Recommendations for Aerobic Endurance Training Based on Subjective Ratings of Perceived Exertion in Healthy Seniors

Lars Donath, Lukas Zahner, Mareike Cordes, Henner Hanssen, Arno Schmidt-Trucksäss, and Oliver Faude

The study investigated physiological responses during 2-km walking at a certain intensity of a previously performed maximal exercise test where moderate perceived exertion was reported. Twenty seniors were examined by an incremental walking treadmill test to obtain maximal oxygen uptake ($\text{VO}_2\text{max}$). A submaximal 2-km walking test was applied 1 wk later. The corresponding moderate perceived exertion (4 on the CR-10 scale) during the $\text{VO}_2\text{max}$ test was applied to the 2-km treadmill test. Moderate exertion (mean rating of perceived exertion [RPE]: 4 ± 1) led to 76% ± 8% of $\text{VO}_2\text{max}$ and 79% ± 6% of maximal heart rate. RPE values drifted with a significant time effect ($p = .001$, $\eta_p = .58$) during the 2-km test from 3 ± 0.7 to 4.6 ± 0.8. Total energy expenditure (EE) was 3.3 ± 0.5 kcal/kg. No gender differences in ventilatory, heart-rate, or EE data occurred. Brisk walking at moderate RPE of 3–5 would lead to a beneficial physiological response during endurance training and a weekly EE of nearly 1,200 kcal when exercising 5 times/wk for 30 min.

Keywords: exercise intensity determination, 2-km walking test, maximal oxygen uptake, maximal heart rate

Demographic changes mostly found in industrial countries have led to a higher proportion of older adults that will have a serious effect on the health care system (Reinhardt, 2003). Projections up to the year 2050 suggest a nearly twofold increase of people age 65+ years in the United States alone (Lutz, Sanderson, & Scherbov, 2008). Cardiovascular disease, coronary heart disease, myocardial infarction, heart failure, cancer, and stroke are still serving as the leading causes of morbidity and mortality in this age group (Yazdanyar & Newman, 2009). Physical inactivity has been called to be the biggest public health problem of the 21st century (Blair, 2009) and is widely accepted as a main contributing behavioral risk factor to increasing mortality and morbidity rates in the elderly (Kruger, Ham, & Sanker, 2008).

Many epidemiological case-control and observational studies suggest regular physical activity to achieve health benefits, maintain daily physical and mental functioning, sustain a high quality of life, and refrain from frequent use of health care services.
Aerobic Endurance-Training Recommendations

...care services (American College of Sports Medicine [ACSM], 1998; Martin, Powell, Peel, Zhu, & Allman, 2006; Sari, 2010). Therefore, specific exercise-training guidelines and recommendations for elderly people have been published in the last few years (Chodzko-Zajko et al., 2009; Nelson et al., 2007a).

Aside from recommending adequate strength, balance, and flexibility training, these mainly preventive guidelines also suggest moderate aerobic-exercise training in older people. Depending on the body system (e.g., cardiac diseases, hypertension, diabetes mellitus, obesity, bone health) and publishing society (e.g., American Geriatrics Society, American Heart Association, American Diabetes Association, American College of Sports Medicine), there is a wide range of training frequencies (3–7 days/week), durations (30–60 min/session, at least 10-min bouts), and intensities (3–6 metabolic equivalents, 50–85% HR_{max}, 60–80% VO_{2max}, and 40–60% HR_{reserve}, as well as 40–85% VO_{2reserve}) used to prescribe moderate aerobic exercise in healthy adults, seniors, and patients. For older adults, however, the relationship between certain exercise intensities during submaximal exercise at a moderately perceived exertion level and its association with established aerobic-exercise intensity recommendations has not yet been disentangled.

Consequently, the current study was conducted to compare submaximal cardioventilatory response to walking 2 km at a constant submaximal load, with a rating of perceived exertion (RPE) of 4 on the CR-10 Borg scale. We derived this moderate perceived-exertion level from a previously conducted exhaustive age-adapted ramp-exercise protocol on a treadmill. On one hand, we would comparatively investigate these RPE-related metabolic, ventilatory, and heart-rate (HR) responses to provide information on the interdependency between frequently recommended moderate aerobic-exercise intensity and moderate perceived-exertion level. On the other hand, the occurrence of gender differences of physiological responses needed to be elucidated in healthy seniors. We planned to measure total energy expenditure to deliver a global and relevant physical activity measure. Finally, we intended to propose a valid, feasible, and nontechnical approach to prescribe a moderate aerobic-exercise intensity based on moderate RPE ratings. Such a procedure would be inexpensive and easily applicable in everyday life regarding preventive health-related aerobic-exercise training.

