Do Neurocognitive SCAT3 Baseline Test Scores Differ Between Footballers (Soccer) Living With and Without Disability? A Cross-Sectional Study

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Objective: To determine if baseline Sport Concussion Assessment Tool, third Edition (SCAT3) scores differ between athletes with and without disability.

Design: Cross-sectional comparison of preseason baseline SCAT3 scores for a range of England international footballers.

Setting: Team doctors and physiotherapists supporting England football teams recorded players' SCAT 3 baseline tests from August 1, 2013 to July 31, 2014.

Participants: A convenience sample of 249 England footballers, of whom 185 were players without disability (male: 119; female: 66) and 64 were players with disability (male learning disability: 17; male cerebral palsy: 28; male blind: 10; female deaf: 9).

Assessment and Outcome Measures: Between-group comparisons of median SCAT3 total and section scores were made using nonparametric Mann–Whitney–Wilcoxon ranked-sum test.

Main Results: All footballers with disability scored higher symptom severity scores compared with male players without disability. Male footballers with learning disability demonstrated no significant difference in the total number of symptoms, but recorded significantly lower scores on immediate memory and delayed recall compared with male players without disability. Male blind footballers' scored significantly higher for total concentration and delayed recall, and male footballers with cerebral palsy scored significantly higher on balance testing and immediate memory, when compared with male players without disability. Female footballers with deafness scored significantly higher for total concentration and balance testing than female footballers without disability.

Conclusions: This study suggests that significant differences exist between SCAT3 baseline section scores for footballers with and without disability. Concussion consensus guidelines should recognize these differences and produce guidelines that are specific for the growing number of athletes living with disability.

Key Words: concussion, neurocognitive testing, SCAT, disability sport

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INTRODUCTION

The World Health Organization (WHO) estimates that there is over one billion people worldwide living with disability.[1] People living with disability gain numerous positive health and social benefits from regular exercise and participation in team sports (such as basketball, football, and rugby).[1–4] In England, the "*Active People Survey 7*" confirmed that 1.7 million people living with disability play sport, of which, 85 600 play "disability football" at least once a week.[5] For these footballers, there are organized "pan-disability" football leagues and leagues specifically for those with hearing and visual impairment (including football for those with blindness and partially sighted); learning disability; cerebral palsy (including head injuries and eligible neurological conditions); power-chair users; and those living with amputation. Each of these forms of adapted football ensures that athlete eligibility is confirmed through classification systems that are unique to each of the sport's governing bodies.[6,7] Despite a long history, growing popularity, and participation rates,[5] very little is known about injury rates, management, or prevention in disability sports.[8]

There are more than 42 separate published definitions of concussion determined by consensus.[9] The potential short, medium, and long-term consequences of concussion have become major issues in many sports, and these issues are at

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least as (if not more) important for athletes competing in disability sports.[10] The authors of the fourth Consensus Statement on Concussion in Sport acknowledged that "science of concussion is evolving, and therefore management and return-to-play (RTP) decisions remain in the realm of clinical judgment on an individualized basis."[11] However, this consensus neither discusses nor makes reference to the large and growing population of athletes with disability and does not discuss the complex issues associated with managing concussion within disability sports. The position statement on concussion in sport by the American Medical Society for Sports Medicine (AMSSM), nevertheless, raises the issue and outlines complexities associated with managing concussion among athletes with certain disabilities.[12]

It is generally agreed that further research is needed to validate current concussion assessment tools to delineate the role of neuropsychological testing and to improve identification of those at risk of prolonged postconcussive symptoms or other long-term complications.[12] This view is equally valid for disability sport. The Sport Concussion Assessment Tool, third Edition (SCAT3) provides a freely accessible internationally recognized tool supported by many sports governing bodies and describes itself as "the standardized tool for evaluating injured athletes for concussion." The tool is stated to be appropriate for use with all athletes aged 13 years and older.[11,13] Preseason "baseline testing" of athletes with the SCAT3 is recommended in the concussion guidelines, with baseline test results helpful for interpreting postinjury test scores. However, the clinical value of SCAT3 testing when an athlete is well (ie, not concussed), and subsequent follow-up (post-concussion) testing is currently not supported by evidence and neither validated in athletes in general nor in athlete subgroups, such as those with disability.[14] Although SCAT3 has not been validated, it has been generated by consensus and is recommended in clinical practice, thereby carrying certain associated important medico-legal clinical obligations.[15,16]

