Is the six-minute walk test appropriate for detecting changes in cardiorespiratory fitness in healthy elderly men?

Marcos G. Santana a,b,c,∗, Claudio A.B. de Lira c, Giselle S. Passos a,c, Carlos A.F. Santos d, Alan H.O. Silva a, Cristina H. Yoshida a, Sergio Tufik a, Marco T. de Mello a,b

a Disciplina de Medicina e Biologia do Sono, Departamento de Psicobiologia - Universidade Federal de São Paulo, Brazil
b Programa de Pós-graduação em Nutrição - Universidade Federal de São Paulo, Brazil
c Universidade Federal de Goiás - Campus Jataí, Brazil
d Disciplina de Geriatria e Gerontologia, Departamento de Medicina - Universidade Federal de São Paulo, Brazil

Received 11 August 2011; received in revised form 4 November 2011; accepted 10 November 2011

Abstract

Objectives: The purpose of this study was to determine whether the six-minute walk test (6-MWT) can detect changes in cardiorespiratory fitness (CRF) induced by exercise training in healthy elderly men.

Design: Randomized and prospective controlled trial.

Methods: Thirty-two healthy untrained men, between 65 and 75 years of age, were randomly assigned to one of three groups: control (C, n = 12), endurance training (E, n = 10), or concurrent training (ER, n = 10). Training groups underwent 24 weeks of exercise, 3 times a week. All participants were subjected to cardiopulmonary exercise testing and the 6-MWT, before and after the training period.

Results: At follow-up, the E and ER groups had significantly higher peak oxygen uptake (\(\dot{V}O_2\) peak) (15.0 ± 9.1 and 12.6 ± 10.4%, respectively) and 6-MWT distances (5.5 ± 5.3 and 4.6 ± 2.8%, respectively) compared to the C group. In pre-intervention (n = 32), the 6-MWT distance correlated positively with (\(\dot{V}O_2\) peak) (r = 0.51, p = 0.001) and \(\dot{V}O_2\) at anaerobic threshold (r = 0.39, p = 0.010). On the other hand, there was no significant correlation between the changes (after–before) in the 6-MWT distance and \(\dot{V}O_2\) peak (E and ER groups: r = 0.38, p = 0.097).

Conclusions: The 6-MWT is not appropriate to evaluate changes in CRF in healthy elderly men who performed endurance and concurrent training for 24 weeks.

© 2011 Sports Medicine Australia. Published by Elsevier Ltd. All rights reserved.

Keywords: Concurrent training; Physical activity; Older adults; Incremental exercise test; Functional capacity

1. Introduction

Chronic exercise has been recommended as an important tool to reduce the risk of cardiovascular and endocrine diseases and to improve bone and muscle conditioning in elderly people.1 It is well established that chronic aerobic exercise improves maximal oxygen uptake due to central and peripheral cardiac adaptations.2 Additionally, exercise interventions that improve endurance and neuromuscular performance in elderly people are becoming recognized as effective strategies to increase functional independence and to decrease the prevalence of many diseases associated with aging.1 In concurrent training, both endurance and strength performance can be simultaneously improved in untrained participants.3 Traditionally, improvements in aerobic power are assessed by increases in peak/max oxygen uptake (\(\dot{V}O_2\) peak/max). This physiological variable is considered the gold standard in the assessment of functional capacity and cardiorespiratory fitness (CRF) and is measured by cardiopulmonary...
exercise testing (CPET). CPET analyses the function of the cardiovascular, respiratory and neuromuscular systems, providing a global assessment of the integrative physiological response. Clinically, a low CRF is associated with all-cause mortality and cardiovascular diseases (CVD) events in healthy individuals. In addition, physical performance have great value when used as baseline factors to discriminate future health and function in elderly people. However, CPET is a high-cost exam and requires specially trained staff. Therefore, simple and inexpensive tests are required in the field to assess functional capacity.