**Methods**

**Subjects**

The Physical Activity Readiness Questionnaire, medical history, and physical examination were conducted in 20 active participants (Table 1) who took part in the current study. The included seniors had to be retired, healthy, and 60–70 years of age, without any history of hypertension, cardiac disease, or artificial knee or hip joints. By means of clinical examination, no one reported any health impairments such as orthopedic, neurologic, and internal diseases. Moreover, all participants underwent a 12-lead electrocardiogram (ECG) during rest. No adverse cardiac events were observed. The participants were asked to refrain from intense exercise in the 72 hr before the examinations. The study was approved by the local ethics committee of the medical faculty of the University of Basel (Switzerland) and complied with the Declaration of Helsinki. All participants signed an informed written consent before start of the study.
Study Design

All participants were examined on 3 days at weekly intervals. Throughout the study, measurements were performed at the same time of day for each individual. With respect to the required exercise ECG and maximal-exercise performance parameters, the first day was obligatorily set as a maximal-exercise test. Before starting maximal-exercise testing, we applied the Freiburger Physical Activity Questionnaire (Frey, Berg, Grathwohl, & Keul, 1999) to avoid gender heterogeneity in physical activity patterns. This questionnaire allows the retrospective (previous week) estimation of physical activity behavior by assessing the minutes or hours of walking, cycling, swimming, gardening, dancing, and stair climbing per week. Specifically performed sports (tennis, squash, football, jogging, badminton, gymnastics, etc.) can be additionally indicated in hours per week. On the second and third days, either the submaximal 2-km walking test or the resting control condition was randomly conducted.

Maximal, Submaximal, and Resting Testing Procedures

On the first day, an exhaustive ramp-exercise test on a treadmill (h/p Cosmos, Pulsar 4.0, HP-Cosmos Sports & Medical GmbH, Nussdorf-Traunstein, Germany) was performed to examine maximal-exercise capacity. To detect potential exercise-induced adverse cardiac events, a 12-lead ECG (Custo cardio 100, Custo med GmbH, Ottobrunn, Germany) was continuously monitored. To obtain maximal-exercise parameters, a well-established age-adapted exercise protocol was applied. This walking-based “pepper protocol” combines increased inclination and velocity and is described in detail elsewhere (Peterson, Pieper, & Morey, 2003). Briefly, this exercise protocol started with an inclination of 0% and a velocity of 1.5 miles/hr (~2.4 km/hr). Intensity was increased every minute by elevating either treadmill inclination or treadmill velocity until subjective maximal exhaustion was reported. After participants were instructed on the use of the RPE scale, perceived exertion level was assessed every minute at the end of each incremental exercise step. Due to the spirometric facemask, subjects had to silently point with a finger to the respective perceived exertion level. After reaching objective maximal-exhaustion levels, subjects maintained walking for an additional minute at lower intensities to avoid orthostatic complications. According to Midgley, McNaughton, Polman, and Marchant (2007), at least two of four objective exhaustion criteria had to be reached: ≥100% of the age-predicted maximal HR (Tanaka, Monahan, & Seals,

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Table 1  Anthropometric Data of the Participants, M ± SD

<table>
<thead>
<tr>
<th></th>
<th>Women (n = 10)</th>
<th>Men (n = 10)</th>
<th>Total (N = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>64.6 ± 3.7</td>
<td>65.0 ± 3.0</td>
<td>64.8 ± 3.2</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>63.2 ± 10.1</td>
<td>76.2 ± 7.5</td>
<td>69.7 ± 10.9</td>
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<tr>
<td>Height, m</td>
<td>1.62 ± 0.05</td>
<td>1.79 ± 0.05</td>
<td>1.70 ± 0.10</td>
</tr>
<tr>
<td>Body-mass index, kg/m²</td>
<td>24.1 ± 3.5</td>
<td>23.9 ± 2.5</td>
<td>24.0 ± 3.0</td>
</tr>
<tr>
<td>Physical activity, hr/week</td>
<td>12 ± 6</td>
<td>10 ± 6</td>
<td>11 ± 6</td>
</tr>
</tbody>
</table>

Note. Physical activity was derived from the Freiburger Physical Activity Questionnaire and the sum score of the validated German version of the Falls Efficacy Questionnaire.
2001), the ventilatory equivalent of oxygen uptake (VO\textsubscript{2}) $\geq 35$, $\geq 1.1$ of the respiratory exchange ratio (RER), and RPE $\geq 9$.

