Para-cycling classification

from a practical point of view

Ingrid Kouwijzer

International Paralympic Committee — Athlete Classification Code

↓

UCI — International classification

↓

KNWU — National classification

Eligible impairments in para-cycling

- Impaired muscle power (e.g. spinal cord injury, post-polio syndrome)
- Impaired passive Range of Movement (i.e. congenital or traumatic)
- Limb deficiency (e.g. traumatic amputation)
- Leg length difference
- Hypertonia (e.g. cerebral palsy, traumatic brain injury)
- Ataxia (cerebellar only; e.g. cerebral palsy, multiple sclerosis)
- Athetosis (athetosis, chorea, dyskinesia; e.g. cerebral palsy, traumatic brain injury)
- Vision impairment

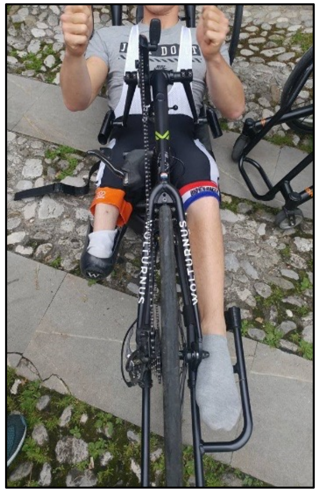
Non-Eligible

- Pain
- Hypermobility of joints or joint instability
- Impaired cardiovascular or respiratory functions
- Impaired metabolic functions

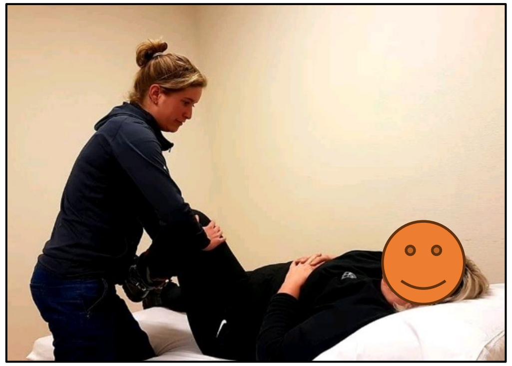
- Altered physiological function such as impaired sympathetic innervation of the heart and temperature regulation in athletes with tetraplegia

Athlete evaluation

1. Anamnesis



3. Technical observation



2. Physical examination

4. Observation during competition

ADAPTING YOUR BIKE IN PARA-CYCLING?

FEATURE

Para-cycling

Cycling

Tricycling

Handcycling

Tandem


CLASSIFICATION
IN PARA-CYCLING
HOW DOES
IT REALLY
WORK?
FEATURE

Para-cycling

Cycling

Tricycling

Handcycling

Tandem

Impaired muscle power

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

Arm Strength

Grip Strength

Trunk Strength

Case

Johan is a professional sitting volleyball player. However, in the last few years he started to be involved in para-cycling as well (on a recreational level).

He is interested in competing in para-cycling and comes in for classification.

He has a double above-knee amputation. His arm-hand function, trunk function and hip-leg connection are intact.

In which class will Johan be competing?

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

Arm Strength

Grip Strength

Trunk Strength

H5

++ Trunk stability
+ Lower limb function
++ Handgrip
++ Arm extension
++ Arm flexion

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Case

Five years ago, Pieter broke his neck during a dive in shallow water. Since then, he has a motor complete C6 spinal cord injury. He uses a wheelchair with an attachable handbike for daily mobility.

Hand function: bilateral loss of handgrip.
Arm function: strong deltoid and biceps (MMT 4-5/5) but weak triceps (MMT 1/5)
Trunk function: complete loss of trunk stability.
Lower limb function: complete loss of lower limb function.

In which class will Pieter be competing?

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Impaired muscle power

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

Arm Strength | Grip Strength | Trunk Strength




Do these five sport classes present five different levels of performance?

We don’t know?
Lack of scientific evidence behind the current classification system.

- All time trial results (average velocity) from 2014 to 2019 (N=1807) were investigated.
- Data from 4 World Championships, 15 World Cups, and 1 Paralympic Games.

- Multi-level regression models
  Correction for:
  - age, sex, event distance
  - country socioeconomic development
  - independent or national representation

All classes different velocities? Or overlap?

- H1 & H2 sign different (medium effect)
- H2 & H3 sign different (medium effect)
- H3 & H4 sign different (small effect)
- H4 & H5 not sign different

