

Effects of musical tempo on physiological, affective, and perceptual variables and performance of self-selected walking pace

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Abstract. [Purpose] This study investigated the effects of musical tempo on physiological, affective, and perceptual responses as well as the performance of self-selected walking pace. [Subjects] The study included 28 adult women between 29 and 51 years old. [Methods] The subjects were divided into three groups: no musical stimulation group (control), and 90 and 140 beats per minute musical tempo groups. Each subject underwent three experimental sessions: involved familiarization with the equipment, an incremental test to exhaustion, and a 30-min walk on a treadmill at a self-selected pace, respectively. During the self-selected walking session, physiological, perceptual, and affective variables were evaluated, and walking performance was evaluated at the end. [Results] There were no significant differences in physiological variables or affective response among groups. However, there were significant differences in perceptual response and walking performance among groups. [Conclusion] Fast music (140 beats per minute) promotes a higher rating of perceived exertion and greater performance in self-selected walking pace without significantly altering physiological variables or affective response.

Key words: Music, Self-selected exercise, Rating of perceived exertion

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INTRODUCTION

Music is often used to ameliorate the monotony of an activity, as a stimulus when performing exercises, or simply as background music^{1, 2)}. Music can affect physical activity by producing psychological effects that influence mood, emotion, affect (i.e., feeling of pleasure or displeasure), cognition, and behavior as well as psychophysiological effects associated with subjective perceived exertion and fatigue²⁻⁴⁾.

Although music can increase motivation and affective components associated with high levels of effort, its effects on low- to moderate-intensity activities such as walking are more pronounced⁵⁾. Many sedentary individuals with little experience in physical activities, especially women, have adopted walking as an exercise to initiate regular physical activity⁶⁾. Walking is a popular form of exercise that is easy and has a low risk of injury; besides promoting physical

fitness, walking can aid the loss and maintenance of body weight⁷⁾.

The effect of music on walking is attributed to psychophysiological and ergogenic changes that mainly affect the final performance of the exercise and perceptual responses⁸⁾. Many attempts have been made to provide greater psychological effects to help beginners adhere to an exercise program⁹⁻¹¹⁾. Self-selected intensity may provide a tolerable, motivating, and effective exercise intensity for the development and maintenance of physical aptitude in individuals with low fitness levels¹⁰⁾. Moreover, music can help beginners during self-selected walking by maximizing motivation and affect as well as acting as a distractor from non-pleasurable stimuli^{12, 13)}.

Although music and self-selected walking can help individuals follow a regular physical exercise regime, few studies have evaluated the effect of musical stimulation on self-selected walking pace exercise. Therefore, this study assessed the effects of musical tempo on physiological, affective, and perceptual responses as well as the performance of self-selected walking pace.

SUBJECTS AND METHODS

The subjects were a convenience sample of 28 adult wom-

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en. The purpose and procedure of the study were explained to each subject, who then voluntarily signed an informed consent agreement before participating in the experiment. All subjects were classified as having a sedentary lifestyle, i.e., performing less than 30 min of moderate physical activity three or more days a week. The inclusion criteria were as follows: (a) 29–51 years of age; (b) ability to participate in regular physical exercise; (c) negative responses to all questions in the Physical Activity Readiness Questionnaire (PAR-Q); (d) body mass index (BMI) from 18.5–27 kg·m⁻²; and (e) a personal statement of not having smoked in the last 12 months. Meanwhile, the exclusion criteria were the presence of cardiovascular, metabolic, or orthopedic disease or any other contraindications as determined by medical history in the preceding 12 months. This study was approved by the Research Ethics Committee of the Department of Health Sciences at the Federal University of Parana (UFPR) in Curitiba, Brazil.

This study had a cross-sectional experimental design¹⁴. The subjects were divided into three treatment groups: the control group, which was not subjected to musical stimulation, musical stimulation at 90 beats per minute (bpm), and musical stimulation at 140 bpm. The genre of music used was pop, and the songs were listened to through headphones. The music volume was adjusted to a level considered pleasurable by the subject before the start of the walk. The subjects were not instructed to walk at the tempo of the music.

