

Towards evidence-based classification – the impact of impaired trunk strength on wheelchair propulsion

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Summary

Introduction: Current methods for classifying impairments in disability sports are based largely on experience and expert opinion, and are therefore of questionable validity. The International Paralympic Committee's Sports Science Committee aims to develop a new evidence based classification system based on the relative strength of association between impairment and activity limitation.

Aim: The purpose of this exemplary pilot study is to illustrate the concept of relating consequences of impairment to sport-specific performance determinants in wheelchair sports. This pilot-study examined the impact of impaired trunk strength (impairment) on wheelchair acceleration from standstill (activity).

Method: One able-bodied wheelchair basketball player (WB) and one wheelchair tennis player with complete T4 SCI (WT) performed a generic (non-sport-specific) and sport-specific force generation test in varying conditions regarding trunk and pelvic support.

Results: The results show that including the abdominal muscles in the generic force generation muscular chain leads to a 41.41% loss of generic force generation in WB compared to 80.59% in WT. As well, including the abdominal muscles during wheelchair propulsion force generation results in a 0% loss of acceleration capacity in WB compared to 42.2% in WT.

Conclusion: The current study demonstrates that the impact of pelvic and trunk strength (impairment) on one of the main determinants in wheelchair sports performance (activity) can be measured and quantified. Such knowledge will have implications for rehabilitation and classification in grass roots and elite-level sport.

Key words

Classification – Evidence-based classification – Wheelchair propulsion – Wheelchair sports

Background

The research agenda of the Sport Science Committee (SSC) of the International Paralympic Committee (IPC) is driven by questions of interest in the Paralympic Movement. While many of these questions concern elite athletes at the summit of their careers, the research outcomes have implications for novice athletes and, in some situations, people in rehabilitation. From the research agenda of the SSC, evidence-based classification is selected for discussion [1], with conclusions drawn in relation to rehabilitation and grassroots' sport.

Evidence-based Classification in Paralympic Sport

The Paralympic Games is one of the largest sporting events in the world. More than 1.6 million spectators attended the 2008 Beijing Paralympic Games and many millions more watched media coverage. Competition in Paralympic sport is based on systems of classification. The purpose of classification is to minimize the impact that impairment has on the outcome of competition, so that the athletes who win are those who have the best combination of anthropometry, physiology, psychology and who have enhanced them to best effect through training and legal technical aids [1]. To achieve this purpose

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requires a method for classifying impairments according to how much activity limitation they will cause in a given sport [1, 2]. Currently there is very little scientific literature evaluating the relationship between impairment and performance [3]. Consequently, current methods for classifying impairments are based largely on experience and expert opinion and are therefore of questionable validity. Given the size and importance of the Paralympic games, the International Paralympic Committee would like to improve evidence underpinning methods of classification and they have recently endorsed a research plan for this purpose. Specifically, the project will aim to develop objective, reliable measures of both impairment (e.g., impaired strength, range of motion or coordination) and activity limitation (e.g., wheelchair propulsion, running or throwing) and investigate the relative strength of association between these constructs in a large, racially representative sample [4, 5]. To illustrate the approach that will be used, results of a pilot-study examining the impact of impaired trunk strength (impairment) on wheelchair acceleration from standstill (activity) are presented. The purpose of this exemplary approach is to illustrate the concept of relating consequences of impairment to sport-specific performance determinants.

Material and Methods

Participants were one able-bodied wheelchair basketball player (WB) and one wheelchair tennis player with complete T4 SCI (WT). These participants represent the maximum range of trunk and pelvic strength, from 0% impairment (WB) to 100% impairment (WT). Players were male and matched for weight and competitive experience (active player career on National level of approximately 10 years). Both participants performed a generic (non-sport-specific) and sport-specific force generation test.

Generic test

Participants were sitting on a chair which is fixed to the ground. Legs were strapped against the chair at the ankles and the upper legs. In front of the participants was a load cell mounted on the wall. The position of the load cell was adjustable in height and width. The load cell plate was positioned at shoulder height in front of the sternum (see figure 1). The participant was sitting in front of the plate with 90 degrees shoulder abduction, 45 degrees horizontal adduction and 0 degrees rotation; and 90 degrees elbow flexion. The participants progressively increased force and then applied for about 3 seconds maximal force perpendicular to the plates (“*push the plate straight through the wall*”) with both hands.

Maximal force generation was measured with backrest with a height to thoracic 1, and without backrest. Three trials were given per condition with sufficient recovery in between trials. The maximum result of three attempts was used for further analysis.



