Evaluation of the SCAT 5 tool in the assessment of concussion in Para athletes: A Delphi Study

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Abstract

Objectives

To investigate if the sport concussion assessment tool version 5 (SCAT5) could be suitable for application to Para athletes with a visual impairment, a spinal cord injury, or a limb deficiency.

Methods

A 16-member expert panel performed a Delphi technique protocol. The first round encompassed an open-ended questionnaire, with round two onwards being comprised of a series of closed-ended statements requiring each expert's opinion using a five-point Likert scale. A pre-determined threshold of 66% was used to decide whether agreement had been reached by the panel.

Results

The Delphi study resulted in a four round process. After round one, 92 initial statements were constructed with 91 statements obtaining the targeted level of agreement by round four. The expert panellist completion rate of the full four round process was 94%. In the case of athletes with a suspected concussion with either limb deficiencies or spinal cord injuries, the panel agreed that a baseline assessment would be needed on record is ideal before a modified SCAT5 assessment. With respect to visual impairments, it was conceded that some tests were either difficult, infeasible or should be omitted entirely depending on the type of visual impairment.

Conclusion

It is proposed that the SCAT5 could be conducted on athletes with limb deficiencies or spinal cord injuries with some minor modifications and by establishing a baseline assessment to form a comparison. However, it cannot be recommended for athletes with visual impairment in its current form. Further research is needed to determine how potential concussions could be more effectively evaluated in athletes with different impairments.

Summary Box:

What is already known on this topic

– The assessment of concussion with able-bodied athletes is well documented but both data and consensus with respect to Para athletes are limited.

- Best methods of formally assessing athletes with an impairment for a suspected concussion in clinical practice are not currently evidence-based.

What this study adds

– This study utilised an expert panel to obtain a better understanding of the clinical assessment of a potential concussion in athletes with an impairment.

- The outcomes provide specific guidance on how the formal assessment for a suspected concussion in athletes with an impairment could be modified and improved.

-The study found that it is problematic to evaluate concussion in athletes with a visual impairment using current assessment tools, a numerically large and vulnerable population within the Paralympic movement.

How this study might affect research, practice or policy

– This study builds on the work of the Concussion in Para Sport Group consensus statement and offers a number of suggestions for solutions and future research into how athletes with an impairment could be assessed for a concussion. It highlights the need for engagement with technological opportunities to house baseline testing and an athletes' data record. Athlete engagement will be essential with support from international federations working collaboratively.

INTRODUCTION

Sport-related concussion (SRC) has formally been defined by the 6th International Conference on Concussion in Sport as "*a traumatic brain injury caused by a direct blow to the head, neck or body resulting in an impulsive force being transmitted to the brain that occurs in sports and exercise- related activities. This initiates a neurotransmitter and metabolic cascade, with possible axonal injury, blood flow change and inflammation affecting the brain. Symptoms and signs may present immediately, or evolve over minutes or hours, and commonly resolve within days, but may be prolonged*" [1] . Whilst the dangers and concerns of concussion in sport have resulted in increasing levels of scrutiny and media coverage [2], more recent concerns have highlighted the risks of such injuries when occurring in Para sports [3]. Indeed, Webborn at al. [4] provided an account of a specific example with video footage that took place at the Rio 2016 Paralympic Games but went unreported by the medical staff. The International Paralympic Committee's Medical Committee has undertaken injury surveillance at the Winter Paralympic Games since 2002 [5] and injury and illness surveillance at the Summer Paralympic Games since 2012 [6]. Although incidences of head and face injuries have been reported in blind football, Para alpine skiing, Para ice hockey and Para snowboarding [3] as well as those recorded at the Sochi and Pyeongchang Paralympic Winter Games [7,8], the actual reporting of concussion has been very low until the Tokyo 2020 Paralympics [9]. Whilst these studies identified some of the risk factors for concussion and have helped international sporting federations understand those risks [4], a call has been made for Paralympic medical and sporting communities to address the lack of funding and epidemiological research in this area [4].

The 'Sports Concussion Assessment Tool' (SCAT) was initially developed in 2004 to serve as an educational tool and to assist medical practitioners when evaluating SRC [10]. The 5th iteration of this tool, known as the SCAT5, was introduced in 2017 [1] and the updated SCAT6 was released in June 2023 [1]. However, despite its periodic revisions, it was agreed by an expert panel that the fifth iteration of this tool was not currently fit for application to Para athletes [3]. This is because it would require both modification of some of its criteria and assessment methods and that any such changes would then require validation [3]. Indeed, these concerns were supported when use of the SCAT3 iteration indicated differences in the baseline scores obtained for footballers between those with a range of impairments and those without [11]. There is a need to progress the Concussion in Para Sport (CIPS) Group's 'first position statement' [3] from merely being aware of the SCAT tools limitations to identifying the specific issues the SCAT possesses and how it would need to be modified for use in Para sport. This paper aims to address this by building upon the 'first position statement' [3]. Its objective is to obtain expert-based consensus of the specific issues and recommend potential solutions for clinicians managing Para athletes in the event of a suspected concussion injury when using the SCAT tool.