All subjects completed three exercise sessions: (1) sample screening and familiarization, (2) an incremental test to exhaustion to determine physiological variables, and (3) a 30-min walk on the treadmill at a self-selected pace. All experiments were conducted in the morning (between 08:00 and 12:00 h) under similar environmental conditions (21 °C and 55% relative humidity). The subjects were advised not to consume alcohol, caffeine, or perform vigorous physical activity 24 h prior to each test.

Physiological responses, rating of perceived exertion (RPE), and affective responses were recorded during walking at a self-selected pace. Thus, the independent variable was musical stimulus (i.e., control, or musical stimulation at 90 or 140 bpm), whereas the dependent variables were physiological responses, RPE, affective responses, and performance at a self-selected walking pace.

To facilitate understanding of the experimental procedures, the subjects performed a familiarization session, during which they were taught to correctly use the scales and resources required to perform the test procedures.

The incremental test to exhaustion on a treadmill was conducted using the standard protocol proposed by Bruce¹⁵, with 3-min stages for the evaluation of $\dot{V}O_{2\max}$. The subjects were verbally encouraged to continue the exercise to the point of exhaustion. The criteria required to achieve $\dot{V}O_{2\max}$ were as follows: (a) a plateau of $\dot{V}O_2$ (changes <150 mL·min⁻¹), (b) respiratory exchange ratio ≥ 1.10 , and (c) heart rate (HR) within 10 bpm of the maximum level expected for the subject's age¹⁶. HR (bpm) was measured every 5 s using a Polar monitoring system (Polar Electro™, Oy, Finland). A metabolic open-circuit breathing system (True Max 2400, Parvo Medics™, Salt Lake City, UT, USA) was used to measure $\dot{V}O_2$, carbon dioxide produced ($\dot{V}CO_2$),

and pulmonary ventilation ($\dot{V}E$) every 15 s throughout the test. Each time prior to the determination of $\dot{V}O_{2\max}$, the gas analyzer was calibrated with known concentrations of gases.

Oxygen consumption at the ventilatory threshold (VO_{2LV}) was determined as described by Caiozzo et al¹⁷. VO_{2LV} was identified as the point at which the ratio of minute ventilation plotting of oxygen consumption (VE/VO_2) versus the ratio of minute ventilation CO_2 production (VE/VCO_2) deviates from normalcy.

We initially conducted a 5-min warm-up at 1.11 m/s without inclination. The subjects were subsequently instructed to self-select a walking pace for the next 30 min as described by Pintar et al¹⁰. Adjustments were made during the first minute of walking and then at 5, 10, 15, 20, and 25 min. The speedometer was hidden during evaluation¹⁰. The physiological variables were evaluated using the same instruments and procedures used in the incremental treadmill test; however, only values obtained at 10, 15, 20, 25, and 30 min¹⁸ were considered. The data recorded during last 2 min in 15-s intervals of the respective stages were averaged, and the overall averages were subsequently calculated using these values to represent the physiological responses during the 30-min walk.

Perceived exertion was determined using the RPE OMNI-RES scale¹⁹. This instrument basically consists of a 10-point Likert scale in which 0 indicates “extremely easy” and 10 indicates “extremely difficult.” Subjects were instructed how to use the scale and perform docking procedures before the tests as described by Utter et al¹⁹. The instrument was administered during the last 15 s of each stage in a minute and during the 30-min walk test. The values obtained at 10, 15, 20, 25 and 30 min were used in the analysis.

Affective responses were determined according to the feeling scale proposed by Hardy and Rejeski²⁰. This instrument basically consists of an 11-point scale with single bipolar items ranging from +5 (“very good”) to -5 (“very bad”) with 0 indicating neutral. The scale was used during the last 15 s of each stage of 3 min, the maximal incremental test, and 30-min walk test at a self-selected pace. The values obtained at 10, 15, 20, 25, and 30 min were analyzed. The subjects were asked to indicate their feelings of pleasure or displeasure at the abovementioned time points. Standardized definitions of affection were presented before the maximal incremental test and 30-min walk test at a self-selected pace.