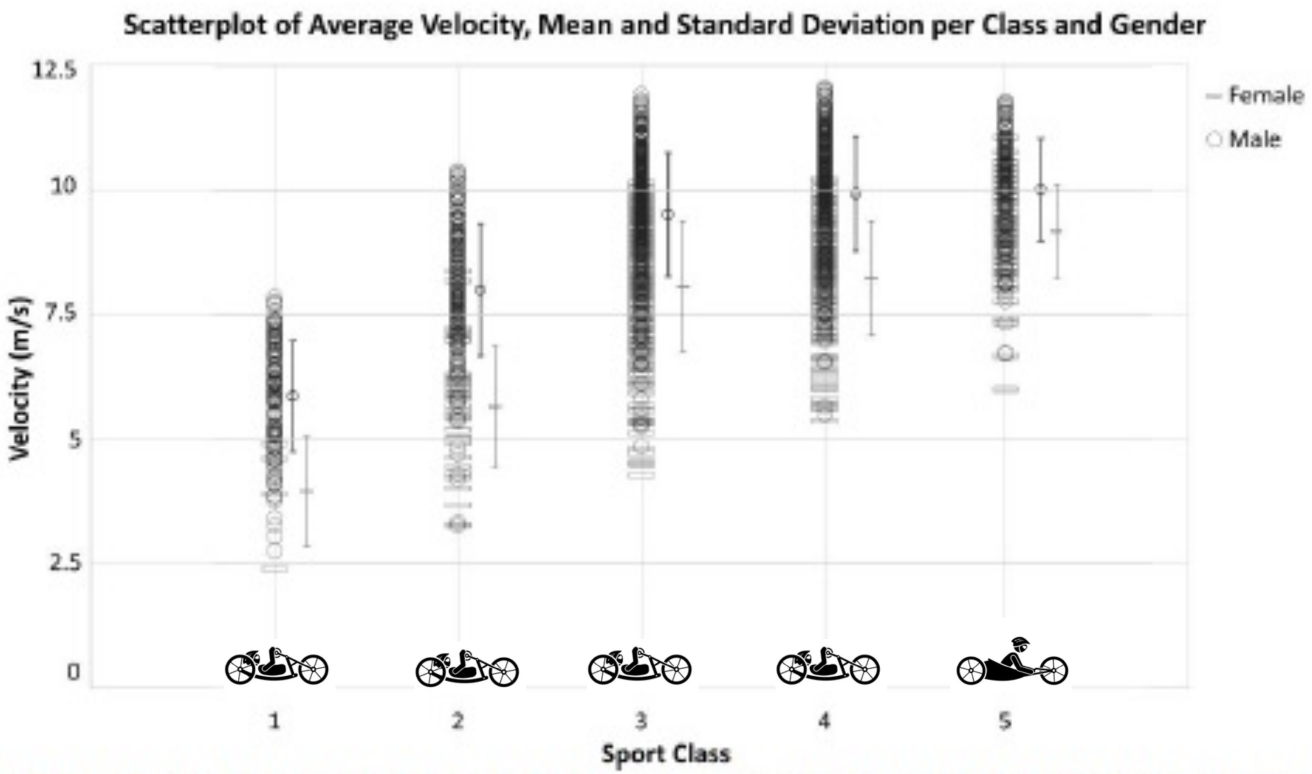


Figure 3 – Scatterplot of raw data of all events per class, with different markers for men and women, and with the addition of mean average velocity and SD. The y axis represents the average velocity. The x axis represents the five sport classes. Note. N = 1,807 (H1, n = 142; H2, n = 239; H3, n = 635; H4, n = 531; H5, n = 26.

Muchaxo REA, de Groot S, van der Woude LHV, Janssen TWJ, Nooijen C. Do Handcycling Time-Trial Velocities Achieved by Para-Cycling Athletes Vary Across Handcycling Classes? Adapt Phys Activ Q. 2020 Oct 6;37(4):461-480.

Impaired muscle power

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

Arm Strength

Grip Strength

Trunk Strength




Impaired muscle power

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

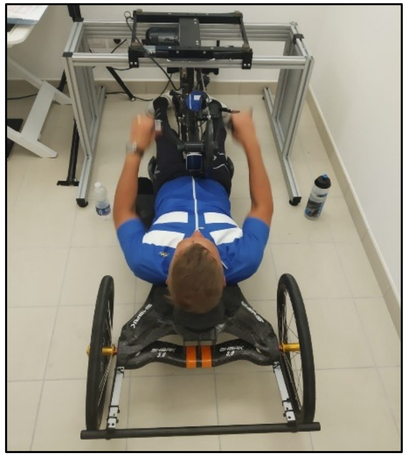
Arm Strength

Grip Strength

Trunk Strength

Trunk involvement in <u>recumbent</u> handcycling?

- World Cup & World Championship 2018 (N=29 H3 & H4 athletes)
- Trunk flexion strength in N
- Trunk flexion, rotation and extension & sitting balance with MMT



Muchaxo R, De Groot S, Kouwijzer I, Van Der Woude L, Janssen T, Nooijen CFJ. A Role for Trunk Function in Elite Recumbent Handcycling Performance? J Sports Sci. 2021 Oct;39(20):2312-2321.

Trunk involvement in recumbent handcycling?

