Research

Creation of Argentina-Sports Concussion Assessment & Research Study (Arg-SCARS): study protocol

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Creación del protocol Argentina-Sports Concussion Assessment & Research Study (Arg-SCARS)

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Abstract

There is an urgent need for an improved understanding of the relationship between repetitive sports concussion and cognitive decline risk. The Argentina- Sports Concussion Assessment & Research Study (Arg-SCARS) explores the link between repetitive sports concussion and cognitive function decline in rugby players. Its objective is to describe the study design and the preliminary results concerning clinical profiles of rugby players following sports concussion. The current paper is a descriptive study of select characteristics and clinical symptoms identified from concussed athletes within 72 h after the injury. The 92 participants had an average age of 22.64 years and had been playing rugby for a mean of 14.72 years. 66.3% had history of concussions, with an average number of clinical concussions of 1.94. The mean of symptoms reported on Post-Concussion Symptoms Scale was 5.41. The mean symptom severity score was 14.49. Acute concussion symptoms, Beck's Depression Inventory and attentional composite score were significantly predictive of symptoms within the first 72h following concussion. As conclusions it was possible to recognize the full spectrum of post-concussion related situations is essential to monitor recovery and tailor interventions for specific cases. Arg-SCARS's findings will help understand the influence of repetitive head trauma in the progress of neurological damage in athletes.

Keywords: Concussion; sports; cognition; cohort; traumatic brain injury; symptoms; assessment; dementia; cognitive impairment; rugby; athletes; longitudinal study.

Resumen

Argentina- Sport Concussion Assessment & Research Study (Arg-SCARS) es un estudio prospectivo y observacional que analiza el vínculo entre las conmociones cerebrales reiteradas y el deterioro cognitivo en jugadores de rugby. Su objetivo es describir el diseño del estudio y los resultados clínicos preliminares en deportistas tras sufrir conmociones cerebrales en el campo de juego. Se describen características y síntomas identificados en las 72 horas siguientes a una conmoción cerebral. De 92 participantes con edad media de 22.64 años y una media de 14.72 años practicando rugby, el 66.3 % tenían antecedentes de traumatismos cerebrales, con una media de 1.94 traumatismos. La media de síntomas informados en la Escala de Síntomas Posconmoción fue 5.41, y el puntaje medio de 14.49. Los síntomas agudos, el Inventario de Depresión de Beck y el puntaje de atención fueron muy predictores de los síntomas de las primeras 72 horas tras estas lesiones. Como conclusiones se pudo reconocer todas las situaciones posteriores a una conmoción cerebral es esencial para supervisar la recuperación y personalizar intervenciones. Los hallazgos ayudarán a comprender cómo influyen los traumatismos cerebrales reiterados en el deterioro neurológico.

Palabras clave: Conmoción cerebral; deporte; cognición; cohorte; lesión cerebral traumática; síntomas; evaluación; demencia; deterioro cognitivo; rugby; atletas; estudio longitudinal.

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Introduction

Athletes —especially those who play contact sports like football, rugby, or hockey— are at higher risk for multiple concussions than the general people (Abrahams et al., 2014; Russo et al., 2020). It is known that sustaining one concussion means that athletes are at risk for more brain injury and for persistent symptoms (McAllister & McCrea, 2017; McMillan et al., 2017). Late studies have shown a link between multiple sports concussions and a higher risk of progressing a neurodegenerative disease at older ages. Traumatic brain injuries have been usually considered indicative of a risk factor for conditions like dementia of the Alzheimer type (Fann et al., 2018; Li et al., 2017) and have been associated with early cognitive decline (Hume et al., 2017). However, the paradigm has recently changed, and it has become clear that repetitive head trauma can progress to a progressive neurodegenerative disorder called Chronic Traumatic Encephalopathy (CTE) (McKee et al., 2016; Omalu et al., 2005). It is necessary to understand the link between repetitive sports concussion and cognitive impairment since sports concussion prevention may prevent the late neurodegeneration.

