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The Effect of the Music Tempo on the Recovery of Cardiopulmonary Function after Aerobic Exercise Based on Personal Health Record

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Abstract The purpose of this study was to investigate the effects of different types of music tempo (No Music, 70 BPM, 120 BPM, 180 BPM) on recovery of cardiopulmonary function after an aerobic exercise, identify the effective tempo (BPM) with the highest recovery rate, and propose an effective method for recovery after exercise. A total of ten (10) healthy recreational men participated in this crossover repeated study. Heart rate (HR), oxygen saturation (SPO_2), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), VO_2, and VCO_2 were measured at four (4) different time periods (immediately after exercise, 2 minutes, 4 minutes, and 6 minutes) for each of the four (4) types of music tempo on separate days. As a result, all the outcome variables showed significant differences for all types of music tempo over the time measured ($p<.05$) SPO_2 which did not show a significant difference ($p>.05$). The comparison between the four music tempos showed no significant difference of HR and SBP at 6 minutes after exercise, RR at 2 minutes, and 6 minutes after exercise ($p<.05$). However, no significant differences were observed in the other values ($p>.05$). No Music showed the fastest recovery rate of HR, SBP, DBP, and RR and 70BPM showed the fastest recovery rate of VO_2 and VCO_2. Therefore, for efficient cardiopulmonary function recovery after an aerobic exercise, listening to slow music at 70 bpm or taking a break without music can be suggested as an effective method for recovery.

Keywords Aerobic Exercise, Cardiopulmonary Function, Music Tempo, Post-Exercise Recovery Time

1. Introduction

Nowadays, music is considered to be important and plays a crucial role in emotion and stress management as well as in social life, regardless of music type. Music regulates various emotions, changes mood, improves work results, and increases excitement. In addition, it has an ergo-genic effect that improves social participation, delays fatigue, and increases exercise performance, endurance, and strength [1]. Listening to music is closely related to the neural processes in the motor cortex and can regulate motor cortical activity [2]. Therefore, stimulation by music can lead to a prolonged exercise period, which can lead to relief of people's stress [1].

Music has been shown to be an efficient way to regulate emotions and autonomic nervous activity [3].

Previous studies showed that music can affect central physiological variables such as blood pressure (BP), heart rate (HR), respiration, EEG measurements, body temperature, and electrical skin response, affecting immunity and endocrine function [4]. Moreover, music can affect not only emotional, social, or physical performance but also human behavior such as cognitive and mental aspects. Additionally, work-related stress pushes people to use music as a stimulant or relaxant according to various situations of daily life [5,6]. Also, music is used to improve depression and communication skills [7,8].

Music has been found to have diverse and beneficial effects in the areas of sports and athletics [9]. Palit and Aysia [10] reported that relaxation while listening to music after an exercise on a treadmill has a positive effect on recovery time. Thus, another study reported a similar result by affirming that music has a positive impact on exercise performance and recovery [11]. Post-exercise recovery is intended to repair the fatigue and damage caused by training, and athletes also spend far more time recovering than training time. Recovery is necessary to ameliorate sports performance. Repeated exercise and intense training without adequate rest can increase the risk of illness, so post-exercise recovery must be essential [12].

Aerobic exercise enables efficient oxygen intake and increases the heart rate so that the lungs work effectively [13]. The cardiopulmonary function is a very important function for humans to breathe effectively. In healthy breathing, oxygen is inhaled and moved by blood flow, and carbon dioxide is used by the body and then expelled by exhalation. The respiration recovery capacity after exercise is important in determining the exercise capacity and is closely related to the quality of life [14]. Alemaryeen et al. [15] reported that respiration rate is one of the important vital signs because it provides important information about a person's health status and physiological stability.

Hutchinson et al. (2018) reported that performing aerobic exercise while listening to music was more enjoyable and able to exercise with a stronger intensity than when not listening to music and doing aerobic exercise [16]. Additionally, aerobic exercise is a well-known effective method for improving cardiorespiratory function, physical and functional ability [17]. Meaghan et al. [18] reported that the heart rate during exercise is affected by music. Participants who completed the exercise with music had a higher rate of heart rate recovery than participants who completed the exercise without music. It can be seen that music is related to the recovery effect after exercise. Karageorghis et al. [19] found that listening to slow music immediately after exercise accelerated the recovery process, and women showed a marked decrease in excitability than men. It has been shown that performing an anaerobic exercise with a difference in music tempo could not improve exercise performance [20].

