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Abstract

The purpose of this study was to assess the reliability and validity of a mobility obstacle course for women with mobility impairments. Participants included 72 adult women with permanent physical disabilities including arthritis, orthopedic conditions, paraplegia, and others. The 60-m course consisted of carpeted runways and turns, ramps, a doorway, a transfer, and object manipulation. Participants completed two trials, walking or wheeling through the course as quickly as possible, safely and without running. Total course time and peak heart rate data were correlated with SF-36 health survey subscales. Overall, peak heart rate was significantly ($p < .05$) correlated with physical functioning ($r = -.328$), limitations due to physical functioning ($r = .261$), and pain ($r = .296$). Total course time was significantly correlated with physical functioning. These findings indicate very high reliability and preliminary evidence of validity.

KEY WORDS: disabled persons, rehabilitation, outcome assessment (health care), walking, women

Introduction

Millions of people are affected by physical disabilities that impair their mobility. Although research is accumulating concerning disease-specific mobility impairments and physical trainability, few studies have established a dynamic measure of mobility that also relates to function and health status. Further, little is known about the physical activity habits of people with disabilities (4). It is generally believed, nevertheless, that a lifestyle that includes regular exercise is conducive to a higher quality of life and functional independence, especially for those with a disability (7,13). For these individuals, physical fitness may help avoid the development of secondary conditions that may interfere with normal function, such as skin sores, depression, or joint contractures (5). Currently, a need exists for a dynamic test of functional mobility and fitness, including strength, endurance, and skill. Such a measure may help clinicians develop appropriate exercise and functional activity programs for individuals with disabilities. Therefore, the authors of this study developed a dynamic test of functional mobility by constructing an obstacle course and assessing its concurrent validity and reliability with a standardized measure of function, mobility, and health status - the Medical Outcome Study Short Form - 36 items (SF-36). If found to be both reliable and valid, it could provide rehabilitation therapists with a means to measure change in mobility performance across a wide range of diagnoses associated with mobility impairment. Additionally, the obstacle course could be used as a functional measure of improvement in mobility in future research projects for people with mobility impairments.

It is generally postulated that persons with mobility impairments are at increased risk of developing secondary medical complications such as cardiovascular disease, hypertension, pressure ulcers, urinary tract infections, and osteoporosis (8). Therefore, improvement in physical capacity is considered to be a major objective of the rehabilitation process. A higher physical capacity can improve the ability to perform activities of daily living (ADLs) and reduce the occurrence of medical complications (2). Analysis of some ADLs such as negotiating a ramp, making transfers, entering/leaving a car, and negotiating environmental barriers are associated with high levels of physical strain, which may lead to a restricted ability to perform the ADL. This, in turn, can negatively impact the patient's independence (8). Research with

patients with longstanding spinal cord injury has shown that improvements in physical capacity over time were associated with a decrease in physical strain during ADLs (6). Objective evaluation tools are needed to assess the efficacy of training and exercise programs on the performance of ADLs (2).

One possible way to assess training programs may be to use a mobility obstacle course. In one study by Taylor and Gunther (14), two groups of subjects (one with normal health and one with arthritis diagnoses) completed a walking obstacle course that included 30, 70, and 90-degree directional changes, moving from sit to stand, stepping over objects, and walking across varying surfaces. Performance on the course was then correlated with performance on the Fifty Foot Walk Test. The authors found high test-retest reliability ($p = 0.38–0.97$) and concurrent validity ($r = 0.72–0.88$) for the two measures. In addition, Mattison, Hunter and Spence (10) used a test course of varying turns to measure energy expenditure during wheelchair propulsion in individuals who were both disabled and non-disabled, as current methods of physiological testing (i.e., treadmills) are not useful for wheelchair users. Both of these studies lend support to use of mobility obstacle courses as dynamic measures of mobility.

