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Preliminary reliability and internal consistency of the Wheelchair Components Questionnaire for Condition

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\section*{ABSTRACT}
Wheelchair durability and maintenance condition are key factors of wheelchair function. Durability studies done with double drum and drop testers, although valuable, do not perfectly imitate conditions of use. Durability may be harvested from clinical records; however, these may be inconsistent because protocols for recording information differ from place to place. Wheelchair professionals with several years of experience often develop a good eye for wheelchair maintenance condition. The Wheelchair Components Questionnaire for Condition (WCQc) was developed as a professional report questionnaire to provide data specifically on the maintenance condition of a wheelchair. The goal of this study was to obtain preliminary test-retest reliability and internal consistency for the WCQc. Participants were a convenience sample of wheelchair professionals who self-reported more than two years of wheelchair experience, and completed the WCQc on the same wheelchair twice. Results indicated preliminary reliability and internal consistency for domain related questions and the entire questionnaire.

\section*{IMPLICATIONS FOR REHABILITATION}
- The WCQc, if administered routinely at regular intervals, can be used to monitor wheelchair condition and alert users and health professionals about the need for repair or replacement.
- The WCQc is not difficult to use, making early monitoring for wear or damage more feasible. The earlier a tool can detect need for maintenance, the higher likelihood that appropriate measures may be employed in a timely fashion to maximize the overall durability of wheelchairs and minimize clinical complications.
- Keeping wheelchairs appropriately maintained allows users to minimize effort expended when using them, and maximize their function. It also lowers the risk of injury due to component failure.
- When assessing groups of similar wheelchairs, organizations involved in funding wheelchairs can use data from the WCQc to make purchase decisions based on durability, and manufacturers can use WCQc data for responsive design change.

\section*{Introduction}
Appropriate wheelchairs are known to increase social participation, enable independence and improve health and quality of life for persons with mobility impairment [1,2]. Durability and good maintenance are factors impacting wheelchair mobility distinct from other aspects of wheelchair function. However, any benefits of a wheelchair with poor durability are lost as the wheelchair fails [3]. Wheelchair breakdowns are known to result in the disruption of wheelchair users’ lives and may cause clinical complications and injury [4–7]. The useful life span of a wheelchair depends on adequate initial durability and adequate repair protocols [7]. Studies indicate that wheelchairs typically require maintenance every three to six months [3,8].

Evaluations of durability or need for repair have been part of periodic clinical evaluations. However, in these cases, data on multiple aspects of wheelchair function are generally collected [9]. Clinical and repair records have been harvested for evidence of wheelchair condition, but methods often differ from site to site and data may be unevenly kept [6]. Retrospective surveys from clinicians and wheelchair users soliciting information on the frequency and consequences of breakdown have been completed, but these rely on individual memory or record keeping [7,8,10]. Durability evaluations of wheelchairs comparing different periods of use and different types of wheelchairs have been completed using fatigue tests [11,12]. Typically, these tests utilize drum-and drop testing equipment and compare results to standards provided by ANSI and RESNA [13,14]. While effective, fatigue tests are time consuming and not available in most clinical settings [11]. Virtual fatigue analysis using computer prototypes of wheelchair types has been attempted, but does not perfectly model conditions of use and is not intended for clinical use [15,16].

A validated questionnaire that would enable a therapist to evaluate wheelchair condition in 15 or 20 min could be used regularly in a clinical setting [17]. Very few questionnaires or protocols aimed specifically at assessing the condition of a wheelchair have been developed [4]. The Wheelchair Assessment Checklist (WAC) is a questionnaire that includes questions regarding adjustment...
and adjustability, maintenance condition and likely harm to the wheelchair user [4]. It produces ordinal data from categorical responses to 26 questions with data summed and weighted for each of six domains to result in one total score [4]. In one study in which the WAC was used, users were also asked to identify wheelchair components in disrepair by circling them on a short list [10]. This addition was perhaps due to the fact that the scoring system grouped components together, making a secondary overview of the condition of particular components helpful.

In the development of any questionnaire, there is a tension between comprehensiveness and brevity [17]. The format of the questions is also important, with higher rates of completion for questionnaires using simple language and questions with fewer than 20 words [17]. Simplicity is especially important if the questionnaire is intended for use in areas where English is a second language, or where translation is necessary [17,18]. The Wheelchair Components Questionnaire for Condition (WCQc) was developed and refined in an attempt to produce a brief questionnaire containing qualitative and quantitative information specific to maintenance condition. Each question uses a visual analogue scale and solicits a comment. The WCQc was originally designed for use in low-resource areas where lack of access to replacement wheelchairs or parts makes durability a special concern, and the questionnaire has been piloted there in several studies [19–21].

