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The research story so far: Wheelchair racing as an exemplar

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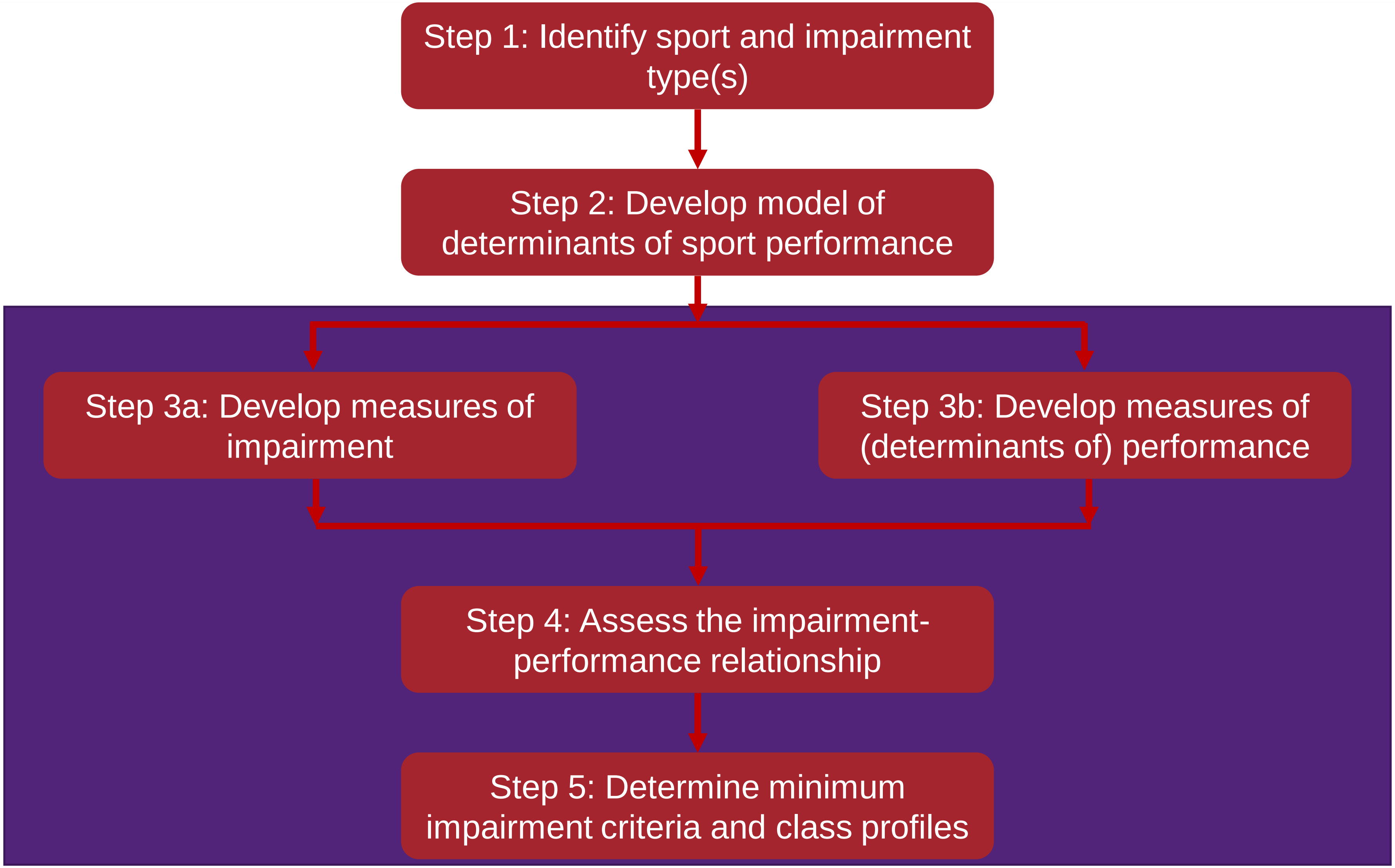
Classification Research Partner

HOW TO PERFORM CLASSIFICATION RESEARCH



HOW TO PERFORM CLASSIFICATION RESEARCH

Step 3a: Develop measures of impairment

Effort Dependence (Intentional Misrepresentation)

Step 4: Assess the impairment-performance relationship

Impact of training

Department of Human Movement Sciences

HOW TO PERFORM CLASSIFICATION RESEARCH

Step 1: Identify sport and impairment type(s)

- Athletics (Wheelchair racing)
- Muscle strength

Step 2: Develop model of determinants of sport performance

Step 3a: Develop measures of impairment

Step 3b: Develop measures of (determinants of) performance

Step 4: Assess the impairment-performance relationship

Step 5: Determine minimum impairment criteria and class profiles

Step 2: Develop model of determinants of sport performance

- Some key muscle groups, positions and actions from published literature and some from expert opinion in Delphi study

Step 3a
Theoretical foundations first….

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Review

Assessing muscle strength for the purpose of classification in Paralympic sport: A review and recommendations

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ABSTRACT

Objectives: Classification in Paralympic Sport aims to minimize the impact of 10 eligible types of impairment on the outcome of competition. Methods for assessing the extent to which a given body structure or function has been impaired are required, but are challenging because it is not possible to directly measure an absence or loss. Rather, impairment must be inferred by measurement of extant body structures or functions.

Methods: This manuscript reviews the literature concerning the assessment of strength with the aim of identifying and describing the most appropriate method for inferring strength impairment in para-athletes.

Results: It is posited that the most appropriate voluntary strength assessment method for inferring strength loss in para-athletes will be multi-joint, isometric tests performed at joint angles that facilitate maximum force production.

Conclusions: Evidence suggests such methods will permit development of tests that are specific to a variety of para-sports and which are reliable, ratio-scaled, and resistant to training. Future research should: develop sport-specific tests which are suitable for assessment of athletes with strength impairments of variable severity and distribution; and scientifically evaluate the extent to which such tests permit strength impairment to be validly inferred, including specific evaluation of the extent to which such measures respond to athletic training.

1. Introduction

There are 27 Paralympic sports – 22 summer sports and five winter sports – and each of these sports has its own sport-specific classification system for impairments. The purpose of classification is to promote participation in sport by people with disabilities by minimizing the impact of eligible impairments on the outcome of competition.[1] There are ten eligible impairment types in Para-

simply because they have an impairment that causes less activity limitation than their competitors.