Likewise, there have been many studies investigating music during exercise and the effect of music on cardiovascular recovery after exercise. However, there is a lack of evidence on the effects of music tempo (BPM) on cardiopulmonary function recovery after aerobic exercise. Therefore, the purpose of this study is to investigate the effect of BPM of music on the recovery of cardiopulmonary function in healthy adult men after exercise and to provide reference data for cardiopulmonary physiotherapy research in the future.

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2. Materials and Methods

2.1. Participant

This study was a crossover repeated measure design (four period-four conditions) conducted on healthy men. In total, ten (10) recreational men between the ages of 20 and 30 were recruited from the same recreational team at Sunmoon University and had the same training program. Participants were excluded from this study if they have abnormal walking function, pain, or discomfort due to breathing, those who have undergone heart surgery, those with cardiovascular disease, respiratory diseases, and those who have been diagnosed with neurological damage to the lower extremities and complained of pain. Prior to participating in this study, participants who expressed their intention to participate were selected and all provided a written consent.

Table 1. General characteristics of the subject

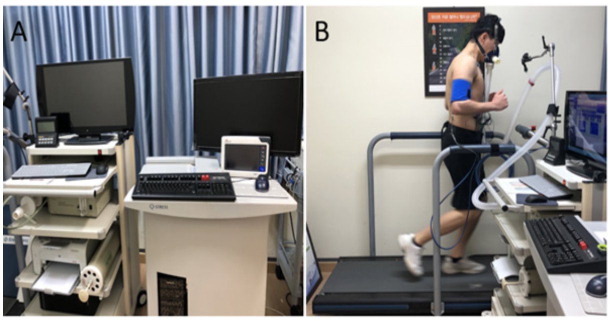
Gender	Male(n=10)
Age	22.80±1.81
Height(cm)	176.40±2.17
Weight(kg)	78.70±3.65
BMI	25.25±1.13

*Values indicate mean ± standard deviation

The study participants were blinded to the nature of the different natures of the recovery conditions. The characteristics of the participants are shown in Table 1. All procedures were in accordance with the Helsinki Declaration and this study has been approved by Sun Moon University Institutional Review Board (SM-202005-024-1).

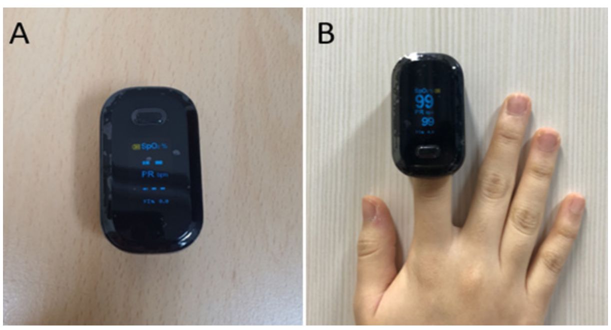
2.2. Measurement Equipment and Method

The CPX test and an oxygen saturation meter were used as experimental equipment to measure the outcomes. CPX Test used Cardiac Stress Test System (Mortara Instrument INC, USA) and Metabolic Test System (ParvoMedics, USA). The cardiopulmonary exercise test is a comprehensive assessment of cardiac, lung, and muscle movements using an electrocardiogram and aerobic gas analysis during exercise load using a treadmill or ergometer (Figure 1). Oxygen saturation was measured by Fingertip Pulse Oximeter (Choice Younker, China) placed on the index finger. Increased oxygen saturation means increased blood circulation. HR, BP, respiration volume (RR), oxygen intake (VO_2), and carbon dioxide emissions (VCO_2) were monitored through the testing machine for exercise loading (Figure 2).



A: Metabolic Test System, Cardiac Stress Test System B: Treadmill

Figure 1. CPX TEST



A: Fingertip Pulse Oximeter B: Measurement of SPO2 using a fingertip pulse oximeter

Figure 2. Pulse oximerter

The resting heart rate (RHR) was measured in order to calculate the target heart rate before the experiment. Participants were instructed to rest on a chair with arms bent at a 90-degree angle, and the first RHR value was obtained. The second RHR value was obtained after 2 minutes and the final RHR score was determined by averaging both values measured scores. This procedure was adopted based on the American Heart Association standards.

