ORIGINAL ARTICLE

Adapted Manual Wheelchair Circuit: Test-Retest Reliability and Discriminative Validity in Persons With Spinal Cord Injury

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ABSTRACT. Cowan RE, Nash MS, de Groot S, van der Woude LH. Adapted manual wheelchair circuit: test-retest reliability and discriminative validity in persons with spinal cord injury. Arch Phys Med Rehabil 2011;92:1270-80.

Objective: To assess the test-retest reliability and discriminative validity of a 14-item manual wheelchair circuit adapted from previous research (AMWC).

Design: Two AMWC trials per subject completed within 15 days.

Setting: Two clinical research and 3 rehabilitation centers.

Participants: Convenience sample of individuals with spinal cord injury (N=50) from centers in the United States (n=38) and the Netherlands (n=12). Mean age ± SD was 46±13 years, and mean injury duration ± SD was 12±11 years. Fifteen had cervical injuries, and 42 were men.

Interventions: An existing 8-task manual wheelchair circuit was modified to remove the need for a wheelchair treadmill and expanded to 14 tasks to attenuate floor and ceiling effects: 5 original tasks—figure-of-8, .012-m doorstep crossing, .10-m platform, 15-m sprint, and making a level transfer; 3 modified tasks—3% and 6% ramp, and 3-minute overground wheeling; and 6 new tasks—.04-m doorstep crossing, propelling over artificial grass, opening/closing a door, 3% side slope, holding a wheelie for 10 seconds, and propelling in a wheelie.

Main Outcome Measures: Reliability of the primary outcomes, sum ability score (sum of all tasks; 0–14 [no.]) and sum performance time (figure-of-8 + sprint + grass; 0–360 [s]), was determined by intraclass correlation coefficients (ICCs) for the whole sample and paraplegia (PP) and tetraplegia (TP) subsets. Independent *t* tests compared PP and TP trial 1 sum ability score and sum performance time.

Results: Sum ability and sum performance time ICCs exceeded .90 for the full sample and the PP/TP subsets. Sum ability was higher for PP than TP (PP, 12.9±1.2; TP, 9.8±2.8; $P<.00$), and sum performance times were lower for PP than TP (20.0±4.0s vs 32.0±1.97s, $P<.00$).

Conclusions: AMWC primary outcomes, sum ability score and sum performance time, are reliable and discriminate between TP and PP.

Key Words: Psychomotor performance; Task performance and analysis; Rehabilitation; Reproducibility of results; Spinal cord injuries; Wheelchairs.

FOR INDIVIDUALS WITH a spinal cord injury (SCI), mobility is foundational to participation and encompasses the ability to transfer the body to/from the wheelchair and navigate a range of environmental barriers encountered in life pursuits.[1] Research already demonstrates a positive association between wheelchair skill performance after SCI and participation in these preferred activities.[2] Thus, these skills need to be trained in rehabilitation programs and reinforced throughout the lifespan.

To enable wheelchair skill assessment, an 8-item wheelchair circuit was developed to evaluate the manual wheelchair performance of persons with a SCI during and until 1 year after rehabilitation in a multicenter Dutch study. It consisted of a figure-of-8, .04-m doorstep, 0.1-m platform, 15-m sprint, 3% and 6% slope, transfer, and 3-minute wheeling.[3] This circuit appeared a reliable and valid tool in a research context.[3,4] The good reliability and validity of this wheelchair skill set is mirrored by similar tools of wheelchair skill assessment in other environmental contexts and subject groups.[3,5-7] Data on the wheelchair circuit showed significant wheelchair skill improvement over clinical rehabilitation; the longitudinal positive impact of physical capacity (fitness) on wheelchair skill[8]; and a cross-sectional association between higher levels of wheelchair skill and (1) greater participation,[2] and (2) a greater probability of resuming employment 1 year postdischarge from inpatient rehabilitation.[9] These associations were found after controlling for lesion level, age, and sex, stressing the critical role of wheelchair skill in daily and societal functioning.[10]

The wheelchair circuit could provide cross-sectional and longitudinal monitoring to rehabilitation clinicians and researchers. However, 3 skills (3% and 6% slope, 3-minute wheelchair propulsion) require a wheelchair-accessible treadmill, a barrier to widespread utilization.[11] In addition, the ability score demonstrated ceiling[3,8] and floor effects

List of Abbreviations

AIS	American Spinal Injury Association Injury Scale
AMWC	adapted manual wheelchair circuit
ICC	intraclass correlation coefficient
PABAK	prevalence-adjusted bias-adjusted κ
PP	paraplegia
SCI	spinal cord injury
TP	tetraplegia

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(S. de Groot, written personal communication, November 19, 2010.), an issue that must be addressed. Finally, the wheelchair circuit was not designed to assess individual changes, which would be important for clinical treatment,[12] where wheelchair skills are evaluated at the individual level. This requires sensitivity to small changes over a wide skill range.

We have therefore adapted the original wheelchair circuit to address the above-described limitations. Clinic friendly adaptations include a 3% ramp, 6% ramp, and a 3-minute overground wheel[13] to replace the treadmill-based 3% slope, 6% slope, and 3-minute wheeling test.[3] Floor and ceiling effects were addressed by adding a 3% side slope,[14] a .012-m doorstep, propulsion on artificial grass, opening/closing a door, making a wheelie, and propulsion while holding a whe elie.[6,15-17] These additional items reflect those used in other measurement tools and clinician input as to what skills both reflect real-world challenges and might attenuate the floor and ceiling effects. The present study assesses the test-retest reliability and discriminate validity of the adapted manual wheelchair circuit (AMWC).