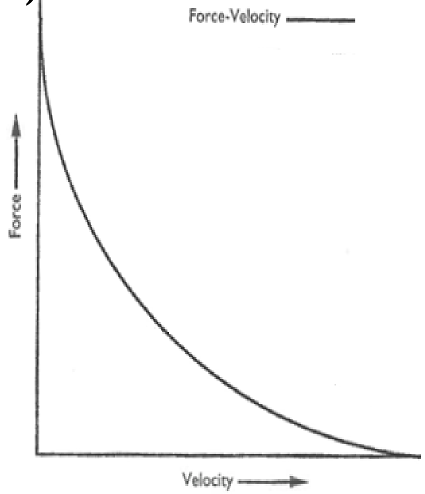
The IPC Classification Code mandated the development of evidence-based classification in all Paralympic Sports,[2] and subsequently the IPC Position Stand on Classification in Paralympic Sport detailed the scientific principles for achieving evidence-based classification. The language used in the Code and the Position Stand is consistent with the International Classification of Functioning, Dis-

Measures of impairment
- objective
- reliable,
- Precise
- Ratio scaled
- specific to the impairment of interest
- parsimonious

(ie, account for the greatest possible variance in sports performance),
- and, as far as possible, be resistant to the effects of training

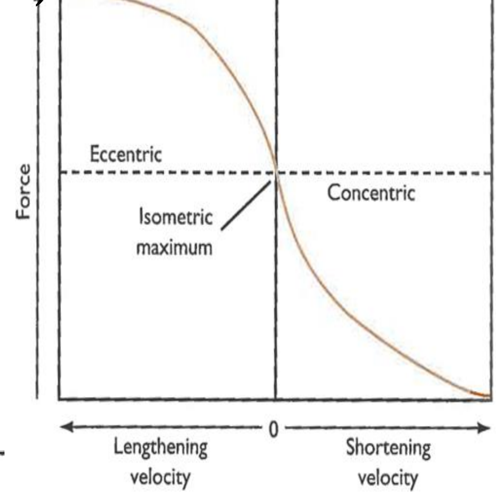
Reviewed strength assessment literature for best available methods

A)

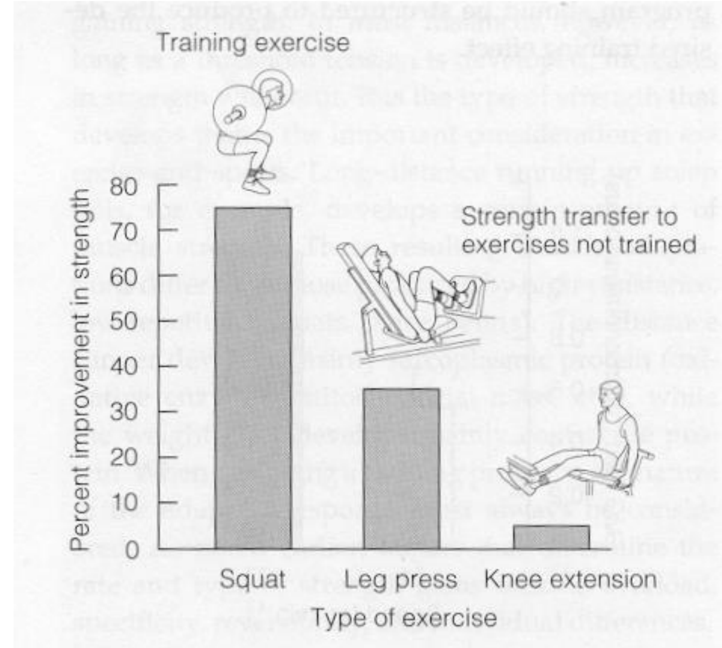


Force-Velocity
Force
Velocity

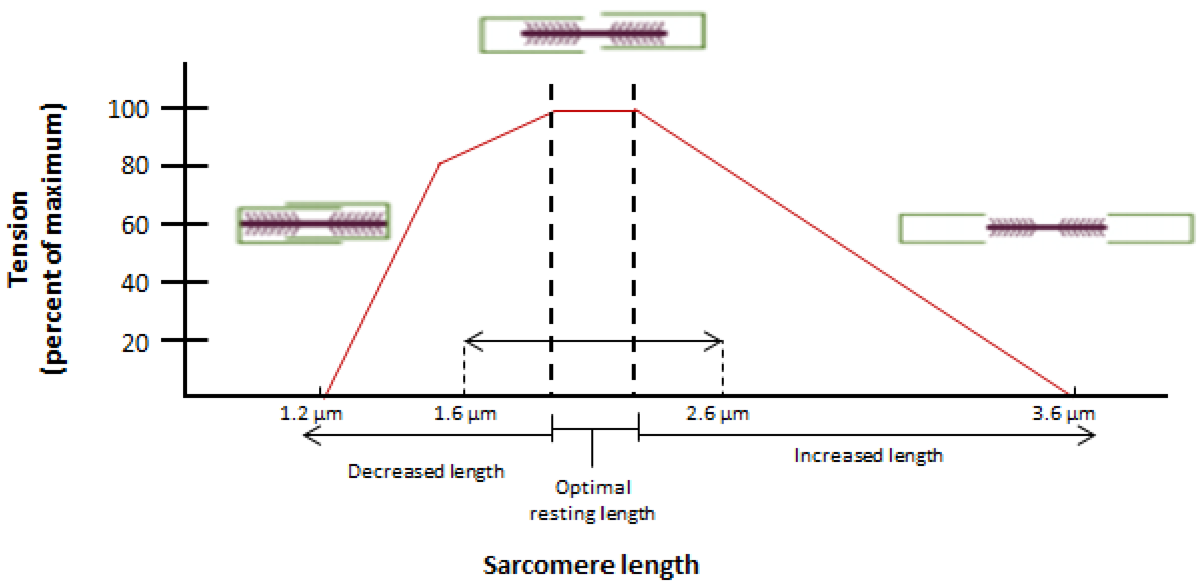
B)



Force
Eccentric
Concentric
Isometric maximum
0
Lengthening velocity
Shortening velocity



Training exercise
Strength transfer to exercises not trained
Percent improvement in strength
80
70
60
50
40
30
20
10
0
Squat
Leg press
Knee extension
Type of exercise



Tension (percent of maximum)
100
80
60
40
20
1.2 µm
1.6 µm
2.6 µm
3.6 µm
Decreased length
Optimal resting length
Increased length
Sarcomere length

…then protocol development and evaluation

- Relevant to determinants of performance
- Assess reliability
- Assess relationship to body size
- Develop normative values

OPEN

Novel Strength Test Battery to Permit Evidence-Based Paralympic Classification

Emma M. Beckman, PhD, Peter Newcombe, PhD, Yves Vanlandewijck, PhD, Mark J. Connick, PhD, and Sean M. Tweedy, PhD

Abstract: Ordinal-scale strength assessment methods currently used in Paralympic athletics classification prevent the development of evidence-based classification systems. This study evaluated a battery of 7, ratio-scale, isometric tests with the aim of facilitating the development of evidence-based methods of classification. This study aimed to report sex-specific normal performance ranges, evaluate test–retest reliability, and evaluate the relationship between the measures and body mass.

Body mass and strength measures were obtained from 118 participants—63 males and 55 females—ages 23.2 years ± 3.7 (mean ± SD). Seventeen participants completed the battery twice to evaluate test–retest reliability. The body mass–strength relationship was evaluated using Pearson correlations and allometric exponents.

Conventional patterns of force production were observed. Reliability was acceptable (mean intraclass correlation = 0.85). Eight measures had moderate significant correlations with body size (r = 0.30–61). Allometric exponents were higher in males than in females (mean 0.99 vs 0.30).

Results indicate that this comprehensive and parsimonious battery is an important methodological advance because it has psychometric properties critical for the development of evidence-based classification. Measures were interrelated with body size, indicating further research is required to determine whether raw measures require normalization in order to be validly applied in classification.