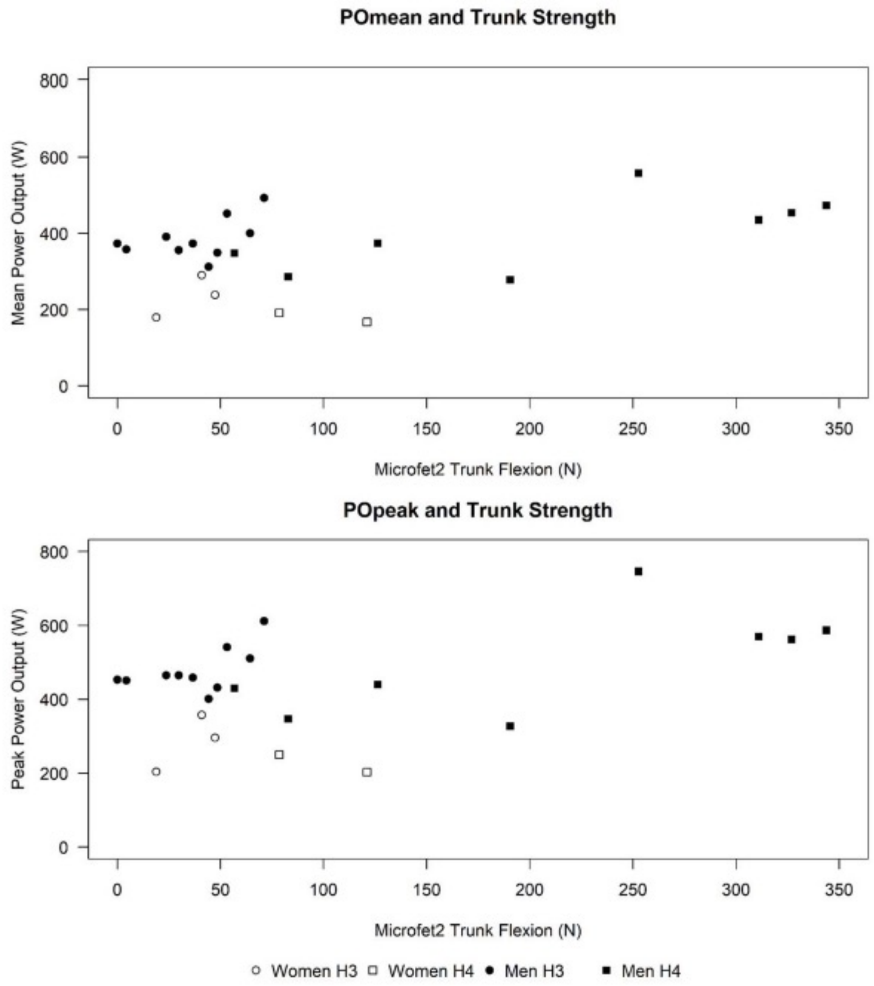


Figure 3 – Scatterplots of trunk flexion strength and handcycling performance during a 20-sec isokinetic sprint: Mean PO (upper graph) and Peak PO (lower graph). Data points are identified by sex and by handcycling class. (H3: spinal cord injury with lesion levels between Th1 and Th10; H4 lesion levels below Th11 or amputations).

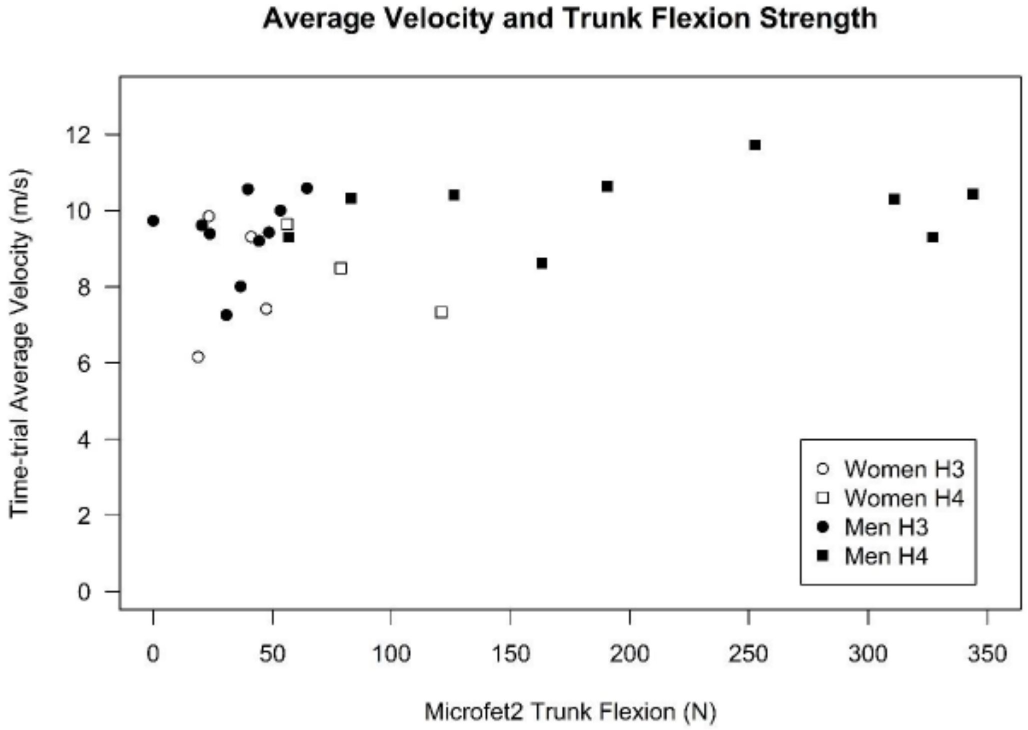


Figure 2 – Scatterplot of trunk flexion strength and average time-trial velocity. Data points are identified by sex and by handcycling class. (H3: spinal cord injury with lesion levels between Th1 and Th10; H4 lesion levels below Th11 or amputations).

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Trunk involvement in <u>recumbent</u> handcycling? A second study

- Time trial results (average velocity) from 2014 to 2020 (N=528) were investigated for H3 and H4 athletes.

Athletes were grouped based on lesion level:

- Th1-Th5 (no trunk function)
- Th6-Th9 (only (part of) upper abdominals)
- Th10-L1 (also (part of) lower abdominals)
- ≤ L2 (full trunk function)

- Multi-level regression models
  Correction for:
  - age, sex, event distance
  - Motor completeness of SCI

Muchaxo R, De Groot S, Kouwijzer I, Van Der Woude L, Janssen T, Nooijen CFJ. A Role for Trunk Function in Elite Recumbent Handcycling Performance? J Sports Sci. 2021 Oct;39(20):2312-2321.

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Trunk involvement in <u>recumbent</u> handcycling? A second study

All levels of trunk function different velocities? Or overlap?

