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Effects of the music tempo during walking exercise on heart rate variation, lactic acid, and aerobic variables in male college students

Se-Young Jeong, Joo-In Yu, Tae-Beom Seo, Young-Pyo Kim*

Department of Kinesiology, College of Natural Science, Jeju National University, Jeju, Korea

The purpose of this study is to investigate the effects of music tempo on heart rate (HR), HR variability (HRV), lactate levels, and aerobic capacity during walking exercise in male college students. Ten male college students randomly participated in three experiments using various music tempos on a treadmill device to prevent data contamination between measurements by allowing a 2-week interval. Walking exercise was performed at a moderate intensity of 60%–70% maximum HR for 30 min, with participants divided into three groups based on music tempo: exercise group with fast tempo music (ExF, 120–160 bpm), exercise group with slow tempo music (ExS, 60–70 bpm), and exercise group without music (Ex). The study was designed using a randomized crossover method. Two-way repeated measures analysis of variance (ANOVA) assessed group-by-time interactions, and one-way ANOVA was used to compare differences between groups. *Post hoc* analysis was performed using Tukey honestly significant difference. As a result, the ExF group had higher HR, ventilation, metabolic equivalent, and oxygen uptake during treadmill exercise than the ExS or Ex group. But there was no significant interaction of HR and HRV during recovery according to music tempo. HRV was significantly higher in the ExF group during exercise when compared to other groups. Blood lactate concentration was significantly decreased in the ExS group. These findings provide new information that music tempo type applied during treadmill exercise might have a positive effect on the maximum oxygen intake and lactate accumulation in the recovery phase.

Keywords: Music tempo, Walking exercise, Heart rate, Heart rate variability, Lactate level

INTRODUCTION

Lack of physical activity and exercise leads to an increase in body fat, which is a major cause of various lifestyle diseases such as obesity, hypertension, coronary artery disease, and diabetes. This situation emphasizes the importance of health care, regular lifestyle and exercise routine (Chopra et al., 2020). Many studies have reported that aerobic exercise is effective management method to prevent metabolic and cardiovascular diseases caused by excessive accumulation of body fat (Liang et al., 2021).

Among various aerobic exercises, walking exercise is considered as a safe exercise because it has lower impact on the ankle and knee joints when compared to running exercise (Wang et al., 2022; Williams, 2013) and the exercise intensity can be easily adjusted according to an individual's physical fitness level regardless of environment, weather, location, or time. In particular, it has been reported that walking exercise at 60%–70% of maximum heart rate (HRmax) improve insulin sensitivity and blood glucose concentration (Henriksen, 2002). These various benefits of Walking exercise have been highlighted in the field of exercise prescription (Inoue et al., 2023).

Recently, people have increasingly turned to music as a means to make exercising more enjoyable. Listening to music while exercising can significantly boost both enjoyment and motivation, enabling individuals to extend their workout duration (Stork et al., 2015). Previous studies reported that young adults who performed

*Corresponding author: Young-Pyo Kim https://orcid.org/0000-0001-6662-1393
Department of Kinesiology, College of Natural Science, Jeju National University, 102 Jejudaehak-ro, Jeju 63243, Korea
Email: kimyp@jejunu.ac.kr
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aerobic exercise while listening to music had a positive effect on emotions such as enjoyment and excitement, allowing them to exercise for longer durations (Suwabe et al., 2021). Additionally, music's characteristics-melody, timbre, rhythm, and tempo-affect the body by modulating autonomic nervous system responses (Mojtabavi et al., 2020). Specifically, aerobic and anaerobic exercise combined with music can improve muscle strength, muscular endurance, aerobic capacity (Greco et al., 2022). These findings suggested that listening to music during exercise can have positive effects on both physical and mental health.