(*Medicine* 93(4):e31)

Abbreviations: ICC = intraclass correlations, IPC = International Paralympic Committee, MMT = manual muscle testing, SEM = standard error of the mean.

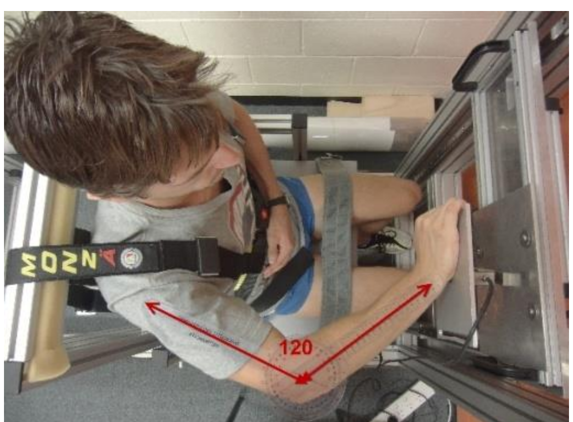
INTRODUCTION

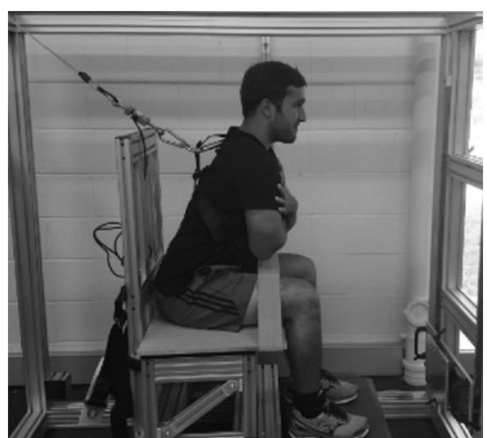
A total of 2.78 million tickets were sold to the London Paralympic Games, making the Paralympic Games the world's third biggest sporting event, after the Olympic games and the FIFA World Cup. The movement is genuinely global —174 countries have National Paralympic Committees—and participation is increasing, with >6000 internationally registered athletes in the sport of athletics alone.[1]

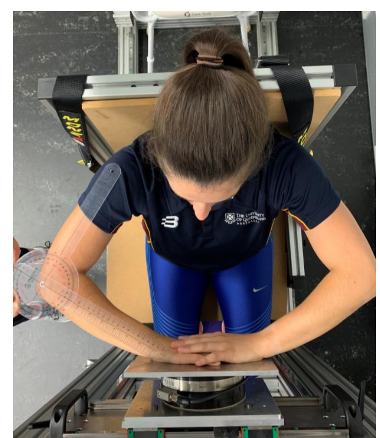
Classification systems are integral to Paralympic sport, being used to determine eligibility and control for the impact of eligible impairment types on the outcome of competition.[2] Valid classification systems facilitate competition in which the athletes who succeed are not simply those who have less severe impairments than their competitors, but those who have the most favorable combination of athletic attributes and have enhanced them to best effect.

Classification that is not valid or that is not perceived to be valid poses a significant threat to Paralympic sport. At the elite level, the legitimacy of an individual's competitive success or athletic achievement can be significantly diminished by the perception that they are in the wrong class, with the potential for considerable personal and financial costs, as well as for discrediting the movement. At the grass-roots level, a classification system that is perceived to be unfair will discourage participation among people with disabilities, rather than achieve the goal of increasing it.

Evidence-based decision making in classification is an essential means of enhancing classification validity, but evidence underpinning current methods of classification is weak. In 2007 the International Paralympic Committee (IPC) mandated the development of evidence-based methods of classification for all Paralympic sports[3] and the IPC Position







Step 3b: Develop measures of (determinants of) performance

Wheelchair racing

- Acceleration
- Top speed

- Custom built ergometers
- Athletics Track

Step 4: Assess the impairment-performance relationship

Trunk Strength Effect on Track Wheelchair Start: Implications for Classification

YVES C. VANLANDEWIJCK[1], JOERI VERELLEN[1], EMMA BECKMAN[2], MARK CONNICK[2], and SEAN M. TWEEDY[2]

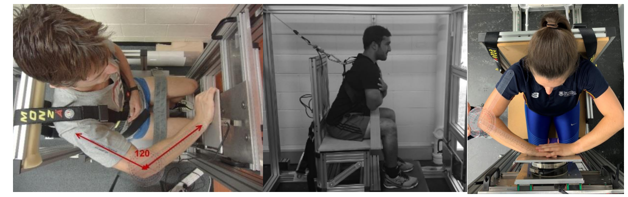
[1]Faculty of Kinesiology and Rehabilitation Sciences, Katholieke Universiteit Leuven, Leuven, BELGIUM; and [2]School of Human Movement Studies, The University of Queensland, Brisbane, AUSTRALIA

ABSTRACT

VANLANDEWIJCK, Y. C., J. VERELLEN, E. BECKMAN, M. CONNICK, and S. M. TWEEDY. Trunk Strength Effect on Track Wheelchair Start: Implications for Classification. *Med. Sci. Sports Exerc.*, Vol. 43, No. 12, pp. 2344–2351, 2011. **Purpose**: The T54 wheelchair racing class comprises athletes with normal arm muscle strength and trunk strength ranging from partial to normal. Paralympic sports classes should comprise athletes who have impairments that cause a comparable degree of activity limitation. On the basis of this criterion, the purpose of this study was to determine whether the T54 class is valid by assessing the strength of association between trunk strength and wheelchair acceleration. **Methods**: Participants were 10 male and 3 female international wheelchair track athletes with normal arm strength. Six were clinically assessed as having normal trunk strength, and seven had impaired trunk strength. Measures included isometric arm and trunk strength and distance covered at 1, 2, and 3 s in an explosive start from standstill on a regulation track, as well as on a custom-built ergometer with four times normal rolling resistance. **Results**: No significant differences were observed between male athletes with and without full trunk strength in distance covered after 1, 2, and 3 s. Correlations between isometric trunk strength and wheelchair track acceleration were nonsignificant and low (0.27–0.32), accounting for only 7%–10% of variance in performance. Correlations between trunk strength and distance pushed under high resistance were also nonsignificant, although values were almost double (r = 0.41–0.54), accounting for 18%–28% of the variance in performance. **Conclusions**: These results provide evidence that impairment of trunk strength has minimal effect on wheelchair acceleration and indicate the T54 class is valid. Results do not infer that athletes with no trunk strength should compete with those who have partial or full trunk strength.