The Argentina-Sports Concussion Assessment & Research Study (Arg-SCARS) combines neurological and cognitive markers in rugby union players within the continuum of brain injury from sports concussion to long-term consequences. The more that is known about the acute and subacute phase of sports-related concussion, the greater the understanding of the long-term impact.

In this manuscript, we describe the design, methodological aspects, and underlying objectives for the Arg-SCARS. We present the general procedures for blood samples, MRI scans, and neuropsychological assessments protocols. The current study is essentially a descriptive study of select post-concussion characteristics, as well as acute and subacute clinical signs/symptoms following sport-related concussion. We discuss the key hypotheses for the study related to the association between sports concussion and continuum of clinical severity.

Materials and Methods

Structure and design of the study

Arg-SCARS is a non-randomized natural history non-treatment study of rugby union players. All aspects of the study will be completed at Fleni clinic located in Buenos Aires, Argentina.

Participants

The Arg-SCARS proposes to enlist subjects from two groups (Table 1): 1- Rugby athletes immediately following concussion ("active players cohort"), and 2- Retired rugby players with and without a previous history of sports concussions ("retired players cohort").

Table 1.
Evaluation instruments in Active and Retired players.

	Active Players	Retired Players
Clinical interview.	+	+
Subjective reporting of symptoms.	+	+
Cognitive testing.	+	+
Behavioral questionnaires.	+	+
Vestibular-Oculomotor screening.	+	+
Blood sample collection.	–	+
Structural Neuroimaging.	–	+

Source: Authors.

For the first cohort study, players from 18 to 35 years old have been enrolling since January 2018. All subjects are evaluated in a uniform manner within the first 72 h after sport concussion, using the Arg-SCARS protocol. The comprehensive, multimodal diagnostic evaluation includes a clinical interview, a subjective description of symptoms, neuropsychological testing, and vestibular-oculomotor screening. To date, we have 92 subjects, of 113 who were screened. The calculated total number of participants is 200 as part of this cohort of players. Included subjects will undergo biannual remote assessment. Since, current recommendations does not support a significant added benefit of baseline testing athletes, we will only consider the evaluation within the first 72 h after sports concussion and the follow-up visits.

The main objectives of this sub-study will be: 1) describe the conceptual design and implementation of Arg-SCARS protocol; 2) determinate a profile-based model for conceptualizing the short-term effect of concussion; 3) explore changing and related factors for the development of clinical symptoms in the acute and subacute phase; 4) develop of specific recommendations and strategies for the prevention of repeated concussions.

The second cohort consisting of at least 140 retired rugby union players with and without prior concussion history and 30 healthy men without any history of participation in contact sports, will begin in early 2022. All subjects will be evaluated in a standardized way at entry and longitudinally thereafter with instruments that include a clinical assessment, a cognitive test battery, a blood sample, and a structural neuroimaging. In all participants, neuropsychological functioning will be assessed at biannual intervals for 12-year follow-up.

Outcome measures will include: 1) rate of change for each neuropsychological test; 2) rates of brain volume changes by magnetic resonance imaging; 3) rates of change for biological markers of brain injury in blood; 4) group differences for each neuropsychological test and biomarker measurement; 5) assessing interrelationships among cognitive results and biomarkers.

Structural organization of the Arg-SCARS

The Arg-SCARS is overseen by a multidisciplinary team and is comprised of five core teams (Figure 1), each of which are directed by a core leadership group.