Additionally, past studies have used obstacle courses to test perceptual motor and balance capacity, but these courses did not require physical fitness of the subjects. For instance, mobility obstacle courses have been used to measure the impact of various interventions with patients with cerebrovascular accident (CVA) (6,17). Webster et al. (17) described the development of an obstacle course to measure the effects of hemispatial neglect on wheelchair navigation. Gouvier et al (6) trained patients with CVA in visual scanning techniques and then assessed the impact of this training using a 94-foot long obstacle course. Means and O'Sullivan (9) used a functional obstacle course to test balance and mobility in elderly ambulatory persons. Evaluation criteria for these studies reflected perceptual-motor abilities of subjects, but were not demanding in terms of muscular strength and endurance.

Few studies have been found that used obstacle course performance time to assess the dynamic mobility of persons with physical impairments of various etiologies. In this study, therefore, the data collected during the obstacle course (time and peak heart rate, HR) were compared to a standardized measurement of function, mobility, and health status (the SF-36). The SF-36 was tested for quality, scaling assumptions, and reliability in a study that found support for its use across diverse populations (11). Concurrent validity and reliability of our obstacle course with this measurement tool, therefore, will lend credibility and acceptability to the use of an obstacle course for assessment of dynamic mobility.

To summarize, specific aims of this study were (a) to assess the reliability of total course performance across two trials on one day, using total time and peak HR as outcome measures, and (b) to determine the relationship (and hence the concurrent validity) between the two outcome measures and standardized measures of function, mobility, and health status.

Corresponding hypotheses, therefore, included (a) intertrial reliability of measuring total course performance and peak HR will be high ($R>.80$) across two trials, and (b) total course performance time and peak HR will be related to SF-36 subscales including physical functioning, limitations due to physical functioning, and pain.

Methods

Participants

The participants consisted of a heterogeneous group of 72 adult women with physical disabilities entering a large-scale physical activity intervention trial in a large Midwestern metropolitan area. Their mean±SD age was 44±9 years, ranging from 21 to 59. The mean±SD body mass index was 32.0±10.2 kg/m^2, ranging from 19-67 kg/m^2 (BMI > 30 kg/m^2 indicates obesity). Thirty-nine participants ambulated without an assistive device, while 25 ambulated with one. Six participants used a manual wheelchair for their functional mode of ambulation. All were independent community dwellers. Diagnoses are summarized in Table 1.

Table 1. Diagnoses of participants

Diagnosis	n
Arthritis	21
Orthopedic conditions	17
Spinal cord injury/Spina bifida/Post-polio	15
Fibromyalgia	10
Muscular Dystrophy	7
Multiple Sclerosis	7
Systemic Lupus Erythematosus	6
Morbid obesity	4
Pulmonary conditions	5
Stroke/ brain injury/cerebral palsy	5
Other	8

Adult women with a mobility impairment between the ages of 18 and 59 were included in this study. Participants of any ethnic, racial or socio-economic group, or employment status were included. They needed to possess normal cognitive skills, be capable of informed consent, and competent to complete all assessments and interventions. All of the participants were "neurologically stable" at least within the last six months prior to screening. Also, the participants were medically stable with no absolute contraindications to moderate exercise. Fifty percent of the participants were randomly selected to be cleared by a medical physician; the other 50 percent completed a general health screening questionnaire. The participants resided within transportation distance of Kansas City. Finally, they were judged to be capable of benefiting from increased physical activity and exercise. If any of these criteria were not met, the prospective subject was excluded from the study.

Recruitment and Screening Process

Recruitment of voluntary participants was accomplished through advertisements distributed to all local newspapers, hospitals, rehabilitation centers, and community disability agencies in the Kansas City, Topeka, and Lawrence, Kansas and St. Joseph and Kansas City, Missouri area. In addition, advertisements were distributed to all university hospital outpatient clinics and placed in its outpatient newsletter.

Phase 1 of screening was a telephone interview to ascertain that the participants met the inclusion criteria (female, age disability, mobility impairment, quick cognitive screen, available during time frame of study, interested enough to participate) and were willing to participate.