Thus, the range of exercises combined music is becoming more various and is having a positive impact on physical changes. However, there is debate over how different tempo in musical elements affects exercise performance and physical changes. For example, it has been reported that music with a fast-tempo is more effective during sub-maximal high-intensity aerobic exercise than music with a slow-tempo (Thakare et al., 2017). Meanwhile, in research reported by Atan (2013), the effects of different types of music (slow and fast) on anaerobic performance were examined on 28 male participants, and it was found that music type and rhythm did not affect anaerobic power, heart rate (HR) or blood lactate concentration. These conflicting findings suggest a need to clarify the effects of music tempo on exercise, specifically on HR variability (HRV), lactate levels, and aerobic variables, both before and after exercise. Therefore, this study aims to determine whether listening to slow-tempo or fast-tempo music during moderate-intensity walking exercise at 60%–70% of HRmax can positively influence physical performance and recovery during and after exercise.

MATERIALS AND METHODS

Experimental design

The participants of this study were 10 healthy male adults aged between 20–30 years with a body mass index (BMI) of 18.5–24.9 kg/m², and without any cardiovascular or musculoskeletal diseases. Participants were required to have a moderate fitness level, defined by their ability to engage in regular physical activities without experiencing undue fatigue. This study was approved by Ethical committee of Jeju National University (JJNU-IRB-2020-042-001). Participants were fully informed of the study's content and purpose before voluntarily signing a consent form. The experimental design was a randomized crossover design. The experimental groups were divided into the exercise group with slow-tempo music (60–70 bpm, n = 10, ExS), the exercise group with fast-tempo music (120–160 bpm, n = 10, ExF), and the exercise group without music (n = 10, Ex). To minimize contamination from repeated measurements on the same participants in the randomized crossover design, all subjects were given a two-week interval. The characteristics of the participants are shown in Table 1.

Table 1. Characteristics of participants

Variable	Mean ± SD
Age (yr)	23.1 ± 1.65
Height (cm)	172.9 ± 3.5
Weight (kg)	76.5 ± 6.3
BMI (kg/m²)	21.7 ± 2.2
% Fat (%)	19.8 ± 4.1
60%–70% HRmax (bp)	147.8 ± 4.1
Speed (km/hr)	6.9 ± 0.3
Exercise distance (km)	3.5 ± 0.3

SD, standard deviation; BMI, body mass index; % fat, body fat percentage; HRmax, maximum heart rate.

Exercise protocol and music tempo

The intensity of the walking exercise was calculated using the Karvonen (1957) formula: Target HR = [(HRmax–resting HR) × exercise intensity (%)] + resting HR. All participants performed treadmill walking exercise at 60%–70% of the HRmax for 30 minutes. Music tempo refers to the speed of the music measured in beats per minute (bpm), and it was categorized into slow music (60–70 bpm) and fast music (120–160 bpm). The music selection process was standardized, with music pieces preselected and randomized from a curated list of popular, classical, and pop music to ensure consistency across sessions. The tempo of slow music was referenced from a previous study by Edworthy and Waring (2006), and the tempo of fast music was referenced from a previous study by Grassi et al. (1995).

Body composition

The participants visited the laboratory at 8 a.m. to measure their height and weight using an automatic height and weight measuring device (DS-103M, Dong San Jenix, Seoul, Korea). Body composition, including body weight, BMI, and percent body fat, was measured by a body composition analyzer (Inbody 270, Inbody, Seoul, Korea).

Blood lactate concentration

Blood lactate concentration in the fingertip was measured a total of 7 times: at rest, immediately after the 1st, 2nd, and 3rd sets of the walking exercise, as well as 3, 5, and 15 min after the exercise. The analysis was conducted using the Biosen C line (EKF Di-

Table 2. Effects of music tempo on heart rate during walking exercise

Variable	Group	At rest	1st	2nd	3rd	*F*
Heart rate	Ex	80.2±12.6	138.7±9.9	142.6±9.1	141.5±11.3	G: 0.315
	ExS	74.7±5.1	143.1±16.1	139.5±9.1	141.6±10.8	P: 281.5***
	ExF	77.0±8.1	146.0±17.9	142.2±8.6	145.3±7.18	G×P: 0.594
		0 Min	3 Min	5 Min	15 Min	*F*
Recovery time	Ex	141.5±11.3	97.1±11.0	93.1±9.9	87.6±7.3	G: 0.630
	ExS	141.6±10.8	92.2±8.4	88.6±10.5	83.3±7.4	P: 582.3***
	ExF	145.3±7.18	96.7±6.9	92.6±7.7	87.5±7.9	G×P: 0.474

Values are presented as mean±standard deviation.
Ex, exercise group without music; ExS, exercise group with slow tempo music; ExF, exercise group with fast tempo music; G, group; P, period; G×P, group×period.
****P*<0.001.

agnostics, Barleben, Germany).

