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Conceptual model of sport-specific classification for para-athletes with intellectual impairment

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ABSTRACT
The present paper describes the conceptual basis of evidence-based classification of para-athletes with intellectual impairment (II). An extensive description of the theoretical and conceptual foundation of the system as currently conceived is provided, as are examples of its applications in the three sports included in the Paralympic programme for II-athletes in 2020 (i.e., athletics, swimming and table tennis). Evidence-based classification for II-athletes is driven by two central questions: i. How can intellectual impairment be substantiated in a valid and reliable way, and ii. Does intellectual impairment limit optimal sport proficiency? Evolution of the system and current best practice for addressing these questions are described, and suggestions for future research and development are provided. Challenges of understanding and assessing a complex (multifaceted and intersectional) impairment in the context of sport also are considered.

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KEYWORDS
Intellectual disability; Paralympic Sport; evidence-based classification; cognition; sport proficiency

Introduction

In today's highly complex world of sport, efforts to promote participation and fairness in competition are as important and fundamental as ever. Segmenting competitors by gender, age or weight are examples of approaches commonly used to achieve this aim. Within the Paralympic movement, classification is the vehicle intended to promote participation by minimizing the impact of eligible types of impairment on the outcome of competition (Tweedy & Vanlandewijck, 2011; IPC Classification Code art. 2.2). As para-athletes gain global recognition in international sporting communities and garner greater public attention, the need for transparent, defensible and equitable classification has intensified.

In the early days of the Paralympic movement medical (based on diagnosis) and functional (implications for physical performance) classification systems predominated. Mostly relying on expert judgement these systems were largely atheoretical and lacked evidence of the underlying relationship between impairment and sport proficiency, which over time raised substantive concerns about the appropriateness of these approaches (Tweedy, 2002). These concerns were addressed in the development of the International Paralympic Committee's (IPC) Athlete Classification Code, first published in 2007 and revised to its current version in 2015 (International Paralympic Committee, 2015). The IPC Athlete Classification Code introduced the requirement for all-para sports to initiate multidisciplinary research to develop their own sport-specific system of classification, and the need for these systems to be evidence-based. An evidence-based system of classification requires substantiation of the sport-specific effects of impairment and the minimum level of impairment at which this occurs as the criteria for eligibility (i.e., minimum impairment criteria).

Central to an evidence-based approach is the classification of athletes with eligible impairments according to scientific data demonstrating the resultant activity limitations in the sport being contested. This is to ensure a competitive structure in which athletic prowess (i.e., the optimal combination of physical, psychological, technical, and tactical attributes), honed through high-performance training, determines success – not underlying differences in degrees of impairment between competitors (Tweedy et al., 2017). To achieve these aims requires greater understanding of the relationship between impairment specific activity limitations across various sports and impairment types. Hence, the impetus for research and development of evidence-based sport-specific classification in contemporary Paralympic sport (Tweedy, 2002; Tweedy et al., 2017).

To facilitate understanding and consistent application of the core tenets of evidence-based classification, the International Paralympic Committee endorsed a Position Stand, written by Tweedy & Vanlandewijck in 2011. As the Position Stand was largely based on experience in classification of athletes with physical impairment, a new Position Stand on sport-specific classification of athletes with vision impairment was published in 2018 that addressed issues specific to athletes with vision impairment (Mann & Ravensbergen, 2018). Intellectual impairment (II), the third eligible impairment type within the Paralympic movement, is the focus of the current paper.

While "intellectual disability" is the term commonly used internationally to denote the complexities of the impairment in interaction/intersection with environmental demands, we use "intellectual impairment" to be consistent with the IPC's

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evidence-based classification approach and the World Health Organization's International Classification of Functioning, Disability and Health (ICF). The ICF is the globally recognized framework for defining and measuring disability and health (WHO: ICF, WHO, 2001). The close taxonomic relationship between the ICF and Paralympic classification is described in the Position Stand by Tweedy and Vanlandewijck (2011), and adopted in the IPC Classification Code (International Paralympic Committee, 2015). Within the ICF framework, a distinction is made between impairment and disability, with impairment being "a loss or abnormality of psychological, physiological, or anatomical structure or function" and disability being "any restriction or lack (resulting from an impairment) of the ability to perform an activity in the manner or within the range considered normal for a human being" (WHO, 2001).

At present, athletes with II participating in IPC sanctioned events are limited to three Paralympic sports (i.e., athletics, swimming and table tennis). This is the artefact of the 2000 Paralympic Games controversy in which a basketball team that included members without II won gold (Brittain, 2016; Burns, 2018). A resultant investigation revealed weakness in the overall eligibility system that prompted exclusion of the entire intellectual impairment group from IPC competition until two conditions were satisfied: (1) the eligible impairment governance procedures were proven valid and reliable; and (2) sport-specific criteria for the assessment of minimum impairment were developed and implemented in the sports targeted for re-inclusion. To achieve these requirements INAS (now re-branded VIRTUS) and the IPC established a joint research group comprised of researchers from a variety of disciplines and sport representatives with relevant expertise. The collective efforts of this group produced a conceptual framework for a revised II-classification system that was approved by the IPC General Assembly in Kuala Lumpur in 2009.