Key Words: ATHLETICS, ACTIVITY LIMITATION, IMPAIRMENT, PARALYMPIC, RACING

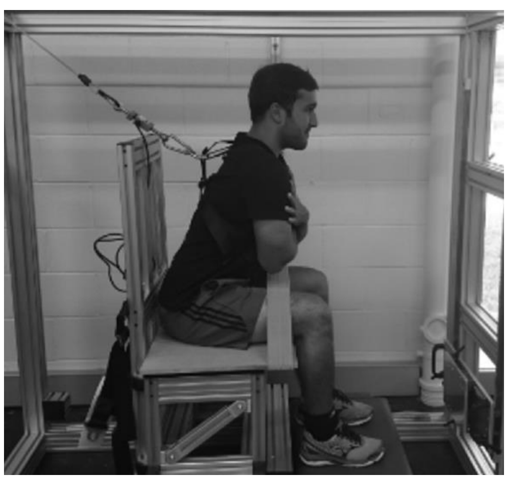
In 2009, the International Paralympic Committee (IPC) endorsed extensive revisions of the IPC Athletics Classification System, which will be implemented after the 2012 London Paralympic Games (10). The stated purpose of the revised system is consistent with the IPC position stand on classification in Paralympic sport—to promote participation in sport by people with disabilities by minimizing the effect of impairment on the outcome of competition (10,11). normal trunk control … Equivalent activity limitation to person with complete cord injury between cord level T8–S4" (10). To determine whether the T54 class achieves its intended purpose—to minimize the effect of impairment on the outcome of competition—requires evaluation of the effect that reduced trunk muscle power has on wheelchair racing performance: if reduced trunk muscle power has minimal effect, then the class will achieve its purpose; if it has a large



Step 4: Assess the impairment-performance relationship

Wheelchair performance

Isometric strength



Cluster analysis of novel isometric strength measures produces a valid and evidence-based classification structure for wheelchair track racing

Mark J Connick,[1] Emma Beckman,[1] Yves Vanlandewijck,[2] Laurie A Malone,[3] Sven Blomqvist,[4] Sean M Tweedy[1]

ABSTRACT

Background The Para athletics wheelchair-racing classification system employs best practice to ensure that classes comprise athletes whose impairments cause a comparable degree of activity limitation. However, decision-making is largely subjective and scientific evidence which reduces this subjectivity is required.

Aim To evaluate whether isometric strength tests were valid for the purposes of classifying wheelchair racers and whether cluster analysis of the strength measures produced a valid classification structure.

Methods Thirty-two international level, male wheelchair racers from classes T51–54 completed six isometric strength tests evaluating elbow extensors, shoulder flexors, trunk flexors and forearm pronators and two wheelchair performance tests–Top-Speed (0–15 m) and Top-Speed (absolute). Strength tests significantly correlated with wheelchair performance were included in a cluster analysis and the validity of the resulting clusters was assessed.

Results All six strength tests correlated with performance (r=0.54–0.88). Cluster analysis yielded four clusters with reasonable overall structure (mean silhouette coefficient=0.58) and large intercluster strength differences. Six athletes (19%) were allocated to clusters that did not align with their current class.

The purpose of these classes is to control for the impact of impairment on the outcome of wheelchair track races, so that the athletes who succeed will be those with the most advantageous combination of physiological, psychological and anthropometric attributes.[1] Conceptually, this requires classes that each comprise athletes with impairments that cause a similar degree of activity limitation in wheelchair racing. Accordingly, class profiles reflect a logical hierarchy (table 1). Class T51 is for athletes with impairments causing the greatest activity limitation. These athletes typically have significant strength impairments in all of the muscle groups required for optimal wheelchair propulsion, these being the shoulder flexors/adductors, the elbow extensors,[2] wrist pronators[2] and possibly the trunk flexors.[3] The hierarchy progresses to T54 in which impairments result in minimal activity limitation in wheelchair racing (eg, below knee amputation or L4 SCI).

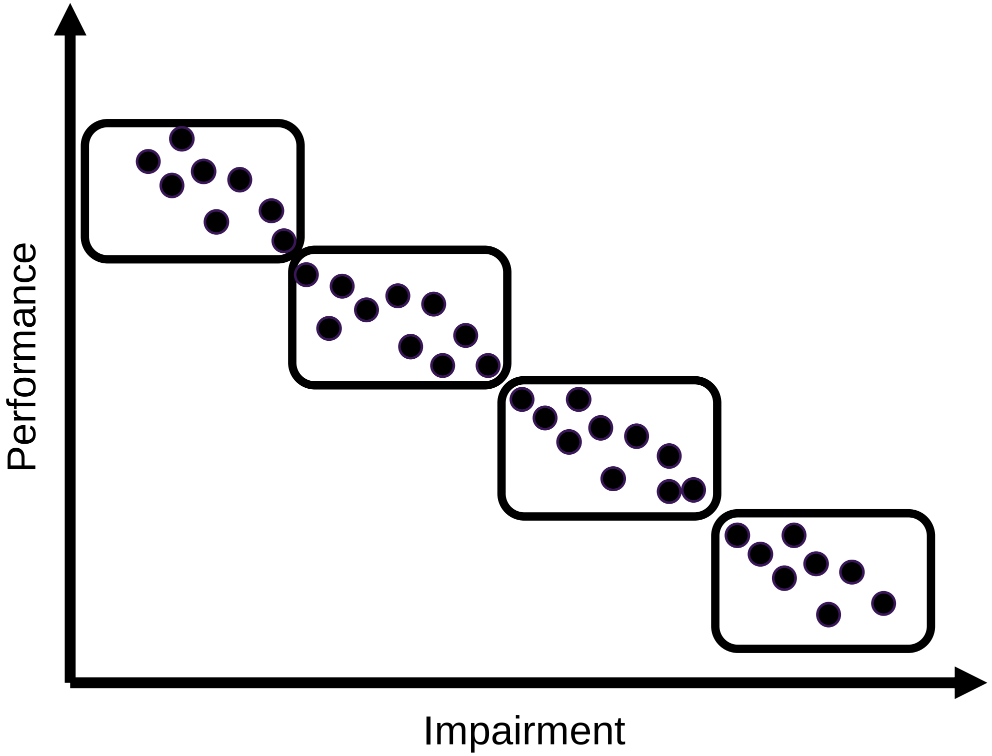
Class allocation for athletes with a motor-complete SCI is relatively straightforward because their impairment profile will be an exact match for one of the class profiles in table 1. However, an increasing number of athletes have impairment profiles which are not an exact match for any one profile, such as impairment profiles resulting from motor-incom-

Step 4: Assess the impairment-performance relationship

Isometric strength measure	Performance Outcome	
	Top-Speed (0-15m) correlation	Top-Speed (Absolute) correlation
Strongest Forearm Pronation	0.70*	0.79*
Weakest Forearm Pronation	0.70*	0.79*
Strongest Arm Extension	0.83*	0.88*
Weakest Arm Extension	0.81*	0.87*
Isolated Trunk	0.54*	0.61*
Arm+Trunk	0.73*	0.78*

Connick, M. J., Beckman, E., Vanlandewijck, Y., Malone, L., Blomqvist, S. and Tweedy, S. Novel isometric strength measures produce a valid and evidence-based classification structure for wheelchair track racing: A cluster analysis. British Journal of Sports Medicine