Statistical analysis

Descriptive data are expressed as mean \pm standard deviation (SD). One-way ANOVA was used to analyze the physiological anthropometric variables (i.e., maximal test) and final results of the 30-min walk test. Meanwhile, multivariate analysis was used to verify the physiological, positive perceptual, and affective responses during the 30-min walk test at a self-selected pace. The level of significance was $p < 0.05$. All data were analyzed using SPSS for Windows version 17.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

Physiological and anthropometric measurements with respect to age are shown in Table 1. No significant differences

were observed among groups.

The physiological, perceptual and affective responses of the groups obtained during the 30-min walk test at a self-selected pace are shown in Table 2. There were no significant differences among groups with respect to % HR or % $\text{VO}_{2\text{max}}$. Although no significant differences in the affective response were noted, the RPE of the groups determined at 10 min ($F_{(2, 25)} = 4.092$, $p = 0.029$, $n^2_p = 0.247$), 15 min ($F_{(2, 25)} = 5.435$, $p = 0.011$, $n^2_p = 0.303$), 20 min ($F_{(2, 25)} = 10.233$, $p = 0.001$, $n^2_p = 0.450$), 25 min ($F_{(2, 25)} = 12.406$, $p = 0.000$, $n^2_p = 0.498$), and 30 min ($F_{(2, 25)} = 10.985$, $p = 0.000$, $n^2_p = 0.468$) exhibited significant differences. However, there was no difference in the RPE ($F_{(2, 25)} = 10.377$, $p = 0.001$) between the control group and the group exposed to musical stimulation at 90 bpm.

The average walking performance after 30 min of self-selected walking is shown in Table 3. There were significant differences in the average walking speed among the groups ($F_{(2, 25)} = 3.897$, $p = 0.034$).

DISCUSSION

In the present study, different musical conditions did not promote sufficient stimuli to change exercise intensity; in particular, there were no significant differences in physiological responses (i.e., HR and VO_2) during 30 min of self-selected walking. These findings are similar to those reported by Brownley et al.¹²⁾, who investigated the effect of music on trained and untrained subjects. Likewise, other studies also found no effect of music on HR or VO_2 ^{13, 21–23)}.

Because of a lack of methodological standards, some

Table 1. Anthropometric and physiological characteristics of the subjects

Variables	90 bpm	140 bpm	Control
n	10	9	9
Age (y)	42.4 ± 4.5	42.7 ± 6.6	41.7 ± 5.0
Weight (kg)	61.1 ± 8.9	59.9 ± 4.6	62.7 ± 11.6
Height (cm)	1.57 ± 0.04	1.58 ± 0.05	1.58 ± 0.05
BMI ($\text{kg}\cdot\text{m}^{-2}$)	24.5 ± 2.7	24.0 ± 2.0	25.1 ± 4.0
Body fat (%)	26.8 ± 4.7	25.1 ± 3.3	25.8 ± 6.4
HR _{max} (bpm)	176.1 ± 9.0	182.8 ± 8.9	174.9 ± 13.8
HR _{VT} (bpm)	143.0 ± 14.2	154.8 ± 10.3	139.6 ± 20.4
VO _{2max} ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	29.7 ± 6.1	29.2 ± 4.3	27.2 ± 4.6
VO _{2VT} ($\text{mL}\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$)	24.2 ± 3.2	23.9 ± 1.7	21.4 ± 4.0

BMI: body mass index; $\text{VO}_{2\text{max}}$: maximal oxygen consumption; $\text{VO}_{2\text{VT}}$: oxygen consumption in ventilatory threshold; HR_{VT} : heart rate in ventilatory threshold; HR_{max} : maximal heart rate; bpm: beats per minute. Data are expressed as mean ± SD.

Table 3. Average speed during 30 minutes of walking at a self-selected pace

Treadmill speed ($\text{mm}\cdot\text{h}^{-1}$)		
90 bpm	140 bpm	Control
81.6 ± 8.3	91.6 ± 8.3*#	80.0 ± 6.6

* Significant differences between 140 bpm group and control group ($p < 0.029$). # Significant differences between 90 and 140 bpm groups ($p < 0.039$). Bpm, beats per minute.