A submaximal 2-km walking test was conducted on the same treadmill as the maximal-exercise testing procedure. The goal was to arrive at an exercise intensity of moderate perceived exertion (related to a moderate CR-10 value of 4). The corresponding velocity and inclination of this RPE value during the maximal-exercise test were then used to apply a constant workload (exercise intensity) for the 2-km exercise test. The subjects had to perform at this exercise intensity for the test duration. The perceived exertion level was requested every 5 min. For this reason, the 10-point RPE scale (CR-10) was applied (Borg, 1998). In addition, HR was continuously assessed using an HR monitor (Accurex Plus, Polar Electro-Oy, Kempele, Finland).

The resting control measurement was conducted on either the second or the third day to achieve HR and ventilatory baseline data. These baseline data are required to calculate HR and VO\textsubscript{2} reserve. Therefore, silence was kept in the examination room and a comfortable temperature was maintained between 21 and 24 °C. Spirometric data were collected while the participant was in the supine position within a time frame similar to that of the individuals’ 2-km exercise test.

### Outcome Parameters

Maximal exhaustive ventilatory parameters (VO\textsubscript{2}, carbon dioxide output [VCO\textsubscript{2}], RER, minute ventilation, breathing frequency, and metabolic equivalents metabolic equivalents) were collected breath by breath using a stationary spiroergometry system (Metamax 3B, Cortex, Leipzig, Germany). Gas- and volume-sensor calibrations of the spiroergometric system were conducted in the morning of every testing day. A predefined calibration gas mixture (5% carbon dioxide, 15% oxygen, 79% nitrogen) and ventilated volume (3-L bellow) were applied according to manufacturers’ recommendations. Spiroergometric breath-by-breath data were averaged to provide data points for every 10-s time interval. The mean of the highest three consecutive VO\textsubscript{2} values within a 30-s time frame of the final exercise step was regarded as the VO\textsubscript{2max}. We similarly proceeded with the other peak ventilatory parameters. Accordingly, the highest recorded HR and RPE were considered maximal values. Absolute and relative power output, exercise time, and treadmill slope and velocity were included in the analyses as relevant performance parameters. To achieve velocity- and inclination-referring power-output data in Watts, we used the formula provided by Lorenz, Franz, Krieger, Zeilberger, and Jeschke (2007). In terms of providing valid submaximal-exercise parameters, the first (VT\textsubscript{1}) and second (VT\textsubscript{2}) ventilatory thresholds were also computed (Beaver, Wasserman, & Whipp, 1986).

The same outcome variables were calculated during the 2-km walking test as during maximal-exercise testing. Therefore, the last 30 s of the oxygen uptake and heart rates of the 5th, 10th, 15th, 20th, and 25th minutes of exercise were included in the analysis. Three subjects who performed faster did not complete the 25th minute. In this case, the average of the last 30 s of exercising was analyzed. To provide an appropriate physical activity measure, the absolute energy expenditure (EE; kcal) and relative EE (kcal/kg) were also calculated using the Weir’s (1949) formula. Finally, the submaximal-exercise session was specified as a percentage of VO\textsubscript{2max}, VO\textsubscript{2} reserve, HR\textsubscript{max}, and HR reserve, as well as relative to the VT\textsubscript{1} and VT\textsubscript{2}. Therefore, the ventilatory and HR variables were averaged from the fifth exercise minute to the end of submaximal-exercise testing.