Hanninen et al[17] recently reported representative normative SCAT3 references values for 304 male professional ice hockey players from Finland in a descriptive cross-sectional study. They split test section scores into cut-off score ranges, based on distribution percentile ranks and categorized these as follows: "Broadly normal," "Above/below average," "Unusually low/high," and "Extremely low/high," accounting for section scores that go up and down respectively and that score distribution was not normally distributed. There have been few studies analyzing non-concussed neurocognitive scores for athletes with disability; and the limited studies available suggest that non-concussed scores for athletes with attention deficit-specific disorders and/or learning disability may differ from athletes without such diagnoses.[18–20] However, none of these studies used the consensus recommended SCAT3 for testing. Other concussion position statements recommend neurocognitive testing more strongly for adolescent athletes at the beginning of a sporting career, athletes with learning disability, athletes with a previous history of concussion, and athletes who have recently suffered concussion.[21–23] The SCAT3 recommends without further specification that it can be used for all athletes from the age of 13 years and makes no inferences on usability for athletes with disability.[11]

In the absence of normative data for SCAT3 scores, and insights into the usability of SCAT3 for athletes with disability, the aim of this study was to determine whether differences exist between baseline SCAT3 scores for footballers with and without disability.

METHODS

Study Design

All England team sports physicians and physiotherapists working for England international football teams commenced recording baseline SCAT3 scores for all players in the season August 2013 to July 2014. In accordance with SCAT3 recommendations, baseline SCAT3 testing was introduced as a mandatory medical requirement by the Football Association in August 2013 for all England players before they train or compete for England, because "preseason baseline testing with the SCAT3 can be helpful for interpreting postinjury test scores."[11] This study provides a descriptive cross-sectional analysis of initial annual baseline SCAT3 test scores for English international footballers playing with and without disability.

Population

The population consisted of a convenience sample of 249 England international footballers after selection for their respective England team (male: 174, female: 75) who underwent SCAT3 baseline assessments. One hundred eighty-five were players without disability (male: 119; female: 66) and 64 with disability (male learning disability: 17; male cerebral palsy: 28; male blind: 10; female deaf: 9).

Age-related SCAT3 differences in year groups younger than 16 years of age are poorly understood.[20,24] To avoid potential cognitive maturation confounding effects during the cross-sectional comparisons, only athletes older than the age of 16 years were included in this study.[9,25,26] The eligibility criteria for players being categorized within each disability football squad were determined by formal international classification criteria.[6,7]

Ethics

University College London Research Ethics Committee confirmed in writing that this study was exempt from the requirement to obtain ethics committee approval, as the study constituted a service provision evaluation of anonymous data extracted without individual identifiers.

Outcome Measures

All England team physicians and physiotherapists performed standardized baseline SCAT3 assessments on players when they were healthy (not concussed). Testing was conducted by experienced medical personnel (English registered and licensed physicians and physiotherapists; (n = 16) who had successfully completed an advanced

resuscitation and emergency aid (AREA) training course, which includes a section on concussion recognition, management, and the application of SCAT3).

The lead author (RW) evaluated every submitted SCAT3 form. SCAT3 forms with incomplete or illegible subsections were excluded (n = 8) from the analysis. Scores for each SCAT3 construct were calculated and recorded in accordance with the SCAT3 guidance,[11,13] including

1. Symptom evaluation: total number (22 items; score range: 0-22) and severity (score range: 0-132);
2. Standardized assessment of concussion (SAC): orientation (score range 0-5), immediate memory (score range: 0-15), and concentration (score range: 0-5); total SAC score range: 0 to 25;
3. Balance examination: modified Balance Error Scoring System (BESS) testing (3 balance tests each with score range: 0-10; total BESS score range: 0-30);
4. Coordination examination (upper limb finger-to-nose test repeated 5 times in less than 4 seconds): upper limb (test failure: 0; test pass: 1); and
5. SAC delayed recall: 5 words from immediate memory test after the balance and coordination examinations (score range: 0-5).

Although total SCAT3 score is not clinically recommended within the SCAT3 tool, it has since been recommended as being clinically useful[25] so total SCAT3 score (range: 0-215) was also calculated by summing each SCAT3 subscore.