Table 2. Physiological, perceptual, and affective responses to 30 minutes of walking at a self-selected pace

Affect (-5 to +5)					
	10 min	15 min	20 min	25 min	30 min
90 bpm	3.2 ± 1.1	3.2 ± 1.4	2.6 ± 1.8	1.6 ± 2.0	1.6 ± 1.3
140 bpm	2.9 ± 2.0	2.2 ± 2.0	1.9 ± 2.3	1.7 ± 2.4	1.5 ± 2.3
Control	3.7 ± 0.9	3.2 ± 1.1	3.3 ± 0.7	3.1 ± 0.8	2.4 ± 1.0
% HR _{max}					
	10 min	15 min	20 min	25 min	30 min
90 bpm	57.9 ± 7.3	60.3 ± 6.9	62.4 ± 7.8	63.9 ± 5.8	65.9 ± 6.6
140 bpm	66.6 ± 9.4	68.7 ± 10	70.3 ± 10.1	71.0 ± 10.4	73.5 ± 10
Control	62.0 ± 9.8	64.6 ± 10.9	67.0 ± 11.5	67.7 ± 13.0	70.3 ± 14.4
% VO _{2max}					
	10 min	15 min	20 min	25 min	30 min
90 bpm	39.8 ± 8.8	40.5 ± 10.7	41.4 ± 13.6	42.1 ± 12.5	42.9 ± 11.8
140 bpm	45.4 ± 13.1	47.1 ± 13.1	50.0 ± 13.7	51.7 ± 13.2	52.9 ± 14.3
Control	39.9 ± 12.1	41.2 ± 12.2	43.0 ± 14.2	46.1 ± 13.2	48.3 ± 13.2
RPE (0–10)					
	10 min	15 min	20 min	25 min	30 min
90 bpm	2.2 ± 0.6	2.8 ± 1.1	3.5 ± 1.4	4.3 ± 1.5	4.2 ± 1.5
140 bpm	3.6 ± 1.9*	4.3 ± 1.7*	5.2 ± 1.3*#	5.7 ± 1.0*#	6.1 ± 1.5*#
Control	2.0 ± 1.0	2.3 ± 1.1	2.6 ± 1.0	2.9 ± 0.9	3.0 ± 1.1

* Significant differences between 140 bpm group and control group ($p < 0.00$). # Significant differences between 90 and 140 bpm groups ($p < 0.019$). Bpm, beats per minute.

studies indicate the effects of music on the RPE are inconclusive^{13, 24}); however, a previous study identified that different musical stimuli can influence perceptual responses during exercise^{25, 26}. Potteiger et al.²¹) observed that subjects who exercised listening to fast, classical, or self-selected music exhibited lower RPE than those who exercised without music. Nakamura et al.²³) found that subjects who exercised while listening to music of their choice covered more distance and exhibited lower perceptual responses than those who exercised while listening to non-preferred songs.

In the present study, music improved fatigue tolerance (i.e., increased RPE) during walking at a self-selected pace, and fast music (140 bpm) promoted greater performance at the end of the walk. According to Karageorghis et al.²), RPE tends to decrease during low-intensity exercise but not moderate-intensity exercise. During self-selected activity, music does not increase subjective perception of exertion. The association between self-selected walking and fast music can have allowed the subjects to dissociate exertional perceptions from walking performance²⁷).

Regarding walking performance, the present results are consistent with the literature, affirming that music can induce an ergogenic effect and improve exercise performance, especially in low- to moderate-intensity activity^{2, 8, 13}). This phenomenon may be related to the potential role of music in motivating and distracting people in monotonous and/or unpleasant situations^{2, 5}). However, few studies have reported the effects of music on exercise-related affective responses; although these investigations were not based on self-selected exercise, their results are consistent with those of the present study, showing no significant differences in music-related affective responses to exercise^{12, 13}).

More importantly, in the present study, even though the RPE was higher with musical stimuli, no affective changes were observed among the three groups examined. Karageorghis et al.²⁸) and Harmon and Kravitz²⁹) suggest this is because fast music can capture the attention and temporarily distract the subject from sensations related to fatigue. Intervention studies should be conducted to observe the long-term effects of listening to music during exercise on perceptual, physiological, and affective responses.

In conclusion, fast music (140 bpm) increases RPE and performance in walking pace without significantly altering HR, VO_2 , or affective responses. Hence, listening to fast music during self-selected walking could help sedentary people or novices perform regular exercise, distract them from tiredness and fatigue, and create a better sense of wellbeing while performing the activity.

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