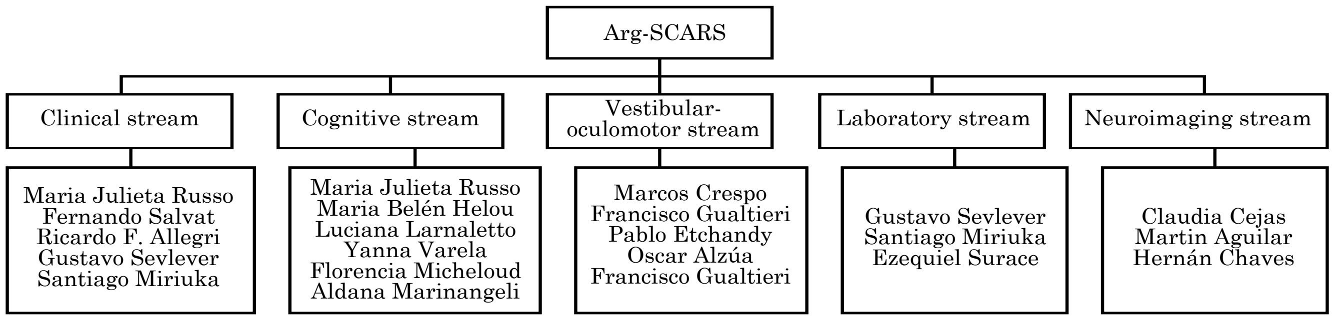

Figure 1. Arg-SCARS Protocol
Source: Authors.

The Arg-SCARS clinical stream

The clinical team is the mainstay in the Arg-SCARS protocol. For the “active players cohort”, athletes who have been removed from competition and diagnosed with a suspected or confirmed concussion are referred for a comprehensive neurological evaluation. Follow-up office-based evaluation occurs within the first 72 h, to reassess the rugby player, confirm the diagnosis and make further management decisions by a qualified professional team skilled in concussion assessment and management. The multimodal comprehensive assessment includes taking a history and physical evaluation, review of clinical domains, and examination and screen for post-concussive symptoms. This information is integrated with the neurocognitive data and vestibular-oculomotor assessment in reaching the conclusions and recommendations presented in a clinical report. Finally, the sports medicine specialist not only communicate with the club but also their player family to ensure there is full understanding and cooperation in the management of their concussion, along with their return to work/learning and playing.

For the “retired players cohort”, all participants will be studied with a semi-structured neurological protocol, clinical and neurological examination, and a set of neurocognitive and behavioral questionnaires. Initial visit consists of explaining the research protocol, getting informed consent and demographic data, deciding inclusion/exclusion criteria, acquiring a medical record, conducting a physical assessment and a neurological examination, administering neuropsychological tests and behavioral questionnaires, obtaining vital signs, conducting blood sampling for blood bank, determining current medications, and making a magnetic resonance image. Follow-up visits will be at biannual intervals for 12-year follow-up.

The Arg-SCARS cognitive stream

Neuropsychological testing is considered a “cornerstone” in the Arg-SCARS protocol. It has clinical benefit and provides significant data as part of the multimodal and multidisciplinary assessment of sports in concussion palyers. A neuropsychological test battery could have added value in the early stages after brain injury. First, cognitive deficits associated with concussion have been described as typically subtle and may exist in several domains. The disorders that are most frequently reported include less attentional span, slower information processing speed and compromise in recent memory. Second, the use of cognitive tests in the management of sports concussion is superior to the characterization of the subjective symptoms of the players, since it is known that they are poorly recognized and variably reported, and allows detecting cognitive deficits, which have been observed to last longer than symptoms in many cases of concussion. Finally, it has been reported that within 72 hours of a concussion, athletes show a lower performance in tests of memory and speed of information processing. Furthermore, athletes with a sports concussion have shown a 47-fold greater decline in 2 or more of the cognitive domains assessed compared to subjects without a concussion.

On the other hand, concussion may lead to secondary cognitive deficits, psychological issues, and psychiatric disorders years after retiring from sports. An extensive and comprehensive cognitive evaluation in each of the visits scheduled over the course of 12 years will allow us to predict cognitive trajectories over time. Also, the same cognitive battery will be doing in retired athletes.

Table 2.
Neurocognitive assessments for the Argentina-SCARS.