Prior to the experiment, the testing machine for exercise loading was pre-heated for 30minute for more accurate results, and the temperature, moisture, and air pressure nearby were adjusted. Using the 3L syringe pump, the air inside the machine was removed for the proper level to check only the amount of breath by the participants. After that, participants were asked to wear an oxygen mask, connect the hose, and proceed when the CO_2 reaches 3% or more within 1 minute. A blood pressure check device is worn on the inside of the arm where blood vessels pass. 10 Electrocardiogram (ECG) were placed on the participants accompanied by a tape to secure the electrocardiogram (Figure 3).

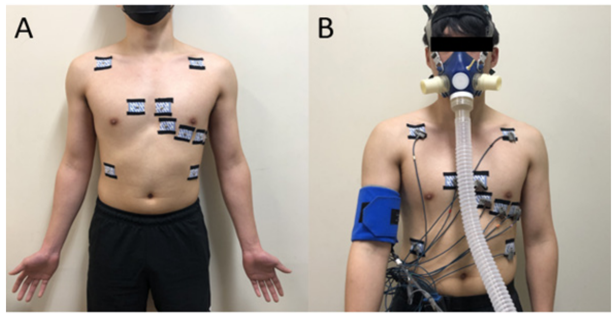


Figure 3. Electrocardiogram (ECG) placement

Participants performed running exercise on the treadmill until they reach their target heart rate. The first 1minute of the exercise was considered as warming-up and the running speed was 5. After the first 1minute passed, the speed was set to 8 and the speed was increased by 1 every 2 minutes. During the exercise process, the Rating of Perceived Exertion (RPE) was shown to the participants, and their current state was regularly checked.

2.3. Experiment Procedures

Participants were instructed to avoid smoking, drinking, and coffee from a day before the experiment. For the safe and accurate measurement on the treadmill, sneakers and comfortable clothes were provided to participants. In order to avoid injury during the experiment, stretching was performed prior to the exercise. When participants experience severe fatigue during the exercise, the experiment was discontinued, and a drink was also prepared for the hydration and the reduction of the fatigue.

There were four types of recovery conditions: "No Music", "70 BPM", "120 BPM", and "180 BPM". Each BPM allows a difference of ± 5. Music was selected using ‘FL STUDIO’ program from company 'lmage-lind' to measure BPM. Standing egg-Old Song was selected for the 70 BPM, BTS-Boy with Luv for 120 BPM, and GFRIEND-Sunrise for 180 BPM. The intensity of the exercise was set at 75% of the target heart rate. The maximum heart rate (Max HR) of subjects was obtained using the maximum heart rate formula (220-age). And the Target heart rate of the subjects was obtained using the RHR value and the KARVONEN formula calculated before the experiment. Participants ended the experiment when they reach their target heart rate.

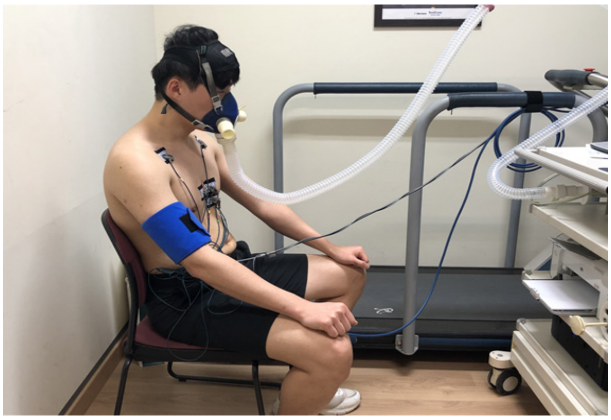


Figure 4. Recovery Position

After the exercise on a treadmill, participants were comfortably seated on a chair and the no music, music at 70 BPM, music at 120 BPM, music at 180 BPM was played and the music order was chosen randomly during their resting period (Figure 4). Participants were placed on each condition on separate days to avoid fatigue. The HR, SPO_2, SBP, DBP, RR, VO_2, and VCO_2 were measured during all the conditions over the four-time period: immediately after exercise, 2 minutes, 4 minutes, and 6 minutes after exercise. The overall research process is the same as in Figure 5.