**Determination of VTs, VO\textsubscript{2}, and HR Reserve**

VT\textsubscript{1} was obtained from the VCO\textsubscript{2}–VO\textsubscript{2} plot, using the V-slope technique (Beaver et al., 1986). Analogously, VT\textsubscript{2} was assessed by plotting minute ventilation (y axis) over the course of carbon dioxide production. The corresponding VO\textsubscript{2} value was also provided. According to Karvonen, Kentala, and Mustala (1957), HR reserve was calculated as the difference between HR\textsubscript{max} and HR\textsubscript{rest}. To adequately determine HR reserve during the ramp-exercise test, actual resting HR was taken from the resting period on the control testing day. Thereby, the lowest three consecutive HR values within a time frame of 30 s were averaged to achieve HR\textsubscript{rest}. We proceeded accordingly to determine VO\textsubscript{2} reserve. To calculate submaximal percentage levels of HR and VO\textsubscript{2} reserves, we applied the following formulas to the HR and VO\textsubscript{2} data, respectively (da Cunha, Farinatti Pde, & Midgley, 2011):

\[
\frac{HR_{\text{sub}} - HR_{\text{rest}}}{HR_{\text{max}} - HR_{\text{rest}}} \times 100\% \quad \frac{VO_{2\text{sub}} - VO_{2\text{rest}}}{VO_{2\text{max}} - VO_{2\text{rest}}} \times 100\%
\]

**Statistical Analysis**

Maximal and submaximal ventilatory (VO\textsubscript{2}, breathing frequency, minute ventilation, and RER), HR, performance (time for 2-km walking test, power output), and RPE parameters were tested for normal distribution using Kolmogorov-Smirnov’s test and Levene’s test to test for homogeneity of variance. Both tests revealed normally distributed parameters and homogeneity of variance. An unpaired \(t\) test evaluated gender-dependent differences of ventilation, HR, performance, and RPE variables at maximal and submaximal exercise level. To estimate the effect sizes of the gender differences for the respective parameter, Cohen’s \(d\) (trivial, \(d < .2\); small, \(.2 \leq d < .5\); moderate, \(.5 \leq d < .8\); large, \(d > .8\)) was also calculated.

Furthermore, separate repeated-measured analyses of variances (rANOVA) with time as the repeating factor (5th, 10th, 15th, 20th, and 25th minutes) were conducted to analyze the change in \(\%HR_{\text{max}}, \%VO_{2\text{max}}, \%HR_{\text{rest}}, \%VO_{2\text{rest}}\) over time during the 2-km test. Tukey’s honestly significantly different post hoc tests were performed on significant main ANOVA effects. Eta-squared effect size was also calculated for each parameter for the time factor.

**Results**

**Physiological Response to the Maximal Incremental Walking Test**

Maximal and calculated submaximal performance parameters, as well as the mean exercise time and treadmill inclination/velocity, are provided in Table 2. All participants reached at least two of the four included objective exhaustion criteria. Gender differences were only found for absolute power output (\(t = -3.5, \, df = 18, \, p = .003, \, d = 1.56\), VO\textsubscript{2max} (\(t = -3.0, \, df = 18, \, p = .01, \, d = 1.40\), RER (\(t = -2.3, \, df = 18, \, p = .04, \, d = 1.15\), and VT\textsubscript{2} (\(t = -2.9, \, df = 18, \, p = .01, \, d = 1.38\)). These differences disappeared when we adjusted for body weight.
Physiological Response to the Submaximal 2-km Walking Testing

