Are Sedentary Women Able to Self-Select a Walking Intensity that Corresponds to Maximal Fat Oxidation (Fatmax)?

Sandro S. Ferreira, Julimar L. Pereira, Ragami C. Alves, Paulo E. Redkva, Hassan M. Elsangedy, Kleverton Krinski, Tácito P. Souza Junior, Cosme F. Buzzachera, Sergio G. da Silva

Centro de Pesquisa em Exercício e Esporte (CEPEE) – Universidade Federal do Paraná (UFPR) – Curitiba – PR. Brasil

ABSTRACT

Ferreira SS, Pereira JL, Alves RC, Redkva PE, Elsangedy HM, Krinski K, Souza Junior TP, Buzzachera CF, da Silva SG. Are Sedentary Women Able to Self-Select a Walking Intensity that Corresponds to Maximal Fat Oxidation (Fatmax)? JEPonline 2013;16(2):32-39. Adults engage in exercise programs not only to improve health, but also to lose or maintain body fat mass. There is the tendency for subjects to exercise at a self-selected a pace rather than a prescribed intensity. The purpose of this study was to determine if sedentary women could self-select a walking intensity that corresponds to Fatmax. This study consisted of 22 adult women with an average age of 42.91 ± 44 yrs. Each subject performed a maximal incremental test to exhaustion and a session of exercise at their self-selected walking pace. Data from the maximal test were used to determine Fatmax and Fatzone. The t test was used to determine differences between the subjects’ self-selected walking pace and the predicted walking speed at Fatmax. Fatmax occurred at 51.3 ± 7.2% of VO\(_2\)\(_\text{max}\) and Fatzone between 46% and 56% of VO\(_2\)\(_\text{max}\). The intensity of the self-selected walking pace was 5.06 ± 0.65 km·h\(^{-1}\), which corresponded to 51.3% VO\(_2\)\(_\text{max}\) and to 66.8% HR max. These findings indicate that sedentary women can self-select a walking intensity that corresponds to an exercise intensity that elicits maximal fat oxidation (Fatmax).

Key Words: Fat Oxidation, Exercise Intensity, Exercise Regulation
INTRODUCTION

Regular exercise is an essential component to the maintenance of a healthy lifestyle (13,19). With the advance of age, physical conditioning and physiological capacities decrease while the percent of body fat increases (16). Hence, it is important that adults initiate an exercise program not only to improve health, but also to lose or maintain body fat mass (8). In an attempt to find strategies to maximize the loss of body fat during exercise, Achten and Jeukendrup (15) introduced the term Fatmax. The concept Fatmax corresponds to the exercise intensity that occurs at the highest rate of maximal fat oxidation (MFO). This relation between the intensity of exercise and MFO rate is based on the intensity where the rate of glycolysis begins to increase sharply due to the necessity of rapid energy supply in response to the increase in exercise intensity (15,22).

In spite of the importance of adequate physiological stimuli for modifications in cardiorespiratory conditioning and body fat, studies have shown there is the tendency for those who are interested in exercise programs to self-select intensities (5). The self-selection has been demonstrated to be related to the production of positive parameters of effort perception and affection (i.e., pleasure vs. unpleasure). Hence, the self-selective process may contribute to increase the individual’s intrinsic motivation to adhere to a regular exercise program (20,21). In particular, this appears to be the case in obese individuals, sedentary women, and older adults (10,11).

In sedentary women, walking has been preferred as a regular activity due to its low risk of injury and relatively easy performance (2). Moreover, it has been used as an intervention strategy in numerous scientific research papers (6-8). Given these considerations, the purpose of this study was to verify whether sedentary women self-select a walking intensity that corresponds to Fatmax.

METHODS

Subjects
Twenty-two female adults participated in this study. They were between the age of 30 and 50 yrs old. Recruitment of the subjects was conducted through personal invitations and printed ads in community groups and centers of cohabitation churches. This study was approved by the Research Ethics Committee of the Federal State University of Paraná, and it was carried out after the explanation of the objectives, experimental procedures, possible risks, and benefits. The following inclusion criteria were established prior to the study getting underway:

- The condition of the subjects as sedentary at the beginning of the study.
- An interest in physical activity that was lower than 30 min of moderate physical activity 3 or more days a week.
- A total of negative responses to the Physical Activity Readiness Questionnaire (PARQ).
- Not taking medications that influence metabolic and/or cognitive functions.
- Eumenorrheic for at least 6 mth, and
- Not using tobacco for at least 6 mth.

Procedures
An ex post facto design (25) was used for this study. Each subject performed three experimental sessions scheduled on different days. During the session #1, the subjects underwent an initial triage, familiarization with the treadmill, and anthropometric measurements. The completion of the second session involved an incremental test to voluntary exhaustion to determine physiological variables. In
the session #3, the subjects developed a 30-min walk at their individual self-selected pace on a treadmill. All experiments were conducted in the morning between 8 am and 12 am and under similar environmental conditions (21°C and 60% relative humidity). All subjects were instructed to refrain from exercise, avoid products containing caffeine for 24 hrs before the tests, and report to the laboratory after a period of overnight fast of 10 to 12 hrs.

