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A comparison of cardiovascular responses and fat oxidation rate induced by the isocaloric treadmill and cycle ergometer endurance exercise

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ABSTRACT

Background: Long duration moderate-intensity aerobic exercise is better called an endurance exercise. The commonest machines used for indoor endurance exercise are treadmill and cycle ergometer. The preferred modality of endurance exercise should be the one that induces higher fat oxidation and lesser cardiovascular response. The aim of the present study is to compare treadmill walking with cycling on the stationary upright ergometer for cardiovascular responses and fat oxidation rate at similar energy expenditure.

Methods: The present experimental cross-sectional study involved physically inactive but otherwise healthy males, aged 20.1±1.8 years having a normal body mass index. Twenty-one participants completed thirty-minutes of treadmill walking and stationary upright cycling on separate occasions to expend approximately 180 Kcal. Systolic blood pressure (SBP), diastolic blood pressure, and heart rate (HR) were recorded just before and immediately after the exercise. Rate pressure product (RPP), a linear correlate of myocardial oxygen uptake, was calculated as the product of SBP and HR divided by 100. Fat oxidation rate was calculated by an indirect calorimetric equation based on the respiratory gas exchange analysis. The paired t-test was applied for comparative analyses. P<0.05 was considered significant.

Results: Treadmill walking caused a significantly lower RPP and HR while a significantly higher fat oxidation rate than cycling on the stationary upright ergometer.

Conclusions: Treadmill endurance exercise could be preferred over cycling for young healthy males. However, further studies are required for the external validity of our results which are approximate rather than precise due to limited resources.

Keywords: Aerobic exercise, Cycling, Rate pressure product, Walking

INTRODUCTION

Physical activity is recognized to have a central role in the multidisciplinary interventions aimed at improving the health-related quality of life. Thirty-minutes of moderate-intensity aerobic exercise every day is recommended for healthy Indian adults. The term

'aerobic' means that the energy demand during exercise is completely met by the oxidative metabolism. However, absolutely aerobic metabolism does not exist during exercise as anaerobic pathways also contribute to the energy production.³ Hence, it is better to use the term 'endurance' for a long duration moderate-intensity exercise that predominantly uses oxidative

phosphorylation to fulfil the metabolic need of the exercising muscle.³

Traditionally, treadmill and cycle ergometer are the commonest machines/mode used in an indoor environment for the endurance exercise. Several studies with different subject characteristics and exercise protocols have reported that walking/running on treadmill results in higher fat oxidation than pedalling on a stationary cycle at submaximal intensity. Further, lower systolic blood pressure (SBP) and heart rate (HR) response to treadmill walking than the cycling exercise had been reported.

The mode of exercise that causes higher fat oxidation with lower cardiovascular demand might be preferred for physically inactive individuals, as decreasing visceral fat could prevent the development of physical inactivity-related health disorders. ¹⁵ There is a scarcity of data from the Indian subcontinent that compares the fat oxidation rate and cardiovascular responses in an endurance exercise on treadmill and stationary cycle by physically inactive young males at similar energy expenditure. The aim of the present study was to bridge that gap.

METHODS

The present experimental cross-sectional study was conducted in the Exercise Physiology Laboratory, Department of Physiology, King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India. The Institutional Ethical Committee granted the clearance to conduct the study in October 2016.

Twenty-five participants were involved in the present study after obtaining a written informed consent from them. Apparently healthy males (determined by the 'Canadian Society's physical activity readiness questionnaire' and physical examination), aged 18-25 years with a normal body mass index (BMI) between 18.5-22.9 kg/m², were recruited from the KGMU. Participants had no history of involvement in the strenuous physical activity for past six months and were physically inactive as assessed by the 'UK health department's general practice physical questionnaire'. There was no family history of the cardiovascular and metabolic disease or history of any disorder (like psychosomatic or neurological) that could have prevented the safe performance of the exercise. Exclusion criteria were the inability to perform exercise at VO₂ (volume of oxygen consumed) of 1.2 L/min with HR not exceeding 60% of the Heart Rate Reserve (HRR), and residual muscle soreness or unwillingness to participate in the study after the familiarisation sessions.

