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The Perception of Exertion and Cardiorespiratory Responses of Rhythmic Exercise Performed to Music Compared with Treadmill Walking Under Three Different Tempos in Postmenopausal Women

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[1]Sportology Center, Juntendo University Graduate School of Medicine, Tokyo, Japan. [2]Department of Nutrition and Metabolism, National Institutes of Biomedical Innovation, Health and Nutrition, Tokyo, Japan. [3]Faculty of Economics and Business Administration, Kyoto Gakuen University, Kameoka, Japan. [4]Faculty of Health and Medical Sciences, Kyoto Gakuen University, Kameoka, Japan

ABSTRACT

Nakagata T, Yoshinaka Y, Yoshida T, Yamada Y, Yokoyama K, Kimura M. The Perception of Exertion and Cardiorespiratory Responses of Rhythmic Exercise Performed to Music Compared with Treadmill Walking Under Three Different Tempos in Postmenopausal Women. **JEPonline** 2018;21(6):114-124. The aim of this study was to investigate the perception of exertion (RPE) and cardiorespiratory responses of rhythmic exercise (RE) versus simple treadmill walking (TW). Sixteen healthy women aged 65 to 78 yrs of age performed both the 4-min rhythmic exercise and TW at three different tempos (90, 120, and 150 beats·min^{-1}) in randomized order. RPE, heart rate (HR), and oxygen consumption (VO_2) were measured. RPE was the same between the two exercise modalities at all tempos. In contrast, HR and VO_2 during RE were significantly higher than during TW at tempos of 120 and 150 beats·min^{-1}. The findings indicate that REs performed to music is a reasonable alternative form of exercise to improve cardiorespiratory fitness versus simple walking at the same RPEs and tempos.

Key Words: Aging, Fall Prevention, Home-Based Exercise, Metabolic Equivalents, Nerve-Muscle Coordination

INTRODUCTION

Loss of physical fitness and function (i.e., cardiorespiratory fitness, muscular fitness, neuromotor fitness, body composition, and flexibility) with age sets the stage for poor health that is associated with functional limitations in the activities of daily life and/or loss of quality of life (25). In particular, falling is very common among the elderly globally, and fall-related injuries such as fractures, head injuries, and death are the leading cause of hospitalizations due to injuries (11). In other words, the fall risk and the rate of fall-related injuries take from the elderly their quality of life (26,29). In general, the fall risk increases with age in both sexes among all age groups though the risk is higher for postmenopausal women than for men (7,10). In Japan, 1 in 5 community-dwelling independent elderly individuals experienced falls in the last year, and 1 in 4 had a high fall risk (18).

The risk factors for falls in the elderly have been identified in many studies. Falls occur as a result of a complex interaction of risk factors (29). The risk is determined not only by leg muscle weakness, balance ability, and gait function disorders, but also by the decline in neuromotor function (18,19). Current physical activity guidelines for the elderly recommend performing neuromotor exercise (such as Tai-chi and yoga) that involves motor skills (e.g., balance, agility, coordination, and gait) 20 to 30 $min \cdot d^{-1}$ to 2 to 3 $d \cdot wk^{-1}$ in addition to aerobic and resistance exercises (6). However, it is not always easy for many people of all ages to change their lifestyle to include regular exercise due to different reasons (e.g., being busy at a job and/or housework, lack of motivation, and no facility) (9). In addition, the fear of falling and the fear of injury while exercising are significant barriers to engaging in regular exercise (5,15) and, as a result, exercise interventions studies in older people have demonstrated declining levels of adherence and persistence rate over time (4). Thus, discussing a exercise option that would not only decrease the subjects' fear of falling, but also increase long-term exercise adherence and persistence rate is important.