Mini Mental State Examination (Allegri RF et al., 1999; Butman et al., 2001; Folstein et al., 1975).
Clock Drawing Test (Freedman MI, 1994).
Logical Memory Subtest of the Wechsler Memory Scale-IV (Wechsler D., 2009).
Rey Auditory Verbal Learning Test (Rey A., 1964).
Boston Naming Test (Kaplan EF, 1994).
Categorical and Phonological Fluency Test (Morris et al., 1989).
Digit Span Test (Wechsler D., 1981).
Trail Making Test, parts A and B (Reitan RM., 1958).
Working Memory Index (WMI) of the Wechsler Adult Intelligence Scale III (Wechsler, 1997).
Arithmetic.
Digit Span.
Letter-number sequencing.
Processing Speed Index (PSI) of the Wechsler Adult Intelligence Scale III.
Digit Symbol-Coding.
Symbol Search.
Frontal Assessment Battery (FAB) (Dubois et al., 2000).
Spanish version of the Dysexecutive Questionnaire (DEX-Sp) (Pedrero et al., 2009).
Functional Activities Questionnaire (Pfeffer et al., 1982).
Neuropsychiatric Inventory Q (Kaufer et al., 2000).
Scale of Cognitive Reserve (León et al., 2011).
NEO Five-Factor Inventory (NEO-FFI) (Costa & McCrae, 1992).
Beck's Depression Inventory (Beck et al., 1961).
Short version of the UPPS-P Impulsive Behavior Scale (Cándido et al., 2012).
Athletic Coping Skills Inventory 28 (ACSI-28) (Graupera Sanz et al., 2011; Smith et al., 2016).
Sport Anxiety Scale-2 (SAS-2) (Ramis et al., 2010; Smith et al., 2006).
Brain Injury-Clinical Impairment Rating (Russo, Salvat, & Sevlever, 2020).

Source: Authors.

The Arg-SCARS vestibular-oculomotor stream

Concussions can directly impair vestibular-oculomotor function. Vestibular symptoms have been reported to be the most common complaint in concussion patients. The Arg-SCARS protocol includes a brief 10-minute concussion screening assessment. Assessment of smooth pursuit, saccadic eye movements, convergence, and vestibular-ocular reflex is part of the neuro-ophthalmological clinical examination.

Vestibular assessment includes the Sensory Organization Test and the Balance Error Scoring System (BESS). To detect balance differences in these concussion population, an instrumented balance-testing in a specialized gait and motion analysis lab is performed. We use 1) the BTS SMART DX7000 system composed of 10 cameras, with a resolution of 4 Mpixel each and a maximum frame rate of 500 fps; 2) 6 BTS P6000 force platforms, which measure ground reaction forces throughout its surface, allowing an interpretation of static and dynamic postural status; and 3) the BTS FREEEMG, a wireless system for real-time motion and surface EMG analysis.

The Arg-SCARS laboratory stream

Blood (separated into plasma and serum) from "retired rugby union players cohort" will be collected at each face-to-face clinical study visit to the Research Center. Polypropylene tubes will be utilized for the plasma and serum samples. Overnight fast is a requirement for plasma and serum sample acquisition.

When plasma and serum samples are stored in the Fluid Bank Laboratory. All samples will be followed using a specific software. A database will be created and used for the inventory of stored samples, in conjunction with a bar code reading system. Measurement of each participant's blood-based biomarker (APOE, Phospho-Tau, Neurofilament Light Chain) levels will be collected through blood sampling. All samples will be frozen for future measurements.