Phase 2 was a functional mobility test only for prospective participants who walked without any assistive device (i.e. lower extremity prosthetic/orthodox device, cane, walker, wheelchair, service dog). "Height-normalized mean velocity" (HNMV) of maximum-speed walking was determined over a 25-foot distance (1). If the subject's HNMV was 1.5 or more standard deviations below the mean HNMV for able-bodied women in their age group, they were included in the project. The mobility obstacle course was not used for this functional screening. Half of the participants who were randomly assigned to the experimental group, passed all screenings before performing on the mobility obstacle course.

Phase 3 screening for half of the participants was a medical examination by a physician. This group will receive treatment intervention for participation in a related study; therefore, clearance was needed. The other half completed a health screening questionnaire to detect possible contraindications. Some participants were referred to the study physician (a physiatrist) or their family physician before they were tested on the mobility obstacle course.

Participants completed all screenings and fitness testing and attended a full-day workshop before receiving a large packet of questionnaires via mail. The packet included the SF-36 health survey and the Physical Activity Scale for Individuals with Physical Disability (PASIPD) (16). The completed SF-36 was scored for the nine subscales: general health, health change, physical functioning, limitations due to physical health, limitations due to emotional health, social functioning, pain, energy/fatigue, and emotional well-being. The PASIPD is a modified version of the Physical Activity Scale for the Elderly (PASE), a survey used to assess activities performed by older individuals (15). Finally, the participants mailed the packet back to the research staff in a self-addressed stamped envelope.

Equipment

A "Polar Vantage NV" ^{TM} HR monitor (Polar Electro Inc., Port Washington, NY) and its companion software (Polar Heart Rate Analysis Software, Version 5.04 (1996) for Microsoft Windows) were used for this study. An Alpha 461 stopwatch (Sportline Inc., Campbell, CA) was used to time the participants on the mobility course. The 60-meter mobility obstacle course included carpeted runways, a platform for transfers, objects for manipulation, ramps and a doorway. (See Appendix A for course diagram and description). The course was designed to be wheelchair accessible, in accordance with the Americans with Disabilities Act of 1990.

Procedures

Informed consent and mobility course assessment was conducted in a gymnasium. The testing procedure and equipment were explained to the subject. The participants' blood pressure was measured with a mercury sphygmomanometer and stethoscope. Height and weight were measured and the HR monitor was attached to the subject's thorax.

The subject was allowed one warm-up trial through the obstacle course. The subject was then given a 3-minute rest. At the start signal given by the examiner, the subject navigated the obstacle course as quickly as possible, safely, without running. The researchers hand-timed the trials using the stopwatch.

Total time for course completion was recorded to the nearest 0.1 second. The participants were given a 3-minute rest between trials during which their blood pressure was measured and HR monitored. If the subject's vital signs had not returned to a safe level, the subject did not complete a second trial. Otherwise, a second trial was completed, the blood pressure was measured, and the HR monitor was removed.

Data Analysis

Peak HR was chosen as an outcome measure for its physiological representation of physical exertion. Time and peak HR were also both chosen for their accessibility to measure and record data. All HR data were computed and the peak HR was determined from the graph of beat-by-beat HR vs. time.

The following data analyses were performed to test the two hypotheses stated above. The 95% confidence level was used in all statistical hypothesis testing.

1. To assess the intertrial reliability of measuring total course time and peak HR across two trials, paired *t*-tests and an intraclass correlation coefficients (random, k model) were calculated (12).

2. To determine the linear relationship of total course performance time and peak HR to measures of function, mobility and health status, 2-tailed Pearson product-moment correlation coefficients were calculated.

Results

Data describing the participants' characteristics are included in Table 2, and the mean, standard deviation, and range for all outcome measures are presented in Table 3.