Rhythmic exercises (REs) that include music and dance-based exercise may be beneficial for the abovementioned reasons (13,21,23). The performance of REs to music is considered attractive and a relatively less exhaustive form of exercise and/or rehabilitation for the elderly (17). Furthermore, a previous study by Park et al. (21) found that an RE performed to music had higher exercise attendance and retention rates when compared to a walking exercise program in older adults. They indicated that RE performed to music led to higher motivation in the subjects versus walking (21). In addition, it is believed that the music during exercise may aid in reducing negative bodily sensations and perceived exertion (12). Therefore, we developed an RE program performed to music for 1.5 min, which was focused on improving the subjects' neuromotor fitness. The REs were performed to music consisted of whole body exercise of which everyone could perform while watching the exercises online (16).

Yoshinaka et al. (31) conducted a home-based intervention study on healthy elderly people using the RE program. Their findings also indicated that the daily performance of RE at home improved the subjects' agility (31). However, the perception of exertion and cardiorespiratory responses such as heart rate (HR) and oxygen consumption (VO_2) during the REs performed to music were not well investigated. The perception of exertion is not influenced by aging in healthy middle-aged and elderly persons (8) and could be associated with HR as a useful tool for the monitoring and prescription of exercise (6). In addition, the perception of exertion and

cardiorespiratory responses would be dependent on exercise tempos, but no studies have investigated this to the best of our knowledge.

Therefore, the purpose of this study was to investigate the perception of exertion and the cardiorespiratory responses of rhythmic exercises performed to music in healthy elderly women.

METHODS

Subjects

This study included 16 elderly independently living, community-dwelling women in Kameoka city (age, 71.7 ± 5.3 yrs; height, 151.8 ± 5.9 cm; weight, 55.1 ± 7.6 kg, Mean ± SD, Table 1). All subjects performed some physical activities or exercises 2 or 3 times·wk^{-1} and were familiar with the REs. Subjects were excluded from the study if they had coronary heart disease, hypertension, or severe damage to the locomotive organs. None of the subjects reported any chronic diseases. Prior to the study, all subjects provided written consent to participate after receiving information on the procedures and purpose of the study. The study protocol was approved by the Research Ethics Review Board of the Kyoto Gakuen University (approval number: 29-6).

Table 1. Subject Characteristics (N = 16).

Variables	Mean ± SD	Range
Age (yrs)	71.7 ± 5.3	66 - 85
Height (cm)	151.8 ± 5.9	142.8 - 163.6
Weight (kg)	55.1 ± 7.6	41.4 - 73.7
Body Mass Index (kg·m^{-2})	23.9 ± 2.9	18.9 - 28.9
Resting SBP (mmHg)	136.9 ± 19.0	112 - 162
Resting DBP (mmHg)	80.9 ± 6.0	67 - 89
Resting VO_2 (mL·kg^{-1}·min^{-1})	3.4 ± 0.4	2.9 - 4.2
Resting HR (beats·min^{-1})	77.1 ± 11.0	62 - 103

SBP = Systolic Blood Pressure, **DBP** = Diastolic Blood Pressure, **VO_2** = Oxygen Consumption, **HR** = Heart Rate. Ranges refers to minimum – maximum

Experimental Protocol

This study had a randomized crossover design with two conditions: RE and TW. The exercise order was determined randomly for each subject. All measurements were carried out in a laboratory where temperature and humidity of the internal atmosphere were adjusted to 20°C and 50%. All subjects completed both experiments on 7 separate days, respectively between June and July 2017.

The subjects in this study refrained from any strenuous physical activity from the day before the experiment started. Fasting (no water restriction) was begun 4 hrs before the experiment was started. The subjects sat on a chair for 7 to 8 min to measure the resting energy expenditure (REE) before performing exercise with 3 different tempos (90, 120, and 150 beats·min^{-1}). In order to eliminate the influence of the execution order, the order of the 3 tempos was randomized between the subjects. Heart rate (HR) was measured using a HR monitor (Polar Electro, Kempele, Finland). Rating of perceived exertion (RPE) was recorded using a 6 to 20 steps Borg scale (2) after exercise.