Karvonen Formula:

Target Heart Rate = [(maxHR - resting HR) × %Intensity] + resting HR

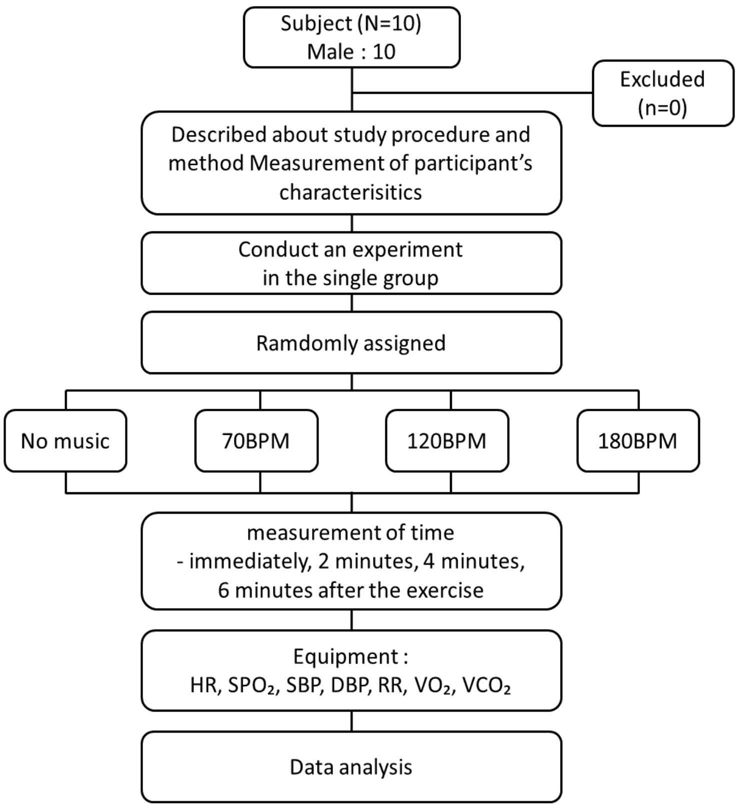


Figure 5. Experiment protocol flow chart

2.4. Data Analysis

In this study, descriptive statistics were used to analyze the general characteristics of the participants. One-way repeated measures ANOVA was used to analyze the change over time, and one-way ANOVA was used to compare changes between the four types of music tempo. A normality test was performed using Shapiro-Wilk, and post hoc analysis was conducted with Bonferroni. The significance level was set at p<.05.

3. Result

The results are expressed as mean value, standard deviation, and significant difference of the variable values as followed below in Table 2. The difference between each BPM over the measurement time is presented in Figure 6.

3.1. Cardiovascular Variables

In this study, we considered HR, SPO_2, SBP, and DBP as cardiovascular variables. The HR showed a significant difference in all the four types of BPM over the different time periods (p<.05). During the recovery after exercise, the recovery rate of HR value according to BPM was observed in the order of No Music>120 BPM>70 BPM>180 BPM. The comparison between the different BPM showed statistically no significant difference between measurement immediately after exercise, 2 minutes, and 4 minutes after exercise (p>.05). However, there was a significant difference at 6 minutes after exercise between No Music and 70 BPM, and No Music and 180 BPM (p<.05).

Regarding the recovery of SPO_2, values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes did not show any significant difference in all the different BPM (p>.05). Additionally, we did not observe any significant difference between the 4 groups (p>.05).