The Arg-SCARS neuroimaging stream

All subjects newly enrolled into "retired rugby union players cohort" of Arg-SCARS will be scanned using a specific 3T MRI protocol. The MRI protocol includes 1) structural MRI, 2) FLAIR, 3) SWAN (Susceptibility-Weighted Angiography), and 4) DTI (Diffusion Tensor Imaging). Structural MRI will be used as a measure of the rate of change as well as a predictor of cognitive decline. Cerebrovascular disease will be measured with FLAIR sequence. Microbleed associated with traumatic brain injury, particularly at gray-white matter junction may have diagnostic and prognostic implications, and possibly an imaging biomarker in sports concussion. Microbleeds will be measured with SWAN. Finally, DTI will allow to assess the indemnity of white matter fibers (DTI).

Data analysis

Statistical analyses were performed with SPSS 21.0. The data calculated were the frequencies or average of the demographic, neuropsychological, and clinical characteristics at post-concussion visit of the "active rugby players cohort." To describe the pattern of acute and subacute symptoms following sports concussion as an indicator of brain injury severity, subjects were split up into two groups between those who were self-referred symptomatic versus those who were asymptomatic. All demographic, clinical, and cognitive data were compared between these two groups. The 2-tailed Mann–Whitney U test for quantitative variables and the X2 test for dichotomous variables were used. Besides, a linear regression analysis was undertaken to explore the association of total Post-Concussion Symptoms Scale score within 72 h following concussion and a range of demographic factors including age, playing career length (years), primary observing sign of concussion, Beck's Depression Inventory score, and episodic memory, attentional, language, and executive functioning composite scores. A p-value of less than 0.05 was considered significant.

Survey and image data are uploaded into an ancillary Arg-SCARS study database at Fleni (documentation available upon request). All participants are identified using a unique study identifier. No personal identification information is included. Survey variables are coded responses. All imaging and non-imaging data collected during the study, are de-identified and electronically stored.

Quality assurance

In accordance with Arg-SCARS infrastructure, we have research-based documentation of all procedures and databases, cleaning of data and locking of completed databases at FLENI prior to analysis, clinical monitoring of data, as well as computerized data editing. During each protocol, computerized data checks are implemented by researchers to confirm that participants meet inclusion and exclusion criteria at the time of entry, identify missing or out-of-range items, identify any duplicate entries into the database, evaluate longitudinal consistency between visits, and track participant status in the protocol (active vs. discontinued). Requests for corrections, rescans, etc. are made.

Ethical considerations

All aspects of the study were approved by the FLENI Institutional Review Board (IRB) on August 1, 2021 (documentation available upon request). All participants give informed consent. Extensive information is provided to the participants regarding risks and benefits. Participants are ensured that all data collected as part of the project are secure. Computers and websites are password protected.

Results

The present study is essentially a descriptive study of select baseline, as well as acute and subacute clinical signs/symptoms following sport-related concussion. A brief report of "active rugby players cohort" is presented. A sample of 92 concussed rugby athletes participated in the current study. Demographic and baseline and postinjury variables are presented in Table 3. The average age of the participants was 22.64 (SD: 4.43; range: 17–34), and their mean education was 14.39 (SD: 2.93; range: 11–25). The mean number of years playing rugby was 14.72 (SD: 5.54; range: 3–29). 66.3% (n = 61) had history of prior concussion, with an average number of clinical concussions of 1.94 (SD: 3.04; range: 0–15). Participants played across different competitive levels, being the group of amateur players (82.6%). Forwards and backs playing position showed a similar distribution (53.8 and 42.2%, respectively). The most frequent injury mechanism was knee to head contact (31.9%), followed by head-to-head contact (23.6%). The two most common contact phases of the game related to sports concussion were tackling (68.5%) and being tackled (10.9%). 77.3% were removed from play after a confirmed or suspected concussion.

Table 3.
Demographic, neuropsychological, and clinical features at baseline visit of the "active rugby players cohort".