The 6-min walk test (6-MWT) is a simple, safe and low-cost field test often used for the elderly and patients with chronic heart failure or chronic obstructive pulmonary disease to regularly assess their functional exercise capacity and the effects of a rehabilitation/exercise program. Previous studies have used the 6-MWT performance to predict the VO2 peak in clinical populations, as well as in healthy elderly people. Kervio et al. estimated the VO2 peak in healthy elderly from anthropometric values and 6-MWT parameters. More recently, Ross et al. demonstrated that the 6-MWT is appropriate to estimate VO2 peak in patients with moderate-to-severe heart or lung disease, using only the covered distance.

Some studies have investigated the association between the distance covered obtained from CPET and the 6-MWT performance. In this way, correlations have been observed between the distance covered during the 6-MWT and VO2 peak in elderly healthy participants. However, to our knowledge, there are no studies that used the 6-MWT performance to evaluate improvement in cardiorespiratory parameters in healthy elderly men submitted to chronic exercise. We hypothesised that changes in CRF could be detected by changes in the 6-MWT performance. Thus, the aim of this study was to analyse whether the 6-MWT can detect changes in CRF induced by exercise training (endurance and concurrent) in elderly men.

2. Methods

The thirty-two participants, recruited using advertisements placed in local newspapers, were healthy men between 65 and 75 years old. The inclusion factors used for the healthy elderly were: untrained, no current smoking, no chronic disease to regularly assess their functional exercise capacity and the effects of a rehabilitation/exercise program. Previous studies have used the 6-MWT performance to predict the VO2 peak in clinical populations, as well as in healthy elderly people. Kervio et al. estimated the VO2 peak in healthy elderly from anthropometric values and 6-MWT parameters. More recently, Ross et al. demonstrated that the 6-MWT is appropriate to estimate VO2 peak in patients with moderate-to-severe heart or lung disease, using only the covered distance.

Some studies have investigated the association between the distance covered obtained from CPET and the 6-MWT performance. In this way, correlations have been observed between the distance covered during the 6-MWT and VO2 peak in elderly healthy participants. However, to our knowledge, there are no studies that used the 6-MWT performance to evaluate improvement in cardiorespiratory parameters in healthy elderly men submitted to chronic exercise. We hypothesised that changes in CRF could be detected by changes in the 6-MWT performance. Thus, the aim of this study was to analyse whether the 6-MWT can detect changes in CRF induced by exercise training (endurance and concurrent) in elderly men.

2. Methods

The thirty-two participants, recruited using advertisements placed in local newspapers, were healthy men between 65 and 75 years old. The inclusion factors used for the healthy elderly were: untrained, no current smoking, no chronic disease, and a body mass index lower than 35 kg m$^{-2}$. After a clear explanation of the procedures, including the risks and benefits of participation, written informed consent was obtained. Participants underwent a detailed medical examination and an electrocardiogram test. Participants then were randomly assigned to one of three groups: control group (C, n = 12, age: 69.8 ± 1.6 years, height: 168.7 ± 8.4 cm, body mass: 75.9 ± 8.9 kg, body mass index: 26.6 ± 2.0 kg m$^{-2}$), endurance training group (E, n = 10, age: 70.0 ± 2.8 years, height: 168.4 ± 6.2 cm, body mass: 75.0 ± 7.0 kg, body mass index: 26.5 ± 2.6 kg m$^{-2}$), or concurrent training group (ER, n = 10, age: 67.6 ± 3.1 years, height: 171.7 ± 3.2 cm, body mass: 71.9 ± 9.7 kg, body mass index: 24.3 ± 3.1 kg m$^{-2}$). All experimental procedures were approved by the Ethics Committee of Federal University of Sao Paulo (Sao Paulo – Brazil) in accordance with the Declaration of Helsinki.

The study was organised in four successive phases: basal medical examination, pre-intervention evaluations, training period and post-intervention evaluations. Basal medical examination was performed three weeks before the beginning of the training period. Participants underwent a detailed medical examination and an electrocardiogram test, with direct medical supervision, to volitional fatigue on a treadmill (Micromed, Centurion 200, Sao Paulo, Brazil). In the week before and after the training period, all the participants performed three exercise tests in the following order: CPET, 6-MWT and 1-RM test. These tests were separated by at least 48 h of rest.