METHODS

Research Design

Given the vast range and number of impairments that Para athletes may have, this study focused on three specific types of impairment that were identified as having a high prevalence in competing Paralympic athletes [12]. The three types of impairment selected for this study, due to their high prevalence, were *visual impairment (low vision, absent vision, absent globe)*, *spinal cord injury* (*quadriplegia and Paraplegia*) and *limb deficiency (upper limb, unilateral or bilateral lower limb)*.

A Delphi Technique process was utilised to evaluate the use of the SCAT5 by these three different types of impairment. The protocol, criteria and method were established a priori. This approach seeks to elicit expert opinion in a systematically derived manner and is performed over a series of rounds [13,14]. The iterative process of rounds involves questioning or providing statements to an expert panel for their consideration. The subsequent findings from each previous round are then communicated back to the respondents and potentially modified to aid in any reassessment of their previous judgements [15]. Therefore, the scope for variation is potentially reduced in the next round in order to hopefully achieve a convergence of opinion [13]. A key characteristic is that the expert's individual responses maintain anonymity from each other throughout the process [16,17]. This technique has been used to address complex issues in Para sport on multiple occasions including the classification of Paralympic swimmers with vision impairments [18], the controversy surrounding the use of prosthetic limbs in running [19] and the classification of athletes in Para Taekwondo [20]. The Delphi questionnaire design for each round was pilot tested on a single respondent prior to each round's formal submission to the panellists.

Equity, diversity, and inclusion statement

The two lead researchers were male. Their expertise included sports medicine, exercise science, biomedical engineering, and consensus data collection. The expert panellists included a spectrum of ages, genders, professions, demographics (Europe, Africa, North and South America) and individuals with and without impairments. Panellists were selected based purely upon their experience in para sport.

Expert Panel Selection

The experts for this study were recruited through purposive sampling on the basis of their involvement in sport with a disability in the past and specifically the majority were all members of the Concussion in Para Sport Group (CIPS). These members had been involved in policy development within this field previously [3]. The panel comprised individuals from a variety of backgrounds or professions including exercise physiologists, physiotherapists, medical doctors (of whom two were former Para athletes), Para sport classifiers and academics from related disciplines (physiology, sports medicine, biomechanics, optometry or Para sport). The expert panel comprised 16 members in total which fell within the typical range of recommended Delphi panel sizes as summarised by Hsu [15]. A summarised list of the panel and their expertise is shown in table 1.

Table 1. Delphi Expert Panel Composition.

Panel Member No.	Expertise	Years of Direct Experience

1	Physiotherapist within elite Para sport. Former medical director for several Paralympic Games	13
2	Clinician. Member of IPC Medical Committee. Former Para athlete.	28
3	Sport and exercise medicine physician. Physician to national Para sport. Member and Chair of IPC Medical Committee.	13
4	Physician. Chief Medical Officer for Para sport national governing body.	12
5	Optometrist. Researcher into visual impairments and impairment classification. Research support to multiple winter Para sports.	5
6	Former Chief Medical Officer of both international and national governing bodies. Member of Parasport medical commission. Chief of Injury Division at Veterans Medical Center. Former Para athlete.	20+
7	Clinical Physiotherapist and board member within Para sport national governing body. Member of IPC Medical Committee.	7
8	Physiotherapist to multiple Para sports.	5
9	Physician to Para national team. Chief Medical Officer to national Para team. Member of IPC Medical Committee. Former Para athlete.	28
10	Physiotherapist to Para national team at multiple Paralympic Games. Medical and Sports Science Director of a sports international governing body. Member of an international Para sport medical committee.	17
11	Physician. Former team doctor for Para sport national team.	7
12	Coach & Physiotherapist. Medical & Scientific Director of international governing body	30+
13	Physician. Chief Medical Officer for multiple Para sports. Former national Para team doctor. Served on medical committee of international governing body.	15
14	Physician. Chief Medical Officer of a national Para sport governing body.	2
15	Chief Medical Officer of national Para teams. Member of IPC Medical Committee.	15
16	Physician. Former national Para team physician. Former Chief Medical Officer of Winter Paralympic Games, Head of Classification for international governing body. Member of an impairment classification committee and international level classifier for IPC.	25

Definition of Delphi Technique Consensus

The notion of consensus varies in both its definition and its implementation [19] and is an area of contention. No clear universal threshold exists for the determination of consensus so any target could be argued to be arbitrary. The threshold of agreement for this has varied with some studies accepting consensus as low as 55% or as high as 100% [19]. For this study, a 66% majority was determined as the minimum threshold. This target had previously been used in Delphi studies investigating athletes with an impairment [18, 19].

Round one

The first round questionnaires with open-ended questions were sent as an e-mail to each panellist, with these questions derived directly from the SCAT5 assessment tool from the ‘symptom evaluation’ and ‘neurological screen’ sub-sections (as these were the areas of concern with their application to Para athletes).