Theoretically…



Step 5: Determine minimum impairment criteria and class profiles

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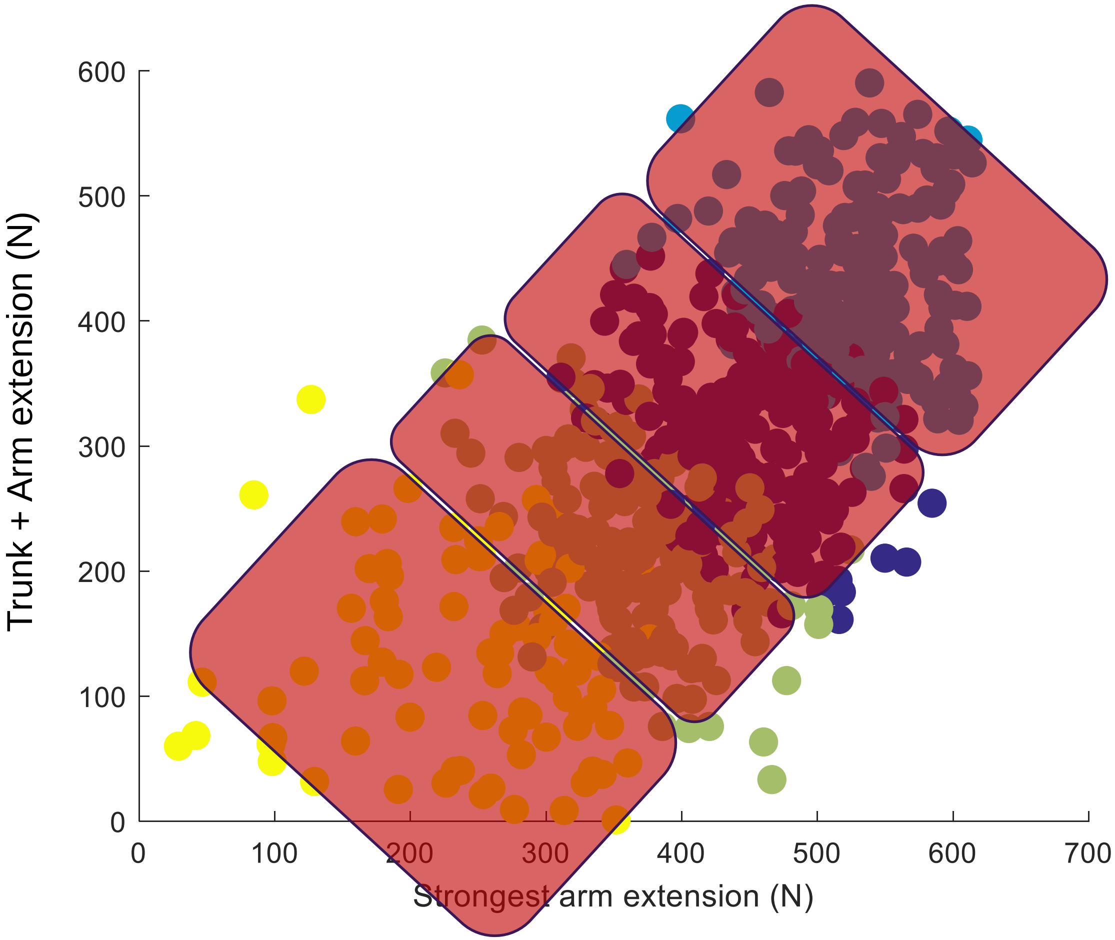
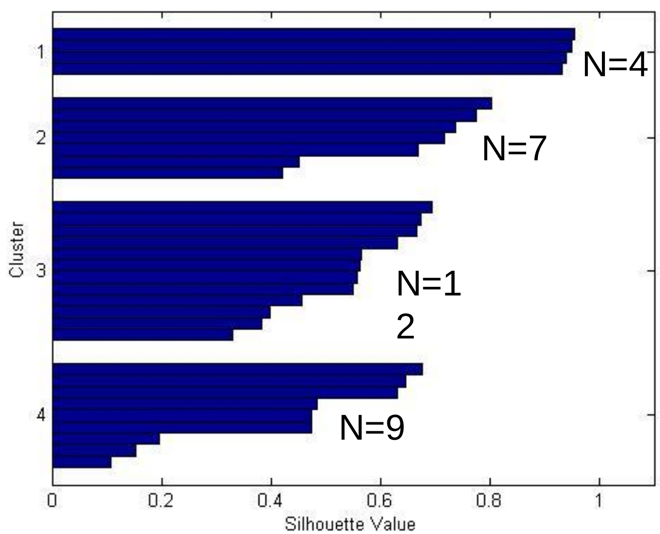


Results: Silhouette analysis of k-means cluster outcomes and current classes

- Silhouette analysis for k-means clusters was superior to the current classes

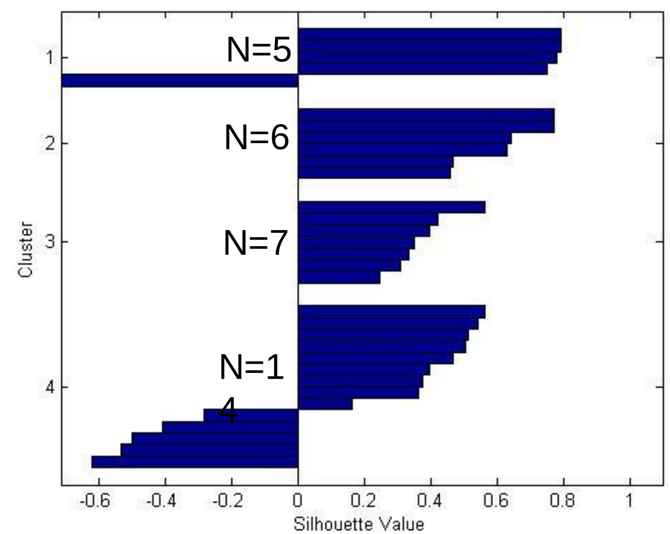
k-means clusters

Mean Silhouette coefficient = 0.58 (good)



