Proposed Paralympic Classification System for Va'a

Information for National federations and National Paralympic Committees

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Introduction

In recent years, the International Paralympic Committee (IPC) has highlighted the importance of sports specific evidence-based classification systems for all athletes with physical impairments to control the impact of impairment on the outcome of competition (Tweedy & Vanlandewijck, 2011). The International Canoe Federation (ICF) initiated research projects aimed to evaluate, develop and present a proposal to the IPC relating to a validated and evidence-based classification system for para-kayak and para-va'a for athletes with impaired muscle power, impaired range of motion and limb deficiencies affecting the trunk and legs. Paracanoe is a relatively new sport where athletes with physical impairments compete over 200 m in either para-kayak or para-va'a. Para-kayak is competed in a kayak which is propelled by a double-blade paddle. Para-va'a is competed in a va'a (outrigger canoe - a boat that has a one pontoon called an ama as a support float) and is propelled by a single blade paddle. The first international paracanoe events (kayak and va'a) were held in 2009 during the World Championships in Canada. Since then, paracanoe and canoe sprint (able-bodied racing) have held their events together.

Para-va'a

Para-kayak

A research team from The Swedish School of Sport and Health Sciences conducted research studies examining the three-dimensional (3D) kinematics and kinetics of able-bodied athletes (n=10) and para-kayak athletes (n=41) when paddling on a kayak ergometer. The research on para-kayak was finished in 2014 and a new classification system was created based on the results of these studies in close collaboration with the ICF and international paracanoe classifiers. The system was accepted by the IPC in 2015 and para-kayak debuted in the 2016 Paralympic Games in Rio. Additionally, the research team also conducted research on able-bodied va'a athletes and para-va'a athletes using the same methods as the para-kayak study. The study involved ten able-bodied va'a athletes and 29 para-va'a athletes. The results were incorporated into a new classification system for para-va'a and the system was also presented

in a proposal submitted to the IPC in the end of 2014. The para-va'a system was not accepted by the IPC due to too few high level athletes included in the study. Para-va'a was not included in the 2016 Paralympic Games. The recommendation from IPC was to include more international level para-va'a athletes in order to have more robust results to base the system on and to submit a new proposal for the 2020 Paralympic Games in Tokyo.

2015 para-va'a classification system

Even though the system did not meet the IPC standard, the ICF Paracanoe Committee decided that the new system was a large improvement over the old classification system. The research showed that the trunk and leg function were important for force production during va'a paddling and therefore it was decided that the classification system should include tests of these functions. This system has been in place since the first international event in 2015 and is currently being used by ICF international classifiers during international events. In addition to the trunk and leg tests, a provisional upper limb impairment assessment was made for athletes with upper limb impairments in a desire to include athletes with this impairment.

Reasons for revising the 2015 classification para-va'a system

To meet the recommendation from IPC to include more high level athletes in the research to have a more robust base to base the classification system on, additional kinematic and kinetic data has been collected during the 2015 and 2016 World championships from 25 para-va'a athletes. Data from ten athletes were excluded from the initial 29 para-va'a athletes due to that they did not meet our new definition of being a high level para-va'a athlete. The total number of athletes included in the study was 44 and consisted of international level athletes from 15 countries. As a consequence of collecting more data and including a higher level of athletes, the results of the research indicated that the 2015 classification system should be revised.

Implementation of research results into a revised classification system

Results of the research showed that the ability to move the trunk in flexion and extension and to rotate the trunk and pelvis was positively correlated with force production for both female and male able-bodied and para-va'a athletes. Furthermore the ability to move the knee and ankle on the bottom hand side[1] in flexion and extension range of motion (ROM) was also positively correlated with force production for both female and male athletes. The upper limbs are also

[1] Bottom hand side refers to the body side of the hand that holds the bottom of the paddle shaft.

important for va'a performance, however since only two athletes with upper limb impairments participated in the study, there were no significant correlations between upper limb movement and force production.

After examining the kinematic and kinetic results from the va'a study it was decided together with members from the ICF paracanoe classification sub-committee that the three classification tests (trunk, leg and on-water tests) currently used in para-va'a classification ought to be modified. Consequently, the tests included in the proposed revised classification system assess the joint movements that were significantly correlated with force production in sport specific ROM (a detailed description of the modified classification tests are presented on page 5-6). This is in line with the recommendations from Beckman, Connick and Tweedy (2016) who stated that it is essential to identify the key muscle groups or joints for performance and that these should then be assessed in a strength test battery to ensure that the tests are relevant to the activity of interest.