Round one asked 30 open-ended questions which were divided into the following sub-sections:

i) Four questions regarding the expert panellist’s background, experience and areas of interest.

ii) Seven questions that asked the expert for their opinion when evaluating an athlete with a visual impairment the symptoms for a potential concussion.

iii) Seven questions that asked the expert for their opinion to determine resolutions to perform a neurological screen for an athlete with a visual impairment for a potential concussion.

iv) Three questions that asked the expert for their opinion when evaluating an athlete with a spinal cord injury the symptoms for a potential concussion.

v) Four questions that asked the expert for their opinion to determine resolutions to perform a neurological screen for an athlete with a spinal cord injury for a potential concussion.

vi) Five questions that asked the expert for their opinion to determine resolutions to perform a neurological screen for an athlete with a limb deficiency for a potential concussion.

On completion of round one, the data were analysed with common themes identified through a process of open coding using the principles proposed by Williams & Moser [21]. These were then developed into a set of statements for inclusion in round two with the aim of gaining agreement with as many of these statements as possible. If any statement did not obtain consensus, it would be either offered back to the panel again for the subsequent round or would be rephrased before then being included in the subsequent round.

Rounds two to four

Rounds two to four were administered via an online questionnaire using the Google Forms app (Google, California, US) and would present a series of statements that the expert panellists would then offer their level of agreement on. A five-point Likert scale was utilised for this purpose. These were 'Strongly Agree', 'Agree', Neither Agree Nor Disagree', 'Disagree' and 'Strongly Disagree'. It was felt that the intensity of the response was not relevant to this study, instead only whether the expert agreed with the statement or not [19]. As a result, the consensus score was calculated by adding both the positive 'strongly agree' and 'agree' options together and likewise for the negative 'disagree' and 'strongly disagree' options. It should be noted that a further Likert category was incorporated from round three onwards based upon some of the qualitative feedback received from the panellists in round two. This extra category was phrased as 'please tick if unqualified to answer'. This provided the means for an expert panellist to 'opt out' of a specific question or not be coerced to provide an answer that was not factually accurate. This then avoided influencing the weighting of answers with opinions that were not from experts in that area. In the event this option was selected, the calculation for consensus would then omit their response for that question. This decision essentially saw the use of the 'neither agree nor disagree' choice made redundant in this study. Both the 'neither' and 'not qualified' options were then omitted from the data analysis.

The survey structure of rounds two to four was organised into five sub-sections. These sub sections were:

- Athletes with a visual impairment: Evaluating the symptoms of a potential concussion
- Athletes with a visual impairment: Neurological screen.
- Spinal cord injury (quadriplegia and paraplegia): Evaluating the symptoms of a potential concussion.
- Spinal cord injury (quadriplegia and paraplegia): Neurological screen.
- Limb deficiency (upper and lower): Neurological screen.

Prior to the study's commencement, it was decided to modify the Delphi process so that any statement that obtained the minimum level of agreement of 66% in any round would be removed from the questionnaire for any subsequent rounds. This ensured that the questionnaire was kept as concise as possible to maximise round-to- round expert panellist retention. Each round included the ability for each panellist to write comments or provide feedback if they so wished.

Results analysis

The final and full list of consensus statements was classified via colour coding. These statements were classified into three colours by the authors to aid this following a similar approach previously adopted [3]. These coding's were:

- Green: Areas where the SCAT5 measures are appropriate and could therefore be adopted verbatim.
- Amber: Areas where respondents feel the SCAT5 could be used but some conditions or minor amendments would be required or that prior baseline testing would be ideally necessary.
- Red: Areas of the SCAT5 that are unsuitable for use in this context, thereby suggesting they should be omitted from any potential concussion assessment entirely or would need to be replaced.

RESULTS

The full completion of the Delphi study was approximately two years from initial agreement of participation of the respondents to the conclusion of round four. The panellist retention rate from round one to four was 94% as one panellist chose to leave the study before all the rounds were completed. The level of panellist agreement from round to round is summarised in table 2.

Table 2. Delphi Consensus Results.

Round	Number of statements	Statements that obtained consensus	Statements that did not obtain consensus
2	93 (50%)	68 (37%)	25 (13%)
3	24 (50%)	16 (33%)	8 (17%)
4	8 (50%)	7 (44%)	1 (6%)

91 separate statements obtained the satisfactory threshold of agreement. By the conclusion of round four, one remaining statement did not obtain the targeted threshold of consensus. However, it was felt that due to its score being just short of the threshold (64%) and having not seen its level of panellist agreement change significantly from round to round, that there was no perceived value to creating a fifth round. The statement was therefore carried with this minor limitation. The final agreed statements are supplied with this paper as supplemental material.

The results of the Delphi process with respect to athletes with a visual impairment and the evaluation of the symptoms of a potential concussion are shown in table 3.

Table 3. Evaluating the symptoms of athletes with a visual impairment: Delphi results.

