

WHEELCHAIR PROPULSION TEST (WPT): DEVELOPMENT AND PILOT WORK

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ABSTRACT

To develop a new Wheelchair Propulsion Test (WPT), we used design criteria, a focus group and pilot work on 20 manual wheelchair users. The WPT was found to be simple, inexpensive and usable for hand- or foot-propellers. It provides data on push frequency (cycles/sec), speed (m/sec), effectiveness (m/cycle) and limb kinematics. Although further study is needed, the WPT appears to hold promise to complement existing measures.

INTRODUCTION

Wheelchairs provide mobility, independence and environmental access for many. However, upper-limb pain and injury are highly prevalent in manual wheelchair users [1]. Some have suggested that optimizing push mechanics could reduce the incidence of such problems [2].

There are a number of excellent existing methods for quantifying wheelchair propulsion. Examples, in order of increasing granularity, include dataloggers (that record such data as daily distance travelled) [3], the Wheelchair Skills Test (WST) [4] (pass/fail and safe/unsafe dichotomous measures on each of 32 skills), instrumented wheels (that measure hand-rim forces) [5-8] and 3-D kinematic analysis [9].

What seemed to us to be missing was a test of wheelchair propulsion that is of intermediate granularity, providing more detail than the WST but less detail than instrumented wheels.

The objectives of this study were to develop such a test (hereafter referred to as the Wheelchair Propulsion Test [WPT]), to use a focus group to help assess its content validity and to pilot test the WPT on manual wheelchair users.

METHODS

This study was approved by the Research Ethics Board of the Capital District Health Authority. All wheelchair-using participants and focus group provided informed consent.

The design criteria that we sought for such a test were that it should be simple and rapid to administer, be inexpensive, require little or no equipment, exhibit good measurement properties, require minimal training for the tester, require minimal time to analyze the data and generate a report, and be applicable to different rehabilitation populations (including foot-propellers). The results of the test should provide data (quantitative, categorical and/or qualitative) regarding whether the subject is able to successfully complete the prescribed distance; the direction of travel; the limbs contributing to propulsion, steering or braking; the time to complete the distance; the total number of propulsive cycles; the push frequency or cadence (cycles/sec); the speed (m/sec); the push effectiveness (m/cycle); the nature of the hand and/or foot contact phases; and the nature of the hand and/or foot recovery phases.

From the design criteria described above, we used a trial-and-error approach to develop a preliminary WPT. We then held a focus group of 6 experienced people from diverse rehabilitation backgrounds (e.g. occupational

therapist, physiotherapist, rehabilitation engineer) to assist in the content-validation phase of the study. After presenting the background for the study, we demonstrated the preliminary WPT and posed a series of questions for the group. The discussion was audio-recorded and transcribed. On the basis of the results of the focus-group discussion, we modified the preliminary WPT, resulting in WPT Version 1.0.

WPT 1.0 consisted of the following:

- From a standing start, the wheelchair user is asked to wheel 10m on a smooth level surface.
- For safety, the tester serves as a spotter, being especially alert to rear tip-over during the initial push cycle.
- The following data are collected by observation:
 - the direction of travel (forward or backward)
 - the limbs contributing to propulsion, steering or braking
 - the limb used for counting cycles
 - time (to the nearest sec)
 - number of cycles
 - whether, if propelling forwards with the two-handed propulsion technique, the participant uses proper contact and recovery phases. (A correct contact phase was defined as when the hands begin their contacts with the hand-rims behind the top dead centers of the rear wheels and remain on the hand-rims until ahead of top dead center [2]. A correct recovery phase was defined as when the hands return to the hand-rims using paths that are primarily beneath the rim [2].)
 - whether, if using one or more feet for propulsion, the subject uses proper contact and recovery phases. (a correct contact phase was defined as when the subject makes initial contact with the heel ahead of the knee and finishes with the heel behind the knee. A correct recovery pattern was defined as one in which the foot is recovered without dragging it on the ground.)

- The following parameters are derived from the collected measures:
 - push frequency (cycles/sec)
 - speed (m/sec)
 - effectiveness (m/cycles)
- A form for collecting the raw data and for calculating the derived data was developed. All of these data could be easily fit on one side of the page and all of the instructions overleaf.

We then administered WPT 1.0 to 20 wheelchair users (10 with hand propulsion and 10 with foot propulsion).

RESULTS

We experienced little difficulty in collecting the necessary data from the 20 wheelchair users. In some cases, especially while we were becoming used to administering the WPT, it was necessary to repeat the test, for instance if we had misjudged which limb should be monitored to count the cycles. Each administration of the WPT required no more than 50 sec (usually < 30 sec) to perform and record the data.

DISCUSSION

We accomplished our objectives for this preliminary phase of the development of the WPT. A test has been developed that appears to meet many of our design criteria. However, further work is clearly needed. Operational procedures will be needed to deal with scoring dilemmas that arise (e.g. when a wheelchair user changes propulsion methods from hand to foot during the test or uses hands and feet at different frequencies). Other future work will include using the WPT on a wide range of manual wheelchair users to further assess feasibility and to develop normative data. Reliability and validity assessments will be needed and are planned for the next phases of the study. Nevertheless, the WPT appears to hold promise to complement existing measures.

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