It is important that any research tool, such as the WCQc, should be tested for reliability and internal consistency by an appropriate cadre of participants [17,22]. Internal consistency measures the similarity of scores for questions, checking to see if they jointly measure the same construct. Cronbach’s alpha is often used for this purpose with results of around 0.7 generally found acceptable, indicating that questions are on the same topic, but not identical [23]. Reliability testing is usually accomplished by completing inter-rater reliability and test–retest reliability studies. Studies can be done in which both test–retest and inter-rater reliability are completed [24]. However, studies for each type of reliability can be completed independently [22,25,26]. Test–retest reliability requires that a group of raters complete a questionnaire twice, rating the same entity at two different time periods [22,27]. A two-day interval between test and retest has found to be acceptable [28]. Longer questionnaires and settings that include extensive distractions are both factors likely to cause raters to forget their exact initial rating, and are thought to be amenable to shorter test–retest intervals [28]. For statistically normal data, intra-class correlation (ICC) can be used for test–retest reliability with scores above 0.75 generally being accepted as evidence of reliability. For finalized questionnaires, this is done with mean scores for questionnaires or for domains intended for standalone use. If researchers are doing a preliminary study to see which questions to retain, ICC can also be used to compare the two iterations for each rater [23,27].

This study was focused on internal consistency and preliminary test–retest reliability. Test–retest reliability scores above 0.80 between the two periods would indicate preliminary reliability. Cronbach’s alpha across the questions of above 0.7 would indicate internal consistency.

Methods

The Wheelchair Components Questionnaire for Condition

The WCQc consists of a total of 17 questions regarding the condition of wheelchair components. The instructions for the questionnaire and the wording in each question emphasize that the focus is only on maintenance condition. Each question utilizes a visual analogue scale and includes an opportunity for qualitative explanatory comment. Questions are brief and include colored emoticons to improve understanding and completion. Grade interpretation letters akin to school grades anchor the visual analogue scale, providing a broadly understood calibration intended to improve inter-rater reliability and the intuitive understanding of results; see Figure 1 for an example of question format.

The questionnaire includes eight domain-specific questions intended for use as a stand-alone questionnaire. These questions cover components found in virtually every wheelchair and include a final question asking for an overall rating. The remaining nine extended questions concern components which may not be present on all wheelchairs, and these questions are intended to be used only to accompany the domain related questions. For the wording of questions, see Figure 1 and also Table 1 in results.

Participants

The WCQc is intended to be completed by wheelchair professionals such as therapists and technicians, ideally those who are familiar with the particular type of wheelchairs being assessed. Data collection for this study was completed at a large international wheelchair conference attended by many experienced wheelchair clinicians. Conference organizers allowed the research team to set up an area for data collection in the exhibit hall, which included room for informational material at a table and two study wheelchairs. The short time period of the conference and busy schedule of the participants limited the overall time frame of the study and the time we could ask of each participant. However we felt this venue was worthwhile because of the benefit of obtaining preliminary reliability and internal consistency from such a broad sample of experienced clinicians. We also felt that the short time interval between test and retest was also somewhat mitigated by the challenging and distracting environment of the conference, and the length of the WCQc.

Wheelchair professionals were sought who reported more than two years of experience with wheelchairs. To recruit participants, undergraduate research students walked through the exhibit hall, interacting with conference attendees. Wheelchair professionals who reported more than two years of experience were shown a cover letter explaining the purpose of the study and the qualifications for participation. They were invited to participate by coming to the data collection area.

The study protocol was approved by the authors’ university. The need for a consent form was waived because the names of participants were not collected. Upon arrival at the study area, each participant was given an identifying number which was recorded and provided to the participant on a card.

1. Rate the seat, include cushions. From: Below F (fallen off or completely destroyed) to above A (excellent new condition)

Poor E/F D C B A Excellent

Comments:

Figure 1. An example showing the question format of the WCQc.
Participants then used the WCQc to evaluate the maintenance condition of one of the study wheelchairs. Those who completed the WCQc once were invited to return at least a day later, present the card with their ID number, and complete the WCQc again for the same wheelchair they had originally evaluated [27]. Participants were given a coffee shop gift card in thanks when they returned for the retest.