- Th1-Th5 & Th6-Th9 non-sign difference (very small effect)
- Th1-Th5 & Th10-L1 non-sign difference (very small effect)
- Th1-Th5 & ≤ L2 non-sign difference (very small effect)

- Th6-Th9 & Th10-L1 non-sign difference (very small effect)
- Th6-Th9 & ≤ L2 non-sign difference (very small effect)

- Th10-L1 & ≤ L2 non-sign difference (very small effect)

- **Overall conclusion: limited role for (isolated) trunk function in recumbent handcycling**

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Impaired muscle power

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-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

Arm Strength

Grip Strength

Trunk Strength

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Case

Three years ago, John had a mountainbike accident where he injured his spine and spinal cord. During surgery, vertebrae T10 to T12 were fixated. Since then, he has a motor incomplete spinal cord injury T11. He uses a wheelchair for daily mobility but has some partial leg function.

Arm-hand function: intact.
Trunk flexion: almost normal (MMT 4/5).
Trunk extension: impaired, but able to lift against gravity (MMT 3/5).
Knee extension: against gravity and partial resistance (MMT 3-4/5) for left and right leg.
Hip extension: weak (MMT 1-2/5) for left and right leg.

John is a typical H4 athlete. Do you think that John has an advantage of his partial leg function compared to athletes who have no leg function in the H4 class?

Impaired muscle power

H1	H2	H3	H4	H5
-- Trunk stability	-- Trunk stability	- Trunk stability	+ Trunk stability	++ Trunk stability
-- Lower limb function	-- Lower limb function	- Lower limb function	+ Lower limb function	+ Lower limb function
-- Handgrip	-- Handgrip	++ Handgrip	++ Handgrip	++ Handgrip
-- Arm extension	- Arm extension	++ Arm extension	++ Arm extension	++ Arm extension
+ Arm flexion	+ Arm flexion	++ Arm flexion	++ Arm flexion	++ Arm flexion

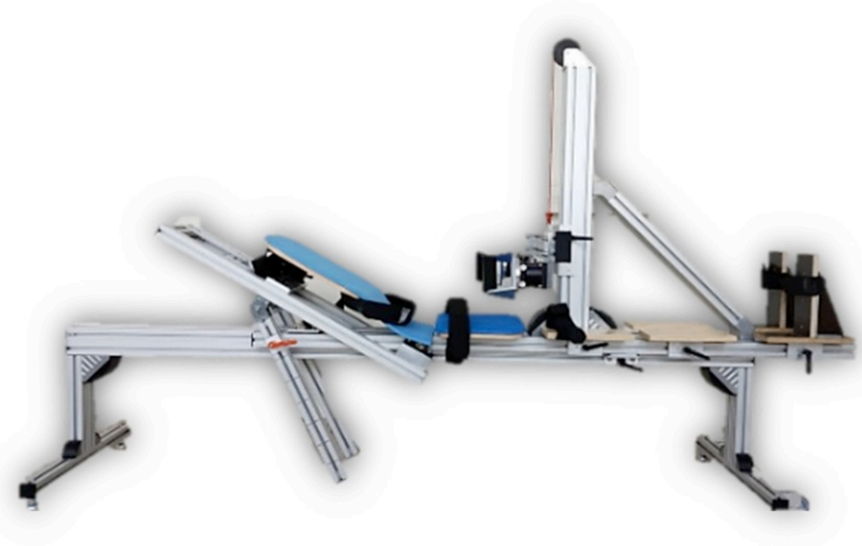
Arm Strength

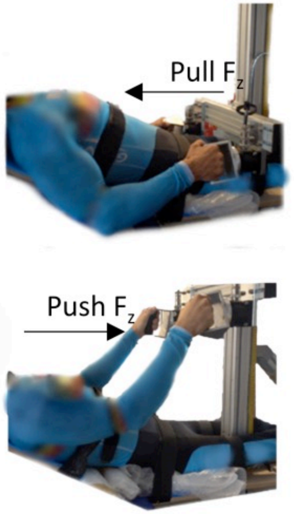
Grip Strength

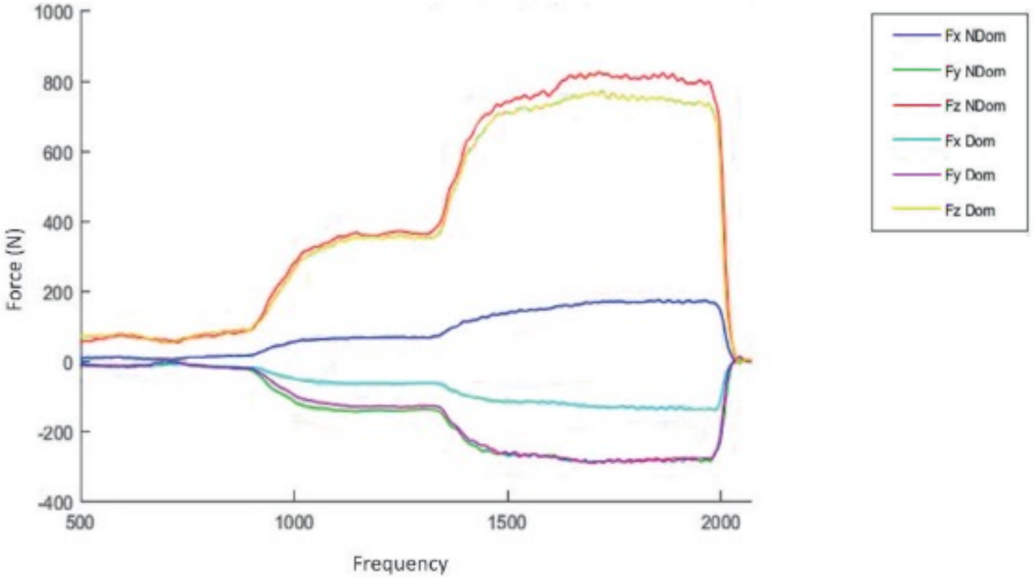
Hip-leg connection & lower limb function

Lower limb function?

