Concurrent validity evidence of a lower extremity performance test: correlation with self-report of physical activity level

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Graduate School

FINAL APPROVAL OF SCHOLARLY PROJECT
Master of Science in Biomedical Sciences
Concentration in Physical Therapy

Concurrent Validity Evidence of a Lower Extremity Performance Test:
Correlation With Self-Report of Physical Activity Level

Submitted by
Suzanne Danch, B.S.

In partial fulfillment of the requirements for the degree of
Master of Science in Biomedical Sciences

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Date of Presentation: 3/24/2005  Date of Approval: 6/08/2005
Concurrent validity evidence of a lower extremity performance test: correlation with self-report of physical activity level

By:

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Completed as Partial Fulfillment for the Degree of Masters of Science in Biomedical Sciences, with a concentration in Physical Therapy, The Medical University of Ohio at Toledo, College of Health Sciences, Department of Physical Therapy, Toledo OH

Advisor: Daniel Cipriani Ph.D., PT
Abstract

Physical therapy needs a partial weight bearing measure of the lower extremity in order to measure functional status of individuals with limited weight bearing. Two squatting tests, performed in partial weight bearing, on an inclined sliding board apparatus have shown to yield reliable data; no data have been gathered about its validity to measure function. Therefore, the purpose of this study was to test how well these two partial weight bearing function tests correlated with self-reported physical activity levels. Fifty-three subjects (ages 21-62, mean = 32.40 ± 13.25) with no recent history of lower extremity injury were tested. Subjects performed a 30 squat repetition test for time and a 20 second test for squat repetitions, executing a single leg squat on the Total Gym. Subjects estimated their self-reported daily physical activity using the Danish Physical Activity Scale (DPAS). The intra-class correlation coefficient for both the timed 30 one-legged squat test and the number of one-legged squats in 20 seconds was .98. This study showed statistically significant correlations between the two squat repetition tests and the METs/hour as reported by the DPAS (r = -.38 and r=.46 respectively). The results provide evidence to support using PWB squats as a measuring tool for LE function in healthy individuals.
Introduction

Injuries of the lower extremity (LE) are often accompanied by a period of non or partial weight bearing. The goal for rehabilitation after a LE injury is to return the individual to the pre-injury activity level in the most efficient manner. Therefore, it is important for clinicians to monitor all patients’ performance as they progress towards advanced activities so the patients can return to a maximum level of function. In order to relate clinical performance to functional level, clinicians use close kinetic chain testing or functional weight-bearing tests (4,6,8,11,13).

Traditionally, clinicians have used isokinetic strength testing as the primary tool to assess a patient’s strength and readiness to progress to more advanced functional levels (3,5,6). This type of testing is often referred to as open kinetic chain (OKC) testing since the distal segment (foot and lower leg) is free and in a non-weight bearing position (13). This position has advantages and disadvantages. The advantage is that the muscle acts in isolation. Therefore, a clinician can easily test and re-test a specific muscle or joint (6,13). However, studies have shown that open kinetic chain testing has deleterious effects on the patellofemoral joint and the anterior cruciate ligament (3,10,13). Additionally, training only in a non-weight bearing position cannot sufficiently prepare an individual to return to a functional level. Stiene et al described open kinetic chain testing as nonfunctional because it lacks proprioceptive input and synergistic muscular
contractions common to normal movements (10). Many studies also suggested that open kinetic chain tests are not valid measures of a person’s ability to perform weight bearing activities (3,5,6,7,13).

More recently, closed kinetic chain (CKC) testing has been preferred due to the evidence that it is more closely related to function than non-weight bearing activities (3,5,6,7,10,13). Functional performance tests have been supported as a good predictor for successful return to pre-injurious activity. These tests have been incorporated into rehabilitation of LE injuries (6,7,8). Examples of functional lower extremity weight bearing tests include one leg hops, step-ups, and running in a figure-8. Research has shown that these tests provide reliable data and valid inferences about lower extremity functions (2,6,9,11,13). Stiene et al concluded that weight bearing exercises are more desirable in lower extremity rehabilitation because of the functional nature of the exercises (10).

Although weight bearing tests have been shown to yield valid inferences and reliable data as testing tools for lower extremity weight bearing performance, there still exists the dilemma of testing an individual with limited weight bearing capabilities (7). These individuals are unable to bare weight through their involved extremity and thus unable to complete functional performance tests, such as the step-ups and running in a figure-8. Munich et al proposed an alternative method (7). An inclined sliding board apparatus, such as the Total Gym (Engineering Fitness, Inc., San Diego, CA), was used to measure partial weight bearing performance of the lower extremity. This apparatus
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consists of an inclined sliding bench that allows individuals to bare some weight through the lower extremity (7,12).

