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Assessing of exercise intensity for a rhythmik exercise program based on cardiopulmonary functions

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This study investigated the determination of exercise intensity for a rhythmik exercise program based on cardiopulmonary functions. Nine female participants in their 20s to 40s performed a rhythmik exercise program for 60 min per session, three sessions weekly, for 8 weeks. All participants underwent a grade exercise test to measure their minute ventilation (VE), oxygen uptake (VO_2), maximal volume of minute oxygen consumption (VO_{2max}), heart rate (HR), and oxygen pulse (O_2 pulse) at the time of anaerobic threshold (AT) and maximal exercise time (ET_{max}). To determine the exercise intensity of the rhythmik exercise program, the Polar Heart Monitor was used for quantification, and the Borg Scale was used to measure the rating of perceived exertion (RPE). We did not observe any significant effects on the reaching time of AT, VE, VO_2, VO_{2max}, HR, and O_2 pulse at either AT or ET_{max}. However, maximal value of VE (VE_{max}) was significantly enhanced at ET_{max}. The exercise intensity of the rhythmik exercise program was found to be low at 62.85% of HR_{max} with an RPE of 12.22. Our results suggest that the rhythmik exercise program did not directly improve cardiopulmonary functions; however, considering the unstructured nature of the rhythmik exercise program, anticipated positive effects on cardiopulmonary fitness are achievable through changes in the program contents and exercise time according to the goals of the participants.

Keywords: Rhythmik exercise program, Cardiopulmonary functions, Exercise intensity, Maximum oxygen uptake

INTRODUCTION

Rhythmik, a German term for music and movement, or a more general term "Rhythmic" in English, means having a regular repeated pattern of sounds or movements. This study developed a program based on rhythmik as a field established in a German style and verified its effects. The program was named rhythmik exercise program, using the German term. Rhythmik is a field that applies "rhythm," as the most fundamental principle that constitutes music, together with body movements. It is closely associated with the muscles, nervous system, sensory organs, brain, and physical movements. Émile Jaques-Dalcroze and Rudolf Bode pioneered rhythmic gymnastics (Rhythmische Gymnastik) with an emphasis on self-expression and musicality. The subsequent combination of movements and the elementary music pedagogy in Europe that highlights holistic development led to the field of rhythmik for integrated arts education. At the heart of rhythmik exercise is an organic liaison between rhythm and movements through music as "a responsive sense," whereby an immediate response is induced as the nervous system is activated. While exercises such as dancing, dance sports, and aerobics encourage participants to learn and mimic a structured set of motions, a rhythmik exercise is unique as it engages the participants to express what is being perceived by the sensory organs with spontaneous movements.

Although one may view such spontaneous movements as being simple, the exercise elicits natural movements that suit each participant based on his or her inherent sense of rhythm, which allows the participant to utilize their inner energy through such tailored movements. Another difference from conventional music-based

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exercises is that rhythmic exercise involves interactions with the members of the exercise team as well as interactions with oneself. For the finger fullness exercise in the rhythmic exercise program, the participants pair up: one person adopts the role of leader and the other of follower. Both participants place the tips of the fingers on a small gym ball and move with the music. During the exercise, the follower moves with their eyes closed while focusing on the peripheral nervous system signals from their fingertips and the whole body. By doing so, they can improve their balance and ability to sense their own movement. In the extension-reduction exercise, participants try to maximally extend or reduce their energy and move their body in step with a given rhythm. By repeatedly fully relaxing or contracting the muscles in each part of the body, participants are expected to improve their muscle strength and joint mobility.

To date, numerous exercise programs have been developed by applying music. For instance, aerobics was popular as a social physical activity for health promotion rather than as a dance sport, as music was applied to add a factor of pleasure that used to be insufficient in conventional exercises. As an exercise combining various dance genres from ballet to folk, modern, rock, and jazz, aerobics is based on the principle of basic training through aerobic exercise. The ability of music, in a training setting, to enhance health-related fitness has already been verified in numerous studies (Karageorghis et al., 2006; Priest et al., 2004). Five recent reviews and approximately 40 empirical studies have also reported that rhythmic stimulation and movements contribute to the improvement of motor and cognitive abilities and quality of life and suggested that music-based movements could serve as a strategy in non-invasive treatments to enhance gait and cognitive abilities (Pereira et al., 2019).

Nevertheless, only a few studies on music-based exercise programs have verified the effects of exercise with a clear focus on exercise intensity and volume in each individual. Measuring cardiopulmonary function using an exercise load test provides a scientific method of calculating the exercise intensity and volume (kcal) from the regression equation between heart rate (HR) and oxygen consumption. Therefore, this study aimed to verify the training effects of a rhythmik exercise program, while examining the exercise intensity and volume based on cardiopulmonary functions.