Rhythmic Exercise Performed to Music (RE)

Aging and lack of physical activity depress the signal transmission from nerves to muscles. The present rhythmic exercise performed to music was designed to stimulate the nerve-muscle coordination in motor units, and consisted of some light intensity movements, such as stepping, opening and closing the palm, bending and extending the arms, and those involving multiple body parts rhythmically in parallel. The instruction video was uploaded at https://www.youtube.com/watch?v=Dv8XVd5XAjY (16). Subjects conducted the RE in the standing position. This original RE has a tempo of 120 beats·min^{-1} and is to be carried out for 1 min though, we arranged for an original tempo (120 beats·min^{-1}), as well as tempos of 90 and 150 beats·min^{-1}. All subjects performed the RE according to the DVD movement with each of the 3 different tempos (90, 120, and 150 beats·min^{-1}) for 4 min to obtain steady-state of oxygen consumption (VO_2).

Treadmill Walking (TW)

Subjects walked on a motorized treadmill at “0” grade for 4 min with 3 different tempos in a random order. We measured their own preferred speed using the treadmill before the experiment, and then all subjects walked at their own preferred speed according to the experimental protocol. The subjects adjusted the rhythm with the sound of a metronome. The experimental schedule for spending the day before the TW was the same as for the RE.

Indirect Calorimetry Measurement

We used a face mask and expiratory gas analyzer (AE-310s, Minato Medical Science Co., Ltd.) to measure respiratory gas sample and volume of expired air as previously described (20). Prior to the start of the experiment, the flow rate sensor was calibrated using a 2 L syringe, and the concentration sensor was calibrated for gas of known concentration (O_2 14.98%, CO_2 4.99%, N_2 balance) and air. All data were processed every 30 sec and the ventilation volume (V_E), oxygen consumption (VO_2), and carbon dioxide production (VCO_2) were measured. The final 2 min or at a steady-state in each exercise was used to evaluate the VO_2, and VCO_2, EE (kcal·min^{-1}) was calculated from the Weir equation (28). During the resting period of 7 to 8 min, the average value during the last 2 min was defined as the individual’s REE. The VO_2 in mL·kg^{-1}·min^{-1} for REE was designated as 1 MET.

Statistical Analysis

Microsoft Office Excel 2017 and PASW Statistics 17.0 (SPSS, IBM Inc.) were used for data processing and statistical analyses, respectively. All variable results are presented as mean ± standard deviation.

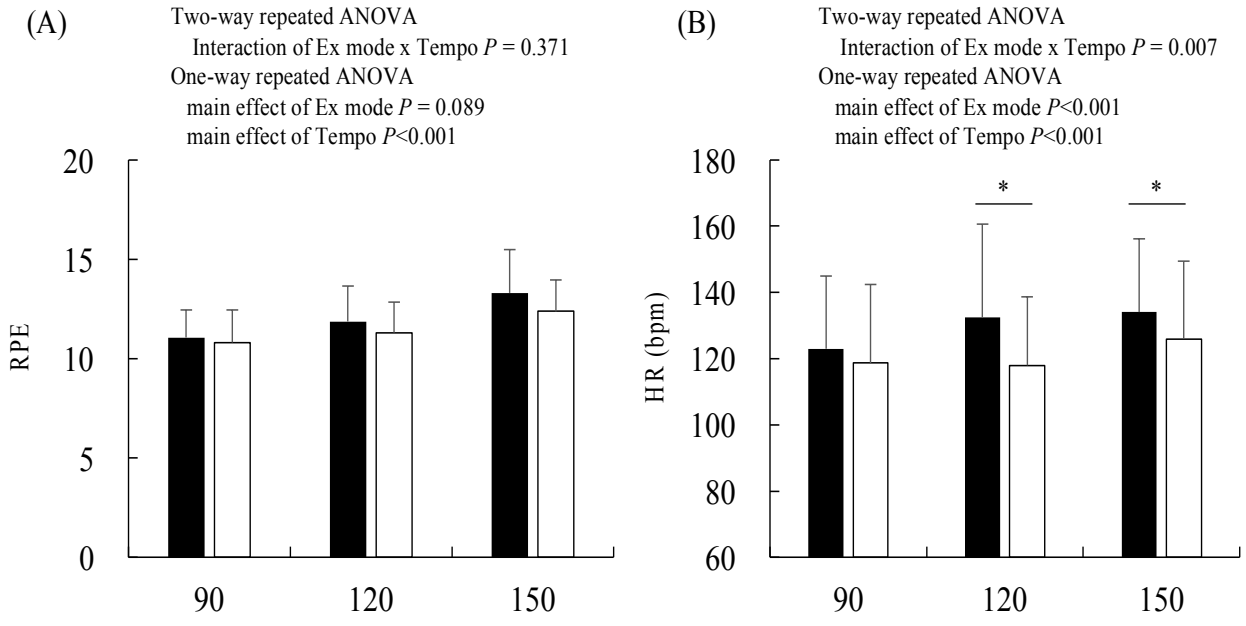
To examine the main effect (Exercise mode and Tempo) and interaction (Exercise mode × Tempo), a two-way repeated ANOVA was conducted for each variable. A one-way repeated ANOVA was conducted to examine the main effect for each variable in each exercise mode separately if a significant interaction was observed. A paired *t*-test was conducted to determine significant differences between RE and TW. The statistical significance was set at an alpha level of P≤0.05.