Participants were instructed to arrive at the laboratory in a rested and fully hydrated state, having not consumed caffeine in the previous 4 h, and to avoid strenuous exercise in the 48 h preceding a test session. To minimise the effects of diurnal biological variation, all the tests were performed in the same time of day (10:00 a.m. ± 2 h).

Participants were given a standardised set of instructions explaining the CPET test. After these preliminary procedures, the participants were submitted to an exercise test on a treadmill (Life Fitness, 9500 HR, Chicago, IL, USA). Following a previous study, the test started at 1.6 km h$^{-1}$, followed by progressive increases in the treadmill speed and slope at a rate of 0.8 km h$^{-1}$ and 1%, respectively, every 2 min until volitional exhaustion was reached. Respiratory gas samples were analysed breath-to-breath using a portable metabolic system (K4b$^2$, Cosmed SRL, Pavona, Rome, Italy). Before each test, the gas analysers were calibrated according to the manufacturer’s recommendations. Heart rate (HR) was recorded using a HR monitor (Polar Electronics, FS1, Kempele, Oulu, Finland).

Peak oxygen uptake and HRmax were defined as the mean oxygen uptake ($\dot{V}O_2$) and HR values, respectively, during the last 20 s of exercise. The anaerobic threshold (AT) was estimated by the gas exchange method, inspecting the inflection point of carbon dioxide output ($\dot{V}CO_2$) with respect to $\dot{V}O_2$ and, secondarily, by the ventilatory method when ventilatory equivalent for O$_2$ ($\dot{VE}/\dot{V}O_2$) and end-tidal partial pressures for O$_2$ (PETO$_2$) increased, while ventilatory equivalent for CO$_2$ ($\dot{VE}/\dot{V}CO_2$) and end-tidal partial pressures for CO$_2$ (PETCO$_2$) remained stable.

The 6-MWT was performed twice to minimise the learning effect. The tests were separated by at least 1 h of recovery. These technical aspects are in line with the American Thoracic Society recommendations for the 6-MWT. The 6-MWT was performed in a 20-m-long indoor hallway free of obstacles. The length of the corridor was marked every 1 m. Participants were instructed to walk at a self-selected pace to cover as much distance as they could during
the allotted time. If necessary, slowing down and stopping to rest were allowed. At the end of each minute participant were given feedback on the elapsed time and standardised encouragement in the form of statements such as “you are doing well, keep it up” and “do your best.” The highest distance between two tests was used for the statistical analysis.

To better characterise physiological response during the 6MWT, VO2 and HR were defined as the mean obtained during the last 20 s of exercise. These parameters were measured with the same metabolic system used in the CPET, previously described and validated.17

Strength performance was assessed by one repetition maximum (1-RM) test to determine maximal strength in the following strength devices: (1) chest press, (2) leg press, (3) vertical traction, (4) leg curl, (5) bicep curl, (6) abdominal crunch, (7) arm extension, and (8) lower back (Technogym, Gambettola, Italy). Briefly, the 1-RM test protocol consisted of a 5-min warm-up on a cycloergometer (Life Fitness, 9500 HR, Chicago, IL, USA) followed by static stretching exercises, then two series with eight repetitions on the test devices, the first with a light load and the second with a heavy one, then the first attempt at the test increasing load until the maximum was obtained in one repetition. There were at most three subsequent attempts at 3-min intervals. The examiner constantly encouraged the participants. All participants were tested by a single evaluator who was trained and experienced in 1-RM test. The participants had three sessions to become familiar with the equipment. The strength tests were performed before (week 0), during (weeks 6, 12, and 18), and after (week 24) the training period. The tests in week 0 served to determine individual workloads. The tests in weeks 6, 12, and 18 served for workload adjustment

Participants in each group participated in their respective training program for 24 weeks (72 training sessions). The exercise protocols were designed in accordance with published guidelines for elderly people. All training sessions were supervised by experienced exercise instructors. All participants of training groups completed 72 exercise sessions. Missed training sessions were compensated for during the subsequent training weeks so that the total amount of training sessions was reached.

