Development of a walking test for the assessment of functional capacity in non-anaemic maintenance dialysis patients

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Abstract

Introduction

Background. Walk tests may be useful adjuncts or even alternatives to the assessment of peak oxygen uptake (VO₂ peak) in patients with low functional capacity. Walk tests are easy to administer, appear to be well tolerated by patients and may represent a more meaningful measure for a patient group as they assess capability as well as fitness. However, the use of walk tests for the assessment of functional capacity in maintenance dialysis patients has received scant attention. The aim of this study was to assess the validity of a walking–stair-climbing test to predict VO₂ peak in non-anaemic maintenance dialysis patients.

Methods. In the validation phase of the study, 14 subjects completed a cycle ergometer-graded exercise test (GXT) for the determination of VO₂ peak and a walking–stair-climbing task (WALK), each separated by a period of 7 days. Three weeks later, 18 subjects completed two WALK tests, each separated by a period of at least 48 h, to facilitate reliability estimation. Estimates of differentiated and undifferentiated ratings of perceived exertion (RPE) were obtained during and immediately consequent to all exercise tests.

Results. VO₂ peak (ml/kg/min) was significantly correlated with total WALK time (s) (r = −0.83; P < 0.001). VO₂ peak (ml/kg/min) could be predicted from total WALK time with a standard error of prediction of 11%. Reliability assessment revealed no significant differences for any aspect of the WALK test performance, with intraclass correlation coefficients ranging from r = 0.71 (RPE legs) to 0.96 (total WALK time).

Conclusion. These results indicate that the WALK test is a valid, reliable and potentially useful method by which to assess the functional capacity of non-anaemic maintenance dialysis patients.

Key words: dialysis; exercise tolerance; non-anaemic; VO₂ peak; walking

Patients and methods

Study design

Volunteers were solicited from the maintenance dialysis patient population of a large renal unit (270 patients, 70 new patient referrals per annum) to participate in a study which examined the validity of a newly developed walking–stair-climbing task (WALK) as a means of assessing functional performance in non-anaemic dialysis patients. Patients with evidence of recent myocardial infarction (within 6 weeks), uncontrolled arrhythmias, uncontrolled hypertension, unstable angina, symptomatic left ventricular dysfunction, uncon-
trolled diabetes and neurological disorder with functional deficit were excluded from the study. The study was subdivided into separate validity and reliability phases, with a 3 week period separating each investigation. The study was approved by the local Scientific merit and Ethical committees and all patients gave written informed consent prior to participation.

Patients

Twenty five patients receiving maintenance dialysis (18 haemodialysis (HD), seven peritoneal dialysis (CAPD)) volunteered and were eligible (Hb > 10 g/dl; Kt/V > 1; inter-dialytic weight gain < 2.5 kg; and pre-dialysis potassium < 5.5 mmol/l) to participate in the study. Fifteen subjects were selected randomly, from the original pool of 25 patients, to participate in the validation phase of the study. A total of 14 subjects (10 men, four women; mean age, 58.8 ± 11.1 years; nine HD, five CAPD; mean duration of dialysis treatment 2.9 ± 1.8 years; haemoglobin 11.2 ± 0.6 g/dl) completed all aspects of the validation study. The reliability study involved 18 patients (13 men, five women; mean age, 61.8 ± 13 years; 13 HD, five CAPD; mean duration of dialysis treatment 3.1 ± 2.8 years; haemoglobin 11.4 ± 0.9 g/dl) selected randomly from the total available pool of 25 patients. Nine patients participated in both phases of the investigation.

Test procedures

Following habituation to exercise tests and laboratory procedures, subjects completed a cycle ergometer-graded exercise test (GXT) for the determination of VO$_2$ peak and a WALK task in the validation phase of the study. These exercise tests were administered in a countercalibrated exposure, with a period of 7 days separating assessments. Following habituation to the WALK test, subjects in the reliability study completed two WALK tests separated by a period of at least 48 h. All repeat assessments were conducted within ±0.5 h at the same time of day. Exercise assessment of HD patients was conducted 1–2 h immediately prior to dialysis, and CAPD patients were tested with dialysis fluid in the peritoneum.