- World Cup & World Championship 2019 (N=62)
- Lower limb function (hip flexion, hip extension and knee extension) with MMT
- Athletes grouped based on muscle strength in their lower limbs (LLF N=21, no-LLF N=41)







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Lower limb function?

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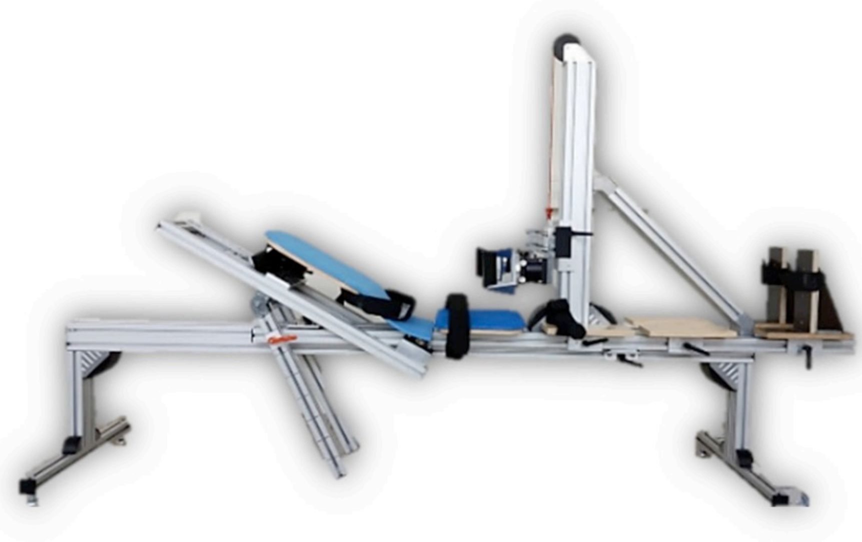

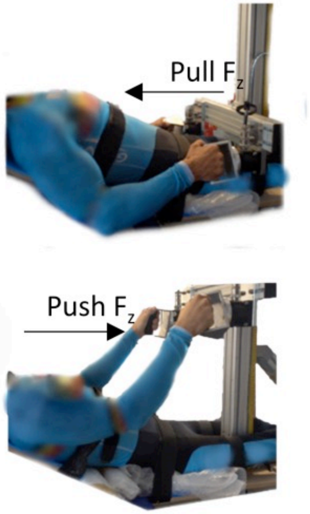

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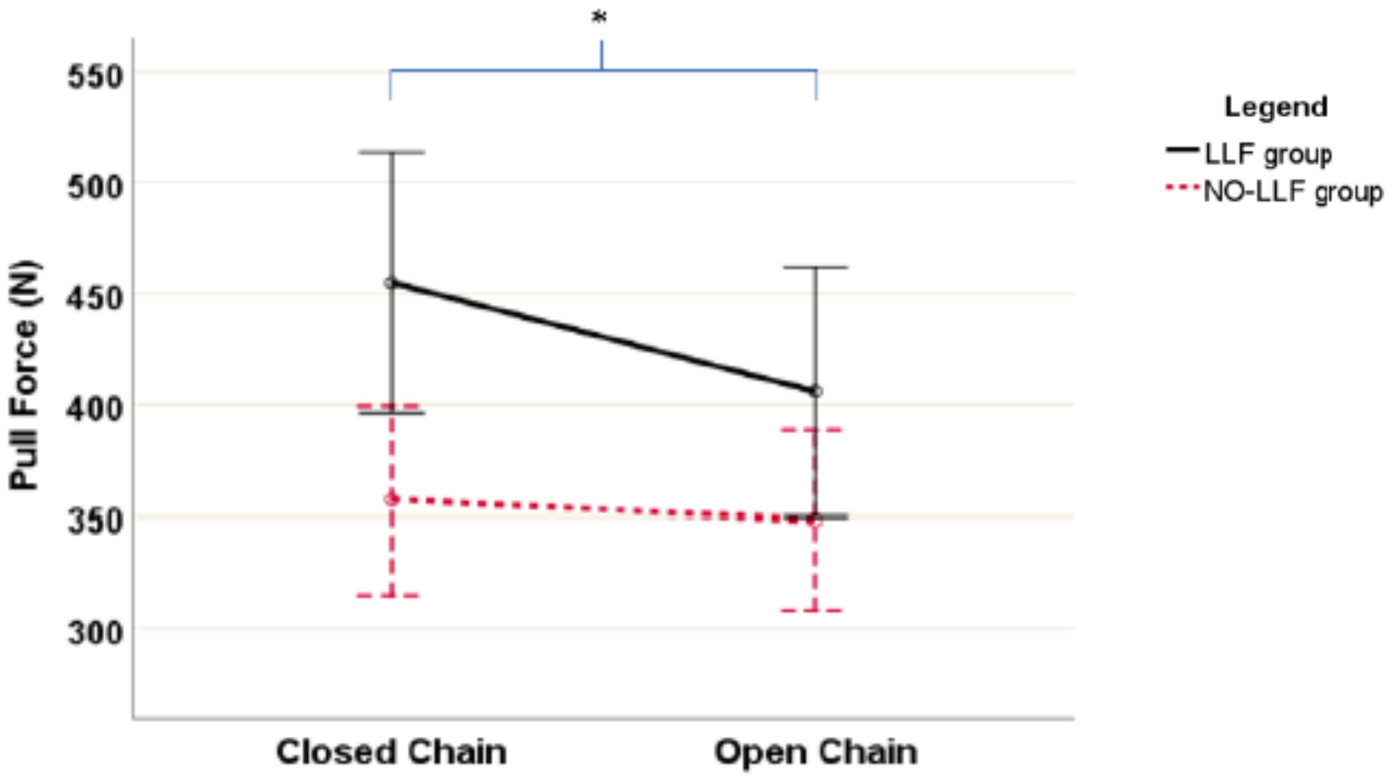
Lower limb function?