Statistical Analyses

IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp, Armonk, New York) was used for statistical analyses. Median scores were compared using the nonparametric Mann–Whitney–Wilcoxon ranked-sum test because the results for SCAT3 subscores are skewed either to zero (eg, the symptom evaluation subscore) or to the maximum score (eg, the cognitive assessment subscore), which allowed null hypotheses to be tested for differences between athletes with and without disability. Statistical significance is accepted for $P \leq 0.05$ values. It is accepted that sex may be a risk factor for concussion and this may influence injury severity;[11,24,27–29] therefore, initial analyses were performed to compare male and female SCAT3 subsection scores to determine if disability athletes should be compared separately by sex.

RESULTS

Participants

Table 1 summarizes the age (mean, SD, and range) and concussion history of the participants in the 6 player-groups. Of the 294 participants, 62 (25.0%) reported having sustained a concussion, but only 8 of these concussions (all from nondisability groups) were sustained in the 6-month period preceding the baseline test. Twenty-seven of the 62 players who reported a previous concussion (43.5%) returned to play/training in less than 6 days. T1

SCAT3 Scores

Table 2 presents differences in median and range values for each SCAT3 section as a function of sex and disability or nondisability status. Comparison of median scores for male and female footballers without disability demonstrated that female scores were higher for the number of symptoms ($P < 0.001$), symptom severity ($P < 0.001$), and orientation ($P = 0.006$), and were lower for the median number of errors on the modified balance error scoring test ($P = 0.003$). T2

Footballers Without Disability Versus Footballers With Disability

Table 3 demonstrates multiple significant differences ($P < 0.05$) between SCAT3 subscores between male footballers with and without disability. All male and female footballers, including blind footballers, were able to complete the finger-to-nose coordination test (scoring one point); therefore, this test was not considered for further analysis. Orientation scores (Table 3) demonstrated no differences between the male footballer groups. Compared with male footballers without disability, male footballers with disability scored significantly higher for symptom severity and footballers who were blind or had cerebral palsy scored significantly higher for total number of symptoms. However, male footballers with learning disability demonstrated no difference with total number of symptoms and scored significantly lower on immediate memory and delayed recall compared with male footballers without disability. Male blind footballers scored significantly higher for total concentration and delayed recall compared with male footballers without disability. Male footballers with cerebral palsy scored significantly higher on balance testing and significantly lower on immediate memory compared with male footballers without disability. Comparison of male footballers with and without disability showed significantly T3

TABLE 1. Characteristics at SCAT3 Assessment for Nonconcussed Footballers With and Without Disability

Footballer Team	No. Athletes	Age Range	Mean Age (Mean ± SD)	No. Players Reporting a Previous Concussion (%)
Learning disability (male)	17	17-24	19.9 ± 2.4	2 (11.8)
Cerebral palsy (male)	28	16-28	19.4 ± 3.5	9 (32.1)
Deaf (female)	9	20-38	24.0 ± 5.6	3 (33.3)
Blind (male)	10	16-42	27.9 ± 7.7	3 (30.0)
Nondisability (male)	119	16-28	17.9 ± 1.7	30 (25.2)
Nondisability (female)	66	16-31	21.0 ± 4.1	15 (22.7)

TABLE 2. SCAT3 Section Baseline Assessment Median and Range Values for Male and Female Footballer Groups With and Without Disability

	Assessment Group; Median (Range) Score					
	Groups Without Disability		Groups With Disability			
SCAT3 Section	Male	Female	Learning Disability, Male	Cerebral Palsy, Male	Blind, Male	Deaf, Female
No. symptoms (max: 22)	0 (0-7)	0 (0-16)	0 (0-5)	1.5 (0-11)	1 (0-18)	1 (0-9)
Symptom severity (max: 132)	0 (0-10)	0 (0-27)	0 (0-15)	2.5 (0-27)	1.5 (0-61)	2 (0-16)
Orientation (max: 5)	5 (3-5)	5 (3-5)	5 (4-5)	5 (3-5)	5 (5-5)	5 (5-5)
Immediate memory (max: 15)	15 (9-15)	15 (13-15)	13 (8-15)	13.5 (9-15)	15 (14-15)	15 (10-15)
Concentration (max: 5)	3 (0-5)	4 (2-5)	3 (0-5)	3 (1-5)	5 (4-5)	2 (1-5)
Delayed recall (max: 5)	4 (0-5)	4 (2-5)	2 (0-5)	4 (0-5)	5 (3-5)	4 (3-5)
Modified BESS (max: 30)	2 (0-11)	1 (0-10)	2 (0-9)	8 (0-30)	0.5 (0-10)	12 (0-30)
Coordination (max: 1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)	1 (1)
TOTAL SCAT3 score (max: 215)	30 (21-45)	31 (21-76)	28 (17-43)	40.5 (23-70)	33 (28-113)	42 (29-79)

higher ($P < 0.001$) total SCAT3 scores for male footballers with cerebral palsy and blindness, compared with male footballers without disability. Comparison of total SCAT3 scores demonstrated no significant differences between male footballers with learning disability and male footballers without disability.

