Effect of Walking and Running on the Cardiorespiratory System, Muscle Injury, and the Antioxidant System after 30 Min at the Walk-Run Transition Speed

Rozangela Verlengia, Lucas de Castro Cardoso, Gustavo Gomes de Araujo, Pamela Roberta Gomes Gonelli, Ivan Gustavo Masselli dos Reis, Claudio Alexandre Gobatto, Maria Imaculada de Lima Montebelo, Philip Newsholme, Marcelo de Castro Cesar

Abstract

Verlengia R, Cardoso LC, de Araújo GG, Gonelli PRG, Reis IGM, Gobatto CA, Montebelo MIL, Newsholme P, Cesar MC. Effect of Walking and Running on Cardiorespiratory System, Muscle Injury, and the Antioxidant System after 30 Min at the Walk-Run Transition Speed. JEPonline 2012;15(5):40-48. This study evaluated aerobic capacity and physiological stress during walking and running at the optimal energy transition speed (OETS) in 10 young men with a mean age of 24.2 ± 2.04 yrs. The subjects underwent five cardiorespiratory treadmill tests; one test to determine the maximal aerobic capacity and four submaximal tests. Two submaximal tests were incremental walking or running tests to determine the subjects' optimal energy transition speeds, and the other two tests were walking or running on a treadmill for 30 min at OETS. Creatine kinase and antioxidant enzyme levels were determined before and immediately after the tests. The findings indicate no significant difference (P>0.05) when running was compared to walking at the OETS. Creatine kinase and antioxidant enzyme levels were not different (P>0.05). The results indicate that walking at the individual OETS may provide benefits to the cardiorespiratory system with little physiological stress in active young men.

Key Words: Aerobic Exercise, Optimal Energy Transition Speed
INTRODUCTION

Although walking and running are popular methods of exercise to improve physical fitness, there are doubts as to what intensity is appropriate to improve metabolic health. Through the analysis of energetic, kinetic movement, and mechanical efficiency research, it is known that walking less 6.0 km·h\(^{-1}\) consumes less energy than running (5). As the intensity is increased, subjects reach a critical speed in which the pace impacts the movement pattern characterized as the walking-running transition (15,26). Treadmill speeds greater than 8 km·h\(^{-1}\) are more efficient in terms of caloric expenditure, oxygen consumption, and mechanical work (3), but the higher speeds cause more muscle damage. This is especially the case when performed at a high intensity that results in increased circulating concentrations of creatine kinase (CK), lactate dehydrogenase (LDH), lipid peroxidation, and protein oxidation (7,10,21).

To better understand the influence of speed in prescribing aerobic exercise for non-athletes, it is important to investigate both the cardiorespiratory responses and the physiological stress. Moreover, at intensities below the walking-running transition, running tends to present values of oxygen consumption slightly higher than at the walk. As fast walking reaches a maximum speed, it begins to exert a greater energy demand (19). Thus, for clinical and safety reasons, choosing the correct form of locomotion is indispensable in the prescription of an exercise program in which individuals exercise at intensities near the walking-running transition.

Traditionally, it has been accepted that moderate exercise between 40-60% of maximal oxygen uptake (VO\(_2\) max) contributes to cardiorespiratory fitness (14) and physical work (12). It was not until 2002 that the American College of Sports Medicine (ACSM) recommended aerobic training 3-5 times per week at an intensity between 60-90% of maximal heart rate (HR max) or 50-85% of VO\(_2\) max (4) to develop and maintain cardiorespiratory fitness in healthy adults. Aerobic training acts as a prophylactic and therapeutic intervention for many chronic diseases, thus contributing to a healthy lifestyle and functional independence (2,12-13).

Walking is a form of exercise that can improve aerobic capacity (16,22). It can also produce health benefits for the elderly (18), including people with chronic diseases such as diabetes, hypertension, and dyslipidemia (33). Although some studies have determined the optimal energy speed in the walking-running transition (28, 25), no studies have yet reported the cardiorespiratory responses and/or acute physiological stress at the optimal speed of walking in a training session compared to the responses obtained from running at the same speed. Thus, the purpose of this study was to evaluate the cardiorespiratory responses, muscle injury, and antioxidant adaptations during 30 min at the walking and running at the same intensity.