Table 2. Descriptive data

Descriptor	Mean	SD	Range
Age	44	9	21-59
Body Mass Index (kg/m^2)	32.0	10.2	19-67
PASPLI (MET x hr/day)	11	8	0-26

Table 3.
Mean, standard deviation and range for outcome measures

	Mean	SD	Range
Dependent Variables:			
Total Course Performance Time (s)	108	78	46-496
Peak Heart Rate (bpm)	124	16	91-165
SF-36 Subscales:			
General Health	37.3	22.4	0-90
Health Change	45.7	27.0	0-100
Physical Functioning	29.6	19.7	0-80
Limitations due to Physical Functioning	24.6	34.9	0-100
Limitations due to Emotional Problems	47.6	41.8	0-100
Social Functioning	55.2	28.0	0-100
Pain	34.5	20.2	0-85
Energy/Fatigue	45.6	30.0	0-100
Emotional Well-Being	63.8	20.2	0-100

Using a paired *t*-test, no significant difference ($p>.05$) was found between trials one and two for either time ($t=.064$, $p=.949$) or peak HR ($t=.887$, $p=.378$). Intraclass correlation coefficients using the random, k model were as follows: $r=.99$ for time and $r=.98$ for peak HR. Intertester reliability was calculated for each tester for total course time, and the mean reliability was found to be 99%. A Pearson product-moment correlation coefficient was calculated for each of the SF-36 subscales with both time and peak HR. All *p*-values, *r*-values, and power analysis results are shown in Table 4.

Four correlations of measured variables and the SF-36 subscales were found to be significant using a Pearson correlation. Total course time correlated significantly with physical functioning ($p=.005$), and peak HR correlated significantly with limitations due to physical functioning ($p=.033$), social functioning ($p=.002$), and pain ($p=.015$). There was no significant finding using a Pearson correlation in comparing time and peak HR ($r=.161$, $p=194$).

Table 4: Pearson correlation coefficients and power for time vs. SF-36 subscales and total course performance time, peak HR, and SF-36 subscales

Time vs. ____	r	p	Power	Peak Heart Rate vs. ____	r	p	Power
General health	.114	.227	.23	General Health	.168	.174	.29
Health Change	.130	.278	.21	Health Change	.162	.190	.28
Physical Functioning	-.328	.005	.81*	Physical Functioning	.136	.273	.21
Limitations due to Physical Functioning	-.149	.210	.24	Limitations due to Physical Functioning	.261	.033	.61*
Limitations due to Emotional Problems	.165	.166	.29	Limitations due to Emotional Problems	.170	.169	.30
Social Functioning	.127	.287	.19	Social Functioning	.376	.002	.91*
Pain	-.100	.405	.13	Pain	.296	.015	.72*
Energy/Fatigue	.172	.148	.31	Energy/Fatigue	.147	.235	.24
Emotional Well-Being	.121	.310	.17	Emotional Well-Being	.173	.161	.31

* denotes $p<.05$

Discussion

The purpose of this study was to determine whether the Mobility Obstacle Course could be used reliably and validly as a measure of dynamic functional mobility of participants with physical disabilities and mobility impairments. In order to utilize the measurement tool with confidence, it was necessary to determine its reliability and its concurrent validity as compared to the generally accepted and standardized SF-36. It was hypothesized that intertrial reliability of total course time and peak HR would be high ($r>.80$) across two trials, and total course performance time and peak HR would be related to some or all SF-36 subscales.

For hypothesis one, paired *t*-tests revealed no significant differences between trials 1 and 2 for the variables "time to complete the course" (time) or "peak HR during completion" (peak HR). The intraclass correlation coefficient (ICC) was also found to be very high trial-to-trial at .99 and .98 for time and peak HR, respectively. Due to the fact that the random, k model of ICC was used to analyze these data, these results may be generalized to other studies in which participants are randomly selected and administered any number of trials. The combination of these two results provides evidence for very high reliability, supporting hypothesis one. Therefore, it is suggested that future investigators use only one valid trial on the course for each participant, thereby saving time for the investigators and effort for the participants.

