Towards an evidence-based classification system for Para dressage: associations between impairment and performance measures

Sarah Jane Hobbs [1,], Jill Alexander [1], Celeste Wilkins [2], Lindsay St. George [1], Kathryn Nankervis [2], Jonathan Sinclair [1] ,Gemma Penhorwood [2], Jane Williams [2] and Hilary Clayton [3]

[1] Research Centre for Applied Sport, Physical Activity and Performance, University of Central Lancashire, Preston, PR1 2HE, UK
[2] Hartpury University, Gloucester, GL19 3BE, UK
[3] Sport Horse Science LC, Lansing, Michigan, MI, USA

Introduction

The current FEI Para Equestrian Classification System is based upon the work of Dr. C. Meaden, which was developed in the 1990s. Although it has been revised over the years, the FEI is, like many Para sports, prioritizing the development of a strong scientific evidence-base for the system in accordance with the IPCs Classification Code. The FEI funded a multi-year study to comprehensively examine the methods used to classify eligible impairments and their impact on performance in Para Dressage.

Initially, a scoping review was performed to identify, from the scientific literature, objective measurements of horse performance in Dressage and the functional abilities of the rider that may predict elite Dressage performance. The review highlighted a number of objective "performance measures" that principally included the postural position and range of motion (ROM) of the athlete's pelvis, trunk, knee, and head, and the timing of rider's pelvic and trunk motion relative to the horse's movement. Athlete and stakeholder input were then collected using semi-structured interviews to provide further insight into key determinants of, and the impact of impairment on, sport-specific performance in Para Dressage. This information ensures that the views and experiences of Para stakeholders are included to inform the development of the Classification system.

A second scoping review was conducted and sought to identify objective, valid, and reliable clinical tools for measuring the eligible impairments for Para Dressage. The review identified five clinical impairment assessments that are reliable and valid across a range of conditions present in the Para Dressage population, capture the physical requirements for dressage performance, are practically feasible for Para Dressage athlete classification, and can be undertaken by all athletes to evaluate the impact of impairment on performance in our study. The identified tools provide measures of coordination, muscle tone, strength, sitting function and trunk control and include: the Function in Sitting Test (FIST), Trunk Impairment Scale (TIS), Scale of Assessment and Rating of Ataxia (SARA), modified Ashworth Scale or "Re-modified Ashworth Scale" (R-MAS), and handheld dynamometry (HHD). All these studies are open-access and freely available through the FEI Classification Research website (https://inside.fei.org/test-para-classification-research) for those who wish to lean more.

The final stage of the research project was informed by the above studies to evaluate the impact of impairment on objective performance measures in Para Dressage athletes. The findings presented in this report include the quantification of performance measures, as defined from our first scoping review and expert opinion from our interview study in Para Dressage and Dressage athletes, using biomechanical measures during ridden tests on a simulator. Clinical impairment measures, defined in our second scoping review, were also conducted to investigate the impact of impairment on Para Dressage performance. This information will inform recommendations for an evidence-based, sport-specific Classification system for Para Dressage, which is in line with the IPC Classification Code's mandate for evidence-based systems of classification.

Methods

Twenty-one elite Para dressage athletes (grades I to V representing 7 eligible impairments) and eleven non-disabled Dressage athletes (competing at Prix St. Georges or Grand Prix) participated. Data were collected in two phases: a performance phase and a clinical phase. In the performance phase, participants performed a two-minute, custom dressage test (Figure 1) on a riding simulator (Figure 2) while kinematic data were synchronously collected using inertial measurement units and optical motion capture. In the clinical phase: the battery of impairment assessment tools, identified in scoping review 2, were administered by qualified therapists. Performance measurements extracted from the kinematic walk and halt data included:

