selecting music for exercise. *Psychol. Music* **2015**, *44*, 249–262. [CrossRef]
31. Gaston, E.T. Dynamic music factors in mood change. *Music Educ. J.* **1951**, *37*, 42–44. [CrossRef]
32. Rhoads, K.J.; Sosa, S.R.; Rogers, R.R.; Kopec, T.J.; Ballmann, C.G. Sex differences in response to listening to self-selected music during repeated high-intensity sprint exercise. *Sexes* **2021**, *2*, 60–68. [CrossRef]
33. Guazzi, M.; Volker, A.; Conraads, V.; Halle, M.; Mezzani, A.; Vanhees, L.; Arena, R.; Fletcher, G.F.; Forman, D.E.; Kitzman, D.W.; et al. Clinical recommendations for cardiopulmonary exercise testing data assessment in specific patient populations. *Circulation* **2012**, *126*, 2261–2274. [CrossRef]
34. Anselmi, F.; Cavigli, L.; Pagliaro, A.; Valente, S.; Valentini, F.; Cameli, M.; Focardi, M.; Mochi, N.; Dendale, P.; Hansen, D.; et al. The importance of ventilatory thresholds to define aerobic exercise intensity in cardiac patients and healthy subjects. *Scand. J. Med. Sci. Sports* **2021**, *31*, 1796–1808. [CrossRef]
35. Astorino, T.A.; Willey, J.; Kinnahan, J.; Larsson, S.M.; Welch, H.; Dalleck, L.C. Elucidating determinants of the plateau in oxygen consumption at VO_2max. *Br. J. Sports Med.* **2005**, *39*, 655–660; discussion 660. [CrossRef] [PubMed]
36. Borg, G.A. Psychophysical bases of perceived exertion. *Med. Sci. Sports Exerc.* **1982**, *14*, 377–381. [CrossRef] [PubMed]
37. Borg, G. *Borg's Perceived Exertion and Pain Scales*; Human Kinetics: Champaign, IL, USA, 1998.
38. William, J.V.; Weir, J.P. *Statistics in Kinesiology*, 4th ed.; Human Kinetics: Champaign, IL, USA, 2012.
39. Vasić, T.; Topalović, N.; Đurić, B.; Mazić, S. The influence of music on cardiopulmonary parameters during a different intensity of physical exercise in the population of students. *Med. Glas. Spec. Boln. Za Boles. Štitaste Žlezde I Boles. Metab. Zlatibor* **2020**, *25*, 37–53. [CrossRef]
40. Karageorghis, C.I.; Mouzourides, D.A.; Priest, D.L.; Sasso, T.A.; Morrish, D.J.; Walley, C.J. Psychophysical and ergogenic effects of synchronous music during treadmill walking. *J. Sport Exerc. Psychol.* **2009**, *31*, 18–36. [CrossRef]
41. Copeland, B.L.; Franks, D.D. Effects of types and intensities of background music on treadmill endurance. *J. Sports Med. Phys. Fit.* **1991**, *15*, 100–103. [CrossRef]
42. Barwood, M.J.; Weston, N.J.V.; Thelwell, R.; Page, J. A motivational music and video intervention improves high-intensity exercise performance. *J. Sports Sci. Med.* **2009**, *8*, 435–442. [PubMed]
43. Lim, H.B.; Atkinson, G.; Karageorghis, C.I.; Eubank, M.R. Effects of differentiated music on cycling time trial. *Int. J. Sports Med.* **2009**, *30*, 435–442. [CrossRef] [PubMed]
44. Terry, P.C.; Karageorghis, C.I.; Mecozzi Saha, A.M.; D'Auria, S. Effects of synchronious music on treadmill running among elite triathletes. *J. Sci. Med. Sport* **2012**, *15*, 52–57. [CrossRef] [PubMed]
45. Karageorghis, C.I.; Hutchinson, J.C.; Jones, l.; Farmer, H.I.; Ayhan, M.S.; Wilson, R.C.; Rance, J.; Hepworth, C.J.; Bailey, S.G. Psychological, psychophysical, and ergogenic effects of music in swimming. *Psychol. Sport Exerc.* **2013**, *14*, 560–568. [CrossRef]
46. Popović, D.; Damjanović, S.; Popović, B.; Kocijancić, A.; Labudović, D.; Seman, S.; Stojiljković, S.; Tesić, M.; Arena, R.; Lasica, R. Physiological behavior during stress anticipation across different chronic stress exposure adaptive models. *Stress* **2022**, *25*, 14–21. [CrossRef]
47. Hutchinson, J.C.; Sherman, T. The relationship between exercise intensity and preferred music intensity. *Sport Exerc. Perform. Psychol.* **2014**, *3*, 191–202. [CrossRef]