One of the major differences that distinguish II athletes from most other impairment groups in IPC sanctioned events is that they compete within a single class structure. This was a governance decision taken at the time to delimit the research group's scope and to accommodate practical game management issues (e.g., limited number of athlete slots available in the Paralympic Games). Consequently, classification of athletes with II is based on satisfying the eligibility requirements with no segmentation by severity of impairment currently. Researchers are, however, actively exploring whether the broad range of severity of intellectual impairment and its implications in the context of sport may substantiate the need for additional classes (see Gilderthorp et al., 2018; and Lemmy, Burns & Jones, 2020 further on in this issue). Intellectual impairment is associated with multifaceted complexities, apart from the impaired intellectual functioning, such as limitations in adaptive behaviour, the high prevalence of co-morbidity (autism, attention-deficit-hyperactivity-disorder), and the psychological vulnerability of the II-population. Furthering knowledge in these areas and others that will be addressed in this paper reflect the ongoing evolution of II-classification.

The theoretical and conceptual foundations of the II-classification system as currently conceived, and examples of its applications in selected sports are the main focus in the present paper. We also reflect on questions requiring further inquiry and the challenges of applying evidence-based sport-specific classification, which by definition must be dynamic and receptive to change. We are dealing with an athlete group in which the impact of impairment is heavily contingent on context (e.g., their higher dependence on external support) and interactions of multiple influences (e.g., mental health issues and physical comorbidities).

The process of II-classification

Determining eligibility of an athlete with II to compete in IPC sanctioned events requires resolution of two fundamental questions: 1. Does the athlete have intellectual impairment according to international standards of assessment (see Figure 1 on top of the green line, i.e., eligible impairment), and 2. Does intellectual impairment impact on the athlete's proficiency in the contested sport (see Figure 1 below the green line, i.e., verify the impact of impairment on key determinants of performance)? The conceptual approach for resolving these two questions follows the four-phase process demonstrating eligibility for IPC sanctioned events depicted in (Figure 1).

The first phase of the process (i.e., Eligible Impairment) concerns the verification of the athlete's impairment (i.e., does the athlete have an intellectual impairment?). This is required by the IPC Athlete Classification Code (International Paralympic Committee, 2015), which explicitly states (article 2.2.1) that an athlete must have an eligible impairment to compete in the sport. There are 10 impairments recognized by the International Standard of Eligible Impairments of which II is one. Additionally, all International Federations offering II sport recognize that the International Organization for Sport for the Disabled (IOSD) responsible for governing the first phase of the eligibility verification is VIRTUS (i.e., the IOSD for II athletes). Complying with phase 1 allows athletes to compete in VIRTUS sanctioned events. Competing in IPC sanctioned events also requires evidence in response to the second question (i.e., whether intellectual impairment impacts proficiency in the contested sport), which is the focus of the next three phases of the process, which are governed by the respective International Sport Federation. What follows is a detailed description of the four phases, including the contribution of

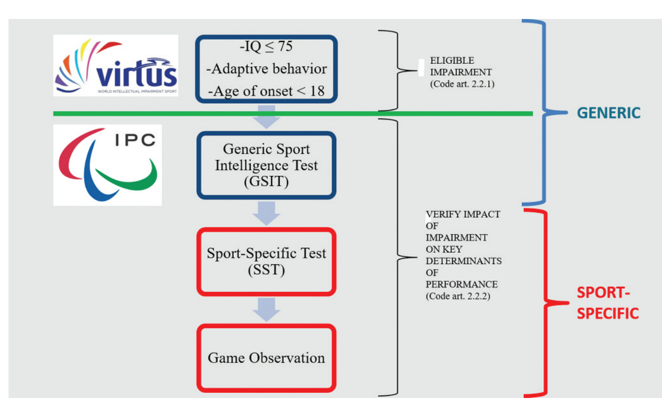

Figure 1. Four phases of the evidence-based system to demonstrate eligibility of athletes with intellectual impairment in IPC sanctioned events.

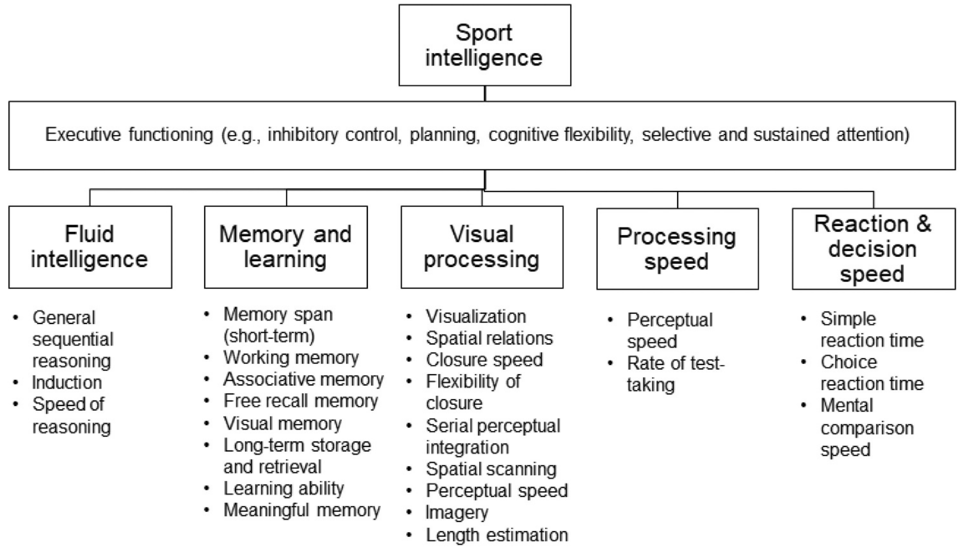

Figure 2. Breakdown to conceptual framework of sport intelligence from the CHC Framework.

each to addressing the questions of interest, and their interconnectedness. Strengths and limitations of this approach are presented along with the need for further research.