Munich et al examined the reliability of two partial weight bearing tests using the Total Gym. The first test consisted of the number of one-legged, partial-weight bearing squat repetitions performed during a 20 second interval. After a short break, the subjects were timed for how long it took to complete 50 one-legged squats. The investigators concluded that the two test protocols yielded reliable data, in healthy subjects (7). However, there has been no evidence regarding the validity of the inferences about function (7).

Another method that clinicians often use to measure their patient’s function is a self-report instrument. Recently, Aadahl et al developed a physical activity scale, the Danish Physical Activity Scale (DPAS), for measuring physical activity in 24 hours. The scale included work, leisure, and sports activities into one measure. The purpose of the study was to develop and examine the validity of this new self-report instrument. Concurrent validity of the scale was examined through comparison of the information from an activity diary. The investigators concluded that the new scale yields reliable data and valid inferences about an individual’s physical activity level (1). A weakness to this scale is that it is not a true physical measure. It is subjective and may result in reporter error.
Purpose

Physical therapy needs a partial weight bearing measure of the lower extremity. Two squatting tests on an inclined sliding board apparatus have shown to yield reliable data, yet no data have been gathered about its validity to measure function. The purpose of this study was to test how well PWB function tests using the sliding incline apparatus (i.e., Total Gym) correlated with self-reported physical activity levels. It was hypothesized that individuals who report higher activity using the DPAS, would perform better on both of the one-legged squatting tests than those who report lower physical activity levels.

Methods

Design

This was a correlational study which included three dependent variables. These variables include the time (seconds) needed to complete 30 one-legged squats on the Total Gym, the number (count) of one-legged squats performed in 20 seconds on the Total Gym, and self-reported activity level, measured in METs/hour, using the Danish Physical Activity Scale.

Subjects

The investigators enrolled healthy adults to participate in the research study. In order to take part in the study, the individual had to be healthy and 18 years of age or older. The participant was to have no recent history of lower back, hip, knee, leg, or foot problems. Other exclusion criteria included pregnant women and those who are not able
to follow instructions. Prior to testing, a signed informed consent with the policies of the Medical College of Ohio Institutional Review Board (# 10457) was collected from each participant.

**Apparatus**

Participants performed both partial weight bearing squat tests using the Total Gym (Engineering Fitness International, Inc., San Diego, CA). The Total Gym is an exercise device that consists of an adjustable sliding board that displaces on a track, handle bars, and a footplate. Munich et al examined two tests that have yielded reliable data. The intra-class correlation coefficient for the 50 squat repetition timed test was .80. The ICC for the 20-second squat repetition test was .89. It was reported that Total Gym protocols could be used to consistently measure the number of repetitions and the time interval per number of squats.

**Figure 1.** Subject positioned on Total Gym (Engineering Fitness International, Inc., San Diego, CA)
Participants estimated their self-reported daily activity using the Danish Physical Activity Scale (DPAS). This scale has been used to provide an estimate of a person’s total energy expenditure over the course of 24 hours (Appendix). Aadahl et al reported this scale to be a valid measure of one’s self-reported activity level.

**Procedure**

Participants performed all tests on the same testing day. These tests included the two squatting tests (the time in seconds needed to complete 30 one-legged squats on the Total Gym and the number of one-legged squats performed in 20 seconds on the Total Gym) and the self reported physical activity level survey. The investigator explained the timing and counting of squats. Participants were informed to perform the squats at their own pace to ensure safety, working as hard as they felt safe and comfortable. Investigators also demonstrated how to perform a squat on the Total Gym. The participant was then given the opportunity to practice the one-legged squats. After the participant was familiar with the procedures, both squatting variations were tested, which were assigned in random order by the investigator. Once both squat tests were complete, the participant was asked to complete the Danish Physical Activity Scale.

**Timed 30 one-legged PWB squat test**

This test involved measuring the amount of time needed to perform 30 one-legged squats on the Total Gym. Prior to testing, the participants flexed their knee to 70° while on the Total gym. A goniometric measurement was taken and the Total Gym was
adjusted to ensure the sliding board would not go beyond 70° of flexion. The subjects were directed to move through a range of 0° extension to a maximum of 70° flexion. They were required to flex their knee as far as comfortable in this limited range. Figure 1 demonstrates the proper positioning of the subject on the Total Gym. Once the participants received instructions on the test, they were allowed to practice the squats. The participants rested for one minute following the practice squats, then the actual test began.

20-second one-legged PWB squat test

This test involved counting the number of one-legged squats in 20 seconds on the Total Gym. Prior to testing, the participants flexed their knee to 70° while on the Total gym. A goniometric measurement was taken and the Total Gym was adjusted to ensure the sliding board would not go beyond 70° of flexion. The subjects were directed to move through a range of 0° extension to a maximum of 70° flexion. They were required to flex their knee as far as comfortable. Figure 1 demonstrates the proper positioning of the subject on the Total Gym. Once the participants received instructions on the test, they were allowed to practice the squats. The participants rested for one minute following the practice squats, then the actual test began.