Cardiopulmonary exercise testing (GXT)

Cardiopulmonary exercise testing was conducted on a friction-braked cycle ergometer (Monark, Sweden). Following a 3 min warm-up period of unloaded pedalling, the exercise intensity was increased by 10–15 W increments every 2 min up to the point of symptom-limited volitional exhaustion (muscle fatigue and/or severe dyspnoea). Minute ventilation, oxygen uptake and carbon dioxide production were measured breath-by-breath (Oxycon Beta, Mijnhardt, The Netherlands) throughout the test. Heart rate was monitored continuously by an electrocardiogram in CM5 configuration (Cardiosys, Marquette-Hellige, Germany). Blood pressure was measured by auscultatory R wave gating (Suntech 4240, Marquette-Hellige, UK). Differentiated (chest, legs) and undifferentiated (overall) ratings of perceived exertion (RPE) were obtained from the subject in the last 30 s of each stage, and immediately upon termination of the test according to the method of Borg [7].

Walking–stair-climbing test (WALK)

The WALK test comprised the time, in seconds, taken to complete continuously a walk of 50 m in length along an internal corridor, a stair climb of 22 steps (total elevation 3.3 m, individual step height = 0.15 m), a stair descent of 22 steps and a post-stair climb-descent walk of 50 m along the same level corridor. Patients were instructed to ‘walk (stair climb) as quickly as possible’ along a hospital corridor and staircase which were well lit and had little traffic. The flooring was of a ‘non-slip’ material and none of the female patients were wearing high-heeled shoes. All WALK tests were conducted individually with no audience, other than the investigator, present. Total time and split times for constituent elements of the WALK were recorded via an electronic stopwatch by an investigator ‘tracking’ the patient without interference or the provision of feedback. Differentiated (legs) and undifferentiated (overall) (RPES) were obtained from the patient immediately upon completion of the WALK according to the method of Borg [7].

Statistical analysis

Concurrent validity estimations were made via computation of the Pearson-product correlation coefficients between VO$_2$ peak (ml/kg/min) and total walk and stair climb times. Linear regression analysis was used to develop a prediction equation for VO$_2$ peak (ml/kg/min) based on WALK performance (total walk time, seconds). Test–retest reliability of the WALK test was assessed via intraclass correlation and computation of the method error of repeated measurements (V%) [8].

Results

Concurrent validity

Graded exercise test and WALK test responses are presented in Tables 1 and 2 respectively. VO$_2$ peak (ml/kg/min) was significantly correlated with total walk time (s) (r = −0.83; P < 0.001) and with stair climb performance (s) (r = −0.81). Figure 1 illustrates the relationship between VO$_2$ peak (ml/kg/min) and total WALK time (s). The prediction equation for peak aerobic power was: VO$_2$ peak (ml/kg/min) = (−0.0767 × total WALK time in seconds) + (27.327), R = 0.689, standard error of the estimate (SEE) = 1.90 ml kg min (corresponding to a standard error of 11%).

Test–retest reliability

Test–retest data for the WALK test are presented in Table 3. Reliability assessment revealed no significant differences for any aspect of the WALK test performance, with intraclass correlation coefficients ranging from R$_{ij}$ = 0.71 (RPE$^{\text{legs}}$) to 0.96 (total WALK time). The method error for total walk time, expressed as V%, was observed to be 3.7%.
A WALK test of functional capacity for non-anaemic dialysis patients

Table 1. Peak responses during the graded exercise test: n=14, mean (SD)

<table>
<thead>
<tr>
<th>VO₂ peak (min)</th>
<th>VO₂ peak (ml/kg/min)</th>
<th>Heart Rate (beats min)</th>
<th>RER</th>
<th>RPEoverall (6–20)</th>
<th>RPEchest (6–20)</th>
<th>RPElegs (6–20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.28 (0.38)</td>
<td>17.1 (3.23)</td>
<td>123.8 (27)</td>
<td>1.04 (0.1)</td>
<td>16.8 (1.6)</td>
<td>14.8 (2.6)</td>
<td>17.8 (1.6)</td>
</tr>
</tbody>
</table>