Eligible impairment

Evidence of Eligible Impairment is the first step in the IPC classification process for athletes with II. VIRTUS manages this process via a rigorous system introduced in 2009 for assessing and verifying each athlete's portfolio of diagnostic evidence (Virtus, 2020). Consistent with the diagnostic criteria for II, each portfolio must provide evidence of impairment in intellectual functioning, deficits in adaptive behaviours, and onset during the developmental period, i.e., age 18 or younger (AAIDD, 2010). Intellectual functioning is usually assessed through an IQ measure. Results from a recognized and approved IQ test (not older than five years, and selected from a closed list of valid and reliable assessment tools) with a full-scale IQ score of 75 or lower must be included. Adaptive behaviour is the combination of conceptual (e.g., communication), social (e.g., following rules) and practical (e.g., daily living) skills essential for functioning in everyday life (Schalock et al., 2010). Deficits in adaptive functioning need to be substantiated by a validated scale such as the Vineland Adapted Behaviour Scale (Sparrow et al., 2016), or if none is available, clinical observation. Adaptive behaviour is culturally dependent and some countries do not have measures validated and normed for their population. In these cases, a defined observational schedule is used to directly assess the individual across a range of functional domains, which is further complemented by additional information drawn from other sources such as caregivers (Newton & McGrew, 2010). A documented development history also is required to show the age of onset to be before the age of 18. Athletes' portfolios are examined by a VIRTUS eligibility panel (independent from the IPC classification panel in the subsequent phases), who are professionals qualified in the diagnosis of II (e.g., certified clinical psychologists) and trained in the VIRTUS and IPC eligibility requirements. Each portfolio is independently evaluated by at least two-panel members who must concur that the evidence provided in relation to the diagnostic criteria is conclusive for the athlete to be deemed eligible and accepted onto the VIRTUS master list. Inclusion on the master list is a prerequisite for possible entry into VIRTUS Regional and World Championships. For athletes to compete in IPC sanctioned events, additional eligibility procedures are required (i.e., phases below the green line shown in Figure 1).

Minimum impairment criteria

Generic sport intelligence test

While IQ testing forms an essential part of the eligible impairment process for athletes with II, the resultant IQ score is a general composite measure that lacks the precision needed to clarify the relationship between cognition and activity limitations in sport. Hence, we isolated components of IQ most likely to affect sport proficiency, which we have named "Sport Intelligence" (SI; see Figure 2). Our approach parallels calls in psychometric intelligence research (McGrew, 2009; Newton & McGrew, 2010) to shift from reliance on general IQ to an emphasis on discrete domains of cognitive functioning relevant to the area of interest such as academic achievement (Newton & McGrew, 2010) or employee management (Agnello et al., 2015). In sport, Van der Fels et al. (2015) applied a similar approach to establish linkages between higher-order cognitive skills (e.g., fluid intelligence, visual processing) and complex motor skills (e.g., bilateral body-coordination).

The underlying framework we adopted to identify relevant categories of cognitive functioning, was the Cattell-Horn-Carroll (CHC) taxonomy (Schneider & McGrew, 2012), which is recognized as the most comprehensive and empirically supported psychological theory on the structure of human cognitive abilities (McGrew, 2009; Newton & McGrew, 2010). According to CHC taxonomy, there are 10 broad domains of cognitive abilities, which range from Fluid Reasoning, defined as 'the deliberate but flexible control of attention to solve novel problems that cannot be performed by relying exclusively on previously learned habits; to Reaction and Decision Speed, defined as "the speed of making very simple decisions or judgments when items are presented one at a time." (McGrew, 2009). From the 10 broad domains in the CHC, five with major relevance to sport proficiency were identified through a rigorous literature review and extensive consultation with international expert panels comprised of leading authorities in contemporary intelligence research and II-sport (Van Biesen, Mactavish et al., 2016). The five relevant cognitive ability domains included fluid intelligence, memory and learning, visual processing, processing speed and reaction and decision speed (see Figure 2 for an overview of the domains and cognitive abilities). Detailed information regarding the domains, including definitions for all components and subcomponents can be found in the paper by McGrew (2009). A similar investigation was performed independently by another team of researchers, which confirmed our results and provides support for the validity of our model (Van der Wardt et al., 2011).

From a neuropsychological viewpoint, executive functioning – a set of higher order cognitive skills that govern thinking – was added to the model as an important overarching concept that bridges cognitive abilities (Ardila et al., 2000). Examples of executive functioning include: problem-solving, planning, sequencing, selective and sustained attention, inhibition, cognitive flexibility, and the ability to deal with novelty (Chaddock et al., 2011). Further support for this approach comes from the work of Vestberg et al. (2012) showing that executive functioning has potential as a predictor of success in sport. They demonstrated that several executive functions (e.g., working memory, inhibition) are associated with success on the pitch (e.g., goals scored, decisive passes) in elite soccer, even when other factors that could affect soccer performance (e.g., age, length, IQ) were controlled.