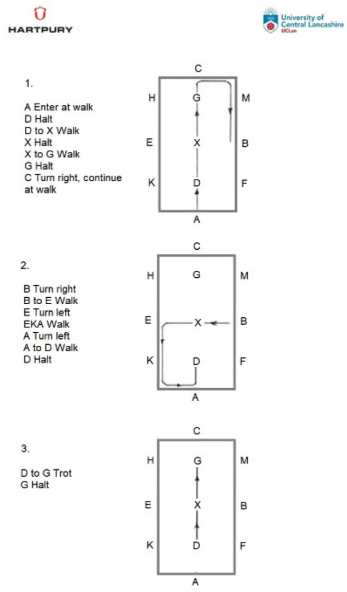

Figure 1. Custom Dressage Test

Figure 2. Simulator Set Up

- **Harmonics** between the cyclic motions of the simulator and rider.
- **Head stability** compares the overall head acceleration against overall simulator acceleration during the halts.
- **Within-athlete coordination variability** the overall rotational movement pattern between the athlete's trunk and pelvis segments.
- **Dynamic symmetry** the motion patterns of the trunk and pelvis in the horizontal plane (as if looking from above the simulator), to measure dynamic posture and differences in left and right movement patterns.

Evidence for the association with eligible impairments

Performance measures were initially compared between Para and non-disabled athlete groups. Relationships between performance measures and impairment assessment measures were then investigated to assess the strength of association between measures. To illustrate the association of performance measures with eligible impairments, athletes were grouped by primary impairment (Table 1) and boxplots were produced for each measure.

Table 1: Grade range for the Para athletes by primary eligible impairment

Impairment	n	Grade range
Impaired muscle power	8	1 to 5
Ataxia	5	1 to 4
Athetosis	2	1 to 4
Hypertonia	1	3
Dystonia	1	3
Impaired Range of motion (ROM)	2	2 to 5
Visual Impairment	2	4

Harmonics: The mean difference between Para (1.27 ± 0.12) and non-disabled athletes (1.06 ± 0.41) for simulator signal power (SPower) was significant, but skewed by three non-disabled athletes who restricted the rotation of the simulator. A significant relationship ($p=0.025$) between SPower and TIS scores was found only for Para athletes (Figure 3A). When grouped according to primary impairment, mean values (black horizontal lines) were similar and the range of data (purple boxes) overlapped between groups, with the exception of dystonia (Figure 3B). Large variability in the non-disabled group is also evident.

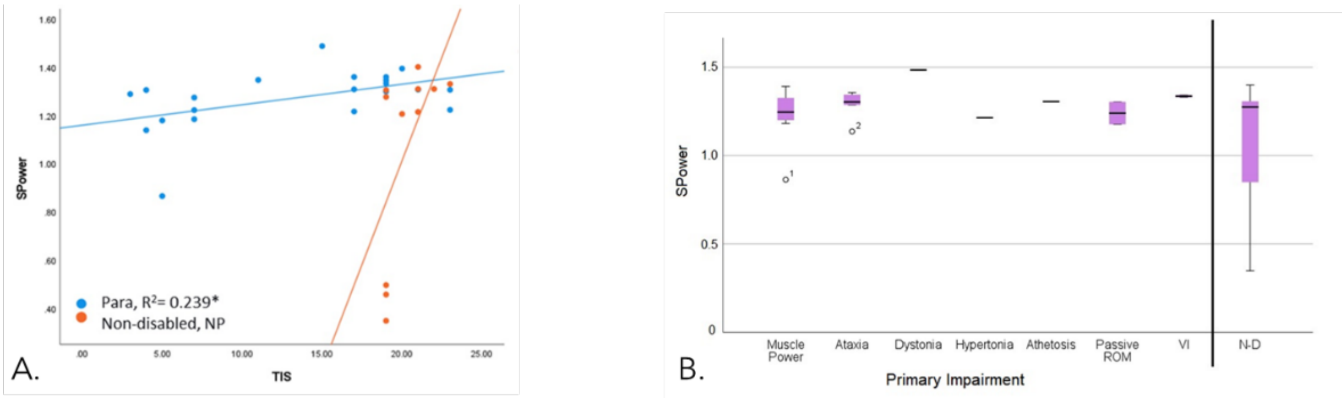

Figure 3. A) Regression analysis showing the significant (p=0.025) relationship between SPower and TIS for the Para athlete group, and non-significant (p>0.05) relationship in the non-disabled group. **B)** Boxplots of SPower grouped by eligible impairments for Para athletes. N-D: non-disabled athletes.