The endurance training protocol consisted of supervised walking/jogging on a treadmill (Life Fitness, 9500 HR, Chicago, IL, USA) three times per week on non-consecutive days. The grade of the treadmill was set at 0%. Training intensity and duration were progressively increased within the 24 weeks. Exercise duration was limited to 30 min during the first and second weeks and was then increased by 5 min biweekly until week 8; after that, exercise duration was fixed at 45 min. Training intensity was determined by the percentage of heart rate reserve (HRR).21 Resting measures of HR were recorded after each participant had sat quietly in a chair for 5 min. The average values of HR recorded over the last minute were considered to be the resting values, as has been previously reported.22 Training intensity was set at 50% of HRR until the 8th week, then intensity was progressively increased (55% in weeks 9 and 10, 60% in weeks 11 and 12, 65% in weeks 13 through 16, 70% in weeks 17 through 20, and 75% for the rest of the training period). Participants could exercise within ±5 bpm of the prescribed intensity. Each session included a warm-up and cool-down period involving 5 min of low-intensity walking.

The concurrent training protocol consisted of endurance and resistance training. Endurance training had the same characteristics as the E group. Resistance training was performed in this order: (1) chest press, (2) leg press, (3) vertical traction, (4) leg curl, (5) bicep curl, (6) abdominal crunch, (7) arm extension, and (8) lower back (Technogym, Italy). The individual loads were determined on the bases of the initial 1-RM test. Resistance training used 50% of the 1-RM in weeks 1–4, 55% in weeks 5–8, 60% in weeks 9–12, 70% in weeks 13–16, 75% in weeks 17–20, and 80% in weeks 21–24. The participants were instructed to perform three sets of 12 repetitions of each activity in weeks 1–12 and three sets of 10 repetitions in weeks 13–24. Each set was interspersed by a 90-s recovery interval. Each session included a warm-up and cool-down period involving 5 min of low-intensity cycling and had a duration of approximately 60 min. The concurrent training protocol included three sessions per week on non-consecutive days. In each session, the mode of exercise alternated between endurance and resistance training; therefore, participants completed 50% of each of the endurance and resistance training sessions.

The C group underwent testing as described above and were asked not to make changes in their physical activity habits over the 24-week treatment period. They received monthly follow-up phone calls during the treatment period. STATISTICA version 7.0 for Windows was used for statistical analyses. All variables presented normal distributions (p > 0.05) according to Kolmogorov–Smirnov tests. Prior to intervention, significant differences were analysed by one-way analysis of variance (ANOVA). The changes in study variables between the groups were compared with an analysis of co-variance (ANCOVA) using the pre-intervention values (week 0) as the covariates. ANCOVA was chosen to eliminate any effect of the relation between the variables and their pre-intervention values. When a significant effect was achieved, Tukey’s post hoc procedures were performed to identify differences between the means. Within group analyses were performed with paired samples t-tests. Pearson product-movement correlation coefficient was used to assess relationships between the CPET and 6-MWT parameters. Differences were considered significant at the level of p < 0.05. Data are presented as the means ± SD.

3. Results

The treadmill performances of the participants are shown in Table 1. No significant differences were observed between groups before the training period. The VO2 peak obtained after the training period was significantly higher in the E
Table 1