RESULTS

All subjects successfully performed both experiments. The preferred TW speed of the subjects in this study was 38.3 ± 16.6 $m \cdot min^{-1}$ (2.3 ± 1.0 $km \cdot hr^{-1}$) on average.

Figure 1 shows the physiological responses, RPE, HR, VO_2, and METs of the subjects during the RE and TW. The HR of one subject could not be measured due to some trouble with the HR monitor during RE. This subject was not included in the analysis for HR.

Two-way ANOVAs showed no significant interactions in RPE, VO_2, and METs values for exercise × tempo, except for HR (P = 0.007). There were significant main effects of tempo on all responses, and these variables were significantly higher at the tempo of 150 $beats \cdot min^{-1}$ than at 90 $beats \cdot min^{-1}$. There were significant main effects of exercise on HR, VO_2 and METs, but not RPE.



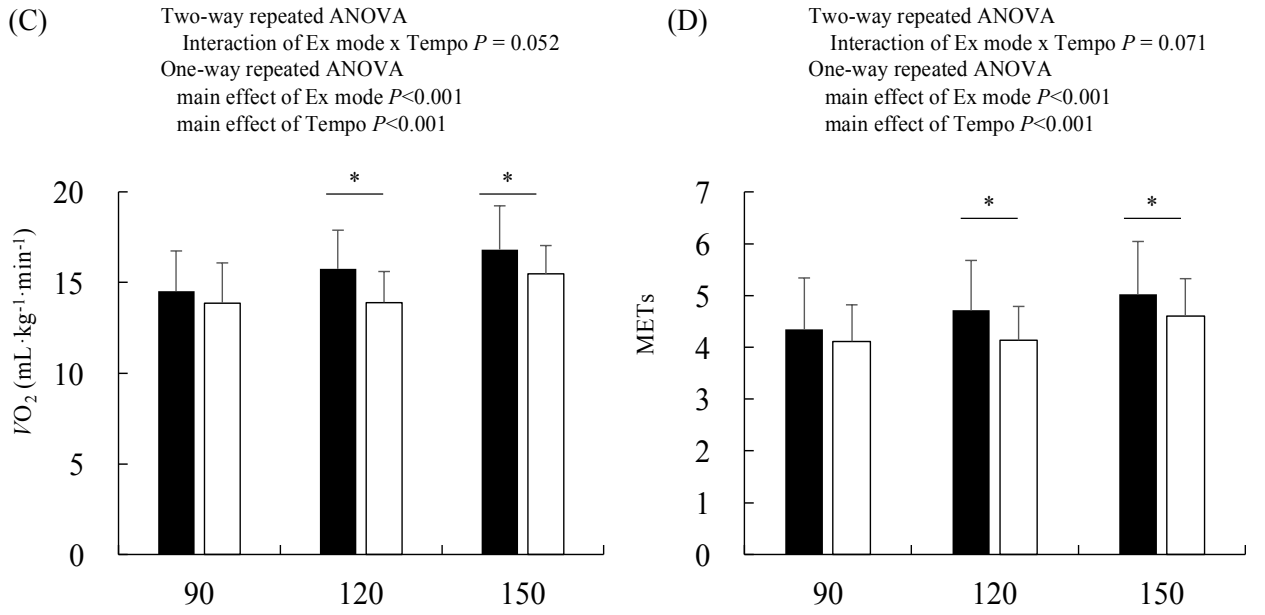


Figure 1. (A) RPE, (B) Heart Rate (HR), (C) Oxygen Consumption (VO_2), and (D) Metabolic Equivalents (METs) during Exercise. Two-way repeated ANOVA shows no significant interactions in RPE, VO_2, and METs values for exercise mode x tempo, except for HR. The HR, VO_2, and METs values during Ex for RE at the tempo of 120 beats·min^{-1} and 150 beats·min^{-1} are significantly higher than for TW. In contrast, there were no significant main effects Ex mode on RPE. *P<0.05, significant difference between Ex modes.

DISCUSSION

Falls are the leading cause of injury-related morbidity and mortality among older adults (11,26,29). Falls occur as a result of a complex interaction of risk factors, and decline of motor function with aging is significantly related with the increased risk of falling (18). Current physical activity guidelines recommend performing neuromotor exercise training involving motor skills (e.g., balance, agility, and coordination) for the elderly (6). We have developed a RE performed to music program that can be performed at home without any supervision by an expert trainer, which was designed to stimulate the nerve-muscle coordination in the motor unit (16).