To operationalize and assess the concept of SI, a Generic Sport Intelligence Test (GSIT) was developed (Van Biesen, Mactavish et al., 2016; Van Biesen, McCulloch et al., 2017). As the name implies, the GSIT is a generic assessment that all athletes undergo as part of the eligibility verification process, no matter what sport they are competing in. As such, Generic Sport Intelligence is defined as "The impact of cognitive abilities on general sport performance, measured in a generic way, i.e., independent of the specific sport discipline". The focus is on those cognitive abilities that are relevant in a broad sport-context. A generic test is essential in this context as generic performance is unlikely to be affected by high-volume sport training (i.e., not targeted by high-volume sport-specific training).

The GSIT is currently comprised of seven subtests. Three are predominantly speed-based, with each subtest increasing the cognitive demand: simple reaction time test, choice reaction time test, and Flanker test. Four predominantly content-based subtests include the Corsi Block-Tapping Test (working memory), the Wasi Block Design test (Spatial Reasoning and Pattern Recognition), the Wasi Matrix Reasoning test (Fluid Reasoning and Visual Processing), and the Tower of London Test (Planning, Executive Functioning). The finger-tapping test was added to the GSIT as an additional test (on top of the seven main tests) to control for psychomotor speed and/or potential motor deficits. Detailed subtest descriptions, including psychometric properties, are available (Van Biesen, Mactavish et al., 2016). Athletes are instructed to perform at the best of their ability for all subtests, with mechanisms in place to verify maximal effort. The GSIT is done twice on different occasions to search for consistency before a confirmed classification status can be given to the athlete. Group reference data is available showing the usual variance between repeated performance for both II and non-II populations. A variation outside of this expected range would raise concern about sub-maximal performance. If the classifiers suspect sub-optimal performance, the athlete and the coach are given a warning, and the classifier notes such performance issues to be considered in decision-making. Other mechanism to detect sub-optimal performance are discussed later in this paper.

Sport-specific testing

To fulfil the IPC requirement for sport-specific eligibility criteria, we shift to the third phase of the process depicted in (Figure 1), sport-specific testing (SST) of key determinants of sport proficiency that are cognitively driven. Identifying and selecting these determinants across a range of sports with varying cognitive demands is a major challenge as research in this area is limited (Burns, 2015). To guide this process, we developed a framework that builds on the work of Williams and Reilly (2000) and Philippaerts et al. (2001), by incorporating extant knowledge about the multidimensional factors that provide an interactional foundation for proficiency in sport (see Figure 3).

Theoretical framework of key determinants of sport proficiency

The core determinants of sport proficiency depicted in (Figure 3) are segmented into two main components, i.e., body factors and mind factors. The body factors, shown on the left side of the model, represent the physical potential of the athletes, including their anthropometry and physical fitness. The mind factors, shown on the right side of the model, include key elements such as the cognitive ability to apply learning across different contexts, generally and in sport-specific high-performance games or race situations. In the middle of the model, "Quality Sports Skills: Tactical & Technical" signify the interaction of body and mind factors in executing the skills fundamental (technical and tactical) to sport proficiency. Technical proficiency is concerned with how well an athlete performs the skills needed for success and tactical proficiency includes competencies such as selection and use of appropriate strategy, and ability to make adjustments according to changing environmental demands. In the model, the distinction between the acquisition of skills and the application of skills is emphasized. For athletes with II, learning and applying knowledge across contexts (e.g., different sports, training versus competition) is often challenging and typically delayed when compared to age-matched peers without II (Peltopuro et al., 2014). It is expected that deficits in higher order cognitive skills

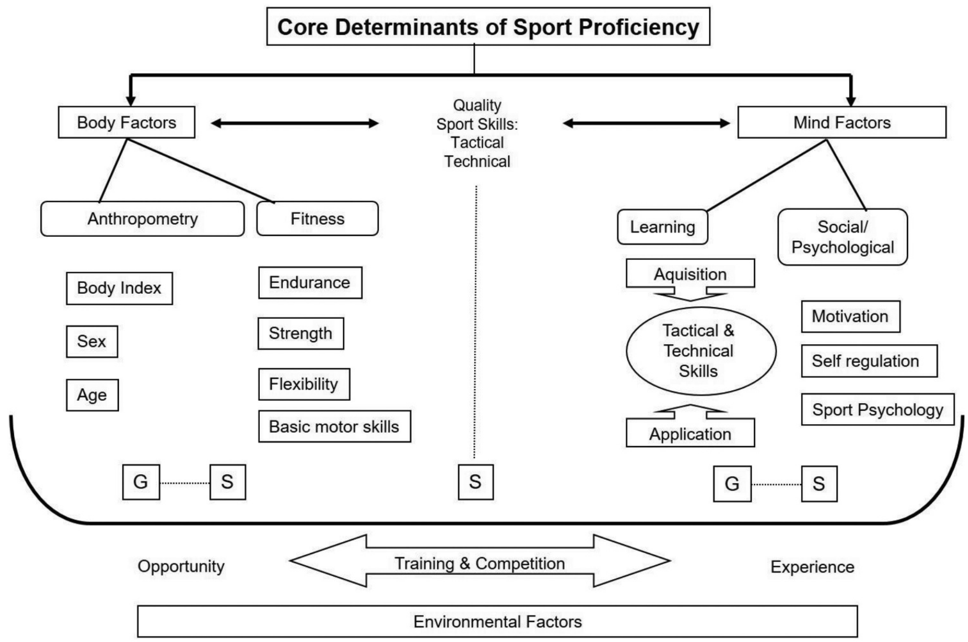

Figure 3. Theoretical framework of the determinants of sport proficiency (adapted from Williams & Reilly, 2000). (G = General, S = Sport Specific).

and impaired executive functions (e.g., cognitive flexibility, response inhibition, planning) play a dominant role as well.