Fig. 1. Generic test to measure the strength of the upper limbs extension with (portrayed) and without backrest support

Sport-specific test

Participants were seated in a wheelchair on a wheelchair ergometer with lower limbs secured to the chair with non-elastic straps into a standardized position (hips, knees and ankles in 90°). The wheelchair ergometer allowed for simulation of inertial forces and was instrumented with a photo-electric device to measure velocity (figure 2).

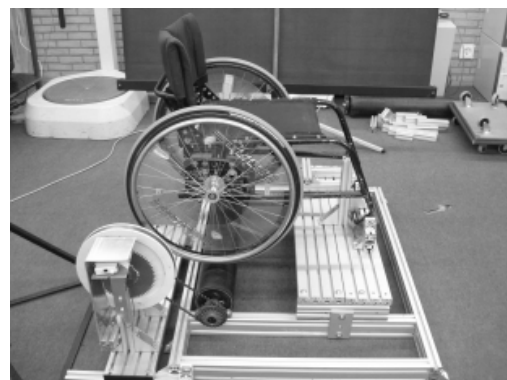


Fig. 2. Stationary wheelchair ergometer. The roller of the ergometer is connected to a flywheel through sprockets on both the roller and flywheel, allowing for individual adjustments for simulating inertial forces

With the wheels of the wheelchair stationary, WT performed a single, maximum effort push in four conditions: a) with backrest but no abdominal strap (allowing loss of trunk balance); b) with backrest and abdominal strap,

c) without backrest, allowing loss of trunk balance, and d) without backrest but balance had to be maintained. WB only performed in conditions a) and d). Peak-velocity was registered for each maximum effort push and the best result out of three attempts per condition was kept for further interpretation.

Results

Generic test

Bilateral force generation in the generic test was 52.02 Kg with backrest versus 30.48 Kg without backrest for WB compared to 54.72 Kg with backrest and 10.62 Kg without backrest for WT (figure 3). Including the abdominal muscles in the active force generation muscular chain results in a 41.41% loss of force generation for WB) compared to an 80.59% loss of force generation for WT.

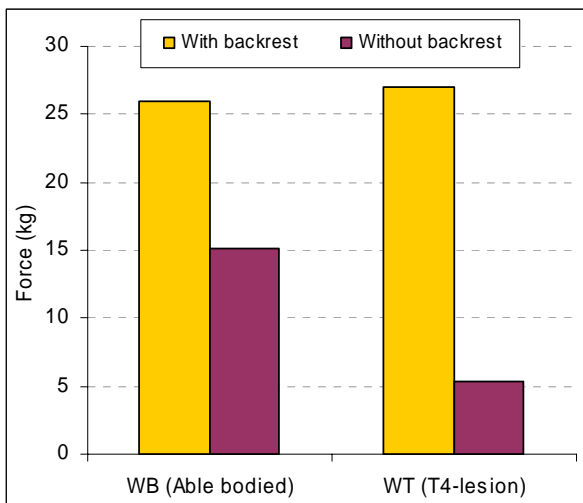


Fig. 3. Impact of trunk and pelvic strength on upper limb force generation in an able bodied wheelchair basketball player (WB) and a wheelchair tennis player with T4-paraplegia (WT)

Sport-specific test

The impact of trunk strength on propulsion force generation is 0% in WB compared to 42.2% in WT (comparing condition [a] and [d] in figure 4). Force generation in condition [a] for WT, however, is overestimated, because compensation (loss of trunk balance) is allowed. Abdominal strapping (condition [b]) significantly improves acceleration performance. However, strapping reduces trunk ROM and push angle, and therefore force generation capacity. In this example, however, the participants' position was standardized and therefore not optimized for trunk stability. A final measurement in competitive conditions (proper chair and optimized position), should clarify if further compensation for trunk balance can positively impact on acceleration capacity.

Discussion

Historically the transition from medical to functional classification systems in Paralympic sports began in the late 1970s, but there was considerable debate surrounding the relative merits of the medical and functional approaches and consequently the transition was slow [3]. One feature of early functional systems was that they comprised less classes than the existing medical systems [6]. Event organisers favoured fewer classes because the complexity of event organisation was significantly reduced. In 1989 the bodies responsible for organising the Barcelona Paralympic Games – the IPC and the Barcelona Paralympic Organizing Committee – signed an agreement which stipulated that all Paralympic sports contested at the 1992 Barcelona Paralympic Games were to be conducted using sports-specific functional classification systems [3]. This administrative decision greatly accelerated the transition to functional classification systems.