Current classes

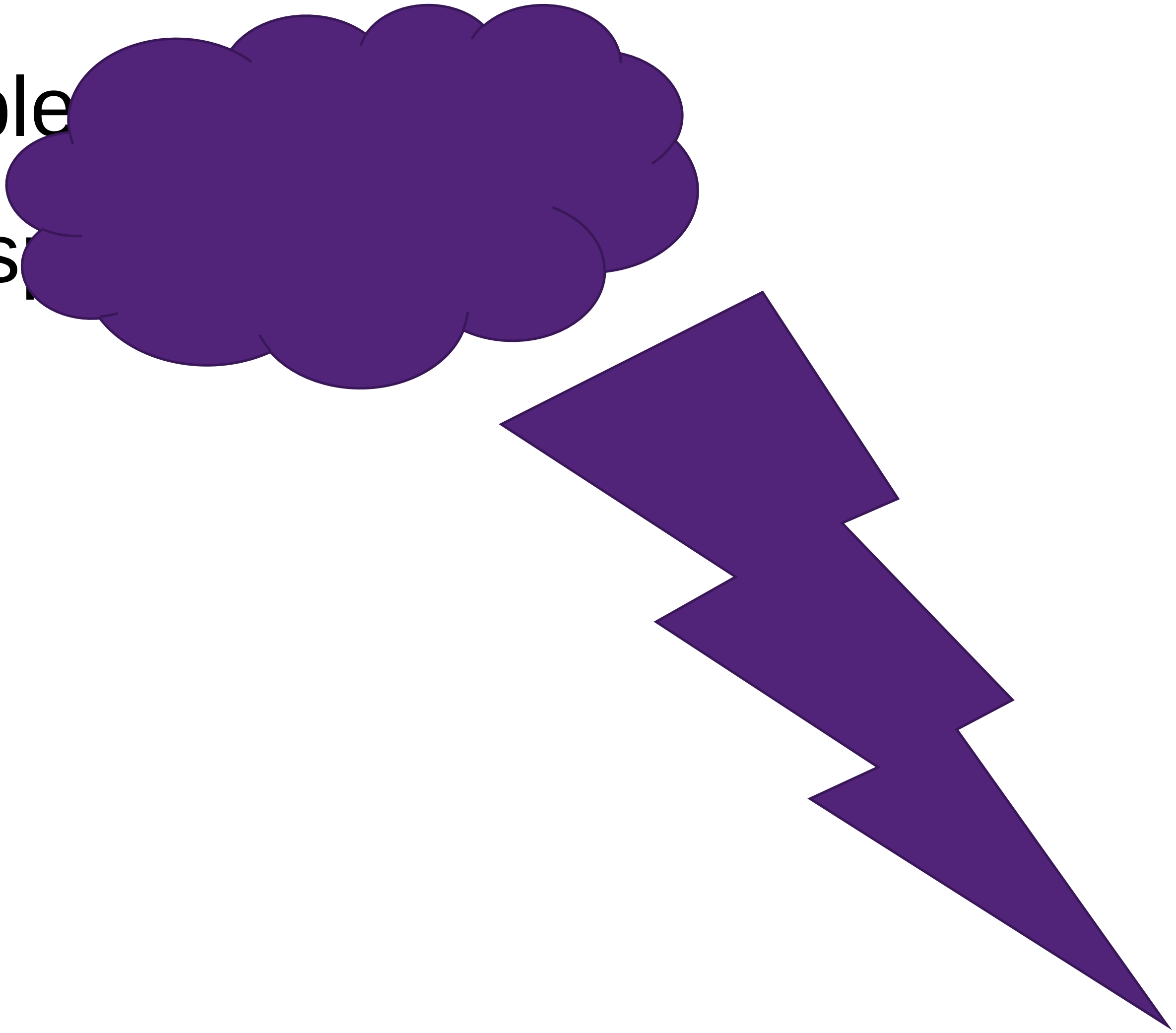
Mean Silhouette coefficient = 0.32 (weak)



What next?

Imple

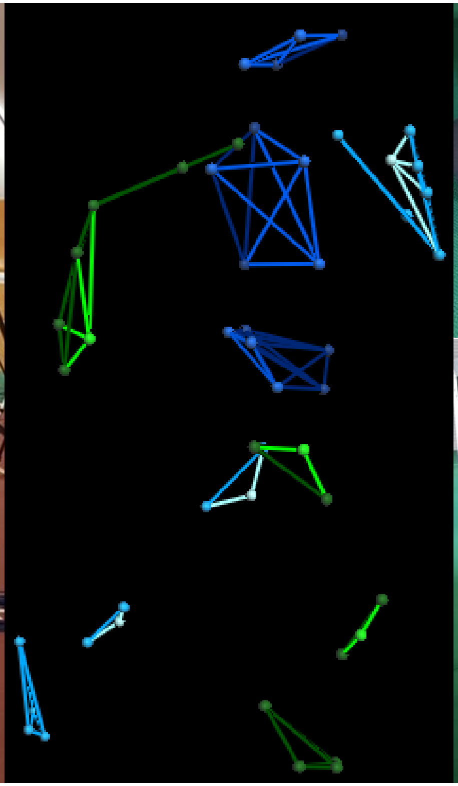
Res



What else?

- Based at the Australian Institute of Sport

“Towards evidence-based classification for runners with brain impairment in World Para Athletics”



HOW TO PERFORM CLASSIFICATION RESEARCH

Step 3a: Develop measures of impairment

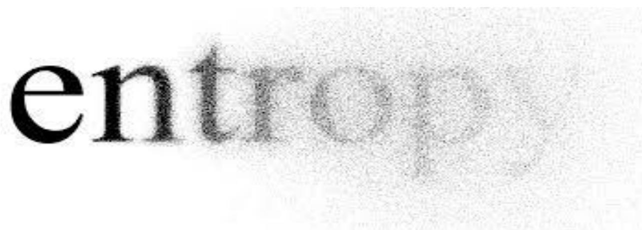
Effort Dependence (Intentional Misrepresentation)

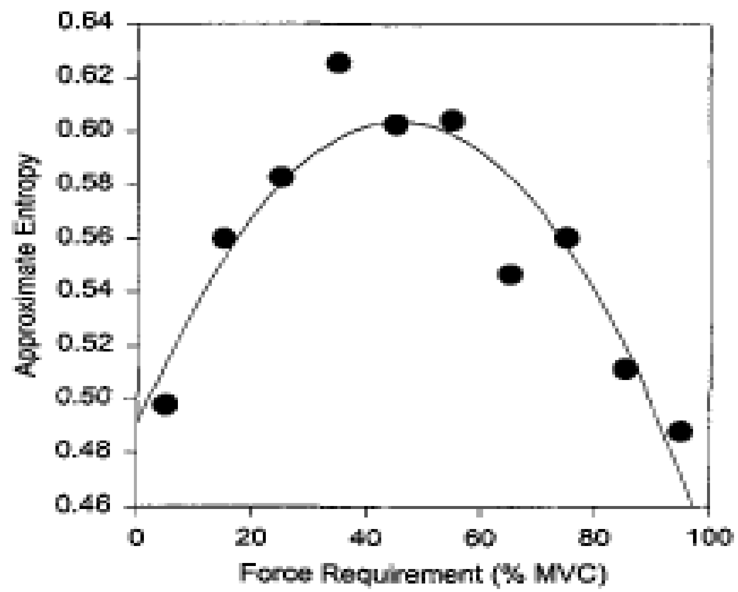
Step 4: Assess the impairment-performance relationship

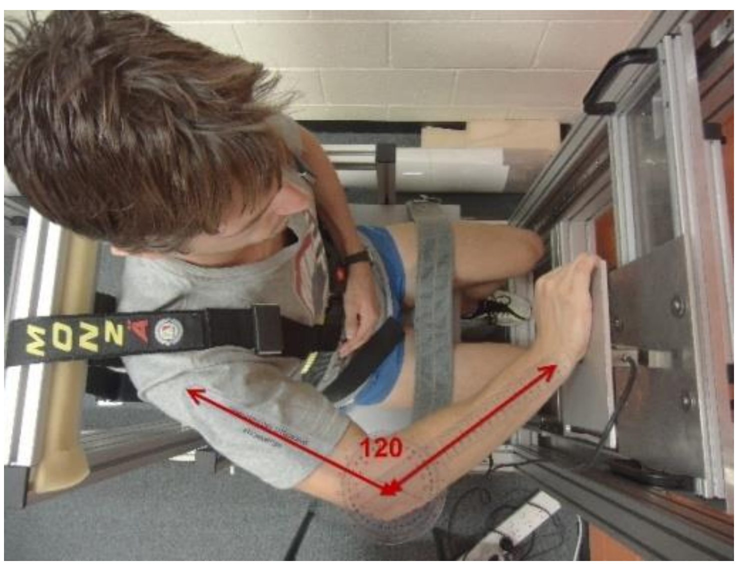
Impact of training

Intentional Misrepresentation

- **PhD Topic** – Developing methods for detecting Intentional Misrepresentation in Strength testing