In all the laboratory procedures, the analysis of the gases was measured breath-by-breath using a gas analyzer ParvoMedics (TrueOne Metabolic Measurement System® 2400 – USA). The equipment was calibrated with known gas samples containing 3.98% CO\textsubscript{2} and 16.02% O\textsubscript{2} while the ventilation flow was calibrated using a syringe with a volume of 3 L (Håns Rudolf, USA). In all tests, strong verbal encouragement was used to motivate the subjects to perform maximum efforts until volitional exhaustion.

**Anthropometric Measurements**
Height (cm, Sanny stadiometer™, São Paulo, Brazil) and body mass (kg, Toledo balance™, São Paulo, Brazil) were measured according to the techniques described by Gordon et al. (14). Body mass index (BMI, kg·m\textsuperscript{-2}) was calculated as body mass divided by the stature squared. Body density was measured using the method of skinfold thickness (biceps, triceps, subscapular, and suprailiac), according to the equation proposed by Durnin and Womersley (9). Subsequently, the percentage of body fat was obtained using the Siri equation (23). Seeking to avoid inter-rater variations, all the measurements were obtained by a single evaluator who was previously trained.

**Determination of VO\textsubscript{2} Max**
An incremental test to exhaustion on a treadmill was performed using the standard protocol proposed by Bruce (4) for the determination of VO\textsubscript{2} max. The subjects were verbally encouraged to exercise until they could no longer sustain the exercise intensity. Voluntary exhaustion was established in the subjects at the moment that they reached for the sidebars and withdrew their feet from the treadmill. During the incremental test, heart rate was monitored by a beat-beat frequency (Polar Electro™, Oy, Finland). The VO\textsubscript{2} max was considered the highest average during the last 30 sec of exercise with at least two of the criteria obtained: (a) HR = maximal age-predicted HR (220-age); (b) respiratory gas exchange ratio = 1.10; and (c) plateau (variations = 2.1 mL·kg\textsuperscript{-1}·min\textsuperscript{-1} between the last 2 exercise stages) (18).

**Determination of Fatmax**
Expired gases were averaged every minute for VO\textsubscript{2} (L·min\textsuperscript{-1}) and VCO\textsubscript{2} (L·min\textsuperscript{-1}) throughout the incremental test to exhaustion. The oxidation of fat and carbohydrate was estimated using a stoichiometric equation (12), with the assumption that the rate of nitrogen excretion in urine was insignificant. For each subject, a polynomial adjusted curve was built showing the rate of fat oxidation (expressed in g·min\textsuperscript{-1}) versus the exercise intensity expressed as %VO\textsubscript{2} max. For each subject, the curve was used to obtain the following variables:

- Maximum fat oxidation (MFO)
- Fatmax (the intensity of exercise in which the MFO was observed), and
- Fatzone interval of exercise intensities with the fat oxidation rates within 10% variation of rates of MFO

**30-Min Walk on a Treadmill at Self-Selected Pace**
Initially, a warm-up was conducted for 5 min at a speed of 4 km·h\textsuperscript{-1}. After that, the subjects were instructed to self-select a walking pace according to the procedures of Pintar et al. (21). The test
started at a speed of 4 km·h⁻¹, allowing the subjects to adjust the speed freely, so that they could
determine a pace that was considered comfortable for a period of 30 min of exercise. Adjustments
were made during the 1st min walking and, then, in the following minutes 00:05, 00:10, 00:15, 00:20,
and 00:25. The speedometer was covered so the subjects were blinded to the actual treadmill speed
(21). The physiological variables were determined using the same laboratory instruments and
procedures of the incremental treadmill test. Physiological responses were reduced to averages of
the last 2 min in intervals of 15 sec of the respective stages and, then, it was calculated as general
averages using these values to represent the 30-min walk of the group.

**Statistical Analyses**

As to data analysis, descriptive statistics was used to characterize the subjects’ average ± standard
deviation. The normality was verified with the Shapiro Walk test. With the normal distribution of data,
the Student $t$ test was used to check similarities between walking speed in a self-selected pace. All
the data were analyzed using SPSS statistical pack version 17.0 (SPSS, Inc., Chicago, USA) for
Windows.

**RESULTS**

The subjects’ demographic, anthropometric, and physiological characteristics are shown on Table 1.
In Table 2, the values are related to the physiological responses of the self-selected walking speed
and its relation to the Fatmax. The results indicate that sedentary women self-selected an intensity
that corresponds to the zone that occurs the maximum fat oxidation, the Fatmax (51.6 ± 3.5% vs.
51.3 ± 7.2% VO₂ max, respectively, P=0.918). The $t$ test showed no significant differences between
the self-selected walking pace and Fatmax. Figure 1 shows the relation between self-selected
walking and the Fatmax.