Average submaximal physiological performance parameters, as well as exercise time and treadmill slope/velocity data, are given in Table 3. Thereby, physiological response was also provided as percentages of HR\textsubscript{max} and VO\textsubscript{2max}, HR\textsubscript{rest} and VO\textsubscript{2rest}, and VT\textsubscript{1} and VT\textsubscript{2}. Absolute EE ($t = -2.23$, $df = 18$, $p = .04$, $d = 1.07$) also differed during submaximal exercise between male and female subjects, but not when related to body weight (Table 3). Percentage values of relevant exercise prescription parameters did not reveal gender differences (Table 3). The consumed relative EE amounts to nearly 3.5 kcal/kg within a total exercise time of about 30 min (Table 3). A significant time effect for %HR\textsubscript{max}, $F(4, 76) = 3.26$, $p = .02$, $\eta_p = .15$, but not for %VO\textsubscript{2max}, $F(4, 76) = 0.85$, $p = .50$, $\eta_p = .05$, during the submaximal exercise was observed. In addition, a time effect, $F(4, 76) = 26.1$, $p = .001$, $\eta_p = .58$, was found for RPE values (Figure 1). However, post hoc testing merely revealed...
<table>
<thead>
<tr>
<th></th>
<th>Women ($n = 10$)</th>
<th>Men ($n = 10$)</th>
<th>Total ($N = 20$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate, beats/min</td>
<td>131 ± 9</td>
<td>124 ± 10</td>
<td>127 ± 9</td>
</tr>
<tr>
<td>VO$_2$, L/min</td>
<td>1.32 ± 0.52**</td>
<td>1.82 ± 0.29</td>
<td>1.57 ± 0.48</td>
</tr>
<tr>
<td>VO$_2$, ml · min$^{-1}$ · kg$^{-1}$</td>
<td>23.2 ± 4.4</td>
<td>24.7 ± 4.2</td>
<td>24.0 ± 4.3</td>
</tr>
<tr>
<td>Rating of perceived exertion</td>
<td>3.7 ± 0.8</td>
<td>4.3 ± 0.9</td>
<td>4.0 ± 0.9</td>
</tr>
<tr>
<td>Respiratory exchange ratio</td>
<td>0.90 ± 0.10</td>
<td>0.98 ± 0.10</td>
<td>0.94 ± 0.10</td>
</tr>
<tr>
<td>Breathing rate, breaths/min</td>
<td>30 ± 5</td>
<td>29 ± 7</td>
<td>29 ± 6</td>
</tr>
<tr>
<td>MET, 3.5 ml O$_2$ · min$^{-1}$ · kg$^{-1}$</td>
<td>6.6 ± 1.3</td>
<td>7.1 ± 1.2</td>
<td>6.9 ± 1.2</td>
</tr>
<tr>
<td>Power output, W</td>
<td>117 ± 18***</td>
<td>150 ± 33</td>
<td>134 ± 31</td>
</tr>
<tr>
<td>Power output, W/kg</td>
<td>1.8 ± 0.4</td>
<td>2.0 ± 0.7</td>
<td>1.9 ± 0.6</td>
</tr>
<tr>
<td>Energy expenditure, kcal</td>
<td>207 ± 36*</td>
<td>246 ± 39</td>
<td>228 ± 42</td>
</tr>
<tr>
<td>Energy expenditure, kcal/kg</td>
<td>3.3 ± 0.5</td>
<td>3.2 ± 0.5</td>
<td>3.3 ± 0.5</td>
</tr>
<tr>
<td>Exercise time, min</td>
<td>28.5 ± 4.0</td>
<td>26.6 ± 3.0</td>
<td>27.5 ± 3.6</td>
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<tr>
<td>Treadmill velocity, km/hr</td>
<td>4.4 ± 0.6</td>
<td>4.6 ± 0.6</td>
<td>4.5 ± 0.6</td>
</tr>
<tr>
<td>Treadmill slope, %</td>
<td>12.1 ± 2.0</td>
<td>13.4 ± 2.8</td>
<td>12.7 ± 2.5</td>
</tr>
<tr>
<td>%VO$_2$max</td>
<td>75 ± 8</td>
<td>76 ± 5</td>
<td>76 ± 8</td>
</tr>
<tr>
<td>%VO$_2$ reserve</td>
<td>75 ± 12</td>
<td>79 ± 9</td>
<td>78 ± 10</td>
</tr>
<tr>
<td>% maximal heart rate</td>
<td>79 ± 4</td>
<td>79 ± 9</td>
<td>79 ± 6</td>
</tr>
<tr>
<td>% heart-rate reserve</td>
<td>65 ± 4</td>
<td>62 ± 6</td>
<td>64 ± 5</td>
</tr>
<tr>
<td>% ventilatory threshold 1</td>
<td>120 ± 17</td>
<td>138 ± 18</td>
<td>131 ± 17</td>
</tr>
<tr>
<td>% ventilatory threshold 2</td>
<td>91 ± 6</td>
<td>92 ± 11</td>
<td>92 ± 9</td>
</tr>
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</table>

Note. VO$_2$ = oxygen uptake; MET = metabolic equivalent.

*p < .05. **p < .01. ***p < .001.