Compared with female footballers without disability, female footballers with deafness scored significantly lower ($P = 0.003$) for total concentration, higher for balance testing ($P < 0.001$), and higher for total SCAT3 ($P < 0.001$) with greater ranges (minimum and maximum both higher) than female athletes without disability (Table 4).

Table 5 compares the results for each group with the classification cut-off ranges calculated by Hanninen et al[17] and demonstrates many large percentage differences within classification ranges between each disability footballer group, professional ice hockey players from Finland, and also male and female footballer groups without disability.

TABLE 3. Comparison of Mann–Whitney–Wilcoxon *P*-values Comparing Non-Concussed Male Disability Footballers With Nondisability Footballers for Each Section Score of SCAT3 Assessment

	Learning Disability	Cerebral Palsy	Blind
Male squad comparison for total number of symptoms score			
Nondisability	0.053	<0.001*	0.001*
Male squad comparison for symptom severity score			
Nondisability	0.043*	<0.001*	0.001*
Male squad comparison for orientation score			
Nondisability	0.664	0.708	0.100
Male squad comparison for immediate memory score			
Nondisability	<0.001*	<0.001*	0.057
Male squad comparison for total concentration score			
Nondisability	0.096	0.056	0.011*
Male squad delayed recall score			
Nondisability	<0.001*	0.085	0.050*
Male squad comparison for total balance score			
Nondisability	0.814	<0.001*	0.183
Male squad comparison for total SCAT3 score			
Nondisability	0.068	<0.001*	0.032*

*Mann–Whitney–Wilcoxon independent samples *P*-value <0.05.

DISCUSSION

This study confirms that significant differences exist between non-concussed SCAT3 subscores for male footballers with learning disability, cerebral palsy, blindness and female footballers with deafness, and their respective male and female footballer groups living without disability. It is not known how these differences affect neurocognitive function or compare with SCAT3 scores after head injury or concussion; however, the assessment of baseline values is important in clinical practice when determining diagnosis and

TABLE 4. Comparison of Mann–Whitney–Wilcoxon *P*-values Comparing Non-Concussed Female Athletes Without Disability and Female Deaf Athletes for Each Section Score of SCAT3 Assessment

	Mann–Whitney *P*
Total number of symptoms (maximum possible 22)	0.130
Symptom severity score (maximum possible 132)	0.141
Orientation score (maximum possible 5)	0.451
Immediate memory score (maximum possible 15)	0.925
Total concentration score (maximum possible 5)	0.003*
Delayed recall score (maximum possible 5)	0.391
Modified balance error scoring system testing (maximum possible 30)	<0.001*
Coordination	1.0
TOTAL SCAT3 score (maximum possible 215)	<0.001*

*Mann–Whitney–Wilcoxon independent samples *P*-value <0.05.

TABLE 5. Comparison of SCAT3 Normative Classification Reference Ranges for Healthy Male Professional Ice Hockey Players[17] Compared With Footballer Groups With and Without Disability

	Assessment Group; % in Range							
	Groups Without Disability							
	Male Professional Ice Hockey				Male Football			
SCAT3 Section	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)
No. symptoms (max: 22)	80	10	8	2	98	2	2	0
Symptom severity (max: 132)	83	8	8	2	96	11	8	0
Orientation (max: 5)	92	N/A	6	1	78	N/A	19	3
Immediate memory (max: 15)	94	N/A	6	1	79	N/A	13	8
Concentration (max: 5)	98	N/A	3	0	79	N/A	13	8
Delayed recall (max: 5)	88	7	4	0	89	8	1	2
Modified BESS (max: 30)	84	13	3	0	81	14	4	1