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control Group</th>
<th>Endurance Group</th>
<th>Concurrent Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>VO₂ peak (mL kg⁻¹ min⁻¹)</td>
<td>48.1 ± 7.6°</td>
<td>52.1 ± 7.9°</td>
<td>53.5 ± 9.0°</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>149.2 ± 17.2°</td>
<td>150.7 ± 17.4°</td>
<td>158.0 ± 17.4°</td>
</tr>
<tr>
<td>% Predicted HRmax</td>
<td>88.8 ± 11.2°</td>
<td>98.5 ± 12.7°</td>
<td>100.8 ± 13.6°</td>
</tr>
<tr>
<td>Duration (min)</td>
<td>15.3 ± 2.1°</td>
<td>15.6 ± 2.3°</td>
<td>15.6 ± 2.3°</td>
</tr>
<tr>
<td>1-MET equivalent</td>
<td>10.2 ± 1.8°</td>
<td>10.2 ± 1.8°</td>
<td>10.2 ± 1.8°</td>
</tr>
<tr>
<td>Δ%</td>
<td>−0.9 ± 1.8°</td>
<td>−1.0 ± 2.1°</td>
<td>−1.0 ± 2.1°</td>
</tr>
<tr>
<td>p</td>
<td>0.001</td>
<td>0.001</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Data are presented as the mean ± SD. C: control group; E: endurance training group; ER: concurrent training group; VO₂: oxygen uptake; HR: heart rate.

4. Discussion

The purpose of this study was to determine whether the 6-MWT is able to detect changes in the CRF of healthy elderly men submitted to two modes of exercise programs. Following 24 weeks of a training program performed by the E and ER groups, there was an increase in VO₂ peak and covered distance in the 6-MWT (Table 1). However, these results did not support our hypothesis that changes in CRF could be detected by changes in the 6-MWT performance, since there was no significant correlation between changes (after–before) in the distance covered in the 6-MWT and changes (after–before) in the VO₂ peak (E and ER groups: \( r = 0.38, p = 0.097 \)).

The magnitude of increase in VO₂ peak was similar between E and ER groups, 15.1% (4.2 mL kg⁻¹ min⁻¹) and 12.7% (4.3 mL kg⁻¹ min⁻¹), respectively, even with a reduced frequency and volume weekly of endurance training in the ER group. These results provide consistent evidence that adding strength training to endurance training does not interfere with CRF development. We also verified that there was increase muscle in strength in the ER group even with a reduced frequency and volume weekly of strength training. As previously observed by Wood et al. and Izquierdo et al., the reduced volume maybe an important factor in designing training regimes to performance adaptations with concurrent training in elderly men.

Physiologically, the increase in VO₂ peak (for E and ER groups) in the current study was higher than 1 Metabolic Equivalent (1-MET = 3.5 mL kg⁻¹ min⁻¹). In a recent meta-analysis, Kodama et al. reported that the increase of 1-MET in CRF is associated with a decrements in risk of all-cause mortality (13%) and cardiovascular diseases (15%). The author explained that a increase of 1-MET in CRF is comparable to a 7-cm, 5-mmHg, 88 mg dL⁻¹, and 18 mg dL⁻¹ decrement in waist circumference, systolic blood pressure, and ER groups compared to pre-training values (15.0 and 12.6%, respectively). Moreover, the time to exhaustion was significantly higher when compared to pre-training values (E: 18.7% and ER: 11.4%).

All participants finished the 6-MWT without difficulty or premature stop. The 6-MWT performances of the participants are shown in Table 2. The distances completed and, consequently, the walking speeds were significantly higher in the E (5.5%) and ER (4.6%) groups when compared to the pre-training values.

The 24 weeks of resistance training for the ER group significantly increased 1-RM in all eight exercises tested. As expected, there were no significant alterations in the C and E groups (Table 3).

In the pre-intervention period \((n = 32)\), the 6-MWT distances correlated positively with the VO₂ peak \((r = 0.51, p = 0.001)\) and VO₂ at AT \((r = 0.39, p = 0.010)\). On the other hand, there was no significant correlation between changes (after–before) in the distance covered in the 6-MWT and changes (after–before) in the VO₂ peak (E and ER groups: \( r = 0.38, p = 0.097 \)).
Table 2
Physiological parameters and percent change obtained in the six-minute walk test before and after 24 weeks of training.