HR and HRV

HR was measured a total of seven times using the Polar system (Polar Electro Oy, Kempele, Finland): at rest, immediately after the 1st, 2nd, and 3rd sets of the walking exercise, as well as 3, 5, and 15 min after the exercise. HRV was measured three times using Ubiomacpa and Ubioclip (BioSense Creative Co., Ltd., Seoul, Korea): before the walking exercise, immediately after the completion of the 3rd set, and resting period at 15 min after exercise. HRV was analyzed in both time and frequency domains. The time-domain analysis, which statistically processes HR and the intervals between successive heartbeats (R-R intervals), included standard deviation of the node-to-node intervals (SDNN) and square root of the mean squared difference of successive R-R intervals (RMSSD). The frequency-domain analysis involved calculating the low-frequency band (LF) at 0.04–0.15 Hz, the high-frequency band (HF) at 0.15–0.4 Hz, and the LF/HF ratio, which reflects the balance between sympathetic and parasympathetic nervous activity.

Graded exercise testing

Aerobic capacity was measured by the graded exercise testing (GXT) protocol in laboratory, maintaining an indoor temperature of 22°C–25°C and humidity of 45%–50%. The measurements were taken using a treadmill and a gas analyzer (Quark CPET, COSMED, Rome, Italy). Data were automatically collected at 10-sec intervals using the gas analyzer. HR, oxygen uptake (VO_2), respiratory quotient, ventilation (VE), maximal oxygen uptake (VO_{2max}), and metabolic equivalent (MET) were measured using the Exercise Auto B/P Monitor (Quark CPET, COSMED, Rome, Italy).

Statistical analysis

This study used IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA) to calculate the mean and standard deviation of each variable, and conducted a two-way repeated measures analysis of variance (ANOVA) to confirm the interaction between groups and time periods according to music tempo. In addition, one-way ANOVA was conducted to confirm the difference between groups, followed by Tukey honestly significant difference *post hoc* test. The significance level was set at $P<0.05$.

RESULTS

Changes in HR according to music tempo during walking exercise

As shown in Table 2, listening to slow or fast tempo music during walking exercise did not lead to revealed no statistically significant interaction effects between group and measurement time for HR (F[1, 21]=0.594, P=0.659). However, in the descriptive statistics, the ExF tended to show higher HRs compared to the other two groups. On the other hand, during the recovery phase, no significant interaction effects between group and measurement time were observed either [F(1, 21)=0.474, P=0.713], but the ExS tended to show lower HRs compared to the other two groups.

Changes in HRV according to music tempo during walking exercise

As shown in Table 3, HRV according to music tempo during walking exercise showed no statistically significant interaction effects between groups and measurement time for the stress index (F[2, 21]=1.236, P=0.313), LF (F[2, 21]=0.879, P=0.464), HF (F[2, 21]=1.326, P=0.312), SDNN (F[2, 21]=0.726, P=0.561), RMSSD (F[2, 21]=0.434, P=0.717). However, in the descriptive statistics, there were statistically significant changes over time.

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Table 3. Effects of music tempo on heart rate variability during walking exercise