In order to evaluate the validity of these revised classification tests positive correlated joint angles and ROMs were compiled into three compartments. The maximal and minimal joint angle (A_{Max} and A_{Min}) for trunk flexion and trunk and pelvis rotation ROM were summed up into a trunk compartment. The bottom hand side hip, knee and ankle flexion ROM which were correlated with paddling force were summed up into a leg compartment. Furthermore, the trunk and the leg compartment were summed up into a sport specific compartment. These compartments were then correlated with paddling force and the results showed that all compartments were significantly and positive correlated with paddling force (Trunk compartment vs. paddling force: Females: $r=0.852$ $p<0.001$, Males: $r=0.729$ $p<0.001$; Leg compartment vs. paddling force: Females: $r=0.657$ $p=0.004$, Males: $r=0.591$ $p<0.001$; Sport-specific compartment vs. paddling force: Females: $r=0.788$ $p<0.001$, Males: $r=0.764$ $p<0.001$).

Thereafter the compartments were correlated with their respective classification test (trunk compartment with the trunk test, leg compartment with the leg test and the sport specific compartment with the on-water test) for the para-athletes. The results showed that the classification tests were significantly positive correlated with their compartment (Trunk compartment vs. trunk test: $r=0.729$ $p<0.001$; Leg compartment vs. leg test: $r=0.609$ $p<0.001$; Sport-specific compartment vs. on-water test: $r=0.811$ $p<0.001$). This demonstrated that the tests well reflected the athletes' functional performance during paddling indicating that the classification tests are sports specific and have a high validity.

Revised classification tests

The sport-specific mean ROM values from the able-bodied group in the study were used to define in what range the leg and trunk function tasks should be measured. The trunk test in the proposed classification system for para-va'a will be conducted in the same manner as before and include 42 trunk tasks (Appendix 1). However, based on the research results, only the dynamic trunk tasks (i.e. moving the trunk in flexion, extension, rotation and side flexion) will be included in the class allocation. The whole test battery with all the 42 trunk tasks will be conducted so that the classifiers can get an overall picture of the athletes' trunk function and minimise the risk of misrepresentation. The leg test for para-va'a will include the same leg tasks as before but the position of the athletes during the test procedure has been modified (Appendix 2). The single leg press test will be conducted on both legs in a sport specific position. The items that will be scored on the on-water test are based on the variables that were shown from the research study to be correlated with producing a greater paddling force. The items are: leg movement, trunk rotation and trunk flexion (Appendix 3). Since there is only a positive correlation between leg movement and paddling force for one of the legs (i.e. bottom hand side), it was decided to only score the movement of one of the legs during the on-water test. In our study it was the bottom hand side leg that moved the most, however due to a variety of paddling styles and techniques used in va'a, the leg that moves the most will be scored during the on-water classification.

Revised minimal eligibility

The previous minimal eligibility criterion for para-va'a was loss of at least 4 points in one leg in the leg test. This could for an example be athletes with a unilateral below knee amputation or unilateral ankle fusion. The results from the research showed that the previous minimal eligibility criterion needed modification. This is due to two main findings; limited ankle flexion ROM during paddling (Table 1) in combination with a low correlation between ankle flexion ROM and force production observed in male athletes and no correlation between force production and leg function in athletes with impaired leg function and full trunk function (Spearman's rho=0.379, p=0.133).

The actual movement in the ankle joint during va'a paddling is very small (Table 1). In va'a the able-bodied athletes had a mean value of 11° for the top hand side ankle flexion ROM and 16° for the bottom hand side ankle flexion ROM. Compared to able-bodied athletes' movement during kayak paddling which was approximately 30° flexion in each ankle, it shows

that able-bodied va'a athletes do not use ankle movement for producing force to the same extent. Due to that the ankle movement is very limited even in able-bodied athletes, it would be very difficult to measure dynamic function during classification and to define level of impairment using the 0-2 scoring system.

Table 1. Ankle flexion ROM (in degrees, °) in able-bodied va'a athletes and para-va'a athletes during paddling on a va'a ergometer. Values are presented as mean + 1 standard deviation.

	Able-bodied (°)	**Para-athletes (°)**
Top hand side Ankle flexion ROM	11	4
Bottom hand side Ankle flexion ROM	16	10

When examining the relationship between the paddling force and leg movement (knee and ankle flexion ROM in both legs) when paddling on a va'a ergometer in male athletes with full trunk function and impaired leg function (either bilateral or unilateral above, below or through knee amputation or having a general leg impairment resulting from e.g. an incomplete spinal cord injury) the result showed that there was no significant correlation between leg movement and paddling force (Spearman's rho=0.379, p=0.133). The results therefore demonstrate that paddling force is not significantly influenced by the leg movement and therefore not affected by the leg impairment if athletes have full trunk function.

