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A reliable and valid outcome battery for measuring recovery of lower limb function and balance after burn injury

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ABSTRACT

Introduction: The measurement of recovery after burns to the lower limbs is hampered by an absence validated injury specific tools. This research aimed to select and validate a battery of outcome measures of recovery after lower limb burn injury (LLBI).
Method: Reliability study: Reliability of the single leg stance (SLS), the Timed Up and Go (TUG) and the tandem walk (TW) tests were measured using a test–retest trial involving 28 patients with LLBI. *Validity study*: Clinical data from 172 patients with LLBI were used to compare changes in each LL outcome measure with changes in the Burn Specific Health Scale-Brief (BSHS-B).
Results: All tests, except the SLS test with eyes closed, demonstrated excellent inter-rater reliability (ICCs = 0.81–0.93). The TUG and the TW-forwards tests were shown to be valid and to provide additional information to the BSHS-B when combined as a battery. The TW-backwards test was redundant while the SLS and ankle DF measures did not correlate highly with the BSHS-B.
Conclusion: This study shows that the TUG test and the TWF are reliable and valid in the burns population and along with the BSHS-B form a useful test battery for measuring recovery from LLBI.

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1. Background

At the Royal Perth Hospital (RPH), the Burn Service of Western Australia manages up to 600 adult patients per year, with approximately 200 each year admitted to the burn center. Of these, ~40% have burns to their lower limbs and, or trunk. Pain, scar tissue contracture, impaired sensation, muscle weakness and postural imbalance are all potential complications of lower limb burn injury (LLBI) which negatively influence a person's ability to function normally [1–4]. Burn injury affects dermal tissue which contains sensory neurones that contribute to the conscious and automatic feedback systems which in turn, control balance and coordination [5–8]. Impediments arising from LLBI are similar to those observed in other populations suffering lower limb disease or pathology and further, these complications cause balance dysfunction [9–14]. Balance and mobility are complex bodily functions integral to discharge disposition, social function and quality of life [15–18]. Therefore, to guide recovery accurately and facilitate rehabilitation after LLBI, multi-factorial assessment is required.

An online search in *Medline*, demonstrates that papers describing recovery from upper limb burn are at least twice as

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frequent as those regarding LLBI. In patient and non-injured populations, there is an abundance of literature and reference values for tests of function involving the lower limb, including balance and coordination [19–21] Despite this, a validated, population specific set of tools for measuring recovery of balance and mobility after LLBI are yet to be established.

The RPH team philosophy for recovery after burn injury focuses on the benefits of rehabilitation from the day of injury [22,23]. Therapy input is designed to restore an individual's pre-injury status and should be directed by longitudinal objective outcome measurements. The use of valid assessment tools provides an accurate picture of patient recovery to guide clinical practice while minimising the impact of unnecessary clinical testing on patients and health services.

In examining tests to be used clinically to measure lower limb outcome, common, standardised tests should be considered [24]. Initially, tests considered for implementation at RPH were examined for clinical utility in the burn environment and for their scientific value against the time taken to perform the test. Pilot trials in small cohorts of burn patients, confirmed that elements of the Berg Balance Scale [20], 10-m walk [25], the Functional Independence Measure (FIM) [26] and the Queen's College step test [27], demonstrated ceiling effects and, or lacked sensitivity (Edgar, D., 2004, unpublished data). Functional 'cardio-vascular fitness' tests [28] such as the 6-min and 2-min walk tests were piloted also with similar results. Further research occurred through discussions with experienced physical therapists in the areas of acquired and spontaneous brain injury and gerontology. Finally, the LLBI battery chosen for testing on the basis of their brevity, sensitivity and applicability in the RPH environment was as follows: the Burn Specific Health Scale-Brief (BSHS-B), the single leg stance (SLS) tests, the Timed Up and Go (TUG) test, tandem walk (TW) tests and ankle range of motion [29–32].

To compile a battery of outcome tools for measuring recovery after injury it is also important that each item 'adds value'. To this end certain, statistical criteria must be met. Each variable or tool must be valid and reliable in the relevant population group, and significantly but only moderately correlated with each other [33]. Where two or more tools are highly correlated they are essentially duplicate measurements and only one is necessary in a battery [33]. Further, it is important to ensure that each tool demonstrates adequate sensitivity, over time, within the population of interest [34].

The BSHS-B and ankle goniometry, were proven to be reliable, valid and sensitive in the burn population [35–42]. The BSHS-B is a validated population specific quality of life measure that, to date, is the only existing measure of overall recovery from burn injury [35,36,43]. It is considered a 'gold standard' measure and therefore, was the comparator for validity for the tests of physical function. The TUG, TW and SLS have previously been validated in other injured and non-injured populations but have yet to be tested in burn patients [21,31,39,44–46].

Thus, the primary aim of this study is to examine the reliability (and responsiveness) of the SLS, TUG and TW in a representative sample of the burn population. Secondly, this paper will use clinical outcome data to examine validity of the individual tests against the BSHS-B. Finally, a standardised battery of lower limb outcome measures for measuring temporal recovery after LLBI will be described.

2. Patients and methods

2.1. Reliability of LL outcome measures

2.1.1. Patient population

Patients with burns to one or both legs were recruited prospectively for population specific reliability testing. The participants who underwent testing included 28 patients (22 males, av. age = 33.4 ± 12.2 years, range: 18–66, av. TBSA = 3.8 ± 4.1%, range: 1–20). Patients were excluded if they had undergone scar revision or release surgery. The group included both inpatients and outpatients with LLBI who were over 18 years of age, could understand the requirements of the tests, could weight bear fully on each LL and perform the test without compromising their safety (as assessed by an experienced physical therapist at the time of testing). All patients provided informed consent and this study was registered with the RPH Clinical Safety and Quality Unit (CSQU # 080429-1), a subgroup of the RPH Ethics Committee, as part of the Burn Clinical Outcomes and Research Project (BCORP).

2.1.2. Development of procedure

Practice attempts to reduce systematic bias and overstatement of treatment efficacy due to a learning effect in test–retest trials of stability tests are presented frequently in the literature [21,47–49]. For each of the balance and mobility trials a practice attempt was included. A pilot study confirmed findings of a learning effect for the TUG and TW. A repeated measures ANOVA demonstrated this to be between 5 and 12% for the TUG ($F_{df=1} = 14.1$, $p < 0.001$) and TW ($F_{df=1} = 5.3$, $p = 0.028$).

2.1.3. Reliability testing procedure

To broaden the clinical applicability and reduce the likelihood of overstatement of concurrence of the tested assessments, the tester group included a mixture of experienced physical therapists and students (for reliability trials only). All staff were trained in the standardised procedures of each test, as documented below, prior to commencement of the reliability trial. In random order, two examiners blinded to each other's activity, performed test–retest reliability trials. All LL tests were performed on a firm surface with the distances clearly marked on the floor. A stopwatch was used to time each test. Each tester repeated the trials within 20 min of each other, on the same day.

2.1.4. Lower limb test protocols

The SLS [29,50,51] is a test of static standing balance with eyes open (SLS-eo) and eyes closed (SLS-ec). Each participant was timed as they balanced on a single leg, on a hard surface, with arms crossed across the chest. The timing ceased at 30 s or if the patient moved their arms or foot significantly from their starting position. Inability to achieve a 30 s limit had previously demonstrated an increased risk of falling and increasing the length of the test did not increase sensitivity

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