This holistic framework of determinants of sport proficiency (Figure 3) clearly indicates the multiplicity and complexity of sport proficiency that researchers need to take into account when developing a classification system for their own sport or discipline. Before such a system in any given sport or discipline can be developed, experts should be consulted to identify key determinants of proficiency in their sport and the cognitive load of each. In a sport like athletics, for example, fast twitch muscle fibres and explosive strength (body factors) are crucial for reaching and maintaining maximal velocity in sprinting, whereas pacing ability (mind factor) is more important in middle- and long-distance events (Abbiss & Laursen, 2008). Several cognitive elements are crucial within pacing; these include the ability to think and visualize race organization in advance, to interpret and manage fatigue, and to accurately judge and react (or not react) to the actions of opponents (Smits et al., 2014).

The "G" and "S" boxes on both sides of the model illustrate our need to understand how activity limitations of II apply in sport "generally" (G) and "specifically" (S). It is known for example, that II-athletes, even elite performers, are generally dealing with impaired motor coordination, which can affect all life domains, including sport – hence it is considered a general limitation (G). The significance of impaired motor coordination will vary by the demands of the sport (e.g., athletics running versus table tennis) and, as such needs to be considered in specific (S) applications to the sport being investigated. Further complexities are introduced when the sport is highly technical (e.g., rotational throws in shot put). As such, it is necessary to consider how activity limitations associated with the underlying impairment influence proficiency in general and in sport-specific ways.

Once the key determinants of proficiency in a specific sport are identified, the next step involves investigating how impairment impacts those determinants. When looking at athletes with II, this impact can be expressed in multiple ways. Basketball is an excellent sport for illustrating the direct impact of II on decision-making, which is critical to quick and accurate responses needed for success in dynamic and fast-paced games. Environmental factors (depicted at the bottom of Figure 3) are important considerations that reflect indirect challenges of the impairment on key determinants of sport proficiency. Examples of these contextual/external influences relevant for athletes with II are the opportunities for optimized quality and quantity of training, access to elite level coaches, and experience. According to the Position Stand (Tweedy & Vanlandewijck, 2011), evidence-based classification must isolate the direct effects of the underlying impairment and disentangle these from enhanced proficiency attributable to other sources (i.e., training quality, volume, intensity, duration). The minimum impairment criteria should be set likewise, with direct impact of impairment on activities fundamental to the sport being the only threshold acceptable for inclusion. While this is the strictly adhered to standard, this stance does not reflect the full spectrum of considerations required to optimize athlete development and achievement. This omission is problematic in II-sport, similar to VI-sport (Mann & Ravensbergen, 2018), as it fails to acknowledge the fundamental impact these types of impairment have on skill acquisition and maturation during training (Capio et al., 2013). In other words, the developmental nature of the II has a culminate and interactional impact on the acquisition of skills and problem-solving abilities over time reducing the capability of the individual to optimize their learning capacity and ultimately the positive impact of training.

Competition observation

The IPC Athlete Classification Code (International Paralympic Committee, 2015) requires all athletes, independent of impairment type, to be assessed using standardized methods, in a controlled, non-competitive environment that allows for the repeated observation of the key tasks and activities required for classification. When necessary, these observations may be cross-checked by classifiers during competition to confirm the standardized results before finalizing the classification outcome. In the context of II-classification, athletes' abilities in non-competitive and competitive contexts are compared as part of the standard procedure. This is done to enhance the sensitivity of the procedure, and as a mechanism for assessing maximal effort. The decision to adopt this approach was necessary as variations in proficiency across contexts is a common artefact of II (Van Biesen et al., 2014b). Differences in competition versus pre-competition situations (e.g., presence and level of opponents, coaching, familiarity of environment) may exacerbate this variability as can a range of internal factors (e.g., stress, anxiety). Stress coping difficulties are commonly associated with II (Blasi et al., 2007; Hartley & MacLean, 2005), which can have significant negative effects on performance and problem-solving capacity of these athletes. Additionally, classifiers need to be aware of, and recognize how limitations in adaptive behaviour (which is a defining element of II) may be expressed in order to observe this during competition.

To verify pacing ability of athletes during competition, individual split-times and corresponding position in the competitive field can be registered. This approach enables assessment of how athletes allocate their energy during the race, and to compare this with optimal pacing profiles (i.e., comparison with Olympic or IAAF World championships final races and world-record races) (Van Biesen, Hettinga et al., 2016). An even more straightforward approach is taken in shot put and long jump, where the same observation protocols to assess maturity of the movement execution during the sport-specific field test are used to analyse and compare the execution during competition (Van Biesen, McCulloch et al., 2017).

After the detailed description of the four phases of the II-classification process, these will be further explored in the remainder of this conceptual paper with applications across various sports, and challenges that can be faced in the decision-making process, including intentional misrepresentation of abilities.