The present study investigated the RPE, HR, VO_2, and metabolic equivalents (METs) values during RE under varying tempos (90, 120, and 150 beats·min^{-1}) using indirect calorimetry, and compared with those of TW at the subjects' own preferred speed. The main finding of this study is that the RPE using Borg's scale was 11 to 13, which is light to moderate. Second, the METs of RE ranged from 3.9 to 4.5 METs, which indicates moderate intensity. Therefore, there were no significant values of RPE, although the MET values are significantly higher as compared to those of TW at their own preferred speed at 120 and 150 beats·min^{-1}.

The rate of perceived exertion (RPE) has been a widely used psycho-physical tool to assess subjective perception of effort during exercise (22) and to monitor the intensity of exercise, because it is related to physiological markers of the stress response to exercise (6). Borg (2)

demonstrated that a strong relationship exists between RPE and HR during exercise. Shigematsu et al. (24) also found a very strong RPE-HR relationship (r = 0.95) in elderly women (75.5 yrs) during a maximal graded cycle ergometer test. Furthermore, the RPE is not influenced by aging in healthy middle-aged and elderly persons (8); therefore, the RPE is also a useful predictor for HR during exercise.

We designed the RE program to consist of 1 min of rhythmic activity because older adults could perform this exercise easily, the RPE during RE using Borg's scale was 11 to 13, which is light to moderate (6). Therefore, from a point of view of exercise prescription, RE is suitable for people with low-fitness and/or beginners. Furthermore, as a strength of the present study, we examined the RPE of RE and compared them directly with those of walking at one's own preferred speed as the control condition, there were no significant differences in RPE between RE and TW at the subjects' own preferred speeds at all tempos. However, the HR during RE ranged 120 to 130 beats·min^{-1} on average, some of the subjects exceeded 150 beats·min^{-1} with a faster tempo and, exercise intensity as HR is equivalent to vigorous intensity (>80% age predicted HR max (6)).