	Assessment Group; % in Range			
	Groups Without Disability			
	Female Football			
SCAT3 Section	Broadly Normal (%)	Below/Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)
No. symptoms (max: 22)	83	9	6	2
Symptom severity (max: 132)	83	8	8	2
Orientation (max: 5)	94	N/A	5	2
Immediate memory (max: 15)	91	N/A	9	0
Concentration (max: 5)	94	N/A	6	0
Delayed recall (max: 5)	89	11	0	0
Modified BESS (max: 30)	86	5	9	0

	Assessment Group; % in Range							
	Groups With Disability							
	Learning Disability, Male				Cerebral Palsy, Male			
SCAT3 Section	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)
No. symptoms (max: 22)	88	6	6	0	71	4	21	4
Symptom severity (max: 132)	71	6	24	0	61	11	25	4
Orientation (max: 5)	82	N/A	18	0	75	N/A	21	4
Immediate memory (max: 15)	47	N/A	12	41	50	N/A	11	39
Concentration (max: 5)	65	N/A	6	29	64	N/A	18	18
Delayed recall (max: 5)	47	18	12	24	86	11	0	4
Modified BESS (max: 30)	77	12	12	0	18	11	39	32

	Assessment Group; % in Range							
	Groups With Disability							
	Blind, Male				Deaf, Female			
SCAT3 Section	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)	Broadly Normal (%)	Below/ Above Average (%)	Unusually Low/High (%)	Extremely Low/High (%)
No. symptoms (max: 22)	60	20	0	20	56	0	44	0
Symptom severity (max: 132)	70	10	0	20	67	0	33	0
Orientation (max: 5)	100	N/A	0	0	100	N/A	0	0
Immediate memory (max: 15)	100	N/A	0	0	78	N/A	0	22
Concentration (max: 5)	100	N/A	0	0	44	N/A	44	11
Delayed recall (max: 5)	100	0	0	0	100	0	0	0
Modified BESS (max: 30)	80	10	10	0	11	0	33	56

management of a player after head injury. This suggests there is a need to develop greater understanding of the clinimetric properties and validity of each SCAT3 subscore against a gold standard and the reproducibility of SCAT3 findings. Although the use of SCAT3 as a baseline tool for evaluating concussion is not validated, multiple differences seen in nonconcussed footballers within this study clearly demonstrate there are cross-sectional neurocognitive differences between footballers living with and without disability. These results suggest the SCAT3 assessment tool may not be applicable for athletes with disability and therefore test-specific validation and reliability assessments are required for these different user groups.

Male footballers with learning disability had significantly lower cognitive scores for immediate memory and delayed recall compared with male footballers without disability. The sport eligibility criteria for those with learning disability require significant impairment in intellectual functioning (defined as a 'Full Scale IQ score of 75 or lower) and limitation in intellectual functioning and adaptive behavior expressed in conceptual, social, and practical adaptive skills, which originates before the age of 18 years. Therefore, these differences in cognitive function are, perhaps, entirely expected.[6,7,30] This suggests that (1) SCAT3 cognitive assessment may not be appropriate and modified SCAT3 assessment is needed for this subgroup; and (2) clinicians should always consider the presence of athlete learning disability, which could be diagnosed, undiagnosed, or unknown.

Male blind footballers scored higher than male footballers without disability for total concentration and delayed recall, which supports studies among blind nonathletes showing improved brain plasticity and neurocognitive function resulting in improved memory.[31,32] The impact of a head injury and the sensitivity of neurocognitive changes after concussion are not known for blind footballers, which is surprising considering that head and face injuries in this group are relatively common injuries.[33] Cerebral palsy and neural-impairment conditions eligible for cerebral palsy football are defined by the World Health Organization's International Classification of Functioning as limiting a person's "functioning," [inclusive of body structures (eg, limbs), body functions (eg, intellectual function), activities (eg, walking), and participation (eg, playing sport)], which in turn may cause "disabilities," such as impairments, activity limitations, and participation restrictions.[34,35] Therefore, higher numbers of errors on balance tests and a lower cognitive SCAT3 score are to be expected, and these differences again suggest that the SCAT3 may not be an appropriate neurocognitive test for this subpopulation of elite athletes with disability.

Compared with their counterparts without disability, male footballers with cerebral palsy and blindness reported significantly different and greater numbers of concussive symptoms. Male footballers with learning disability, cerebral palsy, and blindness have significantly higher baseline concussion symptom severity scores than male footballers without disability. The reasons for these differences are unclear and may vary across disability and population subgroups. The results suggest that SCAT3 symptoms are a more normal experience for footballers with learning disability, cerebral palsy, and blindness and, when reported, are experienced more severely than for footballers without disability.