Head stability: The mean difference between the Para (-13.08 ± 22.23 %) and non-disabled athletes (3.14 ± 14.01 %) for head stability was not significant (p=0.084). A significant relationship between head stability and SARA scores was found for the Para athlete group (p=0.032) but not the non-disabled group (Figure 4A). When grouped according to primary impairment, mean stability for all Para groups except hypertonia were below zero, indicating that the head accelerated more than the simulator (Figure 4B). There was generally more variability in the ataxia, muscle power and passive ROM groups (Figure 4B).

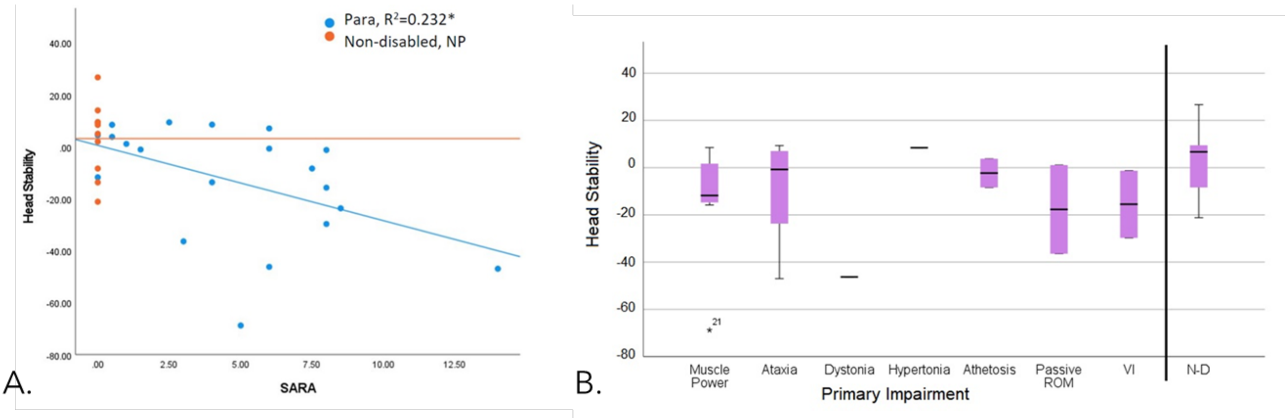

Figure 4. A) Regression analysis showing the significant (p=0.032) relationship between head stability and SARA for the Para athlete group, contrasted by the non-significant (p>0.05) relationship in the non-disabled group. **B)** Boxplots of head stability grouped by primary impairment for Para athletes. N-D: non-disabled athletes.

Within-athlete coordination variability: The mean difference between Para (13.18 ± 8.23 deg) and non-disabled athletes (8.68 ± 2.86 deg) for coordination variability was not significant (p=0.116) largely due to variability between Para athletes. No relationship was found for coordination variability in Para athletes, but a significant relationship (p=0.024) was found between trunk rotation strength to the left and coordination variability in the non-disabled group (Figure 5A). When grouped according to primary impairment, athletes with greater coordination variability were in athetosis, dystonia, and hypertonia groups (Figure 5B).

