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ORIGINAL RESEARCH

Construct Validity of the Trunk Impairment Classification System in Relation to Objective Measures of Trunk Impairment

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Abstract

Objective: To determine the validity of the Trunk Impairment Classification system (TIC) with 4 possible scores (0, most impaired; 0.5; 1.0; 1.5, least impaired) in relation to objective, instrumented measures of impairment.

Design: Cross-sectional design.

Setting: National wheelchair rugby and basketball competitions of The Netherlands and Belgium.

Participants: Volunteer sample of athletes (N = 34) with a minimum of 1-year experience in their sport.

Interventions: Static sitting balance tasks on a stable and unstable surface; dynamic sitting balance tasks in anterior-posterior, left-right, and oblique directions; and trunk muscle strength tasks in forward, left, right, and backward directions.

Main Outcome Measures: Sway area of the center of pressure in static sitting balance, maximum excursion of center of pressure displacement in dynamic sitting balance, and maximum isometric force in trunk muscle strength.

Results: Athletes with TIC score 0 were not able to sit unsupported. The Kruskal-Wallis test showed a significant difference in trunk muscle strength ($P<.001$) and dynamic balance in the oblique direction forward to the left and backward to the right between the TIC scores ($P=.012$). Post hoc analysis showed a significant difference between TIC score 0 and the other TIC scores for trunk muscle strength in all directions. There was a significant difference between TIC score 1.5 on one hand and TIC scores 0.5 and 1.0 on the other hand for dynamic balance in the right oblique direction.

Conclusions: The TIC is a valid scale for trunk impairment, which measures neuromusculoskeletal trunk impairment, independent of the health condition causing the impairment. Additional research is needed for coordination impairment and to assess whether TIC scores 0.5 and 1.0 should continue as separate scores.

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Trunk impairment has an important impact on the performance of seated activities, which are crucial for individuals who use a wheelchair.[1-9] To optimize participation, minimizing the impact of trunk impairment on daily life activities is an important goal of rehabilitation.[6,7,10]

Various clinical scales for measuring trunk impairment are available in the literature and are typically used to set treatment goals during rehabilitation.[11-17]

Most of these scales were developed for a specific health condition, such as spinal cord injury, cerebral palsy, stroke, multiple sclerosis, and traumatic brain injury.[11-13,15-17] However, the application to other health conditions is limited because these scales are highly dependent on specific characteristics of these conditions. In addition, the construct validity has been poorly or never assessed.[1,18-21] Furthermore, the focus has been on trunk muscle strength and coordination of trunk movements, whereas other important impairment types are overlooked, such as limited length of the legs and the trunk and limited passive range of movement (ROM) of the trunk.[22-24] Also, the use of different scales coincides with the use of different terms for impairments and disability. Thus,

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there is a need for a trunk impairment scale that is independent of health conditions, has construct validity, evaluates all types of impairment, and uses the most widely known terms of the *International Classification of Functioning, Disability and Health*.[25]

One of the conceptual cornerstones in classification in Paralympic sport is the measurement of the level of impairment to minimize the impact of impairment on sport performance.[22,26] Because of a large overlap between wheelchair activities in sport and in daily life, measurements applied in Paralympic sport classification systems can also be useful for rehabilitation. Measurements customized in sport classification may potentially overcome the drawbacks of the existing clinical trunk impairment scales because of the explicit focus on impairment type and severity, independent of the health condition causing the impairment. In Paralympic sport classification, the impairment type is defined according to the *International Classification of Function, Disability and Health,*[25] and the impairment type associated with the trunk is neuromusculoskeletal.

In 2010, a classification system for neuromusculoskeletal trunk impairment was developed and adopted for wheelchair rugby.[27] The Trunk Impairment Classification system (TIC) includes all 5 neuromusculoskeletal impairment types that can affect the trunk and which are also considered eligible impairments for Paralympic sport: muscle strength, ROM, coordination (defined as the ability to control voluntary movements), limitations in leg or trunk length, and limb deficiency.[22,26,28] The TIC has 4 possible scores for trunk impairment (0, 0.5, 1.0, 1.5), the lowest score indicating the most severe impairment. The TIC has shown face validity and adequate reliability in wheelchair rugby and wheelchair basketball athletes.[27] However, the construct validity of the TIC has not been assessed.