Table 2. WALK test performance: n=14, mean (SD)

<table>
<thead>
<tr>
<th>Walk component</th>
<th>Trial 1</th>
<th>Trial 2</th>
<th>Rf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-climb walk (s)</td>
<td>45.8 (6.5)</td>
<td>45.7 (7.6)*</td>
<td>0.93</td>
</tr>
<tr>
<td>Stair climb (s)</td>
<td>15.8 (3.0)</td>
<td>15.4 (3.3)*</td>
<td>0.89</td>
</tr>
<tr>
<td>Descent (s)</td>
<td>17.6 (5.6)</td>
<td>17.8 (5.9)*</td>
<td>0.89</td>
</tr>
<tr>
<td>Post-climb walk (s)</td>
<td>48.3 (8.4)</td>
<td>47.7 (7.1)*</td>
<td>0.89</td>
</tr>
<tr>
<td>Total WALK time (s)</td>
<td>127.3 (21.1)</td>
<td>126.4 (22.9)*</td>
<td>0.96</td>
</tr>
<tr>
<td>RPEoverall (6–20)</td>
<td>11.4 (1.3)</td>
<td>11.7 (1.4)*</td>
<td>0.85</td>
</tr>
<tr>
<td>RPElegs (6–20)</td>
<td>11.4 (1.4)</td>
<td>11.6 (1.4)*</td>
<td>0.71</td>
</tr>
</tbody>
</table>

* = not significantly different from trial 1.

Discussion

The observed significant relationship between VO₂ peak and WALK performance ($r = -0.83$) in the current study far exceeds the reported correlations for 6 min walk performance and VO₂ max in patients with congestive heart failure ($r = 0.4–0.58$) [2,9]. This higher correlation coefficient may be attributable to the inclusion of a stair-climbing component and/or the extensive habituation to and practice of the WALK task in the current study, compared with other studies. Another explanation may be an increased heterogeneity in fitness levels of the subjects in the present study, associated with their volunteer and eligibility status.

The prediction error of 11% observed in the present study also compares favourably with the reported standard error of measurement of ~10–20% associated with the prediction of VO₂ peak/max from sub-maximal cycle ergometry in apparently healthy individuals [10]. Estimates of VO₂ peak/max derived from walking performance tests in apparently healthy individuals, including the elderly, are also characterized by prediction errors of ~10% [11].

The reliability of walking tests has been reported previously to vary with test duration, with 6 and 12 min walking tests exhibiting greater reliability than a 2 min version of the walk test [5]. A within-day test–retest correlation coefficient of $r = 0.90$, $P < 0.05$ has been reported for 6 min walk test performance (metres) in patients with chronic renal failure [6]. Data from the current investigation confirm the apparent reliability of walking performance tests in patients with ESRD. Extensive practice of the test prior to the assessment phase of the investigation led to a pleasingly reproducible performance for all constituent elements of the WALK test (see Table 3). These data would appear to suggest that, unlike patients with respiratory disease, a short-duration WALK test is a reliable way to assess functional capacity in non-anaemic patients with ESRD.

Conclusions

Preliminary observations suggest that the WALK test exhibits acceptable validity and reliability characteristics for the assessment of functional capacity in
non-anaemic patients receiving maintenance dialysis treatment. Although self-paced walking performance tests, such as the 6 min walk test, have been shown to have the ability to measure significant changes in physical fitness after exercise-based interventions in patients with chronic heart failure [3,4], respiratory disease [5] and chronic renal failure [6], it is noteworthy that these tests have been characterized, at best, by modest validity coefficients [2,9]. The validity and reliability characteristics \( r = -0.83; \ r = 0.96; \) method error (V%) of 3.7% observed for total WALK time performance in the present study indicate that this newly developed WALK test offers an improved utility for the evaluation of functional performance in patients with ESRD.

Acknowledgements. The research project was carried out in the department of Nephrology at North Staffordshire Hospital Trust, Princes Road, Stoke-on-Trent, Staffordshire ST4 7LN, UK

References


Received for publication: 28.11.97
Accepted in revised form: 6.4.98