The revised minimal eligibility criteria for the legs is a loss of 10 points or more in one leg or a loss of 11 points or more over two legs in the leg test. This corresponds, for example, to an athlete with above knee amputation with no function in the ankle or the knee (will score 18 points including leg press test) or an athlete with partial leg function in both legs. In addition to the minimal eligibility criteria for the legs, a minimal eligibility criterion for the trunk has also been established to include para-athletes with an impairment that affects the trunk more than the legs. The athletes need to have a loss of 7.5 points or more on the dynamic trunk test and in addition they need to have a loss of 8 points or more on the leg test to be eligible.

Non-eligible impairments

Athletes with the impairment types: limb deficiency, impaired range of movement and impaired muscle strength meeting the minimal eligibility criteria, will be eligible to compete in the Paralympic Games in para-va'a. Since no athletes with upper limb impairment participated in this study, conclusions about how to classify athletes with this type of injury could not be drawn.

Therefore, no athletes with only upper limb impairments will be eligible in the Paralympic Games in the proposed revised classification system for para-va'a. Athletes who meet the new proposed minimal eligibility criteria and also have an upper limb impairment will only be classified on their trunk and/or lower limb impairment, thus the upper limb impairment will not be considered.

Revised class allocation

The current total scores for eligible athletes of the classification tests vary with 6 points for the on-water test, 12 points for the dynamic trunk test and 18 points for the leg test. In the overall calculation of Sport Class, it was preferred to have the three tests weighted equally. This was done by multiplying 3 to the on-water test scores and 1.5 to the trunk test scores (Figure 1). Therefore by a simple mathematical calculation each test score is factored to equal 18. The total sum for the three tests was then calculated (maximum total sum score=54 points) (Figure 1). The total sum was calculated for all athletes classified in para-va'a in order to examine how many points athletes with different impairments have.

TEST	Raw Score	Transformation Factor	Transformed Score
Leg	0-18	1	0-18
Trunk	0-12	1.5	0-18
On-water	0-6	3	0-18
		Final Overall Score	**0-54**

Figure 1. Scoring template for transformation of raw scores.

Numerous results from the research indicate that trunk movement is an important factor for va'a performance. The research showed that the trunk movements during paddling are highly correlated with force production (trunk compartment vs. force production: $r \approx 0.78$). The importance of the trunk is also demonstrated in the results of a partial correlation analysis which examined if the leg function affects the correlation between trunk movement and force production. The already strong correlation between trunk movement and force production was minimally affected by the leg function (for males $r=0.649$, $p<0.001$, for females $r=0.709$, $p=0.002$) demonstrating that the leg function is inferior to the trunk function. This is also shown in the result of the correlation test between leg movement and paddling force which showed that there was no significant correlation between these factors in athletes with full trunk

function. In the revised classification system athletes will therefore mainly be allocated a class based on their trunk function assessed during the dynamic tasks of the trunk test; no dynamic trunk function, partial dynamic trunk function and good dynamic trunk function (Figure 2).

The athletes allocated in the lowest functioning class, VL1 (Figure 2), should therefore have no dynamic trunk function which is defined as not being able to sit upright on a bench with the legs hanging whilst the thighs and/or pelvis are secured and not moving the trunk in flexion, extension, rotation and lateral flexion. This corresponds to having 0 points on the dynamic tasks in the trunk test. These athletes should also not have any leg function (0 points on leg test). Since they have no dynamic function in trunk or legs they should therefore also have an on-water score of 0. These athletes should therefore have a total point of 0. Furthermore, during competition and the on-water part of the classification the VL1 athletes should have a non-elastic quick release strap[2] around the trunk to secure the athlete in position.

The athletes with the highest function will be allocated the VL3 class (Figure 2) and will include the athletes with full dynamic trunk function or almost full dynamic trunk function (15-18 points) and can score 18 points or below on the leg test and on-water test. The exception to this rule will for an example be athletes who score 13.5 points or lower on the trunk test but have a high leg score. In order to define exactly the characteristics of these athletes and if they should be allocated the VL2 or VL3 class, a cluster analysis was conducted on three variables, i.e. the scores from the three classification tests; trunk, leg and on-water tests. The cluster analysis showed that athletes scoring a total of 27 points or lower grouped into one cluster and athletes scoring a total of 28 points or over grouped into another cluster. It was therefore decided that athletes who score 13.5 points or lower in the trunk test but have a total score of 28 points or over are also allocated the VL3 class. Furthermore, athletes scoring between 1.5 and 13.5 points on the trunk test and have a total score of 27 points or lower are allocated the VL2 class (Figure 2).

[2] A detailed description of the strap restriction and placement will be provided in the near future.