The purpose of this study is to assess the construct validity of the TIC using objective instrumented analysis. Neuromusculoskeletal trunk impairment can be objectively measured by static and dynamic sitting balance, which are affected by all types of trunk impairment.[2,3,7,23,24,29-31] However, static sitting balance is known to have a ceiling effect.[1,4,32,33] In contrast, dynamic sitting balance has no ceiling effect in patients with spinal cord injury,[1,18-20,31,33] lower limb amputations,[23] and in able-bodied persons,[30] but it is known to have a floor effect. Recent research in wheelchair racing indicated that the trunk muscle strength needed for wheelchair activities may be much greater than the maximum trunk muscle strength that is tested in dynamic sitting balance.[34] To cover the whole spectrum of trunk impairment, addition of a task demanding maximal isometric trunk muscle contraction in a seated position seems to be mandatory. In the current study, we expected that a higher TIC score indicated less trunk impairment and thus a better performance in the objective impairment tests.

Methods

Participants

Thirty-four adult wheelchair rugby and wheelchair basketball athletes participated in this study. They had been playing in the national competition of the Netherlands or Belgium for at least 1 year. The exclusion criterion was pressure sores on the sitting surface.

The impairment type, health condition, and sport class were determined by a physician (V.A.) based on an interview. Body length and body mass were obtained for each athlete.

A TIC score was allocated to the athletes by an experienced international classifier (V.A.) on the day of the testing. The TIC procedures are described in the classification manual of the International Wheelchair Rugby Federation (appendix D, p 78-82).[35] Table 1 shows the health conditions of the participating athletes.

All athletes signed an informed consent. The Medical Ethical Committee for the region Arnhem and Nijmegen (The Netherlands) approved the study (registration no. 2011/378).[36]

Procedures

Athletes performed 3 tasks evaluating static sitting balance, dynamic sitting balance, and trunk muscle strength. To be tested in the static and dynamic sitting balance tasks, athletes had to be able to sit without support for 30 seconds in an upright position. Static and dynamic sitting balance were performed on a specially designed chair as described by van Nes et al.[32] No armrests were present, and during all tests the backrest was removed. The legs of the chair were mounted on an AMTI forceplate (model no. OR6-7MA-1000[a]). Athletes were positioned on the chair in a standardized position with their hips and knees in 90° flexion and their ankles in a 0° neutral position. Figure 1 shows the experimental setup of the sitting balance tasks.

In the static sitting balance task, the athletes were instructed to sit as still as possible, with their arms crossed in front of their chest, for 30 seconds. There were 2 conditions: (1) on a stable surface on a standard foam cushion of 5cm, or (2) on an unstable surface on a cushion that was inflated until the buttocks were raised 2cm from the surface. No feedback was given about the position of the center of pressure (COP).

The dynamic sitting balance task was done on a standard foam cushion and consisted of maximum trunk inclination in 4

List of abbreviations:

COP	**center of pressure**
ICC	**intraclass correlation coefficient**
ROM	**range of movement**
TIC	**Trunk Impairment Classification system**

Table 1 Health conditions of participating athletes

Health Condition	No. of Participants
Spinal cord injury cervical level (AIS A-B)	9*
Spinal cord injury thoracic or lumbar level (AIS A-B)	6*
Spinal cord injury (AIS C-D)	5
Spina bifida	1
Neuromuscular disease	4
Polio	2
Multiple amputations	1
Cerebral palsy	1
Skeletal dysplasia	1
Orthopedic conditions	3
Multiple sclerosis	1

Abbreviations: AIS A-B, American Spinal Injury Association Impairment Scale grades A and B, motor complete; AIS C-D, AIS grades C and D, motor incomplete.

* Two athletes with spinal cord injury also had unilateral above-knee amputation.