Intentional misrepresentation

Intentional misrepresentation is defined in the Classification Code (International Paralympic Committee, 2015) as a deliberate attempt to mislead the classifiers as to the existence or extent of skills relevant to the Sport, or the degree of Eligible Impairment. It is an ongoing concern for all athlete classification and remains so for athletes with II. Apart from observation as a control mechanism for maximal effort during sport-specific testing, there are several other ways within the II-eligibility process to account for the possibility of this behaviour. Finger-tapping, one of the tests within the GSIT, has been used for detecting "malingering" within clinical assessments (Axelrod et al., 2014). The finger-tapping test within the GSIT provides not only a highly sensitive measure of reactivity over time, but also comparative data between dominant and non-dominant hands. A pilot test in which students were instructed to underperform has demonstrated the potential of this test to detect purposeful misrepresentation (Ockerman & Van Hove, 2016). Further testing is required to confirm this utility among participants with II.

Assessing key determinants of proficiency within specific II-sports

As highlighted throughout the previous sections, the development of the sport-specific measures for II-eligibility primarily focus on cognitively driven factors (mind factors) of performance. For the sports currently included in the Paralympic programme, sport-specific tests were developed with this approach in mind. For some sports, table tennis for example, the cognitive load is more readily apparent and testable than in other sports such as athletics (Elferink-Gemser et al., 2018), which is reflected in the amount of research that has informed test development to date.

During table tennis matches, players repeatedly make decisions about services and returns, spin control, velocity and ball placement. To perform well, a player needs to anticipate the actions of the opponent, and recognize the meaningful cues in the context of the game, deciding in a split second the action to take, and executing the appropriate response. These game attributes demand technical and tactical proficiency, which was the initial focus of research on sport-specific testing of II-players. A standardized tactical proficiency test that concentrated on service-return execution was developed because this was judged to be the central determinant of success by a panel of table tennis experts. The score on this test was a composite of return accuracy (where to place the ball), quality of decision (appropriate stroke selection), and return-effectiveness (direct or indirect winner following the return). When applicable (i.e., when no direct or indirect winner was scored), the variation during the rally was also taken into account (Van Biesen et al., 2014a). A technical observation protocol also was developed to assess the maturity level of the various types of table tennis strokes (i.e., smash, topspin, backspin, etc.), expressed as a percentage of the fully mature execution. Controlling for technical proficiency was required to accurately interpret tactical proficiency as a table tennis player might know the correct response for the situation, but may lack the technical proficiency to execute that response.

In athletics, identifying the cognitive determinants of proficiency across the various disciplines is more complex than in table tennis. In running events, it was hypothesized by experts that shorter distances (e.g., 100 m sprint) would be less cognitively demanding than distance events (e.g., 1,500 m) where tactical skills (impulse control, pacing) that are cognitively driven are essential for optimal performance. As such, the 1,500 m was among the initial events selected for II-competitors, with pacing ability being the focus of sport-specific proficiency testing. A standardized field-test was developed that required trained runners with II to maintain a pre-determined submaximal running speed without external prompting (i.e., self-regulation) (Van Biesen, Hettinga et al., 2017). In the field disciplines (e.g., shot put and long jump), identifying core determinants of proficiency that are directly cognitively driven was more challenging (Van Biesen, McCulloch et al., 2017). Given the complex, dynamic and multi-sequenced nature of these events, technical proficiency was the object of assessment. In shot put and long jump, this was operationalized by evaluating how closely the technical execution approximated a fully "mature" or optimal movement, and the consistency of replication across multiple, maximal field testing efforts. The observation protocols used in the field-testing were developed in collaboration with high-level experts and coaches in athletics.

Determining minimum impairment criteria based on evidence collected during the classification process

Once the measures for verifying the impact of impairment on relevant determinants of sport proficiency were validated, cut-off thresholds were needed for determining inclusion in the master list. The cut-off scores for the cognitive and executive function GSIT subtests were identified using comparison data, as shown in (Figure 4) (Van Biesen, Mactavish et al., 2016). The box plots show how the data are distributed across 468 elite international athletes with II and a control group of 162 non-II athletes with similar sport, age, and training volume.

The cut-off thresholds were established by comparing the data distribution (mean and variation) of athletes with II to a large normative sample of equally well-trained athletes without II. The percentage of overlap was calculated between the II and non-II samples for each subtest, and the cut-offs were retrieved from that percentage of overlap. For the four subtests depicted in (Figure 4), the cut-off score is indicated by means of a red horizontal line.

During the classification process, athletes receive a score of one or zero: 1 for scoring above the cut-off score for the subtest or zero if scoring below the cut-off. To allow for natural variance, which the comparison data sets shows to occur, a score above the cut off on one of the GSIT subtests was admissible, but beyond that would result in ineligibility based on the GSIT.

Five of the seven GSIT subtests are factored into decision-making (i.e., the four tests depicted in (Figure 4) and the Flanker Test). Simple reaction time and choice reaction time, are used to familiarize the athletes with the equipment and to ease into the more complex tests. Results of these two tests are not considered in the decision-making process as they lack sufficient sensitivity to discriminate between athletes with and without II (Van Biesen, Mactavish et al., 2016). Ineligible athletes on the GSIT may complete the SST, to enable a complete assessment of the athlete's proficiency profile.

During SST thresholds for decision-making also were established. For example, in the athletics pacing test target time thresholds were set at 80% of the athlete's personal best in the 1500 m race. The athlete's ability to pace was then tested over a number of trials and the deviation from the expected target measured. Statistical norms were set for this deviation and the athlete scores one or zero depending on whether they score within or outside of these norms. To be eligible an athlete must score within the expected ranges on the SST. The results of these tests are then verified by structured observations carried out in-competition. In table tennis, a similar approach is used, with standardized testing of technical and tactical skills pre-competition and verification of the results by structured observations carried out in-competition (Van Biesen et al., 2014b). The scores across the GSIT and the SST provide a quantitative profile, and the observation in competition looks for coherency in performance with that profile.