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HOW TO PERFORM CLASSIFICATION RESEARCH

Step 3a: Develop measures of impairment

Effort Dependence (Intentional Misrepresentation)

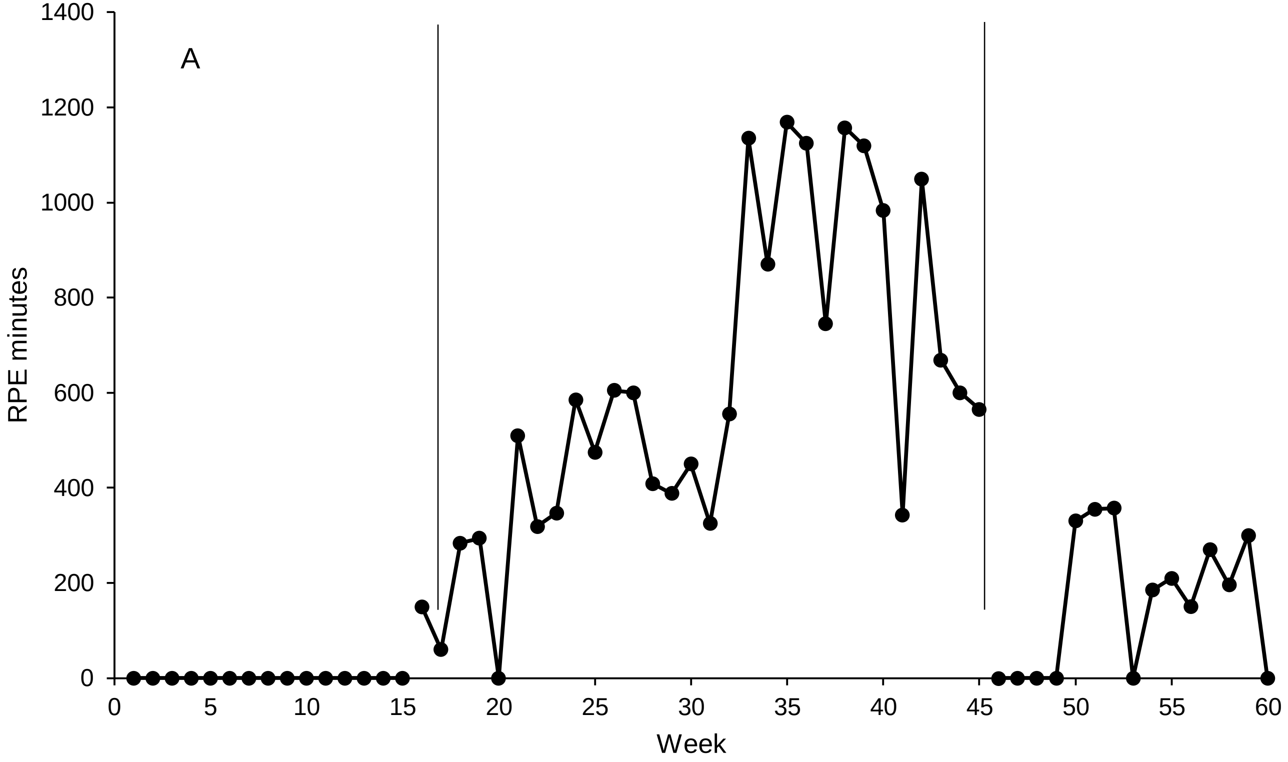
Step 4: Assess the impairment-performance relationship

Impact of training

Impact of training on measures

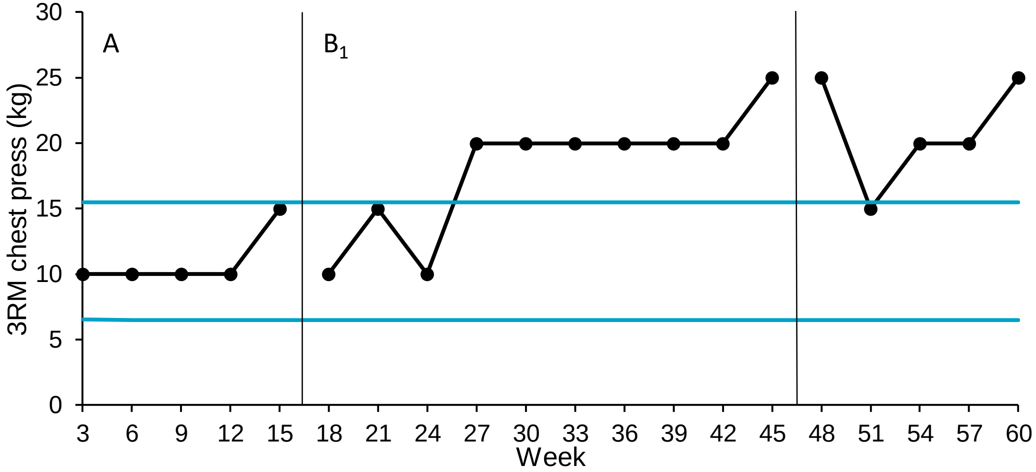
Do measures of impairment developed for the purposes of classifying Para swimmers change in response to performance focused swimming training?

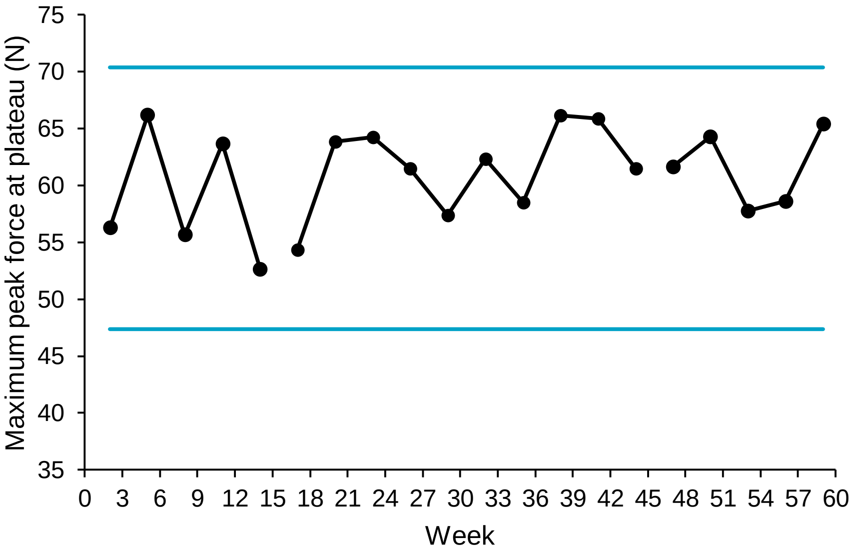
Training load



3RM Chest press

Dynamic Strength





Right upper limb isometric strength

Impairment Specific training assessment tests

Movement Characteristic	Criterion Activity	Test							
	Running	Sidestep Test	Countermovement Jump	Standing Broad Jump	Triple Hop for Distance	Four Bounds for Distance	10 m Speed Skip	Running in Place	Split Jumps
Static balance		✓	✓	✓	✓				
Dynamic balance	✓		✓	✓	✓	✓	✓	✓	✓
Active range of movement	✓	✓	✓	✓	✓	✓	✓	✓	✓
Lower limb coordination	✓	✓	✓	✓	✓	✓	✓	✓	✓
Power	✓		✓	✓	✓	✓	✓	✓	✓
Symmetry	✓	✓			✓	✓	✓	✓	✓
Whole body coordination	✓			✓	✓	✓	✓	✓	✓