Variable	Group	At rest	0 Min	15 Min	*F*
Stress index	Ex	35.0±7.2	38.8±6.0	37.1±5.7	G: 0.850 P: 10.023*** G×P: 1.236
	ExS	34.2±5.4	37.5±5.6	33.5±3.5	
	ExF	34.5±5.3	42.9±6.5	36.8±6.0	
LF	Ex	6.8±0.2	8.1±1.3	8.1±0.5	G: 0.523 P: 56.288*** G×P: 0.879
	ExS	6.5±0.3	8.3±0.8	7.9±0.5	
	ExF	6.7±0.3	8.5±0.7	8.1±0.7	
HF	Ex	7.6±0.8	6.9±0.6	7.2±0.4	G: 1.198 P: 19.240*** G×P: 1.326
	ExS	8.0±0.5	6.8±0.6	7.5±0.5	
	ExF	7.9±0.4	6.7±0.8	6.9±0.4	
SDNN	Ex	53.7±31.1	45.1±28.8	49.3±25.1	G: 0.045 P: 7.49*** G×P: 0.726
	ExS	64.0±18.9	45.2±6.3	46.4±11.5	
	ExF	60.7±26.3	41.5±15.2	52.6±16.1	
RMSSD	Ex	40.8±33.0	17.8±12.4	27.0±15.7	G: 0.041 P: 40.22** G×P: 0.434
	ExS	43.5±17.5	17.4±4.7	30.9±8.6	
	ExF	39.8±16.6	16.5±4.7	32.8±14.3	

Values are presented as mean± standard deviation.
LF, low frequency band; HF, high frequency band; SDNN, standard deviation of the R-R intervals; RMSSD, square root of the mean squared difference of successive R-R intervals; Ex, exercise group without music; ExS, exercise group with slow tempo music; ExF, exercise group with fast tempo music; G, group; P, period; G×P, Group×period.
$^{**}P<0.01$. $^{***}P<0.001$.

Table 4. Effects of music tempo on blood lactate concentration during walking exercise

Variable	Group	At rest	1st	2nd	3rd	*F*
Lactate	Ex	1.9±0.7	2.3±0.4	2.4±0.6	2.4±1.2	G: 1.488 P: 2.071 G×P: 0.766
	ExS	1.8±0.5	2.3±1.2	1.9±0.9	1.6±0.6	
	ExF	1.7±0.5	2.1±0.4	1.9±0.4	1.7±0.5	
Lactate removal concentration	Ex	2.4±0.9	1.6±0.5	1.5±0.3	1.5±0.6	G: 4.001* P: 10.355*** G×P: 0.712
	ExS	1.6±0.6	1.3±0.4	1.0±0.2	1.0±0.4	
	ExF	1.7±0.5	1.3±0.2	1.2±0.1	1.4±0.3	

Ex, exercise group without music; ExS, exercise group with slow tempo music; ExF, exercise group with fast tempo music; G, group; P, period; G×P, Group×period.
$^{*}P<0.05$. $^{***}P<0.001$.

Changes in blood lactate concentration according to music tempo during walking exercise

As shown in Table 4 and Fig. 1, blood lactate concentration according to music tempo during walking exercise showed no statistically significant interaction effects between groups and measurement time for blood lactate concentration ($F[1, 21]=0.766$, $P=0.584$). However, while no interaction effect was observed for the lactate reduction rate ($F[2, 21]=1.488$, $P=0.249$), the ExS group exhibited lower values compared to the other two groups at the 5-min postexercise rest period ($F=8.974$, $P=0.002$).

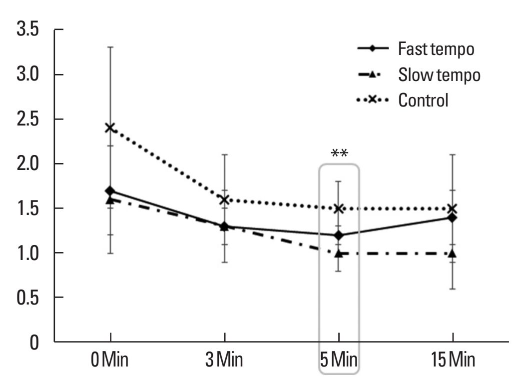

Fig. 1. Changes of blood lactate concentration during walking exercise. $^{**}P<0.01$, slow tempo group vs control group and fast tempo group.