A Training History and Sport Activity Limitations (TSAL) questionnaire is completed for all athletes, and contains information on the training history and experience of the athlete. This information provides useful context that buffers highly proficient athletes from being penalized for years of dedicated training.

The classification panel considers the results and observations from all stages of the athlete evaluation process (Eligible Impairment, GSIT, SST, Competition Observation and TSAL) into their decision-making. This is done by following the procedures as written in the respective sport-specific manuals (e.g., World Para Athletics Intellectual Impairment (II) Classification Manual,

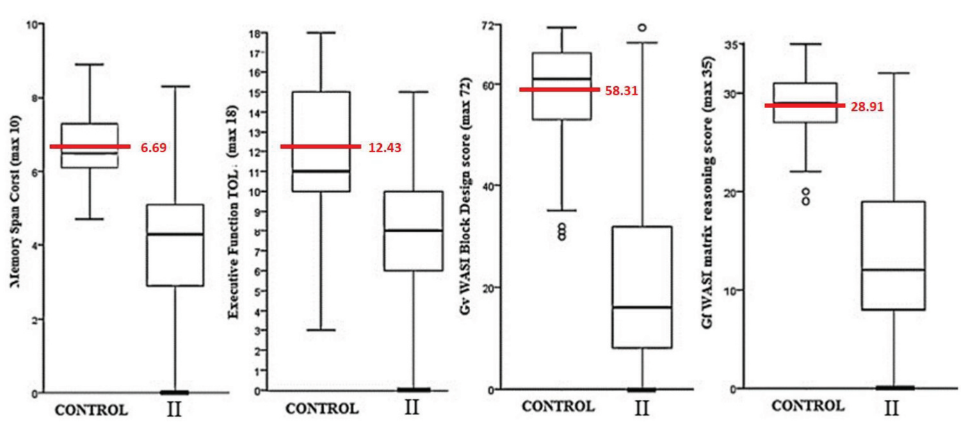

Figure 4. Comparison data for the four content-based subtests of the generic sports intelligence tests, reprinted with permission from Van Biesen, Mactavish et al., 2016.

2019). Classification decisions (inclusion/exclusion) are built mainly, but not exclusively, on the empirical evidence collected through the GSIT and SST. The classification panel can access other sources of athlete data (e.g., TSAL, Eligible Impairment information and Competition Observation) to facilitate their decision-making. For example, if the GSIT results raise questions, the classification panel may consult the Eligible Impairment assessment information (e.g., subtests of the WASI and some subscores on the original IQ tests) as one would expect a relationship between some of these elements and the GSIT. The TSAL data also can be used in the process and while not sufficient for changing the status of a classification decision it can trigger a review when the classifiers judge the training history (frequency, duration, intensity) insufficient to account for the athlete's current level of performance.

Enhancing the quality of evidence-based classification

Evidence-based classification must continuously evolve as new knowledge emerges, and classification procedures reviewed as part of an ongoing cycle of quality enhancement. Our original conceptual approach has morphed with ongoing research, systems have been revised, and areas for future research, expansion and enhancement identified. This evolution was bolstered by the IPC's 2013 recognition of the Adapted Physical Activity unit at KU Leuven as the "International Classification Research and Development Centre for Athletes with Intellectual Impairments" as the coordinating catalyst for furthering research, development and optimization of the II-classification system.

One part of the eligibility procedure that has been closely scrutinized and revised over time is the GSIT. Presently available evidence supports the use of the current GSIT (for more details on psychometric see Van Biesen, Mactavish et al. (2016); and Van Biesen, McCulloch et al. (2017)). All relevant aspects of the sport intelligence model are incorporated in the GSIT (see Figure 2), and each of the subtests have sound psychometric properties, and discriminate well between athletes with and without II. The current version is not the end point, however, as research is currently ongoing to further improve its validity, and ecological validity (i.e., more closely related to the dynamic and complex environment of sport). For example, we are exploring other potential executive functioning tests (e.g., colour trail making test) and more dynamic visual search tests (e.g., multiple object tracking).

Another line of investigation related to the GSIT is refining how scores are factored into the classification decision-making process. The current cut-offs were established based on average scores from a large normative sample; which provided a reasonable stating point as the cognitive profiles of the norm-groups did not significantly vary across sports. With further research since that time and the availability of larger data sets, further analysis should be done to explore the sensitivity of the scores compared to a standard score, how these look in relation to sport-specific performance criteria, and whether the impact differs by sport (i.e., sports with different cognitive loads)

The possible use of cognitive-motor dual-task paradigms also is currently being investigated to replace some of the cognitive tests that are not sensitive enough to discriminate between samples of athletes with and without II when measured in isolation (single task). Cognitive-motor dual-tasking is a novel test-approach, in which researchers examine how athletes allocate their cognitive and attentional resources while performing two or more tasks at the same time. Dual-tasking creates a more realistic testing environment, as it resembles the actual context of sport, where two or more tasks are performed simultaneously at all times (e.g., maintaining optimal speed and proper technique while judging the appropriate time to initiate the turning point in swimming). While executing two or more task simultaneously, the brain needs to constantly decide how to allocate the available cognitive resources, and as individuals with II have limited cognitive resources, this is expected to be more challenging compared to athletes without II (Mikolajczyk & Jankowicz-Szymanska, 2015; Van Biesen, Jacobs et al., 2017).