Wheelchairs

Wheelchairs were sought which would be of types familiar to clinicians at the conference. The chairs were to be worn but still functional, and have most, if not all, of the components listed in the WCQc. Two wheelchairs fitting these criteria, a TiLite TRA (Pasco, WA) and a pediatric Quickie HP, were obtained from the pool of used wheelchairs donated through a regional office of a large international wheelchair charity; see Figure 2. Because there was only one sample of each chair type, and because the age of the wheelchairs was not known, this study was not intended to be of value to the manufacturers of TriLite and Quickie wheelchairs (Phoenix, AZ). Thus, each chair was given a letter designation for the purposes of the study. The Quickie chair was designated A, and the TriLite was designated B.

Analysis

This study focused only on preliminary test-retest reliability and internal consistency. Using the approach described by Bonett, a sample size calculation indicated that 26 raters were needed for adequate statistical power [29]. A return rate of approximately 50% was anticipated for the retest completion of the WCQc. Therefore, our goal was to recruit 60 participants, to enable a test population of 30 raters.

For each question, the length of the visual analogue scale line was measured from the left side to the vertical mark made by the participant. Both the score in centimeter and the qualitative comment were entered into spreadsheets. The SPSS program was used for statistical analysis (International Business Machines Corp. Armonk, NY). Quantitative data was tested for normality. For internal consistency, Cronbach’s alpha was calculated using data from the first iteration of the questionnaire. Test–retest two-way random ICC was calculated for each question, as well as the mean value for the domain related questions and the entire questionnaire.

Table 1. The wording for each questions of the WCQc is provided in this table. Each question also included the phrase “from below F, (fallen off or completely destroyed) to above A, (excellent new condition)”. Two-way random ICC with 95% confidence intervals is provided for each question and for the mean value for the domain related questions and the entire questionnaire.

<table>
<thead>
<tr>
<th>Questions</th>
<th>ICC average measures</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Domain-specific questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the seat, include cushions</td>
<td>0.83</td>
<td>0.66–0.91</td>
</tr>
<tr>
<td>Rate the seat back, include cushions</td>
<td>0.84</td>
<td>0.68–0.92</td>
</tr>
<tr>
<td>Rate the frame</td>
<td>0.90</td>
<td>0.81–0.95</td>
</tr>
<tr>
<td>Rate the front rigging and foot support</td>
<td>0.75</td>
<td>0.51–0.88</td>
</tr>
<tr>
<td>Rate the casters</td>
<td>0.90</td>
<td>0.81–0.95</td>
</tr>
<tr>
<td>Rate the wheels and push rims</td>
<td>0.78</td>
<td>0.60–0.90</td>
</tr>
<tr>
<td>Rate the wheel locks (brakes)</td>
<td>0.82</td>
<td>0.65–0.91</td>
</tr>
<tr>
<td>Rate the wheelchair overall</td>
<td>0.90</td>
<td>0.80–0.95</td>
</tr>
<tr>
<td>ICC for mean – domain-specific questions</td>
<td>0.91</td>
<td>0.82–0.95</td>
</tr>
<tr>
<td><strong>Extended questions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the lap belt and/or harness</td>
<td>0.59</td>
<td>0.17–0.78</td>
</tr>
<tr>
<td>Rate the head support</td>
<td>0.86</td>
<td>0.59–0.95</td>
</tr>
<tr>
<td>Rate the trunk supports</td>
<td>0.78</td>
<td>0.56–0.89</td>
</tr>
<tr>
<td>Rate the hip supports</td>
<td>0.67</td>
<td>0.35–0.83</td>
</tr>
<tr>
<td>Rate the anti-tip device</td>
<td>0.87</td>
<td>0.74–0.93</td>
</tr>
<tr>
<td>Rate the tray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>neither wheelchair – had tray</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate the arm rests</td>
<td>0.89</td>
<td>0.67–0.97</td>
</tr>
<tr>
<td>Rate the abductor and/or adductor</td>
<td>0.80</td>
<td>0.45–0.93</td>
</tr>
<tr>
<td>Rate the uprights and handles (canes)</td>
<td>0.83</td>
<td>0.67–0.92</td>
</tr>
<tr>
<td>ICC for mean of entire questionnaire</td>
<td>0.93</td>
<td>0.87–0.97</td>
</tr>
</tbody>
</table>

Figure 2. Study wheelchairs: A is the Quickie wheelchair and B is the TriLite wheelchair.
for each rater for the domain related questions and the entire questionnaire.

**Results**

In total, 48 participants evaluated the study chairs once, and 35 participants returned to complete the reliability study (20M, 15F) for a return rate of 73%; 19 completed the study with Chair A and 16 with Chair B. Those who indicated their profession (n = 29) included physical therapists, occupational therapists, rehabilitation engineers and rehabilitation technologists, with an average of 15.9 (SD = 10.4) years of experience with wheelchairs.