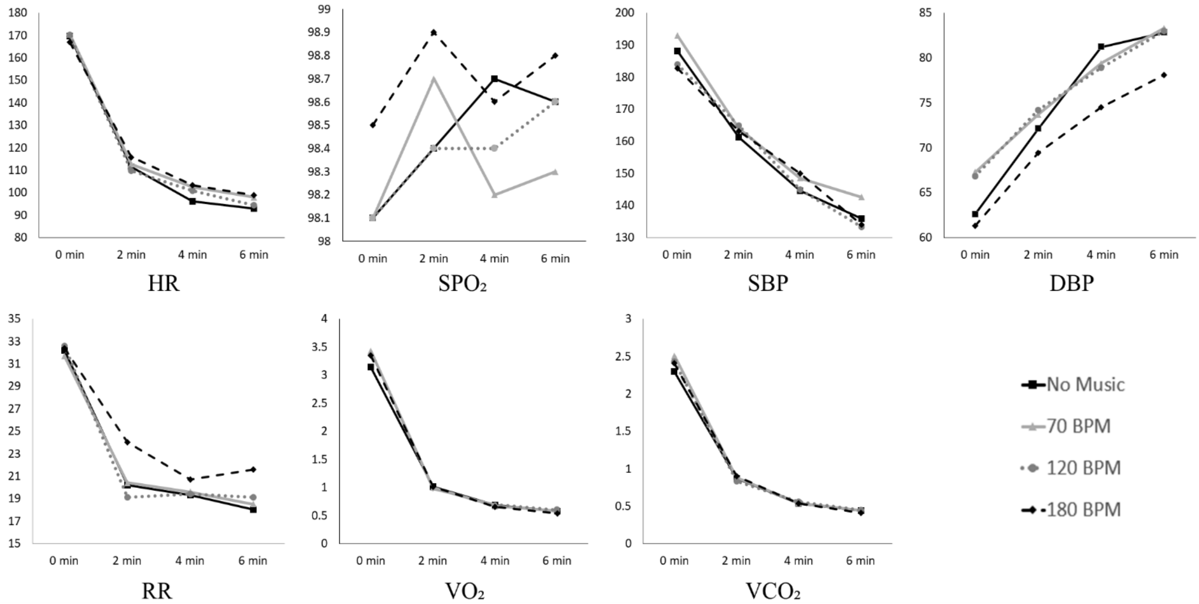
Concerning the SBP, values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes, showed a significant difference in all the BPM types (p<.05). During the comparison between groups, the recovery rate of SBP value was observed in the order of No Music>120 BPM>70 BPM>180 BPM. The comparison between groups over time showed statistically no significant difference immediately after exercise, 2 minutes, and 4 minutes after exercise (p>.05). However, there was a significant difference at 6 minutes after exercise between 70 BPM and 120 BPM (p<.05).

For the DBP, values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes showed a significant difference in all types of BPM (p<.05). During recovery after exercise, the recovery rate of DBP value according to groups was observed in the order of No Music>120 BPM>70 BPM>180 BPM. There was no statistically significant difference between groups during recovery after exercise (p>.05).

3.2. Respiratory System Variables

In this study, we included RR, VO_2, and VCO_2 as respiratory system variables. The comparison of RR values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes showed a significant difference in all the four types of BPM (p<.05). During recovery after exercise, the recovery rate of RR value according to BPM was observed in the order of No Music>120 BPM>70 BPM>180 BPM. The comparison between different BPM showed, statistically, no significant difference immediately after exercise and 4 minutes after exercise (p>.05). There was a significant difference at 2 minutes after exercise between 120 BPM and 180 BPM and at 6 minutes after exercise between No Music and 180 BPM (p<.05).

For the recovery of VO_2, values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes after exercise presented a significant difference in all types of BPM (p<.05). During recovery after exercise, the recovery rate of VO_2 value according to BPM was observed in the order of 70 BPM>180 BPM>120 BPM>No Music. However, there was no statistically significant difference between the different types of BPM during recovery after exercise (p>.05). Regarding the VCO_2, values measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes after exercise showed significant differences in all types of BPM (p<.05). During recovery after exercise, the recovery rate of VCO_2 value according to BPM was observed in the order of 70 BPM>180 BPM>120 BPM>No Music. However, there was no statistically significant difference between the different types of BPM during recovery after exercise (p>.05).



* HR: Heart Rate, SPO_2: saturation of percutaneous oxygen, SBP: systolic blood pressure, DBP: diastolic blood pressure, RR: Respiratory Rate

Figure 6. The change of HR, SPO_2, SBP, DBP, RR, VO_2, and VCO_2 between different BPM during recovery time

Table 2. Differences between various BPM on HR, BP, SPO_2, RR, VO_2, and VCO_2 according to recovery time