HARTPURY

Sport Horse SCIENCE

1828 University of Central Lancashire UCLan

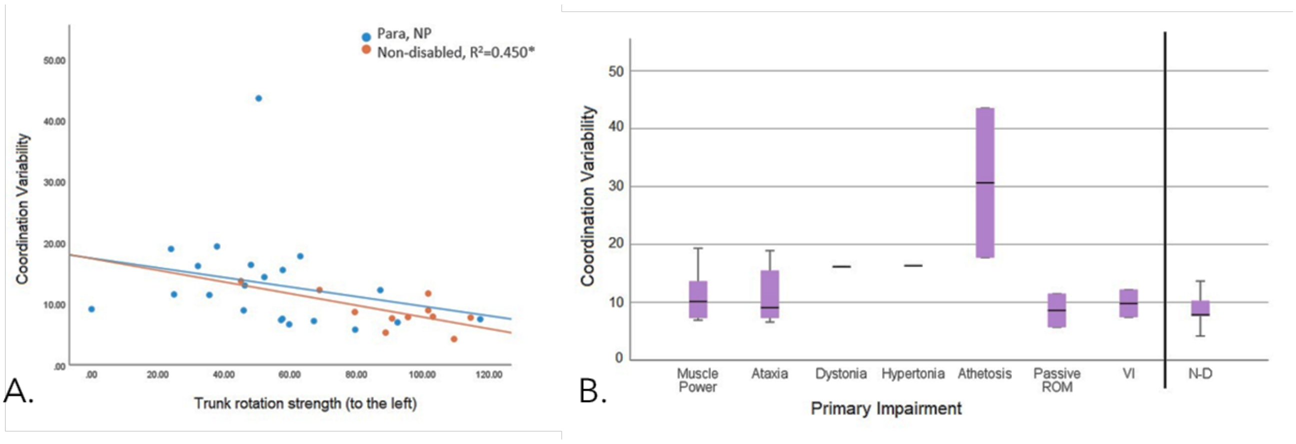

Figure 5. A) Results of regression analysis showing the non-significant (p>0.05) relationship between coordination variability and trunk rotation strength to the left for the Para athlete group, contrasted by the significant (p=0.024) relationship in the non-disabled group. **B)** Boxplots of coordination variability grouped by primary impairment for Para athletes. N-D: non-disabled athletes.

Dynamic symmetry: There was a significant difference (p<0.001) between Para (1.88 ± 0.98) and non-disabled athletes (0.91 ± 0.37) for trunk dynamic symmetry, but not for the central position of the motion pattern (Para 0.17 ± 0.15; non-disabled 0.09 ± 0.05) (p=0.071). Significant relationships (p<0.05) were found between performance measures and impairment measures FIST and SARA (Figure 6A&C). When grouped according to primary impairment, mean trunk dynamic symmetry for all Para athlete groups was greater than the non-disabled group (Figure 7B). The largest variability was in the ataxia group (Figure 6B). The central position of the trunk was further from the pelvis in the static trial for the passive ROM group and greater variability was more noticeable in this group, the ataxia group and the muscle power group (Figure 6D).