When comparing to TW, the HR during RE was significantly higher value than that during TW. A previous study investigating the effect of music during exercise reported that music can be used as an aid to reduce negative bodily sensations and perceived exertion (12). In addition, music and video in combination resulted in a significantly lower RPE during high-intensity exercise (about 70% VO_2 max) when compared to music or video in isolation (3). Therefore, it may be that there were no significant differences in RPE between both exercises, even though he HR during RE was significantly higher value than that during TW. However, the exercise and/or health professional should consider that HR during RE beyond the moderate intensity recommended in physical activity guidelines when prescribing neuromotor exercise programs using RE based on perceived exertion, especially to the low fitness individuals or the elderly (≥65 yrs).

The metabolic equivalents (METs) indicate the oxygen requirements of various activities, and are routinely employed as a guide to exercise training and activity prescription. The Center of Disease Control and Prevention, USA and American College of Sport Medicine (CDC/ACSM) physical activity guideline (27) and Compendium of Physical Activities (1) defined 3.0 to 5.9 METs as moderate intensity; <1.5 METs, sedentary; 1.6 to 2.9 METs; light intensity; and >6.0 METs, vigorous intensity activity. The METs of RE increased with the tempo and ranged from 3.9 to 4.5 METs. The METs of various physical activities and exercises have been investigated in the literature. Tai-chi is the most popular neuromotor exercise for the elderly, which is considered 3.0 METs (code 15670) in the Compendium of Physical Activities (1). When comparing the METs of these exercises, the RE was slightly higher than Tai-chi, which is performed in a semi-squatting posture at extremely slow speed with low-impact, while RE is a whole body exercise that consists of stepping, opening and closing the palm, and bending and extending the arms.

Walking is the most popular aerobic-type physical activity and suitable for all population groups. Therefore, comparing the differences between RE and TW is important when instructing the elderly to perform regular exercises. When comparing with TW at their own preferred speed, the METs at 120 and 150 beats·min^{-1} were higher as compared to TW (Figure 1). We thought that RE could maintain and/or improve cardiorespiratory fitness for the

elderly people by prescribing the RE program as well as a simple walking program at the same RPE.

Physical activity and exercise improve physical function among individuals of all ages (6,30). This is true for older adults as well for whom improved physical function not only reduces the risk of falls and fall-related injuries, but also contributes to the older adults ability to maintain independence (25). Therefore, it is important to maintain and/or improve physical fitness and function of the elderly via physical activity and regular exercise, depending on the individual's physical fitness level and goals.

In this regard, RE, which could improve agility in the healthy elderly people (31), has many possibilities for exercise programs for the elderly. First, the RPE of our RE performed to music that is a whole-body and multicomponent exercise composed of simple movements is equivalent to light-moderate intensity (RPE 11 to 13). Second, the healthy elderly individuals can perform RE easily while watching it online without any tools indoor (home, public hall, and so forth). In general, elderly people prefer a home-based exercise program that is inexpensive (14). Third, RE has the potential to improve cardiorespiratory fitness, which is good given that a higher level of cardiorespiratory fitness is associated with lower risks for poor health (6). The intensity of RE was equivalent to moderate intensity and met the exercise intensity that improves cardiorespiratory fitness. Therefore, the RE may be suitable for performing neuromotor exercise in the elderly, especially in the beginners, and our RE performed to music may keep everyone from being bored when compared to the simple exercise of walking.

CONCLUSIONS

We conclude that the exercise intensity of RE performed to music was moderate on average, from 3.9 to 4.5 METs. The results of this study are valuable for the exercise and/or health professionals to prescribe neuromotor exercise programs using RE for the elderly subjects, low-fitness individuals, and beginners. While all subjects in this study were healthy women familiar with RE, it is important that additional research is carried out to investigate the influence of this program on low-fitness individuals, beginners, and men. From a practical perspective, the REs would be a feasible alternative exercise to improve cardiorespiratory fitness (especially when people cannot engage in regular walking outside). However, our results suggest that RE performed to music could be higher exercise intensity (HR and METs) at faster tempo than TW in exercise prescription based on their perceived exertion. Therefore, the exercise practitioner or clinician should consider the individual's fitness level and monitor HR to prescribe RE programs and, in particular, the low fitness individuals and/or older adults.

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