Comparison of Energy Expenditure and Cardiac Effort Induced by Treadmill Walking and Stationary Cycling at Moderate Perceived Exertion by Young Males

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ABSTRACT

Introduction: Moderate intensity aerobic exercise is recommended for the health promotion. In an indoor environment, the treadmill and cycle ergometer are the commonest modes of aerobic exercise. At home or gyms, an individual exercise based on the perceived exertion rather than the objective parameters that are used to classify the exercise intensity in laboratories. The aim of the present study was to compare the treadmill with cycle ergometer for energy expenditure and rate pressure product reactivity in a thirty-minute exercise bout by moderately active, apparently healthy, young males at a rating of perceived exertion (RPE) of 13.

Material and Methods: Sixteen males, aged 21±1 years with BMI of 20.8±1.6 kg/m^2 were involved in the present experimental study. Participants performed two separate exercise trials on the treadmill and stationary upright cycle ergometer. An indirect calorimetric equation based on the respiratory gas exchange analysis was used to calculate the energy expenditure. Blood pressure and heart rate response were obtained by an automated blood pressure monitor. Rate pressure product serves as a linear correlate of cardiac effort and was calculated as the product of systolic blood pressure and heart rate. Student t-test was applied for the comparative analysis. $P<0.05$ was considered significant.

Results: Exercise on the treadmill caused a significantly higher energy expenditure, while the cardiac effort was similar for both the modalities of exercise at moderate perceived exertion.

Conclusion: The results of the present study suggest that the treadmill walking might be preferred over cycling for the health promotion in young males.

Keywords: Aerobic Exercise, Cycle Ergometer, Treadmill, Rate Pressure Product

INTRODUCTION

Exercise is an effective method to enhance and maintain the health-related quality of life. The current recommendation for physical activity in adults includes moderate-intensity exercise.[1,2] According to the FITT (frequency, intensity, type and time or duration) principle — sixty minutes of moderate-intensity exercise every day that should include thirty minutes of aerobic activity is recommended for the Asian Indian healthy adults.[2]

Treadmill and stationary cycle are the most commonly used machines to perform the indoor aerobic exercise. The total energy expenditure during exercise is related to the improvement in cardiovascular health.[3] Hence, it is essential to find the modality of aerobic exercise that causes higher energy expenditure with lesser cardiovascular exertion. However, studies are lacking from India that could have compared these parameters for the treadmill and cycle ergometer exercise.

Borg's rating of perceived exertion (RPE) is a psychophysical method that allows an individual to assess their subjective feeling of exertion on a numerical scale of six to twenty.[4] The scale is designed such that each rating corresponds roughly to ten times of the heart rate (HR), i.e. RPE of 13 would represent the HR of approximately 130 beats/min. RPE is a practical approach to know the exercise intensity as the objective parameters like percentage of heart rate maximum (%HR_{max}), heart rate reserve (%HRR) and maximum oxygen uptake (%VO_2) is not easily available in the developing countries. RPE is a valid tool to know[5] and match[6] the relative exercise intensity during the treadmill and cycle ergometer exercise. American College of Sports and Medicine classifies RPE of 12-13 as the moderate intensity exercise.[5]

The current study was designed to access the energy expenditure by indirect calorimetry and cardiac effort by rate pressure product (RPP) in an acute bout of exercise on the treadmill and stationary cycle at RPE of 13 by young males.

MATERIAL AND METHODS

The present experimental study underwent at the Exercise Physiology laboratory of King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India from October 2016 to March 2017 after gaining approval from the Institutional ethical committee.

Based on the results of the energy expenditure during walking (2611±223 KJ/h) and cycling (2466±185 KJ/h) at

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RPE of 13 by Katsanos et al.[7], the calculated sample size by G*Power v3.1.9.2 was fifteen at 80% power of the study, 5% alpha error, 60% correlation between the group and effect size of 0.78. Sixteen males were involved in the study after the fulfilment of inclusion and exclusion criteria.