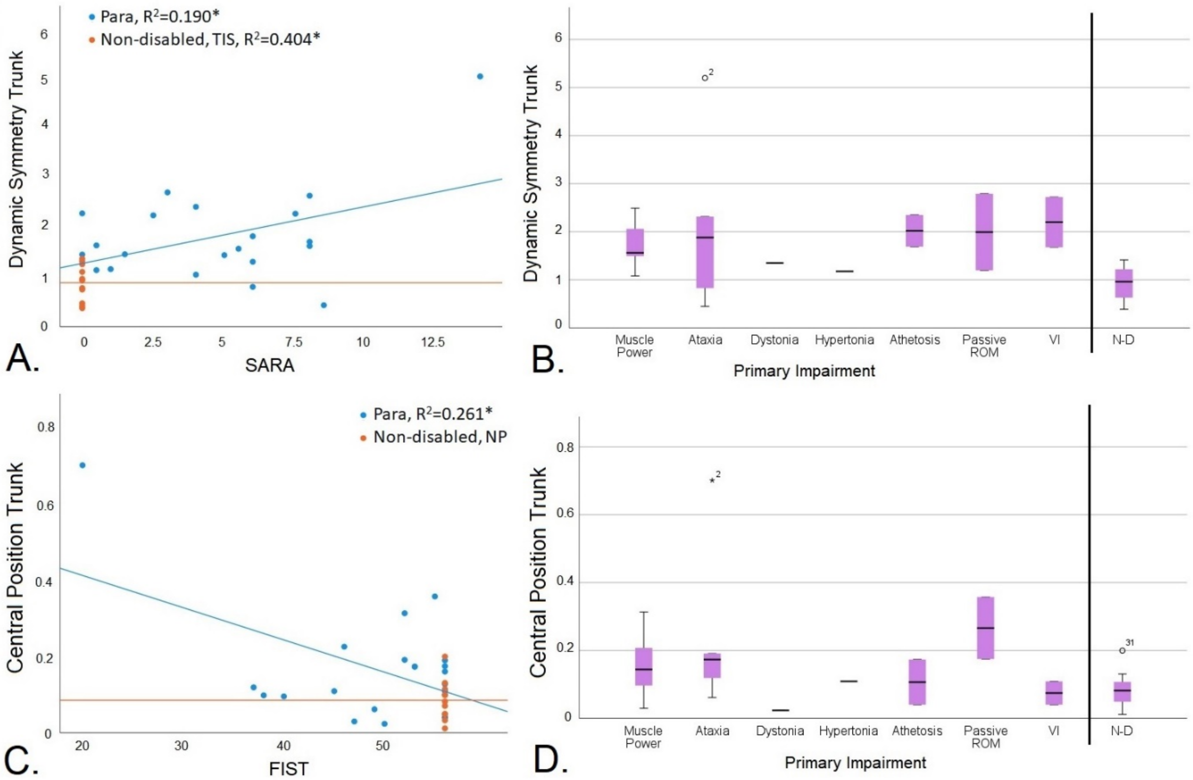

Figure 6 A,C). Results of regression analysis showing the significant (p<0.05) relationships between trunk dynamic symmetry measures and impairment assessment measures (SARA, FIST) for the Para athlete group, contrasted by the non-significant (p>0.05) relationships for the non-disabled group. **B,D).** Boxplots of **B)** trunk dynamic symmetry, **D)** trunk central position, grouped by primary impairment for Para athletes. N-D: non-disabled athletes.

For the pelvis, dynamic symmetry was not significant ($p=0.259$) between groups (Para 1.29 ± 0.73; non-disabled 1.02 ± 0.20), and the central motion pattern was not significant ($p=0.636$) between groups (Para 0.19 ± 0.04; non-disabled 0.18 ± 0.03). Significant relationships ($p<0.05$) were found between performance measures and impairment measures FIST and R-MAS, as shown in Figure 7A&C. Greater mean pelvis dynamic symmetry was evident in all Para athlete groups, except for the muscle power group compared to the non-disabled group (Figure 7B). The largest variability was in the ataxia group (Figure 7B). VI athletes positioned their pelvis more centrally than other athletes, which may indicate a balance strategy to compensate for their impairment (Figure 7D).