The recommended energy expenditure through physical activity for previously sedentary individuals is 14 to 23 Kcal/kg/week or approximately 1,000 Kcal/week. ^{16,17} Based on the frequency (daily), intensity (moderate), type (aerobic) and duration (thirty-minutes) of the exercise

along with the recommended energy expenditure- a target of approximately 180 (±9) Kcal gross energy expenditure was set for the thirty-minutes of exercise on the treadmill and stationary cycle. ^{2,16,17}

Participants exercised randomly on the motorised treadmill (Pro Bodyline Fitness treadmill 950, Rajasthan, India) and stationary upright cycle with magnetic resistance (Pro Bodyline Fitness upright bike 745, Rajasthan, India). A rest period of fifteen days was provided between the two modalities of the exercise. The data from all the participants were later pooled and segregated into two groups, namely 'cycle' and 'treadmill'. The experimental trial (the day when study variables were recorded) was preceded by four to six familiarisation sessions on alternate days.

During familiarisation sessions, participants were instructed, demonstrated and taught to maintain an upright posture during the treadmill walk without holding the side rails of the treadmill or leaning forward as it distributes the body's centre of mass. Also, they were instructed to lightly hold the handle-bars of the cycle without squeezing them so that the isometric contractions can be minimised. The effect of circadian rhythm on cardiovascular variables was eliminated by scheduling all exercise sessions at the same time of the day. Participants were told to abstain from strenuous muscular activity during the study period.

The speed of the cycle and treadmill was adjusted for each individual during the familiarisation sessions such that a steady VO₂ of approximately 1.2 (±0.06) L/min was obtained for a minute. As approximately 5 Kcal are expended per litre of O₂ consumed, hence, VO₂ of 1.2 L/min would cause an energy expenditure of 180 Kcal in thirty minutes.¹⁸ Participants were not able to breathe through the mouth for a long duration, hence respiratory gas analysis by AD Instruments Exercise Physiology System (New Delhi, India) was confined to a maximum of five minutes. HR was continuously monitored by the pulse transducer (AD Instruments, New Delhi, India). HRR was estimated by subtracting the resting HR from HR_{max}, where HR_{max}=208-0.7×age in years. 19 VO_{2max} could not be estimated, hence moderate-intensity of the exercise was ensured by keeping the HR below 60% of HRR.²⁰ The treadmill was manually inclined at 9% grade, while the resistance of the cycle was set at level 4.

On the test day or the experimental trial, participants came to the exercise laboratory after at least six hours of fasting and twenty-four hours of abstinence from any form of nicotine and caffeine-containing products like cigarettes, coffee, tea and carbonated soft drinks. Participants exercised for thirty minutes on the treadmill or stationary cycle starting with the speed predetermined during the familiarisation sessions. Gas analysis was performed during the first 3-5 minutes of the exercise session to further adjust the speed of the machines so that a steady VO₂ of 1.2 L/min could be achieved. Averaged

breath analysis data during the last two minutes of the experimental exercise trial was used to determine the fat oxidation rate in mg/min by the following equation: [(1.67.VO₂ in L/min)]×1000, urinary nitrogen excretion was considered negligible.²¹

SBP and diastolic blood pressure (DBP) were recorded by an automatic blood pressure monitor (Omron HEM 7130-L, Kyoto, Japan) immediately before and after the experimental exercise trial. Participants were made to sit in a comfortable chair having back and arms support with feet lying flat on the floor; cuff (Omron HEM-RML31) was tied at the level of the heart for the estimation of SBP and DBP. Rate pressure product (RPP), a non-invasive and linear correlate of myocardial oxygen uptake was calculated in arbitrary units (AU) as a product of SBP and HR divided by 100.²²

Statistical analysis

Microsoft Office Excel 2016 was used for the primary data entry and calculations. Statistical analyses were done in IBM SPSS Statistics software for Windows v25. Shapiro Wilk test determined that the data of study variables followed a uniform distribution, hence student or paired t-test was applied for comparative analyses.