MATERIALS AND METHODS

Research participants

The study participants were nine women in their 20s to 40s who neither smoked nor had a specific disease that could affect their exercise performance. Individuals who did not meet the criteria of the grade exercise test (GXT) and those with a medical condition that prevented them from participating in the exercise program were excluded. The purpose and contents of the study were adequately explained to all the participants, and a signed consent form was obtained from participants who volunteered. The experimental procedure was approved by the Ethics Committee of Inje University (INJE 2020-10-006-003). Table 1 presents the characteristics of the participants.

Table 1. Physical characteristics of the participants (n = 9)

Variable	Value
Age (yr)	32 ± 9.51
Height (cm)	160 ± 4.07
Weight (kg)	55 ± 4.31
Body fat (%)	26 ± 2.21
Body mass index (kg/m^2)	21 ± 1.59

Value are presented as mean ± standard deviation.

Rhythmik exercise program

The rhythmik exercise program was run for 60 min per session, three sessions per week for 8 weeks under the guidance of an instructor with a master's degree in music rhythmik/elementary music pedagogy from the Dresden college of Music Carl Maria von Weber who is a current board member of the Rhythmics Dresden Hellerau Association. The rhythmik exercise program was structured based on the free expression of movements by listening to sounds as the most primitive sensation that humans can perceive, with a focus on improvised music and movements. For weeks 1–4, the exercise mainly induced flexible and natural movements according to musical elements. For weeks 5–8, artistic expressions were induced based on the sensory response to music according to the elements of movements. The tempo of the music in the rhythmic exercise program was based on the average human heartbeat (60–80 bpm), adjusted according to the activity's objectives, and used duple or quadruple metering to allow participants to move while balancing. The exercise program is described in Table 2.

Body composition

Using an automatic stadiometer (DS-102, Jenix, Seoul, Korea), the participants' height (cm) and weight (kg) were measured, and their body mass index (BMI) was calculated using the formula BMI = weight (kg)/height (m^2). The percent body fat was measured using a body composition analyzer (Inbody 720, Inbody, Seoul, Korea).

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Table 2. Rhythmik exercise program (week 1–4 and week 5–8)

Category	Motion	Description	Time
Warm-up	Self-control	Postural alignment and gait according to the center of motion and center of weight	5 min
Main exercise	(Week 1–4)		
(Rhythm/music)	Improvisation	Spontaneous movements according to the elements of improvised instrumental music (rhythm, melody, magnitude, speed)	50 min
	Rhythm walking	Expression of rhythm during gait (rhythm, magnitude, and speed)	
	Breakbeat	Creation of rhythm within a set box	
Main exercise (voice/sound)	Voice	Expression of the emotion elicited by a song through voice and movements (rhythm, melody, chord, and dynamicity)	
	Speech	Expression of the emotion in reading a poem through movements Expression of the emotion elicited by music or a song through movements	
Main exercise	(Week 5–8)		
Follow movement	Fingers fullness	Movements according to music with fingertips placed on a small gym ball, in a team of two individuals; one leader and one follower (with only the follower closing his or her eyes or with both individuals closing their eyes, and with body relaxing)	50 min
	Floor dance	Maximized mobility of the body with reduced use of the upper limbs	
Energy exercise	Extension reduction	Maximal expansion or reduction of the body and energy according to a set rhythm	
	Staccato legato	Movements with a set of discontinuous motions and connected motions in an ensemble	
Cool down	Breath control	Postural alignment and gait Relaxation with even breathing	5 min

Cardiopulmonary exercise test

For exercise testing, the minute ventilation (VE), oxygen uptake (VO_2), maximal volume of minute oxygen consumption (VO_{2max}), HR, and oxygen pulse (O_2 pulse) of the participants were measured constantly during exercise at the time of anaerobic threshold (AT) and maximal exercise time (ET_{max}). The variables were measured using the treadmill and metabolic gas analyzer system (Quark b2, Cosmed, Rome, Italy). The Bruce protocol was employed to conduct the maximal exercise test. The AT was determined by the Modified V-slope method, and the O_2 pulse was calculated by dividing VO_2 by HR (O_2 pulse = VO_2/HR) at exercise testing.

Exercise intensity monitoring

To identify the exercise intensity during the rhythmik exercise program, the Polar Heart Monitor (Polar Ignite Fitness Watch, Polar Electro, Kempele, Finland) was used. All participants were guided to wear a chest belt with an HR sensor at the center of the chest, and the HR sensed by the wristwatch was analyzed on a computer for quantification. To estimate the exercise volume, the energy consumption (kcal) during exercise was measured based on HR and personal physical measurements.