For hypothesis two, time and peak HR data were correlated with SF-36 subscales to determine relationships between these measures and establish concurrent validity of the mobility course. It was expected that the correlations between the mobility course measurements and those SF-36 subscales that represent physical aspects of the participants' mobility impairments would be high. Other nonphysical subscales were not expected to demonstrate significant correlations. Results included the following: (a) time to complete the obstacle course was inversely related to the physical functioning of the participant as measured by the SF-36 ($r = -.328$), (b) a weak direct relationship was found between the participants' perception of their limitations due to physical functioning and their peak HR ($r = .261$), (c) a positive relationship was found between the participants' peak HR and the level of pain ($r = .296$), and (d) a positive relationship was found between social functioning and peak HR ($r = .367$). As expected, subscales of the SF-36 that measure physical aspects of health were significantly related to either peak HR or time to complete the course, but these relationships were not as strong as anticipated.

There are several possible explanations for these results. First, the relatively narrow range of SF-36 scores (concentrated toward the low-functioning end of the scales) may have artificially reduced the magnitude of the Pearson correlations.

Second, there was extreme heterogeneity of participants in terms of bodyweight, variety and severity of symptoms, ambulation status, use of assistive devices, socioeconomic status, and diagnostic conditions (i.e., primary diagnosis and number and severity of secondary conditions). Additionally, there must be other factors that contribute to general health and quality of life, other than physical activity and mobility that may have

accounted for the weakness of many of the correlations.

Finally, many variables may have influenced peak HR during course performance, including cardiovascular conditioning, anxiety, and medications. Overall, the participants in this study had above average BMI scores and scored low on the PASIPD, indicating highly sedentary lifestyles. Often, this type of lifestyle can lead to many of the above variables.

Retrospectively, it may have been more useful to report change in HR (i.e., peak HR minus resting HR) or mean HR. However, although these correlations were weak, they do provide some preliminary support for the validity of the mobility obstacle course and its use as a measure in outcomes research for people with mobility impairments.

Interestingly, the positive relationship between social functioning (a nonphysical subscale) and peak HR was the most highly correlated. Therefore, a negative correlation between these two variables was expected. It is unclear why participants who scored higher on the social functioning subscale of the SF-36 would have higher HRs upon completion of the obstacle course. However, the p-values for nearly all of the correlations analyzed did not exceed .20, supporting the existence of strong trends toward relationships between all the subscales of the SF-36 and the performance of the mobility course. Further investigation is needed to clarify these relationships.

Limitations

There are several limitations to this study. First, a more homogenous group of participants may have produced stronger correlations between the SF-36 subscales and peak HR and total course time. A study comparing wheelchair users and functional ambulatory may reveal additional information regarding validity of the obstacle course. Second, there was a lack of control over participants' completion of the SF-36. If participants had questions regarding the form, there was no means for investigators to answer those questions. Therefore, they may have answered without fully understanding the implications of the questions. For example, only two questions on the SF-36 address Social Functioning. Misunderstanding the answer scale could result in dramatic differences in scoring. Finally, this study correlated a subjective measure of function (the SF-36) with two objective measures of function (peak HR and total course time). It may be useful in future research to correlate two objective measures of function, such as performance and the Fifty-Foot Walk Test (14).

Clinical Implications

Functional outcomes are valued in the current health care environment as a means to demonstrate efficacy of treatment. Therefore, a valid and reliable dynamic test of functional mobility would provide clinicians with a tool to measure change in functional performance over time. The course is most appropriate for independent community dwellers with no contraindication for moderate-to-strenuous physical exertion. The course was tolerated well and appropriate for participants with a wide variety of diagnoses and physical limitations.

Utility of the Mobility Obstacle Course as a clinical outcome measure is limited by the large space required to set up and administer the course to patients. Perhaps a scaled-down portable version of the course could be useful clinically.