Athletes with a visual impairment: Evaluating the symptoms of a potential concussion		
Delphi Statement	**Outcome**	**% of Agreement Obtained**
An athlete who possesses a LOW VISION impairment may not exhibit the same types of post-concussion vision symptoms as individuals without a vision impairment.	Agree	100
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will possess difficulties to follow and understand verbal instructions.	Disagree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will possess difficulties to follow and understand written or visual instructions.	Agree	81
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will be difficult to evaluate for any blurred vision, a sensitivity to light or double vision.	Agree	94
It is necessary to establish a baseline for someone who possesses a LOW VISION impairment when evaluating their symptoms for any potential concussion in the future.	Agree	100
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will be difficult to assess if their usual state is worsening without prior knowledge of the tests involved.	Agree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will be difficult to assess if their usual state is worsening without use of a baseline comparison of the tests involved.	Agree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will potentially possess balance issues	Agree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses a LOW VISION impairment will be unable to know if their usual (baseline) state has changed.	Disagree	80
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will be unable to fully respond to visual stimuli and follow visual commands.	Agree	100
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will potentially possess balance issues.	Agree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will be unable to assess if they suffer from a blurring of vision.	Agree	100
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will possess difficulties to follow and understand verbal instructions.	Disagree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will possess difficulties to follow and understand written or visual instructions.	Agree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will be difficult to assess if their condition is worsening without a baseline comparison.	Agree	92
When evaluating their symptoms for a potential concussion, an athlete who possesses ABSENT VISION impairment will find it more difficult to know if their usual (baseline) state has changed	Agree	69
When evaluating their symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment should have a distinction made between congenital and acquired blindness.	Agree	67
When evaluating their visual symptoms for a potential concussion, an athlete who possesses an ABSENT VISION impairment will be too difficult to assess adequately so this should not form part of the clinical evaluation.	Agree	81
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will be difficult to assess if their usual state is worsening without a baseline for comparison.	Agree	100
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will be difficult to evaluate for any blurred vision, a sensitivity to light or double vision.	Agree	75

When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment may experience entirely different visual symptoms (such as visual hallucinations).	Agree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will potentially possess balance issues.	Agree	69
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will possess difficulties to follow and understand verbal instructions.	Disagree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will possess difficulties to follow and understand written or visual instructions.	Agree	100
When evaluating their visual symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment will be too difficult to assess adequately and this should not form part of the clinical evaluation.	Agree	80
When evaluating their symptoms for a potential concussion, an athlete who possesses a DOUBLE ABSENT GLOBE impairment may experience entirely different visual symptoms (such as visual hallucinations).	Agree	70
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment will be difficult to evaluate for any blurred vision, a sensitivity to light or double vision.	Agree	94
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment may experience entirely different visual symptoms (such as visual hallucinations).	Agree	75
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment will potentially possess balance issues.	Agree	69
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment will possess difficulties to follow and understand verbal instructions.	Disagree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment will possess difficulties to follow and understand written or visual instructions.	Agree	88
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment will be unable entirely to respond to visual stimuli and follow visual commands.	Disagree	93
When evaluating their symptoms for a potential concussion, an athlete who possesses a SINGLE ABSENT GLOBE impairment may experience entirely different visual symptoms (such as visual hallucinations)	Agree	88
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for blurred vision by comparison to an established baseline.	Agree	81
Difficulties in the objective reliability of assessing blurred vision when possessing a potential concussion can be addressed by utilising more than one method of assessment.	Agree	75
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for balance issues by comparing to an established baseline.	Agree	75
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for a sensitivity to light by comparing to an established baseline.	Agree	75
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for a sensitivity to light by asking them if they have sensed any changes as a result of their injury.	Agree	81
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for trouble falling asleep by comparing to an established baseline.	Agree	81
An athlete who already possesses a VISUAL impairment and has potentially acquired a concussion can be assessed for trouble falling asleep through discussion - but without the need for quantifiable data.	Agree	93

The results of the Delphi process with respect to athletes with a visual impairment and the subsequent neurological screen of a potential concussion are shown in table 4.

Table 4. The neurological screening of athletes with a visual impairment: Delphi results.

Athletes with a visual impairment: Neurological screen		
Delphi Statement	**Outcome**	**% of Agreement Obtained**
A baseline should be established for being able to read aloud for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	75
The provision of braille, large print or digital reading software are viable solutions for someone who possesses a VISUAL impairment with a suspected concussion to then be able to read aloud as part of the neurological screening process.	Agree	88
A baseline should be established for being able to look side-to-side and up-and-down (without moving their head or neck) for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	69
Athletes with VISION/GLOBE ABSENT impairments should use alternative forms of assessment as part of the neurological screening process rather than being able to look side-to-side and up-and-down (without moving their head or neck).	Agree	81
A baseline should be established for being able to perform the finger nose test for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	94
The finger nose test could be successfully performed by athletes possessing a VISUAL impairment with their eyes closed if evaluating a suspected concussion	Agree	75
A baseline should be established for being able to perform tandem gait for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	94
Prior familiarity with the tandem gait test would be needed when assessing a participant who possesses a VISUAL impairment as part of the neurological screening process	Agree	75
Standardised floor markings would be beneficial when assessing a participant who possesses a VISUAL impairment when performing tandem gait as part of the neurological screening process.	Agree	80
A baseline should be established for being able to demonstrate double leg stance balance for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	100
An athlete with a VISUAL impairment could demonstrate double leg stance balance as part of the neurological screening process when assessing a potential concussion.	Agree	100
Prior instruction of the double leg stance balance test would be needed by an athlete with a VISUAL impairment as part of the neurological screening process. (Previous round consensus = 50% agree)	Agree	69