Statistical analysis

All measured data are expressed as mean and standard deviation. To analyze the effects of the exercises, a paired sample *t*-test was performed on the pre- and post-exercise values. All statistical analyses were performed using IBM SPSS Statistics ver. 26.0 (IBM Co., Armonk, NY, USA). The significance level (α) was set at $P \leq 0.05$.

Table 3. Exercise intensity and volume of rhythmik exercise program (n = 9)

Variable	Value
HRavg (bpm)	113.98 ± 7.67
GXT HR_{max}	181.56 ± 7.38
%HR_{max} (%)	62.85 ± 4.79
Step (n)	2,795.33 ± 304.88
TEE (kcal)	289 ± 61.82
RPE	12.22 ± 1.09

Value are presented as mean ± standard deviation.
HRavg, average heart rate; GXT HR_{max}, maximal heart rate of the grade exercise test (GXT); %HR_{max}, %maximal heart rate; Step, total step of the program; TEE, total energy expenditure (kcal); RPE, rating of perceived exertion.

RESULTS

Determination of the exercise intensity

Tables 3 and 4 present the exercise intensity during the rhythmik exercise program. The data show that the exercise intensity was low to moderate; for each motion in the program, the intensity was 65.55%, 54.77%, 56.91%, 57.29%, 56.87%, 62.55%, 63.32%, 71.87%, and 76.57% of HR_{max} for improvisation, rhythm walking, breakbeat, voice, speech, finger fullness, floor dance, extension re-

Table 4. Average heart rate and exercise intensity for each movement in the rhythmik exercise program

Variable	HRavg (bpm)	GXT HR_{max}	%HR_{max} (%)
Improvisation	118.89±12.49	181.56±7.38	65.55±7.08
Rhythm walking	99.33±4.35	181.56±7.38	54.77±2.89
Breakbeat	103.11±8.05	181.56±7.38	56.91±5.40
Voice	103.89±7.54	181.56±7.38	57.29±4.59
Speech	103.22±9.27	181.56±7.38	56.87±4.73
Fingers fullness	113.33±8.83	181.56±7.38	62.55±5.91
Floor dance	114.89±15.52	181.56±7.38	63.32±8.55
Extension reduction	130.22±11.24	181.56±7.38	71.87±7.30
Staccato legato	138.89±14.23	181.56±7.38	76.57±8.02

Value are presented as mean±standard deviation.
HRavg, average heart rate; GXT HR_{max}, maximal heart rate of the grade exercise test (GXT); %HR_{max}, %maximal heart rate.

duction, and staccato legato, respectively. Additionally, the exercise intensity of the entire 8-week program was 62.85% of HR_{max} with a RPE of 12.22, which indicated a low to moderate level. The exercise volume for 60 min was 289 kcal.

Changes in cardiopulmonary functions at AT

Table 5 presents the changes in AT after the rhythmik exercise program. Compared to pre-exercise values, no significant variation was found in the reaching time of AT, VE, VO_2, VO_{2max}, HR, and O_2 pulse.

Changes in cardiopulmonary functions at ET_{max}

As shown in Table 6, the maximal values of VE (VE_{max}) was significantly high at ET_{max}, while no significant variation was found in the reaching time of VO_{2max}, VO_2, VO_{2max}, HR_{max}, and O_2 pulse.

DISCUSSION

The precise determination of physiological exercise intensity is a critical consideration in various aspects, encompassing the formulation of training plans and effective energy distribution during different phases of games across a spectrum of sports. For instance, in the game of floor gymnastics, the exercise intensity is usually ≥90% of HR_{max} (Marina and Rodríguez, 2014); furthermore, in the game of figure skating, the reported mean exercise intensity is 95.4% of HR_{max} (Medeiros et al., 2016). Bell and Bassey (1996) suggested that the HR during the performance of aerobics should be 54%–85% of HR_{max} at low exercise intensity and 65%–92% of HR_{max} at high exercise intensity. The exercise intensity of the rhythmik exercise program in this study was 62.85% of HR_{max}, indicating that the program involved low-intensity exercises. The

Table 5. Comparison of variables associated with cardiopulmonary fitness at AT

Variable	Pre	Post	ΔScore	*P*-value
RAT (sec)	320.00±51.41	348.33±62.65	28.33±50.55	0.131
VE (L/min)	36.98±6.77	38.92±5.22	1.93±5.98	0.361
VO_2 (mL/min)	1,446.00±252.90	1,453.22±227.62	7.22±199.65	0.916
VO_{2max} (mL/kg/min)	25.82±3.84	26.03±3.67	0.21±3.50	0.861
HR (bpm)	151.22±11.77	152.44±19.19	1.22±12.01	0.768
O_2 pulse (mL/bpm)	9.59±1.77	9.60±1.67	0.01±0.93	0.964

Value are presented as mean±standard deviation.
AT, anaerobic threshold; RAT, reaching the time of anaerobic threshold; VE, values of ventilation; VO_2, oxygen uptake; VO_{2max}, maximal oxygen uptake; HR, heart rate; O_2 pulse, VO_2/heart rate.