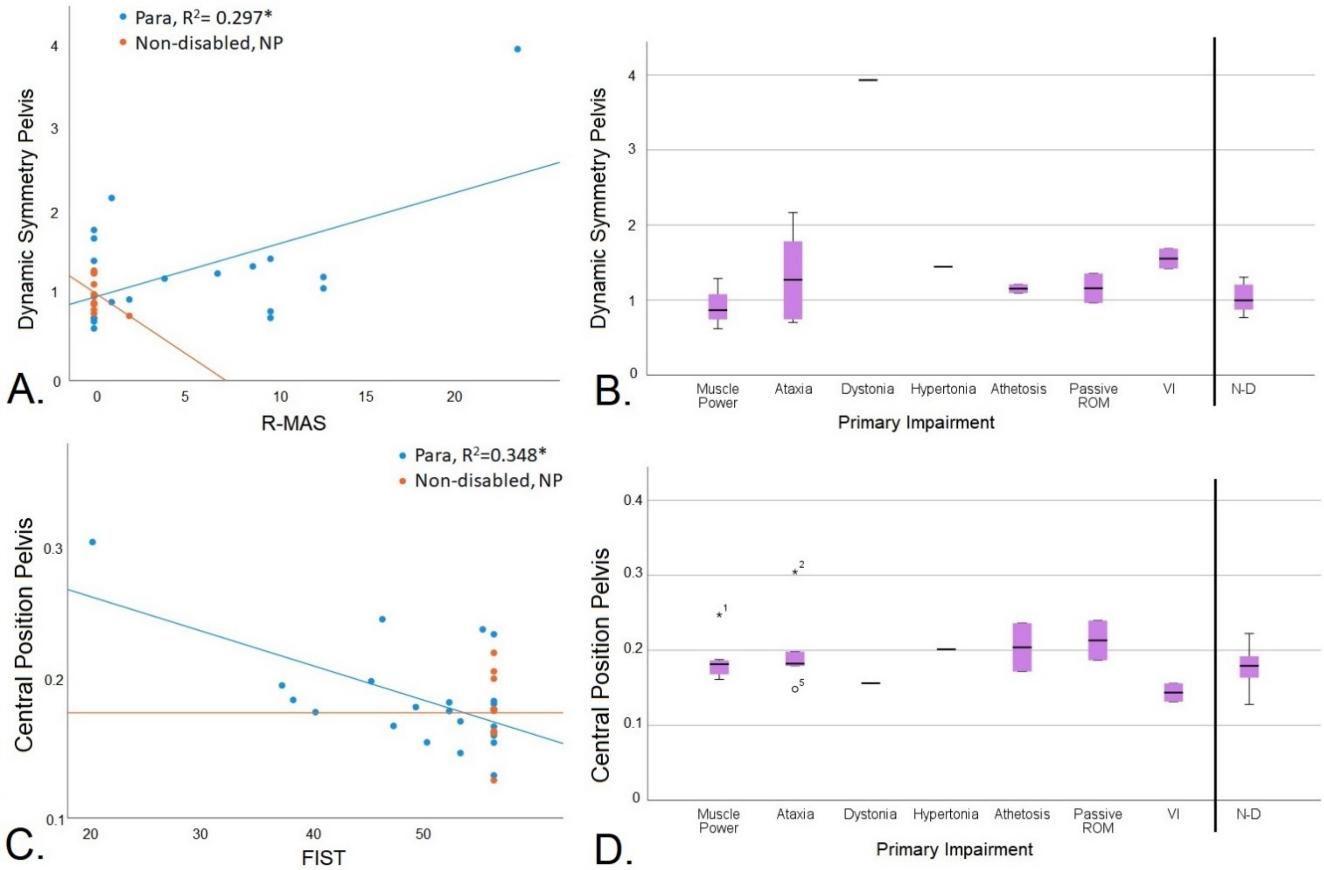

Figure 7 A,C). Results of regression analysis showing the significant ($p<0.05$) relationships between pelvis dynamic symmetry measures and impairment assessment measures (SARA, FIST) for the Para athlete group, contrasted by the non-significant ($p>0.05$) relationships for the non-disabled group. **B,D).** Boxplots of **B)** pelvis dynamic symmetry, **D)** pelvis central position, grouped by primary impairment for Para athletes. N-D: non-disabled athletes.

Both trunk and pelvis symmetry graphs revealed extremely interesting patterns of dynamic motion (Figure 8). These graphs illustrate the functional deficits and/or habitual motion patterns an athlete uses during repeatable simulated riding. Further exploration of the motion patterns could be a valuable source of information for the assessment of performance limitations.