Changes in aerobic variability according to music tempo during walking exercise

As shown in Table 5, GXT-related variables according to music tempo during walking exercise showed no statistically significant interaction effects between groups and measurement time for VE during exercise ($F[1, 21]=0.612$, $P=0.597$), recovery VE ($F[2,

Table 5. Effects of music tempo on aerobic variables during walking exercise

Variable	Group	At rest	1st	2nd	3rd	*F*
VE	Ex	10.2±1.8	46.9±6.6	48.9±5.6	46.3±7.5	G: 0.209
	ExS	9.9±2.2	47.1±8.2	48.9±7.1	48.1±8.6	P: 547.850***
	ExF	10.2±2.3	49.0±8.2	49.3±9.0	51.1±9.0	G×P: 0.612
Recovery time VE	Ex	310.9±30.3	1,897.5±164.9	1,915.7±195.1	1,807.9±268.7	G: 0.146
	ExS	288.8±31.4	1,879.8±160.7	1,894.0±202.2	1,862.4±273.4	P: 332.101***
	ExF	331.6±90.4	1,931.2±227.5	1,919.5±227.9	1,989.9±241.3	G×P: 0.799
VO_2	Ex	310.9±30.3	1,897.5±164.9	1,915.7±195.1	1,807.9±268.7	G: 0.398
	ExS	288.8±31.4	1,879.8±160.7	1,894.0±202.2	1,862.4±273.4	P: 895.08***
	ExF	331.6±90.4	1,931.2±227.5	1,919.5±227.9	1,989.9±241.3	G×P: 0.803
VO_{2max}	Ex	7.2±2.1	25.1±3.2	28.3±2.5	24.8±3.0	G: 3.718
	ExS	5.3±0.9	25.4±1.7	24.9±3.4	26.5±4.8	P: 404.5***
	ExF	5.8±1.3	27.0±3.4	28.1±2.9	31.4±2.9	G×P: 4.402***
RQ	Ex	0.95±0.06	0.98±0.08	0.97±0.06	0.89±0.07	G: 0.609
	ExS	0.91±0.05	0.96±0.08	0.91±0.04	0.92±0.07	P: 3.273*
	ExF	0.89±0.04	0.93±0.07	0.93±0.06	0.91±0.06	G×P: 1.161
MET	Ex	1.2±0.1	7.3±0.5	7.4±0.5	6.9±0.8	G: 0.40
	ExS	1.2±0.1	7.2±0.6	7.3±0.7	7.1±0.9	P: 1,098.2***
	ExF	1.2±0.4	7.3±0.6	7.3±0.5	7.6±0.7	G×P: 1.0

VE, ventilation; VO_2, oxygen uptake during exercise; VO_{2max}, maximal oxygen uptake; RQ, respiratory quotient; MET, metabolic equivalent; Ex, exercise group without music; ExS, exercise group with slow tempo music; ExF, exercise group with fast tempo music; G, group; P, period; G×P, group×period.
****$P<0.001$.

21]=0.799, $P=0.487$), oxygen uptake during exercise (F[1, 21]=0.803, $P=0.504$), respiratory rate during exercise (F[1, 21]=1.161, $P=0.342$), and MET (F[1, 21]=1.0, $P=0.404$). However, an interaction effect was observed for VO_{2max} (F[1, 21]=4.402, $P=0.001$). Upon examining the differences between groups, a significant difference was found in VO_{2max} after the 3rd set of walking exercise ($F=6.772$, $P=0.005$), with the fast tempo group showing higher values than the slow tempo group.

DISCUSSION

Walking exercise is a representative form of aerobic exercise that is relatively simple and easy to enjoy, but it involves coordination among over 100 skeletal muscles and various joints in the upper and lower limbs. Regular walking exercise reduces the risk of heart disease, diabetes, and obesity, and positively improves cardiorespiratory function and overall health (Ussher et al., 2003). In previous studies that applied aerobic exercise combined with music, fast tempo music is more effective in sustaining high-intensity exercise than slow tempo music (Edworthy and Waring, 2006). In our study, HR during treadmill exercise did not show significant interaction effect between groups and measurement time, but HR in the ExF group tended to increase more after the first and third sets of exercise than the other two groups. In addition, HR in the recovery phases 0, 3, 5, and 15 min after exercise was shown to decrease rapidly in the ExS when compared to the ExF and Ex groups. These findings are consistent with previous studies showing that high volume and fast tempo background music resulted in significantly higher HRs and running speed compared to slow tempo music (Edworthy and Waring, 2006). Therefore, listening to fast tempo music during exercise is to enhance performance, whereas slow tempo music is more suitable for promoting physical recovery. However, this study may have been influenced by the participants' familiarity with the music used, which could have affected the results. To address this potential bias, future studies should consider using standardized music selections or assessing participants' prior exposure to the music to control for familiarity.