A baseline should be established for being able to demonstrate single leg stance balance for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	94
An athlete with a VISUAL impairment could demonstrate single leg stance balance as part of the neurological screening process when assessing a potential concussion.	Agree	94
Prior instruction with the single leg stance balance test would be needed by an athlete with a VISUAL impairment as part of the neurological screening process.	Agree	75
A baseline should be established for being able to demonstrate tandem stance balance with their non-dominant foot at the back for an athlete who possesses a VISUAL impairment as part of the neurological screening process to help in assessing a suspected concussion.	Agree	94
An athlete with a VISUAL impairment could demonstrate tandem stance balance with their non-dominant foot at the back as part of the neurological screening process when assessing a potential concussion.	Agree	100
Prior instruction to assess the tandem stance balance with their non-dominant foot at the back test would be needed by an athlete with a VISUAL impairment as part of the neurological screening process.	Agree	75

The results of the Delphi process with respect to athletes with a spinal cord injury and the evaluation of the symptoms of a potential concussion are shown in table 5.

Table 5. Evaluating the symptoms of athletes with a spinal cord injury: Delphi results.

Spinal Cord Injury (Quadriplegia and Paraplegia): Evaluating the symptoms of a potential concussion		
Delphi Statement	**Outcome**	**% of Agreement Obtained**
A baseline should be established for an athlete who possesses a QUADRIPLEGIA when evaluating the symptoms of neck pain for a suspected concussion.	Agree	81
An athlete who possesses a QUADRIPLEGIA could be evaluated for the symptoms of neck pain to assess a potential concussion.	Agree	81
An athlete who possesses a QUADRIPLEGIA could tell the difference between neck pain obtained from a concussion compared to any existing musculoskeletal or central neurological neck pain	Agree	69
A baseline should be established for an athlete who possesses a QUADRIPLEGIA impairment when evaluating the symptoms of sitting balance for a suspected concussion.	Agree	81
An alternative method of assessing a potential concussion should be undertaken if the athlete who possesses a QUADRIPLEGIA has weak trunk muscles and/or cannot sit without support when assessing their sitting balance.	Agree	75
Not all athletes who possess a QUADRIPLEGIA can be evaluated for the symptoms of sitting balance (WESS test) to assess a potential concussion. This element is removed unless baseline testing indicates that the individual is capable of completing it satisfactorily.	Agree	100
An athlete who possesses a PARAPLEGIA could be evaluated for the symptoms of sitting balance to assess a potential concussion.	Agree	88
A baseline should be established for an athlete who possesses a PARAPLEGIA impairment when evaluating the symptoms of sitting balance for a suspected concussion.	Agree	88

An alternative method of assessing a potential concussion should be undertaken if the athlete who possesses a PARAPLEGIA has weak trunk muscles and/or cannot sit without support when assessing their sitting balance.	Agree	75

The results of the Delphi process with respect to athletes with a spinal cord injury and the subsequent neurological screen of a potential concussion are shown in table 6.

Table 6. The neurological screening of athletes with a spinal cord injury: Delphi results

Spinal Cord Injury (Quadriplegia and Paraplegia): Neurological Screen		
Delphi Statement	**Outcome**	**% of Agreement Obtained**
An athlete who possesses a QUADRIPLEGIA could be evaluated when evaluating the range of motion of the cervical spine to assess a potential concussion as part of the neurological screening process.	Agree	69
A baseline should be established for an athlete who possesses a QUADRIPLEGIA impairment when evaluating the range of motion of the cervical spine for a suspected concussion as part of the neurological screening process.	Agree	81
Any concerns surrounding the assessment of a potential concussion for an athlete who possesses a QUADRIPLEGIA when evaluating the range of motion of the cervical spine should lead to alternative tests to be selected.	Agree	69
A baseline should be established for an athlete who possesses a QUADRIPLEGIA impairment when evaluating the finger nose test for a suspected concussion as part of the neurological screening process.	Agree	81
Use of a lower target (below the shoulder plane) is more appropriate for an athlete who possesses a QUADRIPLEGIA is performing a finger nose test when assessing a potential concussion as part of the neurological screening process.	Agree	69
An athlete who possesses a QUADRIPLEGIA could perform a finger nose test to assess a potential concussion as part of the neurological screening process.	Agree	69
An alternative method to performing tandem gait should be utilised for an athlete who possesses a SPINAL CORD INJURY when assessing a potential concussion as part of the neurological screening process.	Agree	81
An athlete who possesses a SPINAL CORD INJURY should not be able to perform tandem gait at all when assessing a potential concussion as part of the neurological screening process	Agree	69
An alternative method to performing Balance Tests (Double leg, Single Leg, Tandem stance) should be utilised for an athlete who possesses a SPINAL CORD INJURY when assessing a potential concussion as part of the neurological screening process.	Agree	75
Seated balance tests would be a viable alternative proposal for an athlete who possesses a SPINAL CORD INJURY rather than performing Balance Tests (Double leg, Single Leg, Tandem stance) to assess a potential concussion as part of the neurological screening process.	Agree	88
If other potential tests become available, they should be investigated.	Agree	94
Someone who possesses a SPINAL CORD INJURY should not be able to perform the standard Balance Tests (Double leg, Single Leg, Tandem stance) to assess a potential concussion as part of the neurological screening process	Agree	71