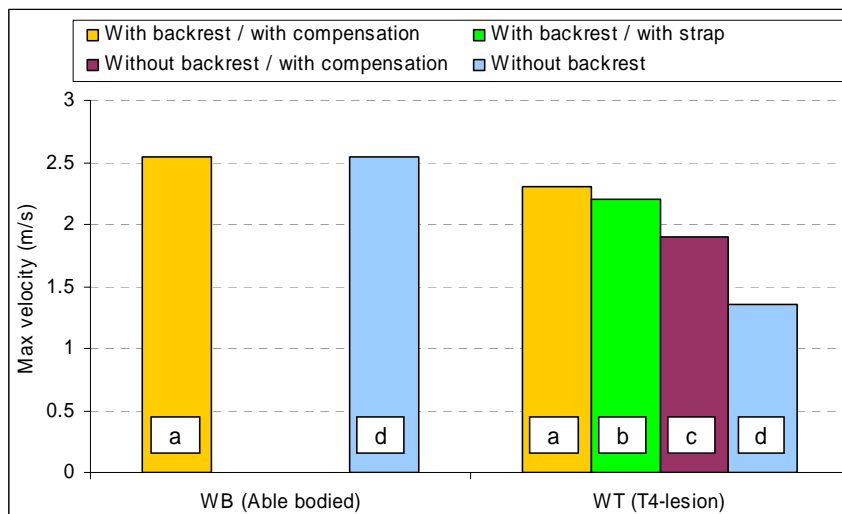


Fig. 4. Peak velocity in accelerating from standstill in four trunk stability conditions

Classification became sport-specific, and as such the development of the system became the responsibility of the sports [3]. The IPC, in its first years of existence, didn't provide a general philosophy of classification, nor a general concept the sports had to adhere to. Many sports had not begun to develop functional systems so, given the short time-frame in the run up to the Barcelona Games, and the absence of relevant scientific evidence, the classification systems that were developed were necessarily based on expert opinion. Within each of the sports, senior Paralympic classifiers from a diverse range of backgrounds – medical doctors, therapists, athletes and coaches – lead the development of functional systems of classification.

The classification systems implemented during the Barcelona 1992 Paralympic Games were hardly revised in the past two decades. Scientific literature on classification addressed the validity of the classification systems in place, demonstrating that interclass significant differences exist with respect to the outcome of competition [7-14], or with respect to physical [11, 14], technical [15] or psychological [16] determinants of performance. To the authors' knowledge, no studies addressed the relationship between impairment and performance.

Conclusions

The current study demonstrates that the impact of pelvic and trunk strength on one of the main determinants in wheelchair sports performance can be measured and quantified. To achieve this purpose, first the main determinants within the specific sport have to be defined. In wheelchair sports, amongst others, the capacity to accelerate the wheelchair from standstill is crucial. Therefore, a standardized, reliable and valid measurement has to be developed to measure the acceleration from standstill under realistic external conditions (e.g. rolling resistance should be simulated). Once this setup has been achieved, the activity should be performed with and without inclusion of the paralyzed muscles in the biomechanically most optimal muscular chain. In the current study, the muscles responsible for pelvic stability and active trunk range of motion are in- and excluded from the muscular chain. As the weakest part of the chain will determine the outcome of the test, the impact of impairment on a sport-specific determinant is quantified. Moreover, compensation strategies such as strapping and positioning can be evaluated, and classifiers can judge in which way alterations to the wheelchair-athlete interface should be taken into account in the classification of an individual athlete.

The relevance to rehabilitation is huge. The understanding of the impact of impairment on specific activities will lead to better guidelines to optimize the wheel-

chair-user interface during rehabilitation. Of course, activities of daily living are extremely diverse and any chosen interface setup will always be a compromise between tasks to be executed. The end result, however, will be a wheelchair which is adjusted maximally to the functional capacity of the user, improving the mobility and social range of action of the person, and therefore, his/her quality of life.

The limitation on this study is of course that it is only exemplary illustration and that only one specific determinant of wheelchair propulsion has been targeted. Studies with statistical power will have to be initiated investigating all determinants of wheelchair propulsion, including the acceleration from standstill, sub-maximal steady state wheeling, and maneuverability.

The above example demonstrates an approach, not only to study the association between impairment and activity limitation, but also to measure the relative impact of compensation strategies such as strapping and positioning. Therefore, this approach will not only serve as a basis for the building of evidence-based classification systems, but also will contribute significantly to the understanding of wheelchair-user interface optimization for executing specific tasks. Such knowledge will have implications for rehabilitation as well as classification in grass roots and elite-level sport.

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