<table>
<thead>
<tr>
<th></th>
<th>C (n = 12)</th>
<th>E (n = 10)</th>
<th>ER (n = 10)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Δ%</td>
</tr>
<tr>
<td>Distance (m)</td>
<td>601.5 ± 61.0</td>
<td>580.8 ± 35.3</td>
<td>−3.0 ± 5.9</td>
</tr>
<tr>
<td>Speed (m.s⁻¹)</td>
<td>1.67 ± 0.17</td>
<td>1.61 ± 0.10</td>
<td>−3.0 ± 5.9</td>
</tr>
<tr>
<td>VO₂ (mL.kg⁻¹.min⁻¹)</td>
<td>24.3 ± 3.0</td>
<td>23.2 ± 3.3</td>
<td>−4.1 ± 10.6</td>
</tr>
<tr>
<td>%VO₂ peak</td>
<td>86.5 ± 11.4</td>
<td>83.8 ± 13.0</td>
<td>−2.9 ± 10.7</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>124.8 ± 14.9</td>
<td>120.8 ± 14.2</td>
<td>−2.9 ± 7.4</td>
</tr>
<tr>
<td>%HRmax</td>
<td>83.9 ± 5.7</td>
<td>80.4 ± 8.5</td>
<td>−3.5 ± 9.7</td>
</tr>
</tbody>
</table>

Data are presented as the mean ± SD. C: control group; E: endurance training group; ER: concurrent training group.

< 0.05, post different from pre.

< 0.05, significant difference versus the control group.

Table 3
Absolute and percent change in muscle strength after 24 weeks of training.

<table>
<thead>
<tr>
<th></th>
<th>C</th>
<th>E</th>
<th>ER</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
<td>Δ%</td>
</tr>
<tr>
<td>Chest press (lb)</td>
<td>105.5 ± 20.9</td>
<td>109.2 ± 21.8</td>
<td>4.4 ± 8.9</td>
</tr>
<tr>
<td>Leg press (lb)</td>
<td>266.7 ± 54.2</td>
<td>283.0 ± 72.8</td>
<td>6.1 ± 11.8</td>
</tr>
<tr>
<td>Vertical traction (lb)</td>
<td>156.2 ± 22.3</td>
<td>157.9 ± 20.4</td>
<td>1.4 ± 6.0</td>
</tr>
<tr>
<td>Leg curl (lb)</td>
<td>95.0 ± 16.4</td>
<td>94.6 ± 17.5</td>
<td>−0.1 ± 10.4</td>
</tr>
<tr>
<td>Biceps curl (lb)</td>
<td>55.0 ± 10.9</td>
<td>52.1 ± 11.8</td>
<td>−5.3 ± 9.8</td>
</tr>
<tr>
<td>Abdominal crunch (lb)</td>
<td>67.9 ± 17.2</td>
<td>70.8 ± 15.3</td>
<td>5.2 ± 8.3</td>
</tr>
<tr>
<td>Arm extension (lb)</td>
<td>107.1 ± 24.1</td>
<td>105.4 ± 19.3</td>
<td>−0.4 ± 11.1</td>
</tr>
<tr>
<td>Lower back (lb)</td>
<td>105.0 ± 16.4</td>
<td>102.9 ± 21.8</td>
<td>−2.6 ± 7.4</td>
</tr>
</tbody>
</table>

Data are presented as the mean ± SD. C: control group; E: endurance training group; ER: concurrent training group.

< 0.05, post different from pre.

< 0.05, significant difference versus the control group.

< 0.05, significant difference versus the endurance training group.
triglyceride level, and fasting plasma glucose, respectively, and a 8 mg dL$^{-1}$ increment in high-density lipoprotein cholesterol. From the clinical viewpoint, these values may be considerable.

With regard to the 6-MWT, the distance covered by the three groups (C, E and ER) before the training period was greater than that reported in previous studies for participants of a similar age. To help predict the total distance walked during the 6-MWT, some researchers established a reference equation. When applying this reference equation, it was revealed that the groups walked about 24% more than the predicted distance in the pre-evaluation. Additionally, the mean walking speed observed during the 6-MWT before and after the training program was between 1.61 and 1.86 ms$^{-1}$, respectively. These speeds are above the comfortable gait speed in healthy adults in the same age group ($1.39 \pm 0.02$ ms$^{-1}$). This highlights the greater performance of our participants and consequently explains the greater relative workload (% VO$_2$ peak) found in the 6-MWT, i.e., above the AT (between 48.6 and 57.5% of VO$_2$ peak).