The results of the Delphi process with respect to athletes with an upper/lower limb deficiencies and the subsequent neurological screen of a potential concussion are shown in table 7.

Table 7. Athletes with a limb deficiency Delphi results.

Limb Deficiency (Upper and Lower Limb): Neurological Screen		
Delphi Statement	**Outcome**	**% of Agreement Obtained**
An athlete who possesses a unilateral UPPER LIMB ABSENCE OR DEFICIENCY could perform a finger-nose test to assess a potential concussion as part of the neurological screening process.	Agree	75
For those possessing a bi-lateral UPPER LIMB ABSENCE OR DEFICIENCY, the finger-nose test should not be used to evaluate a suspected concussion as part of the neurological screening process	Agree	80
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should be allowed use of their walking prosthesis if conducting the tandem gait test to assess a potential concussion as part of the neurological screening process.	Agree	81
A baseline should be established for an athlete who possesses a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY impairment when evaluating the tandem gait test or a suspected concussion as part of the neurological screening process.	Agree	81
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY can be assessed for their tandem gait when assessing for a concussion as part of the neurological screening process.	Disagree **CONSENSUS NOT REACHED**	64 (at round 4)
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should be allowed use of their walking prosthesis if demonstrating the double leg stance test to assess a potential concussion as part of the neurological screening process.	Agree	88
A baseline should be established for an athlete who possesses a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY impairment when demonstrating double leg stance balance for a suspected concussion as part of the neurological screening process.	Agree	88
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should not be asked to demonstrate their double leg stance balance at all when assessing for a concussion as part of the neurological screening process.	Disagree	69
A baseline should be established for an athlete who possesses a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY impairment when demonstrating single leg stance balance using their non-prosthesis foot for a suspected concussion as part of the neurological screening process.	Agree	88
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should be allowed use of their prosthesis if conducting tests to assess their single leg stance balance using their non-prosthesis foot when assessing for a concussion as part of the neurological screening process.	Agree	81
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should be allowed use of their walking prosthesis if demonstrating tandem stance balance with their non-dominant foot at the back to assess a potential concussion as part of the neurological screening process.	Agree	81
A baseline assessment should be established for someone with UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY when demonstrating their tandem stance balance with their non-dominant foot at the back when assessing for a concussion as part of the neurological screening process.	Agree	88
An athlete with a UNILATERAL OR BILATERAL LOWER-LIMB DEFICIENCY should not be assessed to demonstrate their tandem stance balance with their non-dominant foot at the back to assess a potential concussion as part of the neurological screening process	Agree	73

In terms of the colour classification, 31 of the 92 statements presented tables 3-7 were classified as green, 26 were classified as amber and 35 were deemed to be red. The proportions for each of these impairments are summarised in table 8.

Table 8. Colour coding by impairment

Impairment	Green	Amber	Red
Visual Impairment	17 (29%)	17 (29%)	24 (42%)
Spinal cord injury	9 (43%)	5 (24%)	7 (33%)
Limb deficiency	5 (38%)	4 (31%)	4 (31%)

In Table 8 it can be seen that the visual impairment group has a larger number of red coded statements than the two other impairment groups and that most of those were classified red, whilst conversely the spinal cord injury and limb deficiency groups saw their largest numbers of classifications nominated as green.

DISCUSSION

The aim of this paper was to build upon the CIPS Groups 'first position statement' [3] to ascertain the suitability of the SCAT5 for athletes with certain defined impairments and to identify what modifications may be required for it to be suitable for use in Para sport. The Delphi process by itself was judged to be successful in that 99% of its offered statements obtained the pre-determined level of consensus and that only one of its expert panellists was unable to complete the full four round process. Overall, between 31- 41% of tests used in the current SCAT5 should not be used in clinical assessment of suspected concussion in the Para athlete depending upon the impairment. A further 24-31% of SCAT5 tests require modification before use and the results of this study provide further evidence to support the work of the CIPS group [3] in that new methods of assessment will now need to be identified and validated for the Para athlete population. This was not in time for the SCAT6's that was released after the data collection for this study had already taken but should be noted should any further revisions to the SCAT occur in the future. Moreover, most updates included in the SCAT6 do not materially affect the recommendations from our study.