Means with standard deviations were reported for the descriptive analyses. P<0.05 was considered significant. All data except that of VO_2 were rounded to the nearest one decimal place.

RESULTS

Table 1: Characteristics of the participants (n=21).

Parameters	Mean±SD
Age (in years)	20.1±1.8
Height (in cm)	167.0±3.2
Weight (in kg)	57.9±4.3
BMI (in kg/m²)	20.8±1.6

BMI: Body Mass Index, SD: Standard Deviation.

Twenty-one participants successfully completed the study. Table 1 represents the anthropometric data of the participants. Table 2 compares the cardiovascular responses after the treadmill and cycle endurance exercise. Also, Table 2 shows that there was no statistical difference in cardiovascular parameters before the treadmill and cycle exercise. Table 3 compares the fat oxidation rate in mg/min and VO₂ in L/min during the last two minutes of the endurance exercise on the treadmill and stationary cycle.

Table 2: Comparison of the cardiovascular responses to treadmill and cycle endurance exercise (n=21).

Parameters	Before treadmill	Before cycle	P value	After treadmill	After cycle	P value
SBP (mmHg)	121.1±7.4	121.4±7.7	0.466	146.6±7.3	149.6±8.1	0.086
DBP (mmHg)	79.2±6.3	79.1±6.1	0.407	77.7±4.5	78.7±4.6	0.142
HR (per min)	79.3±6.5	78.9±6.5	0.259	134.6±7.5	139.1±8.7	0.028
RPP (AU)	96.0±8.8	95.7±9.0	0.516	197. 7±17.8	208.4±21.7	0.045

Data expressed as mean±SD, p<0.05 is significant, paired t-test was applied to compare the means. SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, HR: Heart Rate, RPP: Rate Pressure Product, AU: Arbitrary Unit, SD: Standard Deviation.

Table 3: Comparison of the fat oxidation rate and VO_2 during the last two minutes of endurance exercise on treadmill and cycle (n=21).

Parameters	During treadmill	During cycle	P value
Fat oxidation rate (mg/min)	253.8±109.4	215.7±109.1	0.038
VO ₂ L/min	1.20±0.03	1.20±0.03	0.599

Data expressed as mean±SD, p<0.05 is significant, paired t-test was applied to compare the means. VO₂: Volume of Oxygen consumed during exercise, SD: Standard Deviation.

DISCUSSION

The present study was conducted to compare the cardiovascular responses and the fat oxidation rate, in an endurance exercise bout of thirty minutes on the treadmill with stationary cycle ergometer, by twenty-one physically inactive but otherwise healthy young males, with a target energy expenditure of 180 Kcal. The present study compared responses to treadmill and cycle endurance exercise at similar energy expenditure because it has been postulated that neither intensity nor the modality but total energy expenditure during an exercise

programme is essential for the improvement in cardiovascular health. 23

Cardiovascular response

Our study results demonstrated a non-significantly higher SBP and DBP response, while a significantly higher HR and RPP response to cycle than the treadmill endurance exercise.

Hermansen et al reported that in young males, at a given submaximal VO₂, mean HR was 6-10 beats/min higher in

response to cycle than the treadmill exercise.²⁴ Grant et al reported that at a given oxygen cost the SBP, HR and RPP was higher for cycle than the treadmill exercise done by male subjects following 'Bruce protocol'. 13 Lafortuna et al concluded on the basis of their study results that thirty-four minutes of exercise by obese females with a target energy expenditure of 200 Kcal would result in the mean HR of 122 beats/min on cycle as compared to 110 beats/min on the treadmill.¹⁴ Same study also reported that the HR response to cycle was higher than the treadmill exercise by normal weight women at almost similar VO₂ of 1.2-1.3 L/min. ¹⁴ In another study, Lafortuna et al concluded that a thirty-minute exercise bout by obese adolescents for an energy expenditure of 200 kcal would require a mean HR of about 130 beats/min on cycle while 125 beats/min on the treadmill.⁴

