Correlational Study of Three Cardiorespiratory Fitness Tests for Men With Mental Retardation

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Previous research has determined that there are few valid and reliable tests of cardiorespiratory fitness for men with mental retardation (MR). Though the use of submaximal bicycle ergometry is a technique often used to predict fitness in some samples, it has been questioned for persons with mental retardation. No studies have attempted to validate the use of a friction-braked bicycle ergometer as a method to estimate cardiorespiratory fitness in men with mental retardation. Thus, the purpose of this study was to determine the correlation among three tests of cardiorespiratory fitness in men with MR.

Data were collected on 15 subjects (25.9 ± 6.1 yrs.; 67.9kg ± 13.5) with mild MR. Subjects performed three tests: (a) submaximal Astrand-Rhyming test on a friction-braked bicycle ergometer; (b) one-mile walk for time; and (c) maximal incremental walking protocol on motorized treadmill. Results from the three tests were: (a) predicted VO2 from bicycle ergometry was 43.54 ± 9.94 ml/kg/min; (b) one-mile walk time was 13.9 ± 2.3 min; and (c) VO2p from the walking protocol was 40.36 ± 10.53 ml/kg/min. Regression analysis of bicycle ergometry predicted VO2, and one-mile walk time revealed that both exercise protocols were significantly correlated with VO2p from the maximal walking treadmill testing. Independent correlational analyses produced coefficients of \( R = .64 \) for bicycle ergometry with VO2p, and \( R = -.84 \) for one-mile walk time with VO2p. While both tests were significantly correlated with laboratory-based treadmill testing VO2p, the one-mile walk time was a better indicator of cardiorespiratory fitness compared to the bicycle ergometry predicted VO2.

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Several studies have established that, as a group, adults with mental retardation (MR) are particularly low in measures of cardiorespiratory fitness (Beasley, 1982; Coleman, Ayoub, & Friedrich, 1976; Pitetti, Rimmer, & Fernhall, 1993; Schurrer, Weltman, & Brammel, 1985; Kittredge, Rimmer, & Looney, 1994). While there is evidence to support that with adequate training opportunities subjects with mental retardation can increase their level of cardiorespiratory fitness (Andrew, Reid, Beck, & McDonald, 1979; Schurrer, Weltman, & Brammel, 1985; Tomporowski & Jameson, 1985; Pitetti & Tan, 1991), procedures to assess cardiorespiratory fitness in this population are less clear (Seidl, Reid, & Montgomery, 1987; Lavay, Reid, & Cressler-Chaviz, 1990).

Most cardiorespiratory fitness tests are based on the premise that there is a linear relationship between heart rate, oxygen uptake, workload, and energy expenditure. While this relationship is not based on intellectual level, assessing the cardiorespiratory fitness of people with MR is difficult because of variations in testing methodology, understanding the concept of best effort, cadence adherence, variable performance by the participant because of learning or motivational changes, and efficiency of movement (Seidl et al., 1987). There continues to be a need to develop various valid and reliable field tests in order to determine the effectiveness of different exercise programs for this population.

Cardiorespiratory fitness tests used with persons with MR have included field tests and laboratory-based tests. Benefits of field tests include more subjects can be tested at one time and little equipment is necessary. While there are several alternatives for field testing cardiorespiratory fitness in persons without mental retardation, fewer alternatives are available for persons with MR. Currently, there appears to be five validated field tests that predict cardiorespiratory fitness for individuals with mental retardation (Pitetti, Rimmer, & Fernhall, 1993). These include: the 1.5-mile walk/run (Fernhall & Tymeson, 1988), the 1.0-mile walk (Rintala, Dunn, McCubbin, & Quinn, 1992), bicycle ergometry testing using the Schwinn Air-Dyne (Pitetti & Tan, 1990), a modified Leger and Lambert shuttle run, and the modified Canadian step test (Montgomery et al., 1992).