Analysis indicated the quantitative data were normal and suitable for parametric statistical tools. Internal consistency was confirmed for the domain related questions with a Cronbach’s Alpha score of 0.71 (95% CI 0.54–0.84), and for the entire questionnaire with a score of 0.83 (95% CI 0.45–0.93). Preliminary test–retest reliability results are provided in Table 1.

**Discussion**

Results support the internal consistency for the domain related questions as a stand-alone questionnaire, and for the entire questionnaire. Although the time frame between test and retest was short, results give support to the preliminary test–retest reliability of the WCQc. Scores for the individual domain related questions gave support to preliminary reliability for those questions. Scores for two of the extended questions were lower than ideal, and there were no results for the extended question regarding the tray since neither study wheelchair included a tray.

The single focus of the WCQc was intended to ensure that the information collected was specific to maintenance condition and provided data on that explicit aspect of wheelchair functionality. This focus on durability and condition is of key importance to manufacturers in evaluating wheelchair durability, and to wheelchair professionals and users who deal with wheelchair repair. If, for example, at a particular clinic over time the WCQc could provide evidence that wheel locks are consistently in loose condition, this could deliver additional impetus and motivation to train wheelchair users and caregivers to tighten and lubricate the wheel locks. Data could also motivate manufacturers to seek a wheel lock design that was more resistant to loosening. When larger comparative studies are done with cadres of wheelchairs of the same make and design, data indicating that a particular component is failing could be especially powerful in motivating design changes by manufacturers. Consequent improvements in wheelchair condition would protect wheelchair users from the loss of function or injury due to wheelchair breakdown.

The participants in this study, most of whom were therapists, seemed to make a special effort to focus on condition. Several expressed aloud their disapproval of some aspect of component design, but acknowledged that they were only assessing condition. However, 5% of comments addressed design issues or other unrelated topics rather than maintenance condition issues, indicating that a few therapists may still have had trouble focusing exclusively on condition. Using the questions developed for the WCQ for different purposes is possible because each question is based on a wheelchair component. Work is underway to use the same basic questions for a wheelchair user to record their own satisfaction with wheelchair components [30].

The use of grades as anchors underneath the visual analogue scale line seemed to provide broadly understood scaling information for participants in this study and in studies done in low-resource areas. At the moment, most raters we have encountered have experienced years of schooling and have an immediate almost intuitive understanding of a school grade. However, the use of grades as anchors will only remain relevant as long as this grading scale is broadly used in school marking schemes.

As a brief questionnaire that can be used easily in a clinical setting, the WCQc could be broadly applied to provide reliable data on maintenance condition. Informal observation indicated the WCQ takes from 15 to 20 min to complete depending on how much time was spent recording comments.

**Limitations and future work**

The test–retest interval for many raters was shorter than a full two days. Even with the distracting and academically engaging environment of the conference, a longer time interval would have been ideal. Intra-rater reliability requires that a few raters rate a wide variety of subjects/wheelchairs, and was not possible in this study because of limited space for additional wheelchairs, and limited time for raters to rate multiple wheelchairs. The estimate of 15–20 min to complete the WCQc is based on informal observation because participants were not formally timed.

Results regarding the reliability of two of the extended questions in this study have reduced statistical power. Chair B did not have a headrest or armrests, and Chair A did not have an abductor block. Many wheelchairs do not include one or more components listed in the extended questions. This was also found to be the case in studies using the WCQ in low-resource areas. Therefore, the reliability of the domain-specific questions as a standalone questionnaire is of key importance in confirming that the data from those questions can be analyzed without the extended questions. A modification of the questions is underway in which the components in the extended questions are folded into domain-specific questions. For example, the head rest and trunk support would be included the “back” question regarding support for upper body. It is thought that comments would provide explanations that would indicate any trouble with specific parts on an individual wheelchair. A shorter simpler questionnaire will also have significant advantages for completion and analysis. Although the WCQc was initially developed for use in low-resource settings, most of the participants in this study primarily worked in the US settings. Reliability testing of the updated WCQc is needed. Inter-rater reliability testing of the updated WCQc done with clinicians working in low-resource areas is underway.

**Conclusions**

Results of this study support internal consistency and preliminary test–retest reliability of the WCQc as a tool for the assessment of wheelchair condition. Further refinement and reliability validation is underway. In a clinical setting, specific data from the WCQc on the condition of the components of wheelchairs could enable repair and replacement and make the loss of mobility and the risk of injury due to failure less likely.

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Disclosure statement

The authors report no declaration of interest.

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