Variables	Mean ± SD / %
Age, X ± SD	22.64 ± 4.43
Education, X ± SD	14.39 ± 2.93
Number of years in rugby, X ± SD	14.72 ± 5.55
Risk Modifiers for Concussion and Prolonged Recovery	
History of Prior Concussion, %	66.30
Number of clinical concussions, X ± SD	1.94 ± 3.04
History of Hospitalization or Neuroimaging for prior concussion, %	46.70
Migraine and Migraine-like Symptoms, %	5.40
Mood Disorders, %	2.20
Attention Deficit/Hyperactivity Disorder and Learning Disability, %	6.50
Level, %	
Professional	15.20
Semi-professional	2.20
Amateur	82.60
Playing positions, %	
Front row	13.20
Second row	13.20
Back row	27.50
Half-backs	7.70
Centre	17.60
Wing	8.80
Full back	12.10

Variables	Mean ± SD / %
Match/Training, %	
Match	89.80
Training	10.20
Mechanisms of head injuries, %	
Head / Knee	31.90
Head / Head	23.60
Unknown	12.50
Head / Shoulder	9.70
Head / Hip	8.30
Head / Field	5.60
Head / Arm	4.20
Head / Foot	4.20
Collision type, %	
Opponent player	76.40
Teammate	15.30
Ground	4.20
Unknown	4.20
Contact phases of the game, %	
"Tackling"	68.50
"Being tackled"	10.90
Unknown	7.60
Ruck or Maul	6.50
Collision	6.50
Removal From Play After Concussion, %	77.30
Observed concussion signs, %	33.30
Reported concussion symptoms, %	66.70
Number of reported concussion symptoms at time of concussion , X ± SD	1.45 ± 1.54
Headache, %	43.30
"Pressure in head", %	12.20
Nausea or vomiting, %	12.20
Dizziness, %	32.20
Balance problems , %	4.40
Sensitivity to light, %	19.60
Feeling like "in a fog", %	5.60
"Don't feel right", %	18.90

Variables	Mean ± SD / %
Number of observed concussion signs, X ± SD	2.14 ± 1.40
Confirmed loss of consciousness, %	40.00
Suspected loss of consciousness, %	12.20
Ataxia, %	32.20
Definite confusion, %	41.10
Disorientation in time, place and/or person, %	16.70
Memory impairment, %	44.40
Motor disturbance, %	10.00
Tonic posturing, %	3.30
Convulsion, %	0.00
Post-Concussion Symptom questionnaire	
Physical symptoms, %	
Headache	66.30
"Pressure in head"	31.50
Neck pain	44.60
Nausea or vomiting	25.01
Dizziness	38.04
Blurred Vision	20.60
Balance disturbance	18.50
Sensitivity to light	19.60
Sensitivity to noise	8.70
Feeling slowed down	20.60
Feeling like "in a fog"	21.70
"Don't feel right"	36.90
Fatigue or low energy	35.90
Cognitive symptoms, %	
Difficulty concentrating	31.50
Difficulty remembering	23.90
Confusion	23.90
Sleep symptoms, %	
Drowsiness	30.40
Trouble falling asleep	11.90
Emotional and mood symptoms, %	
Feeling more emotional	7.60
Irritability	8.70
Sadness	14.10
Nervous or Anxious	15.20