Pitetti and Tan (1990) demonstrated with a sample of 12 adults (8 males and 4 females) that using an air-braked bicycle ergometer (Schwinn Air-Dyne) seemed to provide a valid means for assessing cardiorespiratory fitness as compared to treadmill test results. While these data are encouraging, due to the relatively small sample that included men and women, justification for additional support seems warranted. Other investigators have attempted to determine the reliability of the friction-braked bicycle ergometer as a means of assessing cardiorespiratory fitness in persons with mental retardation. Bundschuh and Cureton (1982) assessed the test-retest reliability of adolescent-aged subjects with mental retardation using the physical work capacity test (PWC 170) at $R = .85$. Cressler, Lavay, and Giese (1988) assessed the reliability of a modified physical work capacity test on a standard friction-braked bicycle ergometer in subjects with mental retardation and determined that for these subjects, the correlation coefficient was relatively low at $R = .64$. However, the validity of the values determined from a standard friction-braked ergometer compared to values from laboratory-based assessment has not been determined with this population. Because many of the bicycle ergometers available for public use are the friction-braked models, paired with the ever present need to increase generalizability of research findings, it was determined that the validity of bicycle ergometry testing should be determined.
Researchers have speculated that certain submaximal bicycle protocols may not be valid methods to predict cardiorespiratory fitness in this population. This may be due to the lack of subject familiarity with cycling and/or the inability to pedal against resistance during submaximal testing which may induce local quadricep fatigue prior to steady state exercise. It has been demonstrated that subjects with poor levels of physical fitness may underestimate cardiorespiratory efficiency when being tested by cycle ergometer (Åstrand & Rodahl, 1977). Though this claim does not refer to subjects with mental retardation, it may be evident as many studies have determined that subjects with mental retardation have lower levels of fitness likely due to a sedentary lifestyle and lack of opportunity to exercise. It is important that multiple options are available, both for assessment and program development, for persons with mental retardation. While there are data to support the relationship between maximal treadmill tests and submaximal bicycle ergometry in men without mental retardation, to date no studies have compared the use of the maximal treadmill testing with the one-mile walk test and submaximal friction-braked ergometry in men with MR. Therefore, the purpose of this study was to determine the correlation among three tests of cardiorespiratory fitness in men with MR. The findings from this study are essential to provide teachers and other direct care providers with additional information to determine the most effective and efficient means of evaluating the cardiorespiratory fitness of men with MR. Appropriate assessment and evaluation of cardiorespiratory fitness is essential in developing successful instructional programs related to the health and well-being of persons with MR.

Method

Subjects

Fifteen male subjects volunteered to participate (25.9 ± 6.06 years, weight 67.9 ± 13.53 kg). Based on available IQ test results and input from the group home supervisors, the majority of the subjects were identified as having mild mental retardation. From the available past IQ records, the scores ranged from 42 to 68 (mean = 53). However, these IQ scores were not recent, varied in test used, and data were not complete for all subjects. The men lived in community group homes or continued to reside with their parents and worked in community-supervised facilities. Only men were chosen due to the limited number of females volunteering to participate. All of the subjects and/or their legal guardians gave informed consent prior to participation in the study.

Experimental Protocol

All participants performed three exercise tests: (a) maximal exercise test on treadmill; (b) submaximal bicycle test; and (c) one-mile walk test. A 3-stage familiarization process was completed to increase the comprehension of testing requirements and comfort with the testing situation (Reid, Dunn, & McClements, 1993; Rintala, McCubbin, & Dunn, 1995).

Maximal Treadmill Test. The VO₂p treadmill protocol required the subjects to walk at 2.5 to 4 mph (depending on the individual's capability) at 0% grade for 2 minutes, followed by a 2.5% grade for 2 minutes. The grade was then increased...
2.5% every minute with a constant speed up to 20% grade. Beyond a grade of 20%, the speed was increased in one-minute intervals until the subject reached volitional fatigue. A Quinton Model Q630A electrocardiograph was used to monitor the heart rate during the test. Blood pressure was taken every other minute using a Quinton Model 410 device. A Parkinson Cowan (PC) dry gas meter was used to measure the volume of inspired air. Expired air was measured with a S-3A oxygen analyzer and a LB2 (CO₂) analyzer from Beckman Instruments (Fullerton, CA). Data samples were taken every 30 seconds and were interfaced into an IBM personal computer. All subjects were tested by the same research team within a 2-week interval.

**One-Mile Walk Test.** The Rockport one-mile walking test (Kline et al., 1987) was conducted in an indoor facility on a measured 1/8-mile course that was marked with cones. Specific verbal instructions were provided to “walk eight laps as fast as you can, as if in a hurry to go somewhere.” Following a one-lap practice walk, each subject walked with a testing assistant who stayed slightly in front of the subject. Total walk time was recorded to the nearest second and used in the analyses. As a safety precaution, subjects wore a pulse monitor and receiver and heart rates were recorded by the assistant following each lap. A minimum of 2 days rest was allowed between treadmill test and one-mile walk test.