Participants were recruited from the KGMU after thoroughly explaining them about the nature and protocol of the study, its benefit and potential hazards. Inclusion criteria were — male, aged 18-25 years with a normal body mass index (BMI) of 18.5-22.9 kg/m^2; apparently healthy as assessed by thorough history and physical examination; and 'moderately active' as assessed by "general practice physical activity questionnaire". Exclusion criteria were the family history of metabolic diseases like diabetes or cardiovascular disorders like hypertension, or any abnormality detected during the examination that could have jeopardized the safe performance of the exercise.

Participants did an exercise bout of thirty minutes at RPE of 13 on the home-based motorized treadmill and stationary upright cycle ergometer having magnetic resistance brakes. Participants performed both, cycling and walking, on two occasions separated by fifteen days. Each participant underwent few familiarization sessions before the experimental trials of cycling and walking. The treadmill was inclined at 3° slope while the resistance of the cycle was set to level 4.

Participants got accustomed to the study protocol, exercise method and working of the machines during familiarization sessions. They were made responsive to Borg's RPE 6-20 scale. Participants were instructed to avoid strenuous muscular activity for a prolonged duration during the study period. Further, they were instructed to wear comfortable clothes and sports shoes for the exercise. Experimental trials were done at the same time of the day (2 to 4 PM) to avoid variability in blood pressure (BP) due to circadian rhythm. Participants were told to maintain a one-day food diary before the first experimental trial and to replicate the same diet on second experimental trial. Also, they were instructed to skip lunch on the day of the experimental trial. A pulse oximeter was used to get an objective measure of exercise intensity. Participants were encouraged to try harder if their HR remained less than the 45% of HRR during the exercise. HR and BP were measured by the validated[8] 'Omron HEM 7130' automated BP monitor, Omron Healthcare Co. Ltd, Kyoto, Japan, before each experimental trial following the recommendations by the American Heart Association[9]. Immediately after the trials BP and HR were accessed again. RPP was calculated as the product of systolic BP and HR. RPP is an accepted indicator of myocardial oxygen uptake or cardiac effort during the exercise.[10,11] RPP reactivity in % was calculated as [(RPP after exercise - resting RPP) ÷ resting RPP] × 100.

During the last two minutes of the exercise trial, participants maintained a steady work rate, and gas exchange data were collected using 'PowerLab software v8' of the 'ADInstruments Exercise Physiology System, New Delhi, India'. Energy expenditure in Kcal/min was calculated by the equation: $(0.55xVCO_2 - 4.471xVO_2)$[12], where, VO_2 is the average oxygen uptake in L/min, VCO_2 is the average carbon dioxide produced in L/min and urinary nitrogen excretion was considered negligible.

Height was measured in an erect posture and barefoot to the nearest 0.1 centimetres by a rigid stadiometer. Weight was measured without heavy clothing by a portable electronic weighing scale nearest up to 0.1 kg. BMI was calculated as the ratio of weight in kg to height in m^2.

STATISTICAL ANALYSIS

Data from all the participants were pooled and then segregated into two groups namely treadmill and cycle ergometer. Initial data entry and calculations were done in Microsoft Excel 2016. IBM SPSS Statistics Software for Windows v25.0.0.1 was used for further analyses. Normality of data was tested by the Shapiro Wilk test. Student t-test was applied and mean with standard deviation were reported. Anthropometric and energy expenditure data were rounded to one decimal place while cardiovascular parameters were rounded to nearest integer. $P<0.05$ was considered statistically significant.

RESULTS

The characteristics of the participants that includes age, height, weight, BMI, baseline SBP, DBP and HR are

n=16	Minimum	Maximum	Mean ± SD
Age (years)	19	23	21 ± 1
Height (cm)	162.2	171.3	167.1 ± 3.2
Weight (kg)	51.7	66.7	57.9 ± 4.0
BMI (kg/m^2)	18.6	22.9	20.8 ± 1.6
Baseline SBP (mmHg)	114	129	120± 4
Baseline DBP (mmHg)	70	87	77± 4
Baseline HR (per min)	66	90	77± 7

Table-1: Participants characteristics.

n=16	Treadmill	Cycle ergometer	P
Energy expenditure in Kcal/min	4.4 ± 0.7	4.1 ± 0.6	0.03
RPP reactivity in %	117 ± 27	112 ± 30	0.38

Student t-test used; P<0.05 was considered significant; RPP: rate pressure product.