Table 3 Relationship between the criterion activity limitation test (30 m sprint) and tests of activity limitation (n = 67)

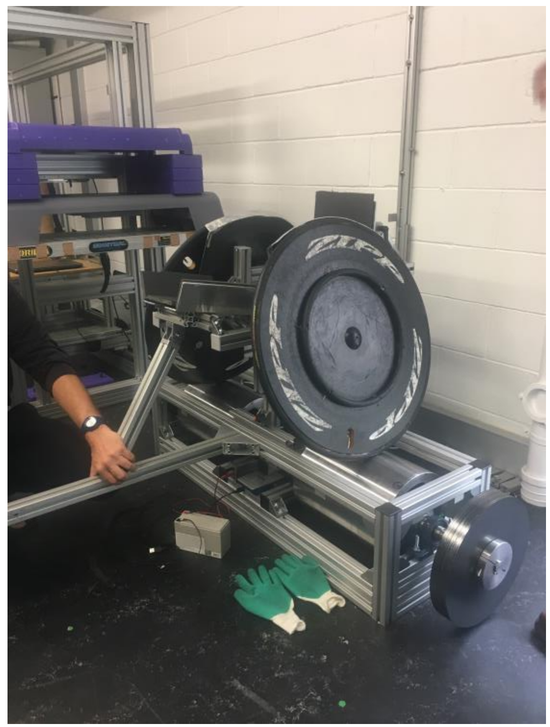
	Correlation with sprint performance
Running in place	0.19
10 m skip	0.67*
Split jumps	0.35*
Standing broad jump (adjusted)	−0.82*
Four bounds (adjusted)	−0.80*

*Correlation is significant at the 0.05 level (2-tailed).

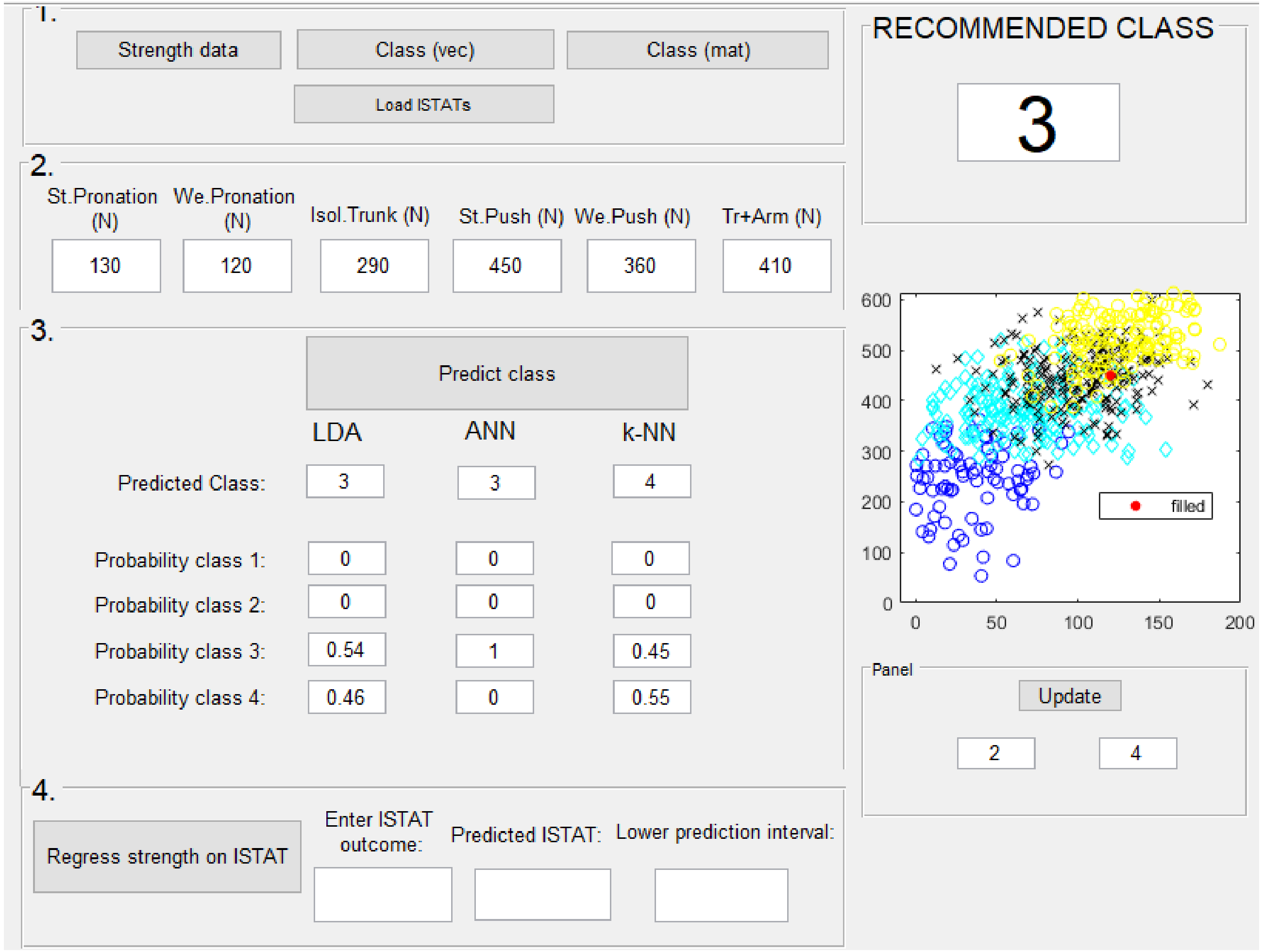
These tests have been introduced into WPA classification for runners with Brain Impairments as of 2019. All athletes classified must undergo these tests

Beckman, E.M., Tweedy, S.M. (2009) Towards evidence-based classification in Paralympic athletics: evaluating the validity of activity limitation tests for use in classification of Paralympic running events. BJSM

Impairment ISTATS Performance



Impairment Specific training assessment tests



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Iain Dutia
Emily Paix
Brittany Smale
Jen O'Sullivan

And all of the athletes, coaches, team staff and research collaborators that make it possible to do what we do

Thank you

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