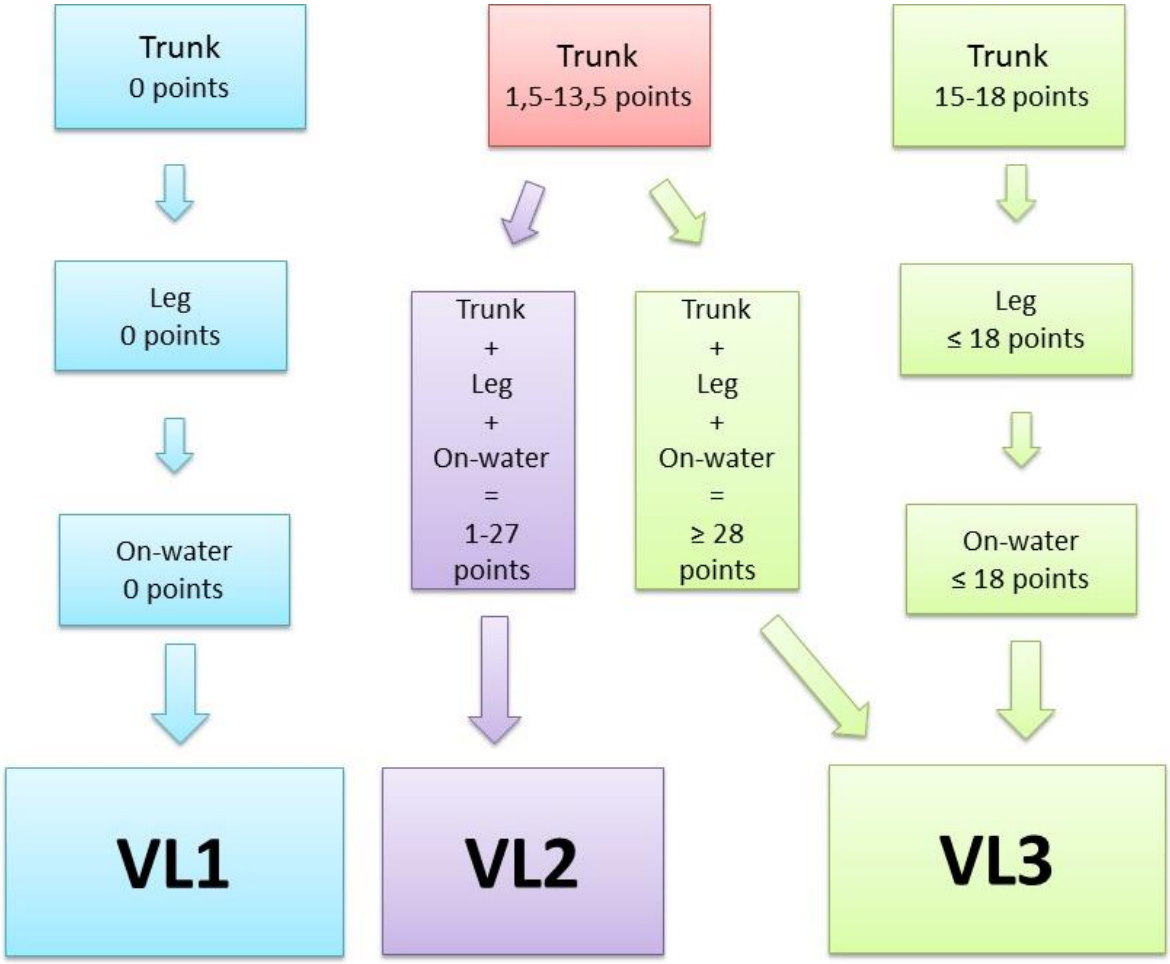

Figure 2. Class allocation description of the revised Paralympic evidence-based classification system for para-va'a.

References

Beckman, E.M., Connick, M.J. & Tweedy, S.M. (2016). Assessing muscle strength for the purpose of classification in Paralympic sport: A review and recommendations. *Journal of Science and Medicine in Sport*, Epub ahead of print.

Tweedy, S.M. & Valandvejick, Y.C. (2011). International Paralympic Committee position stand - background and scientific principles of classification in Paralympic sport. *British Journal of Sports Medicine*, vol. 45 (4), pp. 259-269.

Appendices

1. Provisional 2018 ICF Paracanoe Va'a TRUNK Assessment Chart – DRAFT
2. Provisional 2018 ICF Paracanoe Va'a LEG Assessment Chart – DRAFT
3. Provisional 2018 ICF Paracanoe ON-WATER Assessment Chart – DRAFT
4. Provisional 2018 ICF Paracanoe SUMMARY Chart - DRAFT