The improvements observed in the 6-MWT performance in the E and ER groups were modest (5.5 and 4.6%, respectively), as previously reported by another study in a similar population submitted to a 12-month concurrent training program. These modest improvements are likely the consequence of a possible “ceiling effect”, which takes into account that our participants are healthy and did not have functional limitations, as established by the higher speed obtained during the 6-MWT and normal VO$_2$ peak compared to values expected for their age and gender. In other words, even if the participant is able to run, due to excellent functional capacity, 6-MWT specifications only allow that the test be done walking.

The impact of the health status on the 6-MWT performance was investigated in 165 elderly people. The covered distance decreased significantly with increasing age and with worsening health status (corrected for age). Patients with dilated cardiomyopathy were also investigated, and the results demonstrated that covered distance and VO$_2$ peak were closely correlated. In addition, the authors found a correlation between the 6-MWT covered distance and the New York Heart Association functional class. Corroborating these results, other work has found that the 6-MWT test cannot predict outcomes in patients with a history of heart failure. However, when the authors separated patients into those that covered a distance below 300 m, they found that the 6-MWT was a useful tool to predict outcomes in the lower-functioning patients. In contrast, when the distance covered was above 300 m, the 6-MWT was not able to detect changes. In our study, none of the participants walked less than 300 m. Therefore, in part, this could explain why the 6-MWT was not able to detect changes in VO$_2$ peak resulting from exercise training. Nonetheless, when we analysed the correlation before training, we were able to find the classic results reported in the literature, i.e., a positive correlation between the distance covered in the 6-MWT and VO$_2$ peak.

There was not a significant correlation between changes in the 6-MWT performance and changes in VO$_2$ peak obtained in CPET after the training period. Thus, improvements in VO$_2$ peak after training could not be detected by improvements in the 6-MWT performance. Our findings are in contrast with a previous study that studied children with congenital heart disease submitted to an aerobic training program. Their study found that improvements in CPET variables were correlated with improvements in distance covered during a 6-MWT. These conflicting results are likely a consequence of the excellent functional capacity of our volunteers as discussed above.

A possible limitation of this study was the use of a 20 m corridor to perform the 6-MWT, which induces numerous laps. This could lead to an underestimation of the covered distance during the 6-MWT. To verify this limitation, it would be interesting to conduct other studies using different corridor lengths in the same population.

5. Conclusion

In conclusion, this study showed that, for healthy elderly men, the changes in 6-MWT performance and the changes in CPET measures are not correlated. Thus, the use of the 6-MWT is not appropriate to evaluate improvements in cardiorespiratory parameters resulting from endurance training or concurrent training. However, the 6-MWT is a notable tool to evaluate functional capacity improvements due to exercise programs. Therefore, in healthy elderly people, the information provided by a 6-MWT should be considered complementary to a CPET, not a replacement for it.

Practical implications

- The 6-MWT is a simple, useful test to evaluate improvements in functional capacity after exercise training.
- The 6-MWT is not appropriate to evaluate improvements in CRF of elderly healthy men who have undergone exercise training.
- Although the 6-MWT after exercise training has been sensitive to detect improvements in the functional capacity, relevant to many daily activities, it reflects no improvements on CRF as observed in CPET.
- The CPET and the 6-MWT could be used together in order to provide a complete physical fitness evaluation of health men after exercise training.

Acknowledgements

We would like to thank all of the participants who volunteered their time to participate in the study.
The authors would like to thank the institutions that made this manuscript possible: AFIP, FAPESP, CEPID/FAPESP, CEPE, CEMSA, and FADA/UNIFESP.

References

20. ACSM. ACSM’s guidelines for exercise testing and prescription. 8th edn Lippincott Williams & Wilkins; 2009.