Another line of investigation to strengthen the current system is the work on adaptive behaviour and its impact on sport proficiency. As mentioned earlier, adaptive behaviour is one of the diagnostic criteria for II, and verified during the eligible impairment phase. However, during the subsequent phases of the process, the impact of adaptive behaviour on key determinants of sport proficiency is not considered, and the focus is exclusively on the assessment of cognitive functions (i.e., generic and sport-specific sport intelligence). Paralleling our approach to identifying elements of intelligence specific to sport, efforts are currently underway to define "Sport Adaptive Behaviour" and approaches (generic and sport-specific) to measuring adaptive behaviour and its impact in sport.

Basketball has been mentioned in this paper as a sport with high cognitive demands. Despite II-basketball not being included in the Paralympic programme, it is the sport with the longest and most complete history of evidence-based classification research (Arbex et al., 2017; Pinilla et al., 2015; Pinilla Arbex et al., 2016, 2016; Polo et al., 2017). As the high cognitive demands of team sports such as basketball are apparent, and because basketball is a very popular sport among people with II, with high participation numbers, it has been used as an example sport to guide the research towards the development of sport-specific measures of tactical proficiency. On-court (real game play) and off-court (computerized) decision-making tests were developed to assess basketball-specific speed and accuracy of decision-making. The high-level adult II-basketball players performed below the decision-making level of young basketball players (under 12 years old) playing in regular (able-bodied) basketball competitions (Pinilla et al., 2016, in press).

Various other sports have shown interest in developing their own evidence-based systems of classification for II-athletes (e.g., taekwondo, equestrian, rowing, hockey) (Vivaracho et al., 2018). Some are interested in future inclusion in the Paralympic movement, and others in VIRTUS. In winter sport, for example, cross-country skiing is currently being considered for potential inclusion in the Paralympic Winter Games. In a pilot study, Blomqvist et al. (2018) demonstrated that impaired cognition constrains the ability to select the optimal gear (i.e., skiing technique) according to the characteristics of the slope, which is a key determinant of cross-country skiing proficiency. More research is needed, to evaluate other key determinants of cross-country proficiency such as pacing, but the preliminary results of the studies look promising for the development of a solid cross-country classification system.

Discussion

In their recent paper addressing the evolution and development of best practice in Paralympic classification, M. J. Connick et al. (2018) concluded that not only should a system be scientifically valid, but that it should a) be successfully translated into practice, b) that these practices be acceptable and feasible and that c) Paralympic stakeholders support and understand the system. The system developed for demonstrating eligibility of para-athletes with II has a growing body of supporting scientific evidence. It has been translated into practice and is supported by ongoing research leading to further refinement and enhancement. Some areas require further research and some require a means of balancing the time needed to establish scientifically credible systems and the practical interests and demands of organizations to advance sport participation and competitive opportunities. Aligning these priorities with the way that research priorities evolve and are funded remains an area of tension that needs to be acknowledged and solutions sought.

Working with athletes of diverse cognitive abilities, verbal competencies, linguistic and cultural backgrounds places added demands to selecting the best scientifically available tests and instruments. The resulting classification system we believe is a good fit between these demands, but also raises additional research questions, of relevance wider than Paralympics classification, such as the influence of western and eastern forms of written language on neurological skills such as pattern recognition. In terms of feasibility, classification takes place around the world, usually at sporting events, within tight time frames and financial constraints, and requiring immediate results. These practical realities again necessitate a compromise between scientific best practice and feasibility. The II-classification system developed is portable, immediate, efficient and trainable in terms of recruiting classifiers with appropriate levels of expertise. In general, the Paralympic stakeholders have been very supportive of the approach taken to II-classification, however, one area which perhaps needs further development is the translation of this work to be fully comprehensible by every athlete with II. Currently, there is no real procedure in place to provide a simple introduction to the entire process and its implications in easy and plain language for the athletes.

There are many positives to engaging in evidence-based classification research over and above the resulting robust classification system and the further inclusion of athletes with II in high-level sports competition. One specific gain is the advancement of knowledge through bringing together interdisciplinary research and practice expertise. Classification for II athletes has acted as a focal point between disciplines such as sports science, sports psychology, neuropsychology, and clinical psychology, together with coaching expertise in different sports. A second gain has been to potentially contribute to knowledge and scientific enquiry outside of Paralympic classification to areas such as talent identification and enhancing performance. Insights originating from the work in II-classification can generate understanding of how sport expertise is linked to cognition and how superior cognitive and executive functions might contribute to excelling in sport.

Conclusion

The current best practice regarding sport-specific classification for para-athletes is based on an original conceptual model set out in this paper. The system has its own distinctiveness related to the specific impairment group under investigation. There is a growing body of research substantiating each element of the process. As research and practice is an iterative process, we believe that as new evidence emerges maintaining quality requires continuous review and improvement of the system in place.

Evidence-based is the only way forward for classification, if we want to meet the moral obligations to the athletes for fair and transparent processes and systems. Classification procedures should be the result of an ongoing cycle of quality enhancement, to meet these requirements and also meet the needs of a disadvantaged population that have limited opportunities to speak with its own voice, whilst demonstrating world-class sporting performance.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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