		HR	SPO_2	SBP	DBP	RR	VO_2	VCO_2
No Music	0 min	169.60±0.73	98.10±0.40	188.10±10.10	62.60±1.85	32.20±2.50	3.13±0.18	2.29±0.07
	2 min	111.50±3.07	98.40±0.30	161.30±3.47	72.10±2.30	20.20±1.22	1.01±0.05	0.86±0.03
	4 min	96.10±2.48	98.70±0.15	144.05±2.91	81.20±3.10	19.30±1.18	0.68±0.32	0.53±0.02
	6 min	92.80±2.83a,b	98.60±0.16	135.90±1.92	82.80±4.76	18.00±1.09b	0.57±0.03	0.43±0.34
	F	372.536*	0.926	20.411*	5.485*	36.545*	459.325*	26.394*
70 BPM	0 min	170.30±0.66	98.10±0.40	193.00±7.19	67.30±1.62	31.70±2.17	3.42±0.11	2.50±0.04
	2 min	112.60±2.86	98.70±0.15	164.10±3.87	73.70±1.15	20.40±1.23	0.99±0.05	0.88±0.03
	4 min	102.50±2.28	98.20±0.29	148.50±3.17	79.40±1.09	19.60±1.42	0.66±0.01	0.53±0.01
	6 min	97.90±2.01a,	98.30±0.33	142.60±2.74c	83.30±1.78	18.50±1.18	057±0.01	0.44±0.02
	F	511.312*	1.000	42.804*	26.394*	20.041*	597.123*	973.716*
120 BPM	0 min	170.20±0.84	98.10±0.27	184.00±6.58	66.80±3.52	32.60±2.23	3.40±0.08	2.42±0.07
	2 min	109.70±2.32	98.40±0.22	164.80±4.97	74.20±1.63	19.10±1.03d	0.96±0.02	0.82±0.03
	4 min	100.90±1.60	98.40±0.16	145.00±3.68	78.90±2.24	19.40±1.23	0.69±0.02	0.55±0.01
	6 min	94.40±1.76	98.60±0.16	133.30±2.36c	83.00±2.20	19.10±0.88	0.59±0.02	0.44±0.01
	F	985.113*	1.439	46.868*	19.880*	27.959*	893.219*	157.579*
180 BPM	0 min	166.90±3.05	98.50±0.30	182.80±3.87	61.30±2.79	32.40±2.15	3.35±0.09	2.40±0.06
	2 min	115.80±2.93	98.90±0.10	163.10±4.11	69.40±1.45	24.00±0.97d	1.01±0.04	0.90±0.04
	4 min	103.30±1.71	98.60±0.22	150.00±3.05	74.50±1.96	20.70±0.88	0.65±0.03	0.53±0.03
	6 min	98.80±0.98b	98.80±0.13	134.00±2.07	78.10±2.03	21.60±0.47b	0.53±0.03	0.41±0.02
	F	19.144*	1.500	61.857*	19.338*	27.485*	521.603*	468.063*
F	0 min	0.923	0.319	0.399	1.366	0.029	1.111	1.610
	2 min	0.828	1.367	0.134	1.631	3.584*	0.210	0.730
	4 min	0.816	1.073	0.691	1.642	0.291	0.425	0.336
	6 min	4.616*	0.927	3.408*	1.052	2.948*	0.700	0.445

* $p<0.05$, mean ± standard deviation, HR: Heart Rate, SPO_2: saturation of percutaneous oxygen, SBP: systolic blood pressure, DBP: diastolic blood pressure, RR: Respiratory Rate, a: difference between No Music and 70 BPM, b: difference between No Music and 180 BPM, c: difference between 70 BPM and 120 BPM, d: difference between 120 BPM and 180 BPM

4. Discussion

In this study, we investigated the recovery of cardiopulmonary function according to different types of music tempo (No Music, 70 BPM, 120 BPM, and 180 BPM) after an aerobic exercise in healthy adult men in their 20s. Heart rate (HR), oxygen saturation (SPO_2), systolic blood pressure (SBP), diastolic blood pressure (DBP), respiratory rate (RR), maximal oxygen consumption (VO_2), and volume of carbon dioxide (VCO_2) were measured immediately after exercise, 2 minutes, 4 minutes, and 6 minutes for all participants. As a result of this study, regarding the cardiovascular variables, No Music group showed the fastest recovery rate of HR, SBP, and DBP while SPO_2 did not show any significant difference in all different types of BPM. Regarding the respiratory system variables, No Music has the fastest RR recovery rate, and the 70 BPM has the fastest recovery rate for VO_2 and VCO_2. In other words, not listening to music or listening to music at 70 BPM after exercise is an effective way to a rapid recovery.