Athletes with visual impairments

When evaluating the ability to assess concussion symptoms of Para athletes with visual impairments, it was agreed that the SCAT5 would not be easily adopted in its present form because the majority of such athletes would fundamentally not be able to see and follow instructions easily due to limited vision. For example, the results highlighted a consistent theme that such Para athletes would possess difficulties in following any instructions of the SCAT5 tests and that those with a single absent globe would be unable to respond entirely to visual stimuli or follow visual commands. This suggests that major changes in the delivery and operation of the SCAT5 tests with such athletes would be needed, perhaps using technology specifically designed for individuals with visual impairment. Mixed methods of delivery of the concussion assessment tool might be required but need to be affordable and available solutions.

When considering the neurological screening process, the existing SCAT5 was generally endorsed in its present form as it was agreed that assessments such as the finger nose test, tandem stance balance and single or double leg stance balance might be successfully performed by athletes with a visual impairment. However, such tests would need to be modified such as with the proposed use of standardised floor markings to act as an aid. Additionally, previous familiarisation with the testing procedure for all participants is required and individual baseline measures should ideally be established.

The necessity of having prior knowledge and experience of the tests so that the impairment itself did not distort or affect the results of the assessment was highlighted further when assessing the amber coded criteria. There is currently no mandated requirement to undertake prior practise of the tests but international sport federations could adopt and promote such practices through their medical commissions. Without this, athletes with a variety of visual impairments could not effectively use the SCAT5 and the viability to assess visually impaired athletes at all hinges on these key issues entirely.

Our study proposes that most of the visual impairments identified in this study could not utilise the SCAT5 in its existing format. This could be considered obvious when many such types of visual impairment would find it almost impossible under conventional means to be assessed for blurred vision, sensitivity to light or double vision at all. Also symptoms such as headache, concentration difficulties, fatigue and impaired balance are common among athletes as a consequence of visual impairment without concussion. Further complications could arise when an athlete with a low vision or absent vision visual impairment may not exhibit the same types of post-concussion vision symptoms as individuals without a vision impairment. Ultimately, if it was conceded that some evaluations were either difficult, infeasible or should be omitted entirely – depending on the type of visual impairment. This again suggests that a fresh approach will need to be researched and validated in the future and that not even a slightly modified form of the current SCAT5 would be a feasible solution in the meantime.

Athletes with spinal cord injuries

Our study outcomes stated that whether the Para athlete had quadriplegia or paraplegia, a baseline assessment would be ideally needed to act as a comparison for assessing the symptoms of neck pain, when performing sitting balance tests or when evaluating the range of motion of the cervical spine. It could be assumed that without that in place, the SCAT5 assessment could not take place at all. It was agreed in this study though that such athletes may still be evaluated specifically for the symptoms of neck pain. To do so would be subject to the severity of the concussion symptoms potentially affecting the judgement of the individual. This need for baseline testing also supports the proposals of the same from previous studies [3].

Statements coded red indicated that when assessing the symptoms of a potential concussion, alternative methods of assessment should be pursued when evaluating the range of motion of the cervical spine or balance tests. These should also be removed entirely from the assessment for athletes with quadriplegia or paraplegia who have weak trunk muscles when performing sitting balance tests. This was also the case with athletes with spinal cord injuries attempting to perform tandem gait or standard balance tests. This was in most cases due to the fact that the very nature of their impairment would mean that they would not be able to perform such a motion at all. The experts agreed with this conclusion and determined that alternative assessment methods should be sought out. However, in the case of seated balance tests, the experts proposed and agreed that if such tests were performed seated, these might be feasible. Some preliminary work has assessed modifications of the mBESS test for wheelchair users but at a limited level for those with spinal cord injury [22]. Therefore, a full assessment modification would need to be investigated for its validity and reliability.

When the neurological screening process takes place for athletes with a quadriplegia or paraplegia by performing a finger-nose test, a specific minor modification was also recommended. This would involve lowering the target below the shoulder plane to make the test more suitable for the candidate when considering their lack of stability or range of motion. If this was introduced, the finger nose test would then be achievable. Ultimately, the findings in this study were in accordance with those recorded in the CIPS study [3].

Athletes with limb deficiencies

The expert's opinions suggested that with minor modifications to the SCAT5, it could be suitable for this impairment group. One such modification was that athletes could undertake tandem gait, double leg stance, single leg balance and tandem stance balance tests of the SCAT 5 if they had their prosthetic limbs fitted whilst being assessed. This should be adopted in any future revision of the SCAT. This could be seen as a minor operational change if the SCAT5 were to be utilised now.

There was an unresolved issue in relation to athletes with upper limb absence or deficiency. It was agreed that a finger nose test that forms part of the neurological screen could still be undertaken if the Para athlete possessed a singular limb absence or deficiency. However in the Para athlete with a bi-lateral upper limb absence or deficiency, the panel agreed that the test should not be used at all. As a practical alternative test of coordination, the well-established Heel-Shin test might be offered in any testing procedure going forward. This was not established by the Delphi process in this study but a reflection of the results that were obtained from it. Also in relation to bi-lateral upper limb absence or deficiency, a further round could have clarified if the finger nose test could have been undertaken while the participant was wearing a prosthetic limb, however this might not be an option for all athletes. Going forward it would be most helpful to have Para athlete engagement to understand the challenges and solutions for these issues.