Table-2: Energy expenditure and RPP reactivity to the treadmill and cycle ergometer exercise described in table 1. All participants (sixteen) were young males with normal BMI and no dropouts were recorded during the study. The result of the energy expenditure derived from an indirect calorimetric equation and RPP reactivity to a thirty minute bout of treadmill and cycle ergometer exercise at RPE of 13 is represented in table 2. RPP reactivity to both the modalities of exercise shown no statistically significant difference, however, energy expenditure in Kcal/min was significantly higher for an aerobic exercise on the treadmill as compared to the cycle ergometer.

DISCUSSION

The results of the present study indicate that the higher energy expenditure occurs in treadmill walking than pedalling on a stationary upright cycle by moderately active young males at a moderate perceived exertion or RPE of 13.

Zeni et al. reported a significantly higher energy expenditure in response to graded exercise on the treadmill than cycle ergometer performed by thirteen healthy subjects (eight men and five women) at RPE of 13.[13] The result of the present study is in agreement with the result reported by Zeni et al. Another study by Katsanos et al. reported that treadmill walking by eleven healthy college males caused a non-significantly higher (at RPE 13) or a significantly higher (at RPE 15) energy expenditure than cycling.[7]

However, Scott et al. reported that when exercise was done by physically active to trained volunteers (thirteen male, one female) on treadmill and cycle ergometer till exhaustion, the energy expenditure at equivalent workload was similar for both the modalities of exercise if the difference in blood lactate level and modified excess post oxygen consumption is also taken into account along with the oxygen uptake.[14]

Increase in cardiac effort increases the myocardial oxygen demand (MVO_2) and RPP is a linear non-invasive correlate of MVO_2 during dynamic exercise.[15] The RPP reactivity and hence cardiac effort in the present study was similar for both the treadmill and cycle ergometer exercise. Studies are sparse on the RPP response to the treadmill and cycle ergometer exercise at RPE of 13. However, two studies have reported that at equivalent submaximal exercise intensity (measured as $\%VO_2$) adult females (17-40 years)[16] and children (7-9 years)[17] show a similar cardiovascular response to the treadmill and cycle ergometer exercise. At low to maximal intensity workload, the systolic BP response is higher[18], while the HR response is lower[19] for cycle ergometer than the treadmill exercise performed by young apparently healthy males. Thus, RPP (product of SBP and HR) might remain the same for the treadmill and cycle ergometer exercise.

In contrast to our results, Reed J. reported that cycling performed at 40-60% HRR by sedentary African women induces greater blood pressure reactivity than the walking[20]. Hermansen et al. reported that at a given submaximal VO_2, cardiac output was similar, but HR was higher for cycling than the walking done by young males.[21] Esco et al. reported that the heart rate variability recovery was more delayed after moderate intensity exercise on cycle than treadmill by fourteen apparently healthy young men.[22] It has been postulated that greater sympathetic stimulation and delayed parasympathetic reactivation occurs after cycling than the walking.

There are several limitations in the present study that includes the estimation of energy expenditure by an equation based on indirect calorimetry, which might lack precision and accuracy. Respiratory gas exchange analysis was obtained during the last two minutes of the exercise as continuous monitoring was not possible due to non-compliance of participants to mouth breathing for thirty minutes. Sample size could have been larger. It is possible that the participants were more familiar with walking than cycling that could have resulted in better adaption to the former mode of exercise.[23] Future studies focusing on different age groups and gender might strengthen the data of the current study.

CONCLUSION

Treadmill walking causes higher energy expenditure with similar cardiac effort as compared to cycling on the ergometer at moderate perceived exertion. The results of the present study might be considered in the exercise prescription to young healthy males.

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