The current research objectives are to establish (1) the test-retest reliability of the AMWC sum ability score, sum performance time, and individual skills; (2) the ability of the AMWC to discriminate between persons with paraplegia (PP) and tetraplegia (TP); and (3) whether the floor and ceiling effects have been reduced. We hypothesize that (1) reliability coefficients for the sum ability score and sum performance time will be .75 or greater[18]; (2) persons with PP will have a greater sum ability score and a faster sum performance time than persons with TP (discriminate validity); and (3) floor and ceiling effects will be reduced compared with the original wheelchair circuit.

METHODS

Research Design

The current analysis uses the common data set generated by research protocols conducted by the Dutch SCI program and the Miami Project Cure Paralysis.

Participants

Individuals satisfying the following criteria voluntarily completed the study after providing written informed consent: (1) chronic SCI (American Spinal Injury Association Injury Scale [AIS][19] A–D); (2) self-reported ability to self-propel a manual wheelchair; and (3) age 18 years or older. The International Standards for Neurological Classification of SCI (American Spinal Injury Association and International Spinal Cord Society,)[19] provided AIS subject classification benchmarks. Specific exclusion criteria were (1) surgery within 6 months or a pressure ulcer within 3 months before the study; (2) upper limb pain limiting exercise completion; (3) recurrent acute infection or illness requiring hospitalization or intravenous antibiotics; (4) pregnancy; and (5) previous myocardial infarction or cardiac surgery.

Protocol

This protocol was approved by the local Medical Ethical Committee (Netherlands) and by the University Institutional Review Board (Miami). Each subject completed two 90-minute AMWC trials under supervision of the same researcher on 2 nonconsecutive days within 15 days. Subjects were requested to abstain from caffeine, smoking, or alcohol for at least 2 hours before testing; empty their bladder before each trial; and abstain from practicing the AMWC skills between trials.

Personal, lesion, and health information was documented at trial 1. Subsequently, subjects performed the first AMWC trial using their own wheelchair when possible. Five participants were unable to use their own chair for testing. These participants used a laboratory chair for testing that was individually fitted to their anthropometrics. Two of these participants used a manual wheelchair in their homes and neighborhood, but it was too burdensome to travel to the testing site in their manual wheelchair. Three of these participants were typically manual wheelchair users, but were in the process of securing a new chair and were without use of their previous chair. All participants completed both trials in the same wheelchair, with tire pressure standardized between trials.

Adapted Manual Wheelchair Circuit

Fourteen standardized wheelchair and personal mobility skills were conducted in the following fixed order with a 2-minute rest between each: (1) figure-of-8 shape; (2) .012-m doorstep crossing; (3) .04-m doorstep crossing; (4) .10-m platform ascent; (5) 15.0-m sprint; (6) propelling over 4m of artificial grass; (7) 4-m 3% ramp ascent and descent; (8) 4-m 6% ramp ascent and descent; (9) opening and closing a door; (10) 3-m 3% side slope; (11) holding a wheelie for 10 seconds; (12) propelling 3m in a wheelie; (13) making a level transfer; and (14) a 3-minute overground wheeling test. In the Netherlands, the 3-minute wheeling used a 60-m square course with 15-m sides. In Miami, it used a 30-m loop course with two 180° turns separated by 15m. The floor surface was tarpaulin (Netherlands) or linoleum tile (Miami). All items performed correctly within the designated time are assigned 1 point, with half points available for each doorstep, platform, and transfer. Similar to the original wheelchair circuit,[3] a sum ability score was computed from all individual task ability scores. Primary outcomes are the sum ability score and sum performance time (figure-of-8 [s] + 15-m sprint [s] + grass [s]). Secondary outcomes are the individual task abilities and performance times. Each skill and scoring is further described in appendix 1. Of note, performance heart rate was an original wheelchair circuit outcome but was not included as an AMWC outcome.

Statistics

Reliability is both the degree to which a test is free from measurement error and the consistency of participant scores over multiple administrations (assuming the tested construct is unchanged).[20] Importantly, reliability is not a fixed characteristic of the measurement tool. Rather, it is a characteristic of the tested sample.[21] Thus, any measurement tool can have many different reliability scores. In fact, it is expected reliability will be different for a mixed sample and any homogenous subgroups of that sample.[21] In the context of this study, this means we anticipate that the reliability calculations for our whole sample (mixed TP, PP) and the injury subgroups (TP, PP) could differ. In light of this, and the fact that reliability calculations are an important determination of sample size calculations, all reliability statistics were calculated for the full mixed sample and the PP and TP subsets.

Preliminary analysis. The data were first inspected for quality, checked for normality, and summarized by descriptive statistics. Next, *t* tests and corresponding nonparametric tests compared subject characteristics and AMWC scores between the Netherlands (n=12) and Miami (n=38) and complete versus incomplete injuries. Because the analyses indicated both subjects and outcomes did not differ between locations or injury completeness, the data were pooled for analysis, with significance set at α less than .05.

Test-retest reliability. Intraclass correlation coefficients (ICCs) determined test-retest reliability of the (1) sum abil-