Table 6. Comparison of variables associated with cardiopulmonary fitness at ET_{max}

Variable	Pre	Post	ΔScore	*P*-value
RVO_{2max} (sec)	488.33±49.81	545.00±73.86	56.67±100.56	0.129
VE_{max} (L/min)	58.53±6.47	64.45±10.51	5.92±5.96	0.018
VO_2 (mL/min)	1,793.22±254.08	1,784.22±266.08	-9.00±160.23	0.870
VO_{2max} (mL/kg/min)	32.10±3.95	31.94±4.37	-0.15±2.82	0.873
HR_{max} (bpm)	181.00±6.96	183.67±9.77	2.67±6.50	0.253
O_2 pulse (mL/bpm)	9.93±1.62	9.73±1.58	-0.19±1.12	0.612

Value are presented as mean±standard deviation.
ET_{max}, maximal exercise time; RVO_{2max}, reaching time of maximal oxygen uptake; VE_{max}, maximal value of ventilation; VO_2, oxygen uptake; VO_{2max}, maximal oxygen uptake; HR_{max}, maximal heart rate; O_2 pulse, VO_2/heart rate.

American College of Sports Medicine (2018) recommends an exercise intensity of 64%–95% of HR_{max} to enhance the respiratory and circulatory systems, and the exercise should be performed at least three times a week for ≥30 min per session. The exercise program in this study was performed for 60 min per session thrice a week to satisfy the criteria of weekly exercise duration; however, the exercise intensity hovers at the lower end of the recommended spectrum. Moreover, the RPE in this study was 12.22, which further highlights the low intensity of the rhythmik exercise program in this study. The exercise volume during the 60 min program was 289 kcal, a level similar to walking at a fast pace.

Previous studies on AT as the time when fatigue is sensed after exercise reported that the performance of exercise was more closely associated with AT than with VO_{2max} (Kumagai et al., 1982). In this study, no significant variations were observed between pre-exercise and post-exercise variables at the time AT was reached. This result is presumably due to the influence of factors such as the low intensity of the rhythmik exercise program, the low load of movements in the program, and the insufficient continuity across movements.

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VO_2 increases proportionally with the escalation of exercise intensity and then reaches a plateau as the maximal exercise load is attained. The VO_2 at this point is defined as the VO_{2max}; further, to ensure more accurate differentiation across individuals, the VO_{2max} per weight is used (Shephard, 1984). Baldari and Guidetti (2001) compared the VO_{2max} of ballet dancers, gymnastics athletes, and the general population and reported that the VO_{2max} of these groups were 47.5 mL/kg/min, 51.5 mL/kg/min, and 34.5 mL/kg/min, respectively. Wigaeus and Kilbom (1980) reported that the VO_{2max} during the performance of a folk dance was 53.2 mL/kg/min in men and 42.8 mL/kg/min in women, constituting 70% and 90% of the VO_{2max} for men and women, respectively. In this study, the VO_{2max} at ET_{max} was 32.10 mL/kg/min pre-exercise and 31.94 mL/kg/min post-exercise, which are slightly lower levels than those in previous studies (Baldari and Guidetti, 2001). This may be because our study participants were women in their 20s to 40s who were selected from the general population and did not have a habit of exercising regularly. Nevertheless, the VE_{max} among the tested variables was significantly high, and could be attributed to an enhancement in pulmonary function due to the 8-week exercise intervention.

Regarding the cardiopulmonary mechanisms of the rhythmic exercise program, the sounds and music stimulate the autonomous centers, while the resulting movement promotes repeated inhalation and exhalation at a certain rhythm and depth. As such, the mean HR repeatedly quickens and slows with a consistent rhythm, and the rhythms of the breathing and the HR become coupled. This provides the participants with positive effects such as a peaceful feeling, pulse and blood pressure regulation, and increased VE.

Upon a comprehensive review, the results of this study obtained before and after the rhythmik exercise program, did not reveal statistically significant alterations. Moderate to high exercise intensity is required for improvement in cardiopulmonary fitness. However, the intensity of the rhythmik exercise program in this study was low. Since this was the first study of a music-based rhythmic exercise program, one limitation is the lack of previous studies or different rhythm exercise groups for comparison. An advantage of a rhythmik exercise program is that varying levels of exercise intensity can be designed based on individual components as the program is unstructured. Therefore, further studies should develop programs that carefully factor in the incorporation of moderate- to high-intensity movements, seamless transitions between movements, and optimal exercise duration. Such considerations can potentially enhance a range of physiological parameters.

CONFLICT OF INTEREST

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

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