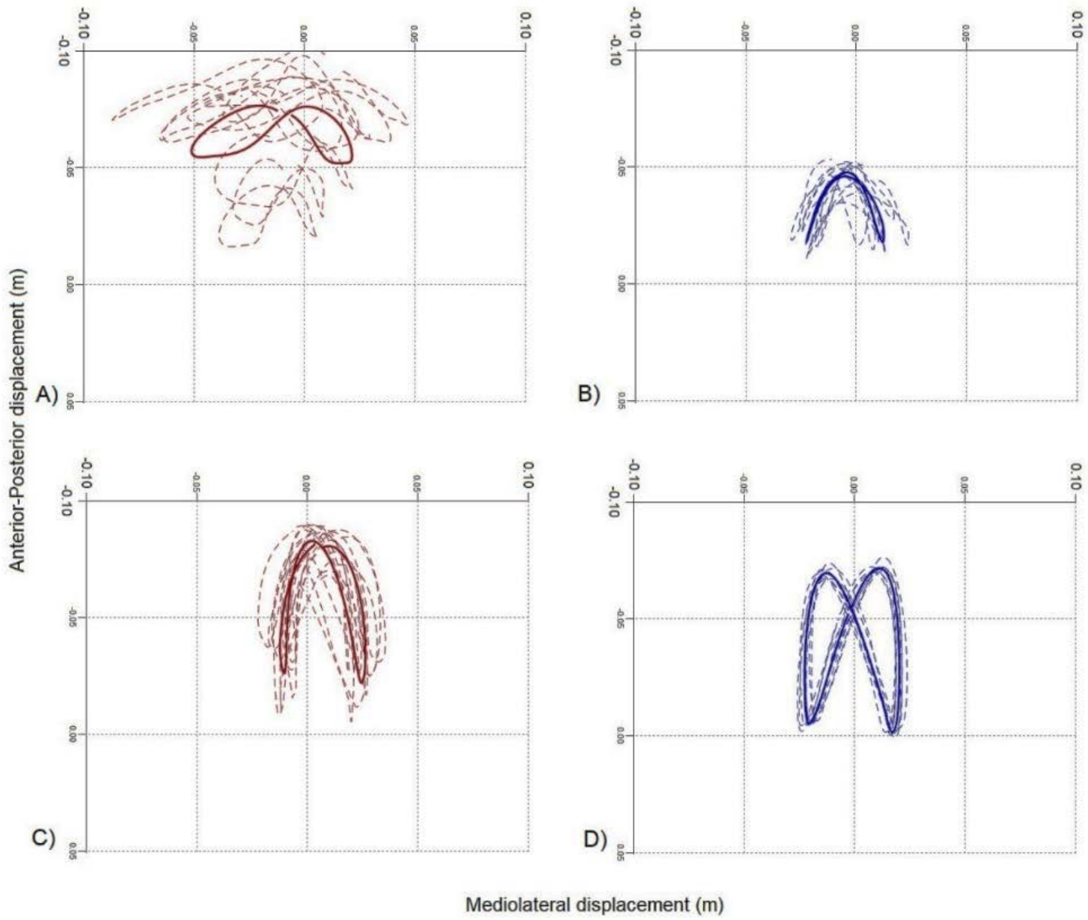

Figure 8. Examples of the COM path in the horizontal plane of the trunk and pelvis used to develop dynamic symmetry measures for one Para athlete with impaired muscle power and one non-disabled athlete. **A)** Para athlete trunk, **B)** non-disabled athlete trunk, **C)** Para athlete pelvis and **D)** non-disabled athlete pelvis.

Conclusion

Our findings demonstrate relationships between measures of impairment and measures of performance for Para and non-disabled dressage athletes. When refined to establish the most useful measurements in determining the impact of impairment on performance, three impairment assessments were identified that could predict between 19% and 35% of the impact of impairment on performance in Para dressage athletes, and not in non-disabled athletes. Of these, FIST and SARA impairment assessments most strongly identified impairments related to sitting function, and R-MAS uniquely identified impairments related to muscle tone.

Trunk control was evaluated using dynamic posture and symmetry performance measures. The latter was found to be the most promising indicator of the impact of impairment on performance, as there were clear differences between the Para and non-disabled athlete groups. Impairment assessment measures that could predict trunk dynamic symmetry performance were SARA and FIST. Although pelvic symmetry was not different between groups, R-MAS could predict 30% of the variation in Para athletes. These findings provide the basis for a robust, scientific evidence base, which can be used to aid in the refinement of the current classification system for Para dressage.