The accumulation of lactate in the blood is considered a major indicator of exercise fatigue and interferes with muscle contraction. In the present study, we performed a treadmill walking exercise at a speed of 6.9±0.3 km/hr for 10 min over three sets and then measured blood lactate levels at rest, immediately postexercise, and during recovery. There was no significant interaction effect in fatigue index between group and measurement time, but lactate metabolic clearance rate were increased at 0, 3, 5, and 15 min postexercise. In specific, the ExS group showed the lowest lactate levels

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at 5 min postexercise. Previous studies suggested that listening music during exercise could influence lactate removal and fatigue recovery (Jebabli et al., 2023; Silva et al., 2016) as well as music with slow tempo might be more effective in conditioning recovery after high-intensity exercise (Atan, 2013). Therefore, all it these findings demonstrated that listening slow tempo music after exercise might have a positive effect in lactate metabolic clearance and improve physical conditioning.

Aerobic exercise positively influences the autonomic nervous system, which consists of the sympathetic and parasympathetic nerves. The sympathetic nerve increases HR and cardiac output, while the parasympathetic nerve activates physical recovery through a decrease in HR and cardiac output (Peçanha et al., 2014). The ability to regulate the autonomic nervous system is an important biological mechanism for maintaining homeostasis, and can be analyzed using HRV equipment (Vinik et al., 2003). In our study, HRV was analyzed over time to assess the autonomic nervous system, including LF, HF, LF/HF, SDNN, and RMSSD. All indices in HRV did not show any interaction effect between group and experimental time, but technical statistics revealed changes in HRV according to music tempo during exercise. Rastović et al. (2017) reported that increase in body weight and body fat inactivated SDNN, RMSSD, and HF, and activated LF and LF/HF. A decrease in autonomic nervous system activity can negatively affect health through increased sympathetic activity and relatively decreased parasympathetic activity (Chen et al., 2008; Grassi et al., 1995). Thus, regular exercise with music can positively influence the balance of the autonomic nervous system.

Exercise can be categorized into aerobic and anaerobic types that differ based on the intensity and type of muscle fibers incorporated. Among these type of exercise, aerobic exercise is effective for improving stress and cardiopulmonary functions, which involve repetitive use of large muscle groups and supply a large amount of oxygen to form strong vascular tissues (Andersson et al., 2000). In specific, VO_{2max} is developed through high-intensity aerobic exercise, and aerobic exercise is the most therapeutic method for managing metabolic syndrome, including obesity, hypertension, hyperlipidemia and diabetes (Chiu et al., 2017). We investigate the effects of music tempo on aerobic variables during walking. There was no significant interaction effect in VE, oxygen uptake, respiratory rate, MET during exercise, but the exercise group with fast tempo music tended to show higher values in VE and VO_{2max} than the other two groups. On the contrary, the exercise group with slow tempo music decreased values in VE during recovery. In previous studies reporting the effect of listening music during exercise have reported that music can help you forget your hardships by releasing dopamine in the brain (Greco et al., 2022; Terry et al., 2020). Taken together, we thought that listening music during exercise would change the perceived difficulty of the workout into an enjoyable feeling, and this change would enhance performance and oxygen uptake (Terry et al., 2020).

To enhance the practical relevance of these findings, they could be applied in fitness and rehabilitation programs. For instance, fast tempo music could be used to boost performance during high-intensity training sessions, while slow tempo music could aid in recovery phases or therapeutic exercises aimed at relaxation and stress reduction. Implementing these findings can help tailor exercise programs to maximize both performance and recovery benefits.

Therefore, the findings of this study suggest that aerobic exercise with fast tempo music enhances exercise performance, while aerobic exercise with slow tempo music positively affects physical recovery during recovery phase.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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