Total SCAT3 scores for female footballers with deafness were significantly higher than female footballers without disability, whereas deaf athletes scored significantly higher for total concentration and balance testing. Only a small proportion of people with hearing loss have problems with balance,[36] and this is more likely a result of an acquired acoustic trauma or ototoxins.[37] Use of BESS within SCAT3 is problematic, because proprioception can be learnt and improved by children with deafness[38] and is also a common method used by sporting populations to prevent injury.[39] It was beyond the scope of our study to analyze use and concordance of proprioception programs for individual athletes, but this may have affected results. SCAT3 guidance does not suggest that clinicians take such programs into account.

Our results for each disability football group were compared with Hanninen et al reference ranges: "Broadly normal," Below/above average," "Unusually low/high," and "Extremely low/high."[17] Many large differences are evident between percentages of athletes within SCAT3 subsection score classification cut-off ranges, when comparing each footballer disability group and athletes without disability. The majority of percentages were much lower; however, blind male footballers all scored "broadly normal" for orientation, immediate memory, concentration and delayed recall, and deaf female footballers all scored "broadly normal" for orientation and delayed recall. These results further suggest that reference ranges for athletes without disability are not appropriate for athletes with disability, and differences are seen in neurocognitive function at baseline between disability groups.

The results presented in this study relate to relatively small sample populations and limited ranges of disabilities and forms of adapted football; however, the results strongly suggest that further studies are required to understand the complexities of concussion diagnosis in disability sport. Future research should therefore include larger sample populations, athletes with other disabilities, and athletes from other sports to develop more robust versions of SCAT for disability sport.

Little is known about concussion for athletes with disability, and previous guidelines have therefore not been able to provide more specific guidance. Future concussion consensus group research recommendations have suggested the looking at efficacy for inclusion of vision tests such as King–Devick and clinical reaction time tests, which will have limitations for many athletes with disability including those with visual impairment[8,40,41] or neuromuscular impairment, such as cerebral palsy. Furthermore, learning disability often goes unrecognized in sporting environments. In England (and many other countries), there are no records of the number of people with learning disabilities,[42] so it is unsurprising that the incidence of learning disability in sport also remains unknown. The AMSSM Position Statement on concussion in sport[12] recognized that learning and attention disorders share many common features with concussion, such as difficulty with memory, attention, and concentration.[18–20] These are included in SCAT3 at baseline and

postconcussion generating clinical implications. AMSSM therefore concluded that baseline testing was "more important in those with learning disability or attention disorders if testing is going to be used postinjury to assist in return-to-play decisions."[12] Our results support the importance of this conclusion, as we found nonconcussed athletes with learning disability, cerebral palsy, deafness, and blindness share many features with concussion when measured with SCAT3. Although it is not known how these SCAT3 scores may change when measured postconcussion for athletes within these disability groups, the differences in numerical subscores at baseline do not support the use of the whole SCAT3 as an assessment tool for athletes with disability as they will change the sensitivity and specificity.

Normative nonconcussed neurocognitive differences between footballers with disability have important implications on the sensitivity and specificity of many other clinical tests, such as musculoskeletal and neuromuscular tests. All of these clinical tests require neural (for movement) and cognitive elements to be performed and, to our knowledge, none have been validated in disability populations. Furthermore, if injury rates within disability sport are unknown[8,43] and the diagnostic accuracy of clinical tests for athletes with disability are suspected to be different, then barriers to accurate diagnosis, improved recognition and management of concussion, and other sports injuries may hamper research within disability sport.

CONCLUSIONS

The results of this study suggest that significant cross-sectional differences exist between SCAT3 baseline section scores for footballers with disability and footballers without disability. Therefore, caution is needed when interpreting baseline SCAT3 scores for athletes with disability. Normative values and postconcussion SCAT3 score sensitivity for athletes with disability remain unclear. Clinicians therefore must consider the presence of disability in athletes when using SCAT3, which has important implications in wider clinical practice (eg, the presence of learning disability may be unknown, undiagnosed or not considered). There is an evident need to develop greater understanding of the clinimetric properties (ie, validity and reliability) of each SCAT3 subtest. Concussion consensus guidelines should recognize these differences and produce guidelines and assessment tools that are specific for the growing number of elite athletes living with disability.

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