**Table 1. Descriptive Characteristics of Participants and Physiological Responses at the End
of a Maximal Exercise Test.**

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average ± SD</th>
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<th>Average ± SD</th>
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<tbody>
<tr>
<td>Age (y)</td>
<td>42.91 ± 4.4</td>
<td>FFM (kg)</td>
<td>45.46 ± 4.9</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>61.92 ± 8.7</td>
<td>Fat mass (kg)</td>
<td>16.45 ± 4.5</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>158 ± 5.0</td>
<td>VO₂ max (mL·kg⁻¹·min⁻¹)</td>
<td>28.74 ± 5.5</td>
</tr>
<tr>
<td>BMI (kg·m⁻²)</td>
<td>24.82 ± 3.0</td>
<td>RER</td>
<td>1.19 ± 0.09</td>
</tr>
<tr>
<td>Body fat (%)</td>
<td>26.13 ± 4.6</td>
<td>HR max (beats·min⁻¹)</td>
<td>177.5 ± 11.3</td>
</tr>
</tbody>
</table>

BMI = body mass index; FFM = fat-free mass; VO₂ max = maximal oxygen consumption; RER =
respiratory exchange ratio; HR max = maximal heart rate. The data are expressed as average ± SD.
Table 2. Physiological Responses to the 30 Minute Walk on a Treadmill at Self-Selected Pace and Percentage Exercise with Maximum Fat Oxidation (Fatmax).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Average ± SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂ (mL·kg⁻¹·min⁻¹)</td>
<td>13.3 ± 3.5</td>
</tr>
<tr>
<td>%VO₂ max</td>
<td>51.6 ± 3.5</td>
</tr>
<tr>
<td>HR (beats·min⁻¹)</td>
<td>118.3 ± 16.0</td>
</tr>
<tr>
<td>%HR max</td>
<td>66.8 ± 9.4</td>
</tr>
<tr>
<td>Treadmill speed (km·h⁻¹)</td>
<td>5.06 ± 0.65</td>
</tr>
<tr>
<td>Fatmax (%VO₂ max)</td>
<td>51.3 ± 7.2</td>
</tr>
</tbody>
</table>

VO₂ = oxygen consumption; VO₂ max = maximal oxygen consumption; HR = heart rate; HR max = maximal heart rate. The data are expressed as average ± SD.

DISCUSSION

Currently, many researchers are focusing their studies on self-selected walking (6,10) with the aim of promoting greater adherence to physical activity programs. This method has been presented as being relevant. Meanwhile, intensities of self-selected walking exercises still diverge in a variety of different investigations. Fortunately, the studies that undergird the Fatmax analysis expand the perspectives related to exercise and fat metabolism (15,22).
In particular, low to moderate exercise intensity is scientifically recognized as the appropriate intensity to maximize the contribution of fat metabolism. Whether instinctively or as a direct result of the subjects’ physiological capacity, the self-selected intensity of low to moderate exercise complement the oxidative energy source for muscle contraction and Fatmax (6). Yet, up to the present moment, only a few studies have sought to demonstrate this physiological connection.

The objective of this research was to determine if sedentary women were able to self-select a walking intensity that corresponded to Fatmax. The statistical findings indicate that this was the case. The challenge is to understand the literature related to Fatmax and the different protocols and subjects with different characteristics that complicate comparisons with the other studies.

Although there are differences among the various studies, there are, in a general way, similar values in the percentage of the VO$_2$ max for the zone of maximum fat oxidation. Achten and colleagues (1) justify this fact in their study that reported the Fatmax zone occurred early in the tests for both maximal cycle ergometer and treadmill. Yet, despite the physiologic problems of finding research with similar characteristics to the present study, as well as protocol and subjects, Venables et al. (26) found that Fatmax at 52% VO$_2$ max. In another study, Stisen et al. (24) reported in untrained females a Fatmax at 53% of VO$_2$ max. Then, too, Bogdanis (3) observed a Fatmax zone between 27% and 44% of VO$_2$ max. In this regard, though, it is possible that these results were influenced by the BMI of the overweight subjects. Thus, there seems to be a rather large range of subject fitness status that contributes to the maximization of fat oxidation and, therefore, health and well-being (17,20,21).

CONCLUSION

The findings of this study indicate that the sedentary adult women were able to self-select an exercise intensity that was complimentary to the oxidation of fat, which supports the basic thinking that underpins the concepts of Fatmax and Fatzone. The practical importance of these findings should help guide the planning and monitoring of the exercise programs for the population at large for health and well-being.

Address for correspondence: Sergio Gregorio da Silva, Departamento de Educação Física, Universidade Federal do Paraná, Rua Coração de Maria, 92, CEP: 80215-370 - Curitiba, PR, Brasil, Telefone, +55 41 3360-4331, Email: sergiogregorio@ufpr.br

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