Conclusion

For people with disabilities, lifestyles that include regular physical activity may lead to more positive outcomes, including increased functional independence and decreased risk of secondary conditions. A need currently exists for a dynamic test of functional mobility. Based on the results of this study, the Mobility Obstacle Course was found to be a reliable tool to measure change in the functional mobility of women with mobility impairments. In addition, some preliminary evidence was found for the validity of the course; however, more research is needed to further validate its use with specific clinical populations and with men.

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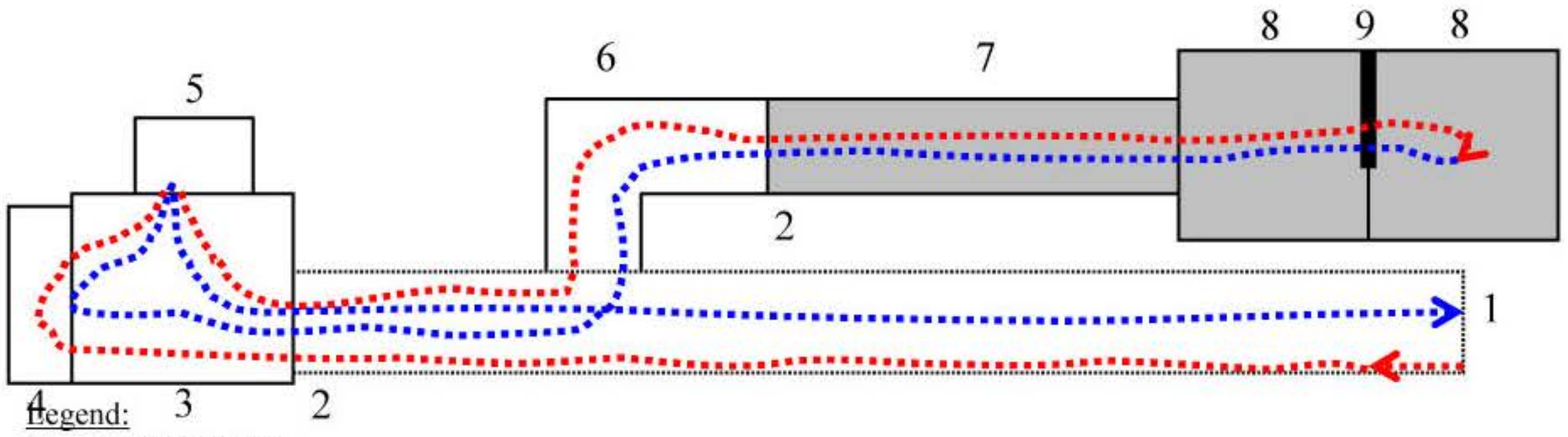
Appendix A: Mobility Obstacle Course



Legend:

1. start/finish line
2. flat 0.5" pile carpeted runways (3 ft. x 40 ft.)
3. 0.25" pile carpet (6 ft. x 7 ft.). All carpets were secured to floor with duct tape.
4. transfer to, or sit down and stand up from, padded mat with rails (76 in. long x 26 in. deep x 18 in. high)
5. Move common objects on 13 and 36 in. high shelves: (a) 100-fluid oz. plastic jug, and (b) 56-oz. telephone book
6. flat carpet (same as 1-2.)
7. wooden ramp, 12 ft. long x 3 ft. wide, elevates 12 in. from left to right
8. 2 5 ft. x 5 ft. raised wooden platforms. Ramp and platforms were surrounded by 4-in. high curb guards and 34.5-in. high railings. Railings were made of 1.75-in.-diameter PVC pipe.
9. 36-in.-wide door with lever handle. Door opening and closing forces were 0.5 lb.

Course rules:

Participants must walk or wheel as quickly as possible, safely, without running.

Course proceeds from start, down runway, transfer, moving objects, back to wooden ramp and platforms, and door. Open and close door each time pass through. Repeat transfer and moving objects, and go to finish line. Participants must stay on carpeted runways, close door each time they pass through, and switch the position of each object on the shelves.

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