Figure 1 — Kinetics of perceived exertion level using the CR-10 Rating of Perceived Exertion scale (circles), percent maximal heart rate (triangles), and percent maximal oxygen uptake (%VO$_2$max; squares) during the course of the 2-km exercise test, $M \pm SD$. The gray horizontal bar indicated the range between 3 and 5 of the CR-10 scale.
significant differences between the 5th and 10th (3.0 ± 0.7 vs. 4.1 ± 0.5, \( p = .001 \)) and the 10th and 25th (4.1 ± 0.5 vs. 4.6 ± 0.8, \( p = .009 \)) minutes of the 2-km test.

**Discussion**

The current study was conducted to investigate submaximal ventilatory, cardiocirculatory, and metabolic responses during a submaximal 2-km exercise test at unchanged exercise intensity where a moderate RPE level was reported in the previously performed maximal treadmill ramp-exercise test in healthy and active seniors. We aimed to clarify the relationship between submaximal RPE kinetics and the percentage response of aerobic exercise parameters such as maximal HR and VO\(_2\), HR, and VO\(_2\) reserve, as well as VTs.

A moderate RPE level of 4 on the CR-10 scale led to adequate ventilatory, metabolic, and HR responses according to established health-related aerobic-exercise recommendations (Garber et al., 2011). The current study revealed no gender differences for the primary ventilatory, cardiocirculatory, and metabolic EE data when adjusting for body weight. Percentages of HR\(_{\text{max}}\), VO\(_{2\text{max}}\), HR reserve, VO\(_2\) reserve, and VT\(_1\) and VT\(_2\) were also not different between male and female subjects. The achieved mean exercise EE during the 2-km test was slightly above 3 kcal/kg body weight for about half an hour of submaximal exercise and did not reveal gender differences. This finding seems plausible due to a steep decline of age-induced ventilatory and cardiocirculatory capacity in male compared with female seniors (Weiss, Spina, Holloszy, & Ehsani, 2006). However, gender-dependent differences in physiological parameters decrease during the aging process.

When considering the current stand of the ACSM concerning exercise prescriptions in seemingly healthy adults, the RPE levels, HR\(_{\text{max}}\) percentages, HR reserve, and VO\(_2\), as well as VO\(_2\) reserve, are provided (Garber et al., 2011). To obtain the aforementioned aerobic-exercise parameters, an objective and reliable maximal physical exhaustion test is needed. These calculated percentages of maximal-exercise parameters, however, may not reflect a specific submaximal physiological response to exercise and may vary from one individual to the next, and, thus, several authors have emphasized the significance of taking into account submaximal aerobic-exercise approaches to determine aerobic-exercise intensity (Meyer, Gabriel, & Kindermann, 1999; Scharhag-Rosenberger, Meyer, Gassler, Faude, & Kindermann, 2010). In this regard, we also provided submaximal-exercise data derived from VTs. This comprehensive approach is of even more interest given the aerobic-exercise intensity recommendations of the ACSM and the American Heart Association (AHA) in older adults. The ACSM and AHA recommended, for example, that an RPE of 5–6 is moderate intensity and 7–8 is vigorous intensity on the CR-10 RPE scale (Garber et al., 2011). Such RPE-related exercise-intensity determinants seem to be fairly arbitrary since a RPE value of 5 is almost encoded as “strong” or “hard” and comparative cardiocirculatory, ventilatory, and metabolic data are not provided in these guidelines, especially for seniors. RPE-related approaches to determine exercise intensity are indeed easily applicable. However, they may lead to an increasing diminished estimation of actual physiological responses, accompanied by the danger of individuals’ overestimation of their physical strength. Thus, the current comparative investigation to determine the physiological response at moderate RPE and its physiological response is essential for older adults.
During incremental-exercise testing, exercise intensities that refer to a moderate RPE of 4 on the CR-10 RPE scale derived from maximal incremental-exercise testing led to a constant exercise-induced drift of the RPE during the 2-km walking test. This finding is comparable to the well-known HR drift. This upward HR drift decreases stroke volume so that cardiac output can be maintained. It has also been suggested that increased blood pooling in resting muscle accounts for the underlying upward HR drift during moderately prolonged exercise (Kimura, Matsuura, Arimitsu, Yunoki, & Yano, 2010). In contrast, VO₂ did not drift during the entire 2-km walking test. When a moderate RPE was stated, the maximal HR and VO₂ did not exceed 85% in any subject. The observed exercise-intensity percentages correspond to general moderate exercise-intensity recommendations of the ACSM and AHA for older adults (Garber et al., 2011). However, considering these percentages and the corresponding MET values during the 2-km walking test, a moderate RPE can be physiologically vigorous in some healthy seniors when applying the recommended range of 5–6 on the RPE scale in seniors (Nelson et al., 2007b). In contrast, an RPE value around 4 is physiologically placed between VT₁ and VT₂. This range of exercise intensity has been frequently reported to be promising in terms of adequate cardiovascular and metabolic adaptations to exercise training (Fujimoto et al., 2010; Meyer, Auracher, Heeg, Urhausen, & Kindermann, 2007).