11%



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Case

John is a typical H4 athlete. Do you think that John has an advantage of his partial leg function compared to athletes who have no leg function in the H4 class?

Answer: yes, likely he has an advantage

Implementation of these findings in the classification system?

- The UCI can only make major rule changes after each Paralympic Games (every 4 years).
- Implementing research findings into classification systems is a challenging process.

- To aid this process, a **Delphi study** was conducted.
  - Investigate consensus in an expert panel, regarding statements on recent scientific findings and their implications for handcycling classification.

Methods

Three rounds of online questionnaires were sent to an international panel (n = 53) consisting of para-cyclists, para-cycling coaches and team managers, classifiers, and researchers within para-sport or paralympic classification.

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Delphi study

Table 2 – Demographic information of the Delphi panel (n = 53).

	N	(%)		N	(%)
Sex			**Role**		
Men	40	(75)	Athlete	28	(53)
Women	13	(25)	Classifier	10	(19)
Age (years)			Coach/Team Manager	17	(32)
<30	4	(8)	Researcher	5	(9.4)
30-39	10	(19)	Other*	2	(3.8)
40-49	20	(38)			
50-59	12	(23)	**If athlete, sport class:**		
60-69	6	(11)	C	10	(19)
≥70	1	(2)	H	12	(23)
Continent			H1	2	(4)
Africa	5	(9.4)	H2	2	(4)
America (North)	8	(15)	H3	4	(8)
America (South)	1	(1.9)	H4	3	(6)
Asia	1	(1.9)	H5	1	(2)
Europe	33	(62)	T	4	(8)
Oceania	5	(9.4)	Other**	2	(4)

n.b.: some panel members had more than one role, for example, being a researcher and a coach
* 1 UCI board member and 1 UCI para-cycling athletes' representative; **2 visually impaired cycling athletes

Questionnaire with for each round 2 sections with 7 topics each.

For each topic, a summary of recent findings from published and unpublished data were presented.

Answer options: Agree; Disagree; Not able to answer. With open text box.

75% agreement was set as consensus.

Example: trunk function

Q2.1

- The current handcycling classification system measures strength to allocate athletes with impaired muscle power to different sport classes. Strength is assessed using the Manual Muscle Test (MMT) (UCI, 2021). In this test, trunk flexion strength, trunk flexion-rotation strength, and trunk extension strength are assessed manually and graded from 0 (no muscle activity) to 5 (normal muscle strength).

Table 1 – Classification rules to allocate athletes in H3 and H4 based on impaired muscle power. Focused on trunk related rules

H3	H4
Paraplegia with impairments corresponding to a motor complete lesion from chest to abdominal level (from T1 to T10 level). No motor function in the legs	Paraplegia with impairments corresponding to a lesion at and below abdominal level (from T11 or below). No or impaired motor function in the legs
Trunk varies from "zero to minimal muscle strength" to "reduced to normal abdominal muscle strength". (MMT score 0-4)	Normal or almost normal trunk abdominal muscle strength. (MMT score 4-5)

- Trunk strength is considered an important determinant during classification of athletes to classes H3 or H4 (UCI, 2021).
- A study on sport class performance with data from 353 elite handcyclists found that the difference in time trial average velocity between H3 and H4 was small (Muchaxo et al., 2020)
- A study on a group of 81 H3-H4 athletes investigated whether groups with different levels of spinal cord injury (lumbar ≤L2 /abdominal T10-L1 / abdominal T6-T9/ high thoracic T1-T5) showed differences in time trial average velocity. No significant differences in time trial average velocity were found among these groups (Muchaxo et al., not published).
- A study on a group of 29 H3-H4 athletes investigated the impact of trunk flexion strength on recumbent handcycling performance. It was found that the impact of trunk flexion strength on standardized 20s sprint performance and on time trial average velocity was small and not significant (Muchaxo et al., not published).

- The Figure 1 shows the relationship between trunk flexion strength and time trial average velocity. In the figure it is visualized that H3 and H4 athletes show differences in the amount of trunk flexion strength, however, both classes show similar values of time trial average velocity.
- Previous studies showed that trunk movement is very limited in recumbent handcycling, especially in very aerodynamic handbikes, and movement occurs mostly around chest-neck-head (Faupin et al., 2006; Quittmann et al., 2018; Stone et al., 2019; Verellen et al., 2012).
- Studies performed in able-bodied people showed abdominal muscle activity during handcycling without observed movement, which could indicate that abdominal muscle activity is used for stabilization (Quittmann et al., 2019).
- It is known that athletes with higher thoracic spinal cord lesions (at or above T6 – chest level) may also present an impaired heart rate and blood pressure regulation and other autonomic responses that may restrict performance. However, impaired regulation is not considered an eligible impairment and should not interfere in Paralympic classification according to the IPC Athlete Classification Code and the UCI regulations (IPC, 2015; UCI, 2021).