As discussed with other impairment types, the panel agreed that a baseline assessment would ideally be required. Given that this theme occurred more than once in the results, a pragmatic solution is to advocate baseline testing for all assessments. This should be recommended and promoted to the sports' governing bodies for all future SCAT revisions.

Summarising the value of the SCAT5

Across each of the three impairment groups in this study, there were several overarching themes that occurred consistently throughout the Delphi process. These were the need for baseline records of the specific Para athlete; identifying and validating alternative assessments when existing ones were not suitable; and the exclusion of some existing assessments entirely. It is reasonable to infer that a specific revision of the SCAT5 is warranted for Para athletes so that they can be removed from practice or play in the event a concussion is suspected. An additional consideration is the clinician carrying out the assessment. In some Para sports, (e.g. wheelchair rugby or basketball), the team clinician is permitted on the field of play and at courtside and so would have prior knowledge of the individual and their baseline performance. In other sports such as athletics, the tournament medical staff have initial contact with the injured athlete but would not have any prior knowledge of the individual. The feasibility of the Para athlete concussion passport for recording baseline data and subsequent examinations, whether annually or after incidents, should be considered as a way forward. Discussions with athlete bodies to discuss logistical and data protection policies requires consideration but the concept of persons carrying their own health data is not new. There will be similarities and differences across different sports which might facilitate development. In particular the technological advancements required for modifications to accessibility with assessment of visually impaired athletes would apply to many sports.

Clinical Implications

The aim of this study was to determine whether the SCAT5 tool is suitable for implementation when considering three different types of Para athlete impairments and to build on the 1st position statement of the Concussion in Para Sport group [3]. Whilst the use of the SCAT5 tool may be feasible with those possessing spinal cord injuries or limb deficiency/absence, the expert panels highlighted that this is not appropriate for athletes with visual impairments. As a result, athletes with visual impairments would require alternative tests, validation and revised assessments put in place before adoption.

Limitations

This study has limitations in terms of its panel selection. Because the members originated from the CIPS Group, the members would be largely known to each other, even though their Delphi statement responses would not. It is feasible that their prior working relationship could have contributed to the high level of statement consensus ultimately obtained in this study creating some degree of underlying bias. Furthermore, it is not known if the issues investigated in this study probably would have been discussed to some level prior to this study commencing. This could mean that this study may well have merely validated their views rather than to explore them from an unknown starting point such as Delphi studies that recruit expert panellists in the Para sport field more broadly [19]. Given the specialised area of this topic of study, it was felt that the panellists represented the leading experts in this field and that given the anonymity of their individual responses were retained through all rounds, that the aims of the study and the integrity of the Delphi technique protocol were maintained. We recognised that the number of practitioners with expertise in the field of concussion in Para sport is limited and certain panel members were included for their knowledge in a particular field, e.g. visual impairment. Finally, it is also acknowledged that the panel may not possess all of the expertise across all domains within it at all times. As a result, it should be considered an expert panel but not one that may have the knowledge in totality for all eventualities or future needs.

It is recognised that modifying the Delphi Technique by removing statements from a subsequent round that had obtained the required level of consensus in a round preceding it could be seen as contentious. This was a pragmatic decision made in advance of the study taking place to ensure the maximum number of panellists could complete the maximum number of rounds when evaluating a large number of statements. It is conceded that it is possible that a panellist's view could change from round to round.

It should also be mentioned that a further modification of the Delphi process by adding the two positive options together and also the two negative options together in the data analysis created a simplification. Whilst this is not viewed as a limitation it should be noted.

Furthermore it should be noted that this study only investigated three overarching forms of impairment. It is therefore conceivable that future investigation of others forms of impairment could provide further insight or contradictions that would then benefit future

SCAT revisions. As a result, it is strongly advocated that the investigation of other impairments that were not covered in this study are now also investigated.

CONCLUSION

A Delphi study was undertaken by a panel of experts to ascertain the suitability of the SCAT5 when applied to Para athletes who possessed a visual impairment, a spinal cord injury or a limb deficiency. After four rounds, the Delphi process produced 92 statements of which 91 obtained the targeted level of consensus.

In the case of athletes with limb deficiencies or spinal cord injuries, it was concluded that a baseline assessment would ideally be needed on record before the symptom assessment or a neurological screen phases of concussion assessment could take place. However, provided such athletes were allowed to use their prostheses or if some minor assessment modifications were made, it was agreed that the SCAT5 could be feasibly utilised. With respect to visual impairments, it was conceded that some evaluations were either difficult, infeasible or should be omitted entirely – depending on the type of visual impairment. This study builds on the work of the CIPS Consensus statement and offered a number of suggestions for future developments and research for a pathway forward.

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