Danish Physical Activity Scale

This scale asked participants to estimate the amount of time spent in nine different levels of activities in 24 hours. The levels of activity ranged from inactivity, such as
sleeping, to strenuous activity, as in playing sports. Each level of activity represented a
certain level of metabolic equivalents (Figure 2). Once the survey was completed, the
amount of time spent in each level was used to estimate the METs in that level. For
example, 8 hours in level A = 8hrs x .9 MET = 7.2 METs. Since many of the participants
did not fully account for 24 hours a day on the Danish physical Activity Scale, the
estimated METs were standardized to represent METs/hour for each participant.

<table>
<thead>
<tr>
<th>Test Level</th>
<th>Example of activity</th>
<th>MET level</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Sleeping or resting</td>
<td>.9 MET</td>
</tr>
<tr>
<td>B</td>
<td>Sitting, reading, watching TV</td>
<td>1.0 MET</td>
</tr>
<tr>
<td>C</td>
<td>Eating, Working at a desk, sitting in a meeting</td>
<td>1.5 MET</td>
</tr>
<tr>
<td>D</td>
<td>Standing, cooking, driving a car</td>
<td>2.0 MET</td>
</tr>
<tr>
<td>E</td>
<td>Light cleaning, grocery shopping, slow dancing</td>
<td>3.0 MET</td>
</tr>
<tr>
<td>F</td>
<td>Brisk walking, bicycling for pleasure, painting</td>
<td>4.0 MET</td>
</tr>
<tr>
<td>G</td>
<td>Gardening, carrying light objects upstairs</td>
<td>5.0 MET</td>
</tr>
<tr>
<td>H</td>
<td>Aerobics, health club exercising, shoveling snow</td>
<td>6.0 MET</td>
</tr>
<tr>
<td>I</td>
<td>More effort than level H, bicycle racing, playing sports</td>
<td>7.0 MET</td>
</tr>
</tbody>
</table>

Figure 2. *DPAS Activity Levels*

Additional Data Collected

Other information collected from participants included age, gender, height, and
weight. The participant’s body mass index (BMI) was estimated from the subject’s
physical data. This information was used for descriptive statistics of the participants in
the study.

Data Analysis

In order to determine how well the two lower extremity performance tests
correlated with the self-reported activity scale, the investigators analyzed the data using a
Pearson’s correlation analysis. The lower extremity performance tests were correlated
Results

Fifty-three individuals participated in this study: twenty-nine females and twenty-four males. The age range of subjects was 41 years (21-62 years) with an average age of 31.07 for females and 34.00 for males (Table 1). The intra-class correlation coefficient for both the timed 30 one-legged squat test and the number of one-legged squats in 20 seconds test was .98. There were no gender differences (p > .05) for any of the dependent variables. The right lower extremity was used for all analyses.

The results of the correlation analysis supported the hypotheses. There was a negative correlation (r = -0.38, p < .05) between the amount of time needed to complete 30 one-legged squats and the METs/hour reported on the physical activity scale (Table 3). There was a positive correlation (r = 0.46, p < .05) between the number of one-legged squats performed in 20 seconds and the METs/hour reported on the physical activity scale (Table 3).

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years)</td>
<td></td>
<td>32.40</td>
<td>13.25</td>
</tr>
<tr>
<td>Height (m)</td>
<td></td>
<td>1.73</td>
<td>0.08</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td></td>
<td>73.12</td>
<td>11.21</td>
</tr>
<tr>
<td>BMI</td>
<td></td>
<td>24.27</td>
<td>3.74</td>
</tr>
</tbody>
</table>

Table 1. Subject characteristics.
### Table 2. Measures.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG 30 reps</td>
<td>30.00</td>
<td>8.72</td>
</tr>
<tr>
<td>TG 20s</td>
<td>22.64</td>
<td>5.69</td>
</tr>
<tr>
<td>MET per hour</td>
<td>1.80</td>
<td>0.39</td>
</tr>
</tbody>
</table>

### Table 3. Correlations.

<table>
<thead>
<tr>
<th></th>
<th>TG 30 reps</th>
<th>TG 20s</th>
<th>MET per hour</th>
<th>Age</th>
</tr>
</thead>
<tbody>
<tr>
<td>TG 30 reps</td>
<td><strong>-0.89</strong></td>
<td>-0.38</td>
<td><strong>0.49</strong></td>
<td>0.00</td>
</tr>
<tr>
<td>TG 20s</td>
<td>-0.89</td>
<td><strong>0.46</strong></td>
<td>-0.30</td>
<td>0.00</td>
</tr>
<tr>
<td>MET per hour</td>
<td>-0.38</td>
<td><strong>0.46</strong></td>
<td>0.13</td>
<td>0.24</td>
</tr>
<tr>
<td>Age</td>
<td><strong>0.45</strong></td>
<td>-0.25</td>
<td>0.11</td>
<td></td>
</tr>
</tbody>
</table>