MATERIAL AND METHODS

Subjects and Procedures

Ten physically active males 24.2±2.04 yrs of age with a mean height of 180.7±3.8 cm and a mean weight of 79.5±8.6 kg participated in this study. All procedures were approved by the Research Ethics Committee of the Methodist University of Piracicaba according to the current national laws and regulations. The subjects gave written informed consent after receiving both a verbal and a written explanation of the experimental protocol and its potential risks. After answering a health history questionnaire, the subjects performed one maximal and four submaximal cardiorespiratory tests with intervals between 48 and 72 hrs between tests. All tests were performed during the morning between 8-10 a.m. to minimize the effects of diurnal biological variation. Testing occurred in an air-conditioned laboratory on a computerized treadmill (ATL Inbrasport®). Expired gases were measured directly by a
Medical Graphics VO2000® metabolic gas analyzer. Heart rate was determined by telemetry (Polar® Vantage NV).

Maximal Cardiopulmonary Exercise Testing
The subjects performed a graded exercise test (GXT) on the treadmill. The GXT consisted of walking at 5.0 km·h⁻¹ at a 0% grade for 2 min, after which the speed was increased by 1.0 km·h⁻¹ every minute up to 14.0 km·h⁻¹ followed by 2.5% incline per minute increments until exhaustion (27). Maximal oxygen uptake (VO₂ max) was based on at least two of the following criteria: (a) plateau of VO₂ (<2.0 mL·kg⁻¹·min⁻¹) despite an increase in workload; (b) maximal heart rate (HR max) that was within ± 5.0 beats·min⁻¹ of age-predicted maximum HR; (c) respiratory exchange ratio >1.10; or (d) a perceived exertion (RPE) greater than 17 (6-20 scale) (9). The ventilatory threshold (VT) was defined as the VO₂ at which the ventilatory equivalent for oxygen (VE/VO₂) increased without an increase in the equivalent for carbon dioxide (VE/VCO₂) (32).

Determination of Optimal Energy Transition Speed of Walking (OETS)
To determine the individual OETS, the subjects performed two submaximal cardiopulmonary exercise tests. One test was performed while walking and one while running. Both tests followed the protocol of increasing load on a computerized treadmill with an initial load of 5.0 km·h⁻¹ during 2 min followed by increments of 0.5 km·h⁻¹ every minute until 9.0 km·h⁻¹. Recovery consisted of 1 min at 5.0 km·h⁻¹. Five subjects performed the walking test and five performed the running test. The OETS of walking was determined by comparing the VO₂ between walking and running.

Walking and Running Tests to Determine Optimal Cardiopulmonary Responses
Except for water, the tests were performed after fasting for 8 hrs (34). Using the same computerized treadmill, the subjects performed a walking and running test that began with a warm-up of 2 min at 3.0 km·h⁻¹ followed by 30 min at OETS. Recovery consisted of a 2 min walk at 3.0 km·h⁻¹. Five subjects performed the walking test and five performed the running test. Oxygen consumption (VO₂), heart rate (HR), oxygen pulse (VO₂/HR), pulmonary ventilation (VE), ventilatory equivalent for oxygen (VE/VO₂) and ventilatory equivalent for carbon dioxide (VE/VCO₂) were determined during the tests.

Blood Collection
Blood samples were taken from each of the subjects before and immediately after the walking test or the running tests (identified as M1 and M2, respectively). The blood was drawn from the antecubital vein into a 10 mL Vacutainer tube (with Ethylene Diamine Tetra-acetic Acid [EDTA]). Plasma was obtained by centrifugation of the blood at 2,500 rpm for 10 min at 4 ºC. The plasma was then stored at −80 ºC until analysis.

Determination of Activity of Creatine Kinase
The enzyme creatine kinase (CK) was measured spectrophotometrically using a commercial test kit (Laborlab-Products Laboratory Ltda. Guarulhos-SP, Brazil).

Determination of Antioxidant Enzyme Activity
Superoxide Dismutase Activity of plasma was measured by the Cayman SOD Assay kit (706002) utilizing the tetrazolium slat for detection of superoxide radicals generated by xanthine oxidase and hypoxanthine. One unit of SOD was defined as the amount of the enzyme to exhibit 50% dismutation of the superoxide radical. The SOD Assay Measures all three types of SOD (Cu / Zn-Mn and Fe-SOD). The Glutathione peroxidase (GPx) activity of the plasma was measured by the Cayman Glutathione Peroxidase Assay Kit (703102). The GPx activity was indirectly measured by the coupled reaction with glutathione reductase (GR).
Determination of Protein Oxidation
The sulfhydryl group was used to determine the oxidation of proteins. The test was performed according to Faure and LaFond (11). Briefly, an aliquot of 50 µL of plasma was mixed with 1 mL of Tris-EDTA at 1 mM, and the first reading was at 412 nm (A1 reading). Then, 20 mL of 5,5’-ditiobis 2-nitrobenzoic acid (DTNB) at 10 mM was added. After 15 min of incubation at room temperature, a new reading was taken (reading A2). The sulfhydryl group totals were calculated according to the formula A1-A2-B x 1.57 mM, where B = the blank (DTNB and Tris-EDTA).