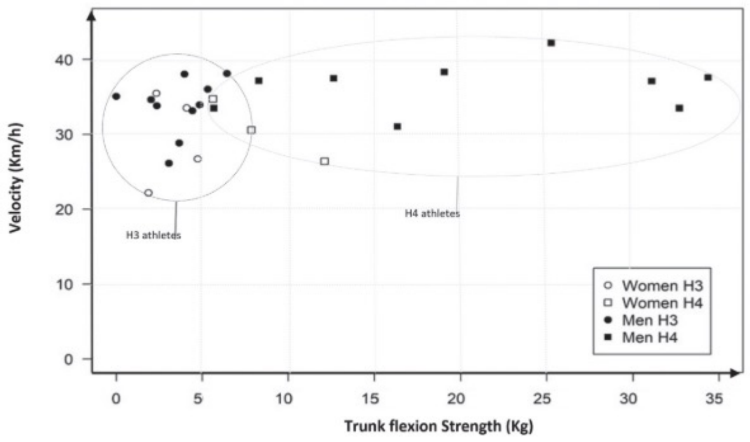

Figure 1 – Relation between trunk flexion strength (horizontal axis) and time trial average velocity (vertical axis) (26 athletes). Each dot represents the values of a single athlete.

Q2.1) Consider only the impact of <u>trunk flexion strength on recumbent handcycling</u> (without taking the impaired heart rate or blood pressure regulation into account). What is your opinion regarding the role of trunk strength in the current classification to allocate athletes to either class H3 or H4?

a) I agree with using trunk strength to classify athletes in H3 or H4 and with the current classification rules as described in Table 1.
b) I agree with using trunk strength to classify athletes in H3 or H4 but not with the classification rules as described in Table 1.
c) I disagree with using trunk strength to classify athletes in H3 or H4.
d) I disagree with using trunk strength to classify athletes in any recumbent class.
e) Not able to answer. Please justify.

First round: no consensus.

Example: trunk function

Trunk Flexion Strength

In the previous round, it was asked whether the panel agreed with the inclusion of trunk flexion strength in the current classification to allocate athletes to either class H3 or H4. The panel did not reach consensus as:

65% Agreed and **35% disagreed** with including trunk flexion strength during the classification of athletes in H3 or H4

Some answers were supported with additional comments including:

- Impact of physiological parameters (for example, heart rate);
- Role of trunk during technical skills (cornering, uphill, sprinting, stability, etc.);
- Circuit characteristics;
- Variability of trunk strength in H3 and H4 sport classes?
- Strength from both classes (some H3 athletes are equally stronger than H4 athletes;)
- Performance similarities between athletes of H3 and athletes of H4;
- Trunk strength as minimum impairment criteria vs. trunk strength as class allocation determinant;

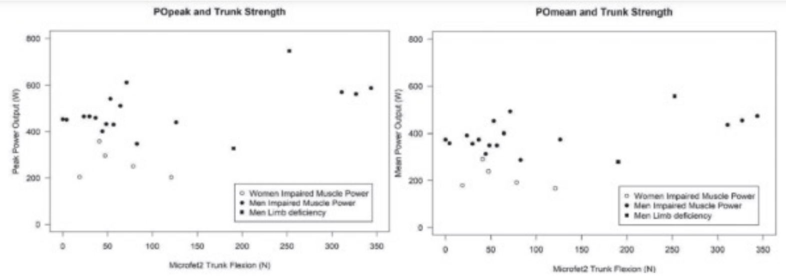

Figure 2 – Relation between trunk flexion strength (horizontal axis) and sprint test power output (vertical axis). Left graph shows peak power output. Right graph shows mean power. Each dot represents the values of a single athlete.

In the above graphs, the trunk flexion strength was assessed with the use of a handheld dynamometer (Microfet2), with the participant supine in a semi-recumbent position on an examination table (see Figure 3). The participant sat against a rigid backrest with a 55-degree angle with the horizontal and the legs extended and strapped with an adjustable Velcro belt to the table at thigh level. The Microfet2 was placed at and perpendicular to the sternum.

Figure 3 – Left: Device used to measure trunk flexion strength (Handheld dynamometer). Right: Athlete position while performing trunk flexion strength test.

Q4.2 Consider only the impact of **trunk flexion strength** on **recumbent** handcycling performance. Given the additional information provided and the feedback from the panel, what is your opinion regarding the role of **trunk flexion strength** in para-cycling classification **to allocate athletes to either class H3 or H4**?

a) I agree that **trunk flexion strength** is a main factor to classify athletes in H3 or H4

b) I disagree that **trunk flexion strength** is a main factor to classify athletes in H3 or H4

c) Not able to answer. Please justify why you are not able to answer.

Second round: no consensus.

Example: trunk function

In the first round of the Para-cycling Delphi study, **65% of the panel agreed** on including trunk flexion strength during the classification of athletes to H3 or H4. Furthermore, **49% of the panel agreed** that additional trunk strapping should be allowed independently from the level of trunk function.

In the second round, **60% of the panel agreed** that trunk flexion strength is a main factor to classify athletes into H3 or H4. Furthermore, **70% of the panel agreed** that the use of additional trunk strapping would give unfair advantages to athletes with moderate to good trunk function compared with athletes with more severely impaired trunk function.