Variables	Mean ± SD / %
Total number of Post-Concussion symptoms, M ± SD	5.41 ± 4.48
Post-Concussion symptom severity score, M ± SD	14.49 ± 18.32
Post-Traumatic Amnesia, %	47.25
Duration of Post-Traumatic Amnesia, %	47.25
< 5 minutes	23.40
5 - 60 minutes	51.06
1 - 24 hours	17.02
1 - 7 days	8.51
Cognitive Examination, X ± SD	
Mini-Mental State Examination Test	29.46 ± 0.70
WMS-IV-Logical Memory (Immediate Recall)	23.24 ± 5.57
WMS-IV-Logical Memory (Delayed Recall)	19.85 ± 6.47
WMS-IV-Logical Memory (Recognition)	17.14 ± 2.60
RAVLT-Total	51.26 ± 8.36
RAVLT-Delayed recall	11.32 ± 2.77
RAVLT-Recognition	13.54 ± 1.75
Boston Naming Test	27.18 ± 1.94
Categorical Fluency Test	22.04 ± 4.46
Phonological Fluency Test	15.16 ± 3.74
WAIS III-Digit Span	9.67 ± 2.57
WAIS III-Arithmetic	10.29 ± 3.14
WAIS III-Letter-number sequencing	10.29 ± 3.19
WAIS III-Working Memory Index	98.89 ± 16.37
WAIS III-Digit Symbol-Coding	9.34 ± 2.39
WAIS III-Symbol Search	12.13 ± 9.50
WAIS III-Processing Speed Index	100.48 ± 15.45
Trail Making A (seconds)	23.95 ± 7.3
Trail Making B (seconds)	57.88 ± 19.43
Frontal Assessment Battery	17.66 ± 0.88
Beck's Depression Inventory - amount of symptoms	1.54 ± 2.10
Beck's Depression Inventory - total score	1.65 ± 2.33

Abbreviations: RAVLT, Rey Auditory Verbal Learning Test; WAIS-III, Wechsler Adult Intelligence Scale-III; WMS-IV, Wechsler Memory Scale-IV.

Headache was the most described symptom, presenting in 43.3% (n = 40) of sports concussions. The percentages of primary reporting symptoms are showed in Figure 2. More than one symptom was recorded by 64.1% (n = 59) of athletes. Confirmed loss of consciousness was the most common primary observing sign by another (physician, coach, referee, etc.), being reported in 40% (n = 36) of concussions. The percentages of primary observing signs are showed in Figure 3.

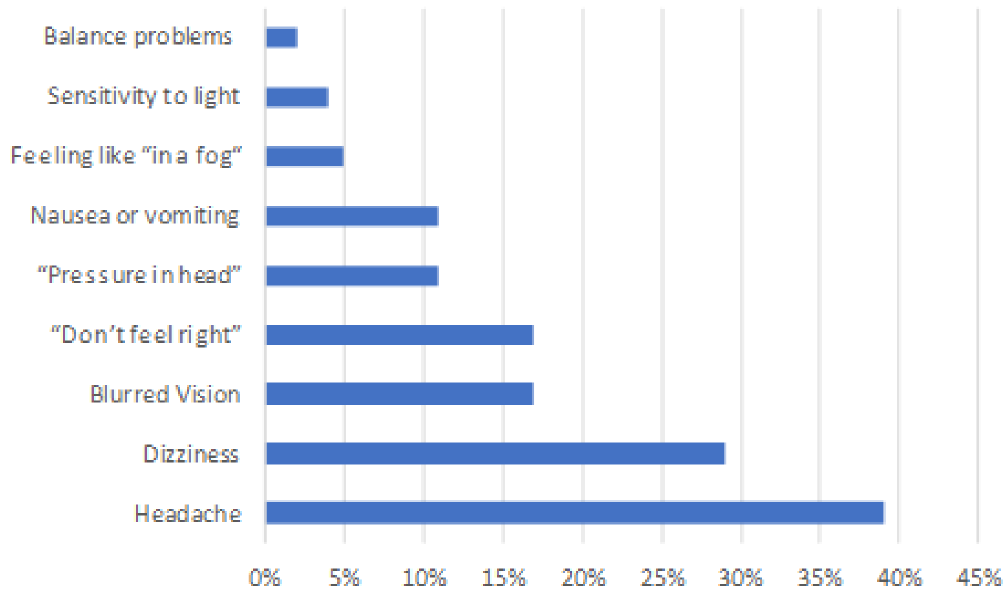

Figure 2. Reported concussion symptoms at time of concussion
Source: Authors.