Statistical Analysis
The data were analyzed using the Shapiro-Wilk test to find values that shows a normal distribution. To compare the data that showed normality, the t-test was used for related samples. For variables that did not have normal distribution, the Friedman test was used. The results were reported as the mean and the standard error of the mean (SEM) of all observations with the level of significance set at P=0.05. The software Biostat 5.1 was used to process the data.

RESULTS

Determination of Aerobic Capacity
The subjects’ results of the maximal cardiorespiratory testing are presented in Table 1. The average OETS of walking was 7.4±0.3 km·h⁻¹ (minimum 7.0 and maximum 8.0 km·h⁻¹).

Cardiopulmonary Responses
Cardiopulmonary exercise testing at submaximal load at each subjects’ OETS was not found to be significantly different, as assessed by VO₂ (mL·kg⁻¹·min⁻¹ and a percentage of VO₂ max), HR (beats·min⁻¹ and percentage of HR max, Table 2) and VO₂/HR, Vₑ, Vₑ/VO₂, Vₑ/VCO₂ (Table 3).

Physiological Stress Response
The activity of creatine kinase, urea and total antioxidant enzymes Superoxide Dismutase and glutathione peroxidase, and the marker of protein oxidation (sulfhydryl group content) are presented in Table 4. No statistically significant differences were observed between walking and running with respect to samples taken in periods before and immediately after the tests.

Table 1. The Standard Error of the Mean of Maximal Cardiorespiratory Testing (n=10).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean ± SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂ max (mL·kg⁻¹·min⁻¹)</td>
<td>48.1 ± 2.28</td>
</tr>
<tr>
<td>HR max (beats·min⁻¹)</td>
<td>189.4 ± 2.43</td>
</tr>
<tr>
<td>VO₂VT (mL·kg⁻¹·min⁻¹)</td>
<td>34.3 ± 1.55</td>
</tr>
<tr>
<td>HRVT (beats·min⁻¹)</td>
<td>155.4 ± 6.36</td>
</tr>
<tr>
<td>Speed VT (km·h⁻¹)</td>
<td>10.2 ± 0.41</td>
</tr>
</tbody>
</table>

VO₂ max - maximal oxygen consumption; HR max - maximal heart rate; VO₂VT - oxygen consumption ventilatory threshold; HRVT - heart rate ventilatory threshold; Speed LV - speed of the ventilatory threshold
### Table 2. The Standard Error of the Mean and Statistical Analysis of Oxygen Consumption and Heart Rate During Walking and Running at Optimal Speed of Walking Energy (n=10).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Walking</th>
<th>Running</th>
<th>P (Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO(_2) (mL·kg(^{-1})·min(^{-1}))</td>
<td>24.5 ± 0.09</td>
<td>25.9 ± 0.06</td>
<td>0.22</td>
</tr>
<tr>
<td>VO(_2)%max (%)</td>
<td>52.0 ± 3.41</td>
<td>54.7 ± 2.43</td>
<td>0.47</td>
</tr>
<tr>
<td>HR (beats·min(^{-1}))</td>
<td>136.8 ± 4.27</td>
<td>135.3 ± 3.00</td>
<td>0.71</td>
</tr>
<tr>
<td>HR%max (%)</td>
<td>74.3 ± 2.06</td>
<td>73.1 ± 1.58</td>
<td>0.59</td>
</tr>
</tbody>
</table>

VO\(_2\) - oxygen consumption; VO\(_2\)%max - the percentage of oxygen uptake in relation to maximal oxygen uptake, HR - heart rate, HR%max - percentage of heart rate in relation to the maximal heart rate.

### Table 3. The Standard Error of the Mean and Statistical Analysis of Cardiorespiratory Variables During Walking and Running at Optimal Speed of Walking Energy (n=10).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Walking</th>
<th>Running</th>
<th>P (Value)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO(_2)/HR (mL·beat)</td>
<td>15.2 ± 0.73</td>
<td>14.7 ± 0.38</td>
<td>0.45</td>
</tr>
<tr>
<td>VE (L·min(^{-1}))</td>
<td>40.2 ± 2.47</td>
<td>43.9 ± 2.31</td>
<td>0.15</td>
</tr>
<tr>
<td>VE/VO(_2)</td>
<td>20.5 ± 0.44</td>
<td>21.0 ± 0.79</td>
<td>0.57</td>
</tr>
<tr>
<td>VE/VCO(_2)</td>
<td>22.3 ± 0.25</td>
<td>22.2 ± 0.63</td>
<td>0.88</td>
</tr>
</tbody>
</table>

VO\(_2\)/HR – oxygen pulse; VE – ventilation; VE/VO\(_2\) – ventilatory equivalent for oxygen; VE/VCO\(_2\) – ventilatory equivalent for carbon dioxide.