Comments provided by the members who agreed or disagreed, respectively, regarding trunk flexion strength as a main factor in classification of athletes to H3 or H4

Agreed	Disagreed
A clearer distinction of trunk strength should be implemented between H3-H4 classes. It is important for sprinting, climbing, and cornering. It is dependent on backrest configuration. It is involved in body stability and muscle tension. Athletes with no trunk function showed lower pulling forces compared with athletes with partial to good trunk function. There is evidence of greater higher force production in people with residual trunk strength;	It is not a main significant differentiator of performance in these athletes. Strapping and stabilization of the body compensate the trunk impairment. There is no scientific evidence of its importance in a recumbent position; Additional trunk strapping impacts manoeuvrability; Trunk strapping would not be relevant if other factors have separated athletes with no trunk function from athletes with partial to good trunk function. Athletes should be allowed to maximize their performance and therefore use the strapping accordingly.

Comments provided by the members who agreed or disagreed, respectively, regarding potential unfair advantages as a result of additional trunk strapping

Do you agree that, rather than a significant *determinant* of performance in recumbent classes, trunk function may play an important role in generating and transferring force to the upper-limbs power production?

a) Agree
b) Disagree
c) Not able to answer

Third round: 90% agreement.

Q.2.2. Based on this perspective of trunk generating and transferring force, do you agree that, rather than separating athletes solely based on trunk strength and stability, separation of athletes should be based on the ability to use core and lower-limbs muscle groups to generate and transfer force, and in this way making use of an intact closed chain. For example, an athlete with no trunk neither lower-limb function separated from athletes with partial to normal trunk and lower-limb function.

a) Agree
b) Disagree
c) Not able to answer

Third round: 95% agreement.

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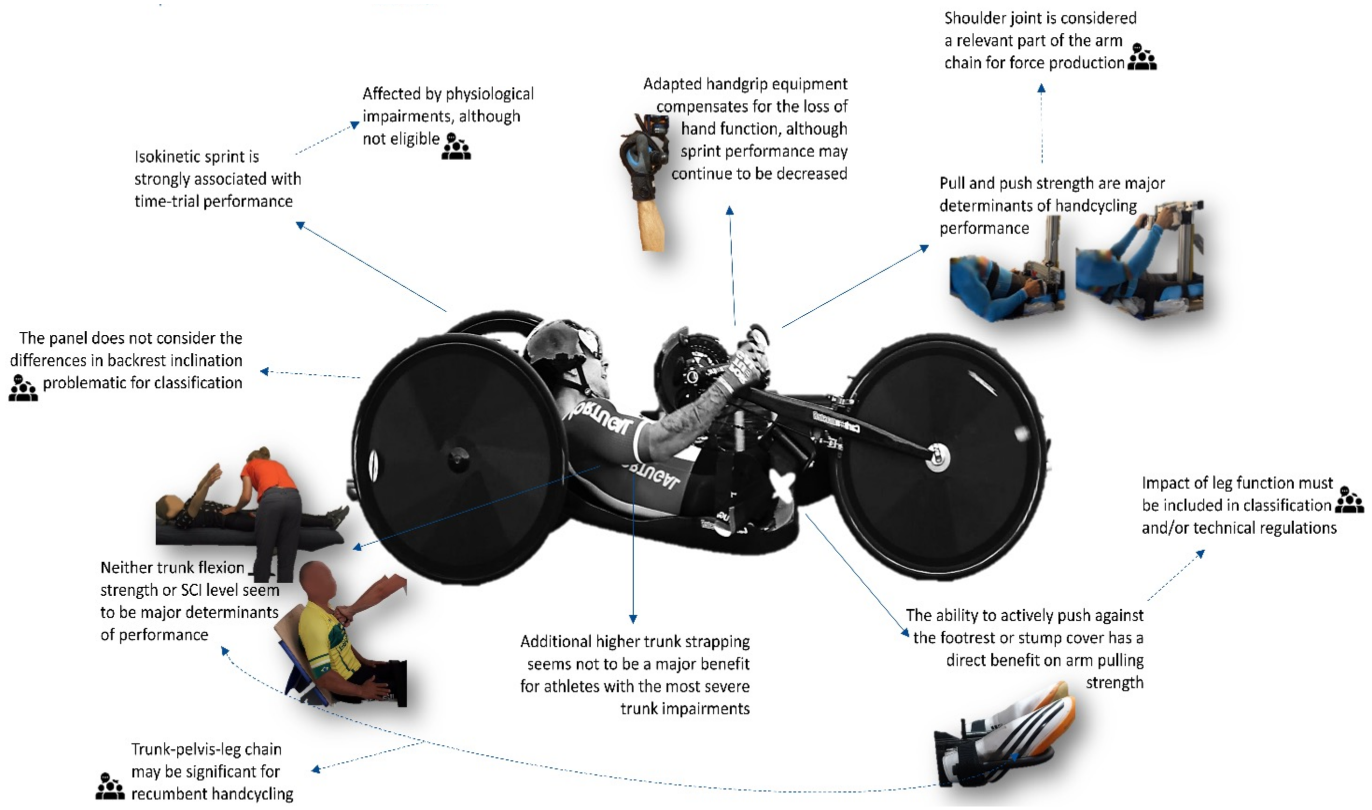
Delphi study

Hopefully, the results of Rafael's thesis, together with the consensus of the expert panel on each topic, will aid in the further development of the para-cycling classification system.

We hope that para-cycling classification research will be continued in the next years to further develop the current classification system and to make evidence-based changes in the future, if necessary.



UCI

Thank you for your attention

Questions?

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