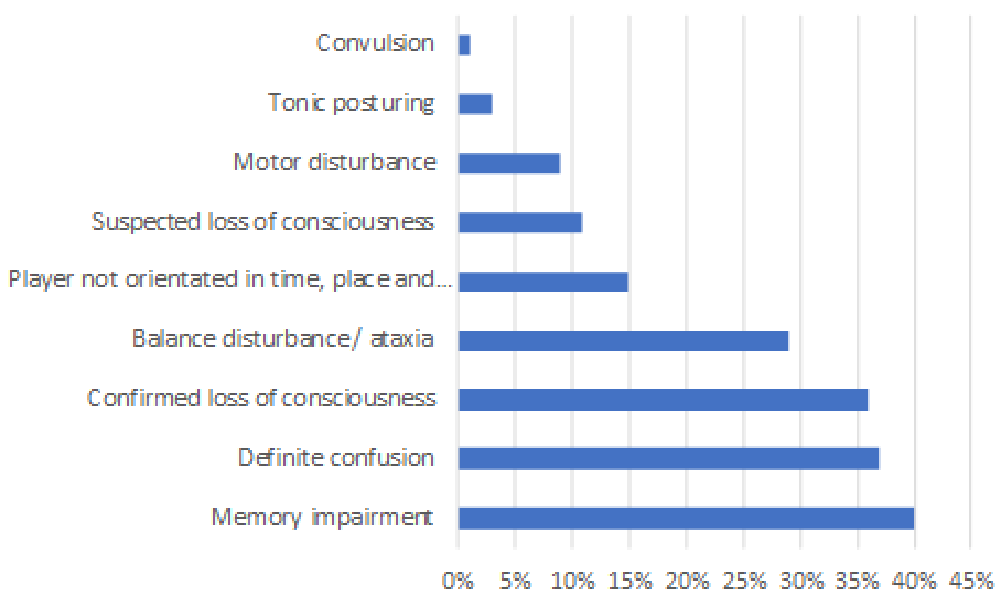

Figure 3. Number of observed concussion signs.
Source: Authors.

Data regarding office-based symptom assessment was accessible for 100% of participants. The mean of symptoms reported on PCSS forms were 5.41 (SD: 4.48; range: 0–17). The mean symptom severity scores were 14.49 (SD: 18.32; range: 0–96). Headache was the most frequent somatic symptom (66.3%). Nervousness/anxiety (15.20%) and sadness (14.10%) were the most frequent emotional and mood symptoms. Approximately 30% reported symptoms related to cognitive functioning or sleep pattern.

Episodic memory and working memory composite scores were below average using norm referenced test data in 13.2% and 10.2%, respectively.

When participants with and without immediate report of symptoms related to sport concussion were compared (Table 4), we observed that those subjects with presence of immediate reported symptoms showed a higher number of observed concussion signs (U = 700.50 , p = 0.038) a higher number (U = 481.50 , p = <0.001) and severity (U = 500.10 , p = 0.001) score of Post-Concussion symptoms, a higher amount (U = 693.00, p = 0.027) and severity (U = 702.50 , p = 0.032) score in the Beck's Depression Inventory, and a lower arithmetic performance (U = 630.50 , p = 0.047) in the cognitive assessment.

Table 4.
Comparisons between participants with and without immediate report of symptoms related to sports concussion.

	Absence of immediate reported symptoms	Presence of immediate reported symptoms	U	p
	Mean rank	Mean rank		
Age	49.02	45.22	867.500	0.518
Education	46.00	46.75	930.000	0.895
Number of years playing rugby	47.84	44.39	816.500	0.556
Number of clinical concussions	42.95	46.71	810.500	0.509
Number of observed concussion signs	38.60	50.52	700.500	0.038
Total number of Post-Concussion symptoms	31.53	54.11	481.500	0.000
Post-Concussion symptom severity score	32.29	51.78	501.500	0.001
Duration of Post-Traumatic Amnesia	40.23	49.69	751.000	0.084
Mini-Mental State Examination Test	45.24	47.14	906.500	0.715
WMS-IV