### Table 4. Concentrations of Serum CK, SOD, GPx and Sulphydryl Group Pre- and Post-30 Min of Walking and Running (n=10).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Walking</th>
<th>Running</th>
</tr>
</thead>
<tbody>
<tr>
<td>CK (U/L)</td>
<td>84.0 ± 29.9</td>
<td>82.5 ± 38.0</td>
</tr>
<tr>
<td>SOD (U/mL)</td>
<td>3.2 ± 0.67</td>
<td>2.1 ± 0.65</td>
</tr>
<tr>
<td>GPx (U/mL)</td>
<td>884.8 ± 272.5</td>
<td>760.0 ± 413.7</td>
</tr>
<tr>
<td>SULFHYDRYL GROUP (mM)</td>
<td>0.23 ± 0.03</td>
<td>0.22 ± 0.03</td>
</tr>
</tbody>
</table>

CK- creatine kinase; SOD - urea and total antioxidant enzymes Superoxide Dismutase; GPx - glutathione peroxidase. *No statistically significant differences were observed between walking and running with respect to samples taken in periods before and immediately after the tests.

### DISCUSSION

The findings from this study demonstrate that walking at speeds that promote optimal energy utilization is an efficient way to benefit from an aerobic training intensity that does not result in physiological stress in healthy young men. The velocity at OETS was below VT in all subjects, and values for VO\(_2\) and HR during walking at the subjects’ OETS were not significantly different from those during running within the recommended limits for aerobic training (2,4,14). Moreover, the
results indicate that moderate intensity exercise (1) at OETS is sufficient for aerobic training. These results differ from those obtained by Cesar et al. (9). They studied young men and found higher values for VO$_2$ and HR during running, but it should be noted that in the present study a fixed speed of 7.0 km·h$^{-1}$. On the other hand, our results are in agreement with Monteiro and Araújo (20). They found no significant differences in VO$_2$ and HR between walking and running at speeds 0.5 km·h$^{-1}$ below the transition speed between walking and running. Higher values were found only when their subjects walked 0.5 km·h$^{-1}$ above the speed of transition. The VO$_2$ and HR values in our study were close to those reported by Monteiro and Araújo (20).

The $V_E$/VO$_2$ and $V_E$/VCO$_2$ values in the present study did not differ between walking and running. The values are similar to those reported by Wasserman and Whipp (31) in men riding on an ergometer cycle at an intensity below anaerobic threshold, while slightly lower than those obtained by Monteiro and Araújo (20) (at velocities 0.5 km·h$^{-1}$ below and above the transition speed for walking and running). This indicates that the OETS provides a voluntary response appropriate to the energy demand. It also agrees with the results obtained by Monteiro and Araújo (20). They found that there were no significant differences in $V_E$/VO$_2$ and $V_E$/VCO$_2$ responses during walking and running at velocities of 0.5 km·h$^{-1}$ below the transition speed for walking and running (with higher values obtained only when walking at 0.5 km·h$^{-1}$ above the speed of transition).

The results obtained from the damage markers (CK) and oxidative stress (total-SOD, GPX and sulfhydryl group) indicate that the workload performed (walking and running) by individuals did not exceed the metabolic capacity of muscle thus did not cause muscle damage, probability because intensity at OETS was below the VT. Similar data were observed by Balci et al. (2010), who reported an energy demand similar to this study; there were no changes in indicators of oxidative stress and muscle damage. However, several studies demonstrated the presence of markers of oxidative stress and cellular damage following high intensity exercise (17,23-24). Moderate-intensity exercise does not result in oxidative stress and cell damage in healthy young men.

CONCLUSIONS

Given that high intensity running involves a greater degree of physical effort and, therefore, a greater cardiorespiratory overload than walking or a low- to moderate-intensity running exercise, individuals interested in improving their physical fitness should start a walking exercise program before beginning a running program. The OETS appears to represent a safe and appropriate level of aerobic training with a very low risk of injury. Hence, it should be beneficial for individuals who are elderly, sedentary, and/or obese, especially since aerobic exercise is important for the maintenance of metabolic health.

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Address for correspondence: Rozangela Verlengia, Master in Physical Education – FACIS-UNIMEP Campus Taquaral Rodovia do Açúcar, Km 156, s/n, Piracicaba -SP, Brazil. e-mail: rverleng@unimep.br
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