**Correlation is significant at the .01 level (1-tailed)**
* Correlation is significant at the .05 level (1-tailed)

### Discussion

In this current investigation, we attempted to examine concurrent validity evidence of two lower extremity squat tests using the Total Gym. With this device, participants were tested in a partial weight bearing position. The two test variables that were examined, the 30 repetition timed test and the 20-second repetition test, revealed statistically significant correlations with the DPAS (Table 3). These results provide evidence to support using PWB squats as a measuring tool for lower extremity function in healthy individuals.
**Figure 3.** The relationship between the time to complete 30 one-legged squats and METs/hour

This study showed statistically significant correlations between the 30 repetition timed squat test and the DPAS ($r=-.38$). The time it took to complete 30 one-legged squats negatively correlated with the individual’s self-reported physical activity level reported by the DPAS (Table 3). Therefore, the more active an individual reported to be, the shorter amount of time needed to perform 30 squats. Similarly, the less active an individual reported to be, the longer it took to complete 30 one-legged squats. Figure 3 is a scatter plot demonstrating the linear relationship between the time to complete 30 one-legged squats and METs/hour.
20-second one-legged PWB squat test

Figure 4. The relationship between the number of squats completed in 20 seconds and METs/hour.

This study also showed statistically significant correlations between the 20-second repetition squat test and the DPAS ($r=.46$). The number of one-legged squat repetitions completed in 20 seconds positively correlated with the individual’s physical activity level reported by the DPAS (Table 3). Therefore, the more active an individual reported to be, the more one-legged squats they performed in 20 seconds. Similarly, the less active an individual reported to be, the fewer number of one-legged squats performed in 20 seconds. Figure 4 is a scatter plot demonstrating the linear relationship between the number of squats completed in 20 seconds and METs/hour.

The results of this study were consistent with the energy expenditure required to complete this test. The number of squat repetitions one performed depended on the individual’s strength and level of conditioning. The more active an individual’s lifestyle, the more likely they were to have the strength to perform a greater number of one-legged squats and vice versa. Therefore, one can conclude that the more active individuals
performed better than those who were less active. Results from this study also showed a
definite correlation between age and performance of the tests (Table 3). As age
increased, the time needed to perform 30 one-legged squats increased. Also, as age
increased, the number of repetitions performed in 20 seconds decreased. Both
correlations demonstrate that the squat tests are sensitive to changes shown with age. As
people age, they tend to be less strong and have less endurance as those who are young.

Limitations

A major limitation in this study was that many participants had problems
understanding that the minutes and hours for each time of activity level in the DPAS had
to total 24 hours. Accounting for time of each activity in 24 hours may have been
difficult for subjects to recall. Another limitation was using healthy, full-weight bearing
subjects. The results may have been different if the subjects had a lower extremity
dysfunction.

Future Studies

Future studies involving the correlation between lower extremity squatting tests
with physical activity level would be beneficial. A change that may be beneficial would
be to have the subjects perform physical testing in order to obtain MET levels, rather than
use of a self-reported activity scale. This method would be a better indicator of physical
activity. It may result in a more accurate measure of an individual’s activity level. Since
this current study only focused on healthy individuals, another change that may be
beneficial would be to test individuals with lower extremity dysfunction.
Conclusion

The results of this study provide correlation evidence to support the use of two lower extremity partial weight bearing performance tests. These tests can be used to measure the functional ability of patients during rehabilitation. This may allow therapists to better document a patient’s progress, early in the rehabilitation process.
References


## Appendix

### Physical Activity Scale

<table>
<thead>
<tr>
<th>Examples</th>
<th>Minutes</th>
<th>Hours</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A  Sleeping, resting</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>B  Sitting, watching TV, reading</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>C  Working at desk, sitting at mtg, eating meals</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>D  Standing, cooking, washing dishes, driving</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>E  Light cleaning, vacuuming, walking downstairs, slow dancing, grocery shopping</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>F  Bicycle for pleasure, brisk walking, painting or plastering</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>G  Gardening, carrying wood, carrying light objects</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>H  Aerobics, exercising, shoveling snow</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
<tr>
<td>I  More effort than level H, bicycle racing, playing sports</td>
<td>□ □ □</td>
<td>□ □ □</td>
<td>1  2 3 4 5 6 7 8 9 10</td>
</tr>
</tbody>
</table>