Reed reported that the SBP and DBP reactivity was higher for cycle than the treadmill exercise performed by sedentary African women at 40-60% HRR. ¹¹ Kim et al reported a significantly higher SBP and RPP response to the graded exercise performed by the apparently healthy young males on cycle as compared to the treadmill. ¹² The differences in exercise protocols, subject characteristics and equipment utilised could be an explanation for a non-significant SBP and DBP response obtained in the present study.

Fat oxidation rate

The result of the present study indicates a significantly higher fat oxidation rate in treadmill than the cycle endurance exercise at a comparable VO_2 consumption of 1.2 L/min.

Zakrzewski and Tolfrey reported a higher fat oxidation rate in treadmill than the cycle exercise done by prepubertal children at VO₂ ranging from 0.7 to 1.3 L/min for boys and 0. 6 to 1.0 L/min for girls. Lafortuna et al reported that the treadmill exercise by obese adolescents at VO₂ of 1.10 L/min caused greater fat oxidation than cycle. Cheneviere et al reported a significantly higher fat oxidation in cycling than running at 55-85% of VO_{2max} in moderately trained individuals. Similarly, Achten et al, Capostagno and Bosch, Knechtle et al, and King et al reported a higher fat oxidation in response to treadmill than the cycle exercise. 6.8-10

The exact mechanism of the higher fat oxidation and cardiovascular response to treadmill than the cycle endurance exercise has not been elucidated to date. Koyal et al had reported that the arterial lactate was higher while pH and bicarbonate were lower for cycle than the treadmill exercise at similar VO₂. Higher metabolic acidosis during cycling than walking was attributed to the use of smaller active muscle mass causing the mean metabolic rate per unit of contracting muscles to be greater during the cycle than the treadmill exercise to generate the same power output. Also, it has been

hypothesised that the less efficient type II muscle fibres (fast glycolytic fibres that have a high speed of contraction but low oxidative phosphorylation capacity) are recruited more during cycling leading to a higher accumulation of metabolites than the walking. 8,27,28 Thus, anaerobiosis could be expected to occur earlier during the cycle as compared to the treadmill exercise at equivalent VO₂. 26

A small decrease in pH produces a large reduction in the carnitine palmitoyltransferase-1 activity (considered as a rate-limiting step in the oxidation of long-chain fatty acids) that might contribute to the decrease in fat metabolism during the cycle endurance exercise as compared to the treadmill.²⁹

Greater anaerobiosis during the cycle exercise might have caused the intensified metaboreflex thereby resulting in delayed parasympathetic reactivation and heightened sympathetic activity as compared to the treadmill exercise. Even though the cardiovascular response to exercise is multifactorial, the aforementioned could explain the higher HR and RPP response to cycle than the treadmill exercise.

One of the major limitations of the study is that the respiratory gas analysis was done only during the first 3-5 and last two minutes of the exercise trial as mouth breathing through the mask for thirty-minutes was intolerable to the participants. Biochemical analyses like blood glucose, lactate, and free fatty acid levels were not obtained that could have provided a better insight into the mechanisms explaining the observed findings. The present study involved only physically inactive but otherwise healthy males within a narrow range of age and BMI, hence the data might not be applicable to the general population. The results of the present study are approximate rather than precise due to the involvement of an indirect calorimetric equation for fat oxidation estimation and use of an automated blood pressure monitor to record the cardiovascular responses. Hence, further studies with larger sample size are merited to confirm the findings of the present study.

CONCLUSION

Myocardial oxygen uptake or RPP and HR was significantly lower after the treadmill than the cycle endurance exercise. Further, treadmill resulted in a significantly higher fat oxidation rate than the cycle endurance exercise. The results of our study could be used to design the exercise protocol for physically inactive young males.

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