Regarding the association between the RPE drift and the corresponding %HRₘₐₓ during the submaximal 2-km walking test, we found that a RPE value of 3 corresponded to a range of 70–75% of HRₘₐₓ. An RPE of 4 is related to a range of approximately 75–80% of HRₘₐₓ. Comparable findings have been reported for walking in middle-aged adults applying the 16-point RPE scale (Schwarz, Urhausen, Schwarz, Meyer, & Kindermann, 2006). It seems that there are no age-dependent associations between %HRₘₐₓ and RPE in active older adults. Therefore, an intended RPE of 4 on the CR-10 scale is appropriately applicable as it achieves reliable perceptions of moderate exercise intensity and serves as an adequate alternative to HR monitors. Two times when the RPE scale should be used are during exercise interventions when HR monitors are not available for a large number of participants and when there is a lack of willingness to use HR monitors in older or female subjects due to perceived discomfort. RPE-related exercise intensities result in a relative EE of approximately 3 kcal/kg body weight within half an hour of submaximal walking in seniors. Thus, when complying with the recommendation of exercising five times per week for 30 min at moderate intensity, seniors will achieve an additional EE of approximately 1,200 kcal/week.

Some limitations of the current study need to be addressed. The participants examined in this study were an exemplary group of healthy and active seniors undergoing aerobic-exercise training. Considering the Physical Activity Questionnaire data, it seems reasonable to assume that the included subjects already met the recommended volume of health-related physical activity. A transfer of our findings to physically less active individuals, seniors suffering from specific diseases, or any other types of exercise should be handled with caution, especially since during swimming, bicycling, and hand-ergometer exercise, as well as in detrained, obese, or morbid seniors, lower maximal HRs are reached (Salvadori et al., 2003). Despite a low interindividual variability of relevant percentage exercise-intensity parameters in the current study, the application of RPE scales can lead to additional variability, depending on cognitive development and mental health status (Chandler-Laney et al., 2009).
Despite a standardized and internally valid approach at constant exercise intensities, the external validity and transferability of the current findings might be restricted since the given submaximal-exercise intensity was fixed and not adjusted by an RPE-related self-paced 2-km exercise test. However, due to preventive aerobic-exercise training and public health considerations, the current findings might be suitable in terms of a feasible and simple way to prescribe a relevant window of moderate RPE levels to achieve adequate aerobic-exercise intensities in a submaximal walking test in healthy seniors.

In conclusion, we found no relevant gender differences of ventilatory, metabolic, HR, or EE variables during the 2-km walking test. Compared with the HR kinetics, similar drifts of the RPE level at a given walking velocity and treadmill inclination have been observed. An intended moderate RPE of 4, derived from maximal-exercise testing, did not exceed 85% of maximal HR or VO2 during the submaximal 2-km test. Regarding the practical implications of the study findings, moderate walking at a given velocity and inclination related to an RPE of 4 on the CR-10 scale results in an adequate HE, ventilatory, and metabolic response according to available health-related physical exercise recommendations in approximately 30 min of submaximal walking. Thereby, an overestimation of individual strain can be ruled out. In addition, such moderately perceived and quick walking of around RPE 4 lasting for 30 min, five times per week, would lead to an additional weekly EE of nearly 1,200 kcal in healthy seniors. Therefore, seniors should be encouraged to undertake brisk walking for nearly half an hour per day to meet the amount of health-related physical activity recommendations per week.

Acknowledgments

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References