**Submaximal Bicycle Test.** All subjects performed a submaximal bicycle test on a friction-braked bicycle ergometer using a modified Astrand-Ryhming protocol (1954). Subjects pedaled at 50 revolutions per minute at workloads between 600 and 900 kpm for 6 minutes that produced a steady state heart rate between 130 and 150 bpm. Heart rate was taken every minute with the average heart rate recorded during the 5th and 6th minutes. A computerized version (from Mt. Sinai Hospital, Miami, FL) of the modified Astrand-Ryhming nomogram (Åstrand, 1960) was used to estimate VO₂ from submaximal heart rate values at a given workload.

**Data Analysis**

Simple regression analyses were performed to evaluate the predictive ability of the one-mile walk test and the submaximal bicycle test of the sample group. Statistical analysis of the data were performed using Statgraphics 512 for the Macintosh computer. Peak VO₂ from the treadmill testing was used as the criterion variable for each analysis. An alpha level of 0.05 was established to indicate statistical significance (see Table 1).

**Results**

A significant (<0.05) negative correlation coefficient was determined between VO₂p and the one-mile walk time ($R = -0.84$), and a significant positive correlation was determined between VO₂p and the bicycle ergometry test ($R = 0.64$). While both correlations were determined to be significantly different from 0, as reflected by the $F$ statistic, further inspection of the data indicate more clearly why the one-mile walking test is a better predictor of aerobic capacity in the sample studied.

The data presented in Table 2 illustrate some important factors in the analysis. The coefficients of determination ($R^2$), or the amount of variance that can be explained, was .71 (one-mile walking test) or .41 (bicycle ergometer test). During
Table 1  Descriptive Aerobic Performance Data for All Subjects

<table>
<thead>
<tr>
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<th>Mean</th>
<th>SD</th>
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<tr>
<td>Peak VO₂ (treadmill)</td>
<td>40.36 ml/kg/min</td>
<td>10.53 ml/kg/min</td>
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<tr>
<td>Predicted VO₂ (bicycle protocol)</td>
<td>43.54 ml/kg/min</td>
<td>9.94 ml/kg/min</td>
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<td>Mile time</td>
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<td>2.26 min</td>
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Table 2  Multiple Regression Summary Tables for VO₂ and Walk Time and Bicycle Test

<table>
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<tr>
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<th>DF</th>
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<th>R²</th>
<th>Sf. R²</th>
<th>Std. error</th>
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<td>Bicycle test</td>
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<td>.41</td>
<td>.365</td>
<td>7.919</td>
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The findings of this study indicate men with mild mental retardation can successfully participate in two types of field tests to evaluate cardiorespiratory fitness. Though both measures used in this study have acceptable levels of validity, the one-mile walk test appears to be the better alternative to laboratory-based VO₂ assessment. The figures demonstrate that the one-mile walk test does not appear to overestimate or underestimate the aerobic performance in these subjects. This differs from the findings of Kittredge, Rimmer, and Looney (1994) in which the predicted VO₂p in a high percentage of the subjects was overestimated, based on the one-mile walk time. It should be noted their sample (n = 25) included 12 males and 13 females.

In this study, the bicycle test was a more difficult test to administer as subjects experienced problems with cadence adherence and handling changes in workload. This required more practice in the preliminary stages prior to testing,
Regression of Observed VO2max vs. Walk Time

\[ y = 95.236 - 3.9342x \quad R^2 = 0.711 \]

Figure 1 — Scattergram and regression line for estimating aerobic capacity for men with mental retardation when using the one-mile walking test.

Regression of Observed vs. Predicted Bicycle VO2max

\[ y = 10.818 + 0.67852x \quad R^2 = 0.410 \]

Figure 2 — Scattergram and regression lines for estimating aerobic capacity of men with mental retardation for the Åstrand Ryhming bicycle ergometer test.
which in essence took more time and effort in test administration. The fact that testing was more problematic, together with the supported evidence from the correlation analysis, justifies the use of the one-mile walking test as a preferred predictor of aerobic performance.

The subject pool was relatively small which may effect generalizability of these findings. Further research to determine whether similar findings are noted for other people with mental retardation, including females and individuals with more severe levels of mental retardation, is warranted. In addition, evidence that demonstrates that the one-mile walk test can be valid and reliable without the use of 1-to-1 ratio of subjects to testing assistants is needed. It is hoped this information will be helpful to teachers and other practitioners that may need information about cardiorespiratory fitness levels of persons with mental retardation. The results of this study further substantiate that a relatively easy to administer test, requiring only walking space and testing assistants, can provide meaningful information to assist in monitoring the fitness levels of similar individuals. Perhaps teachers and other health-care providers can use this process of assessment to justify the need for more programs and promote opportunities to improve physical fitness in this population.

References