Aerobic exercise increases sympathetic activity and decreases parasympathetic activity, resulting in an increase in HR, and the increased HR rapidly declines after the cessation of exercise. This quick HR recovery helps to avoid very high cardiac work after exercise [21]. HR decreased after exercise facilitated by parasympathetic reactivation and sympathetic extract [22]. HR, BP, heart rate recovery (HRR), and heart rate variability (HRV) are generally used in noninvasive evaluations to assess parasympathetic function [23]. Peçanha et al. [24] reported that the analysis of cardiac autonomic recovery after exercise is a practical clinical tool for assessing cardiovascular health, and reduced HRR has been widely found in cardiovascular disease and has a high relation with the increased risk of cardiac problems and mortality. Parasympathetic nerve reactivation after exercise is known to be an important factor protecting heart functioning [21].

Our findings are partially similar to previous studies showing that cardiovascular recovery after exercise was faster in slow music [25-27]. However, we found that not listening to music after exercise may be more effective for rapid recovery of cardiovascular variables (HR, SBP, and DBP) and slow music effective for respiratory variables (VO_2 and VCO_2). The difference observed with those previous studies may be explained by the type of music used for the experiment. Musical interventions have inconsistent results in many clinical and research studies [28,29,30]. In a previous study, authors found that the music genre had an effect on the recovery time when the recovery time was confirmed by intervening three music genres (new age, pop, rock) with a slow tempo after treadmill exercise [31]. This study limited the genre of music to K-POP. However, music is composed of various elements such as melody, rhythm, harmony, and musical instruments, and this complexity affects the parasympathetic nervous system. Therefore, it is thought that a standardized protocol should be established in order to use music as an intervention. Also, in prior papers, randomization was not performed [32]. It is thought that the randomization of the study may also affect the results of the study.

In a previous study, music was mainly effective at the end of the recovery period, and external auditory stimuli were not beneficial during the fatigue state in the early period of recovery. However, a positive effect was observed when fatigue was reduced. Additionally, most of the participants reported that listening to music after exercise was unpleasant [33]. Jiang et al. [34] found that music has a property that induces excitement and pleasure, and slow music is reported to be more effective than fast music in relieving tension or anxiety. Moreover, it has been reported that when active music therapy (AMT) and passive music therapy (PMT) were performed based on 60BPM, listening to music (PMT) activated the sympathetic nerve [35].

In other words, listening to music activates the sympathetic nervous system more than when not listening to music, and listening to slow music can activate the parasympathetic nervous system more than when listening to fast music. This is consistent with the results of our study showing that listening to slow music at 70 BPM or not listening to music has a positive effect on cardiopulmonary recovery.

Nowadays, people live closely with music in their daily lives. People often listen to music not only when exercising but also when recovering after exercising. Cardiovascular recovery is used as an important indicator of mortality [24]. The cardiovascular system and pulmonary function are closely related, and today, there are many risk factors for causing cardiovascular disease. Problems with cardiopulmonary function can cause various complications, dyspnea, fatigue, and reduced exercise capacity. Therefore, it is important today to improve cardiopulmonary function.

This study presents some limitations. First, the participants were limited to healthy adult men in their 20s, and the number was not sufficient to generalize the present results to a large sample of participants with various age ranges. Second, it was not possible to limit the daily exercise of the study subjects participating in the experiment. Since participants' exercise levels and life patterns cannot be controlled and managed, the experimental value may vary. Finally, the result value may vary depending on the condition of the subject on the day of the experiment. Further study is needed to provide evidence on various populations.

5. Conclusion

This study was conducted to investigate the effects of 4 types of music tempo (No Music, 70 BPM, 120 BPM, 180 BPM) on cardiopulmonary function recovery in healthy adult men after exercise. As a result, the recovery rate of

HR, SBP, and DBP were fastest on no music during recovery, and SPO_2 did not show any significant change according to different music tempos. Regarding the respiratory system variables (RR, VO_2, VCO_2), RR had the fastest recovery rate during the no music for recovery and 70 BPM showed the fastest recovery rate in VO_2 and VCO_2. Thus, recovery after exercise without music or listening to music at 70 BPM can be suggested as a faster and more effective recovery method.

Acknowledgments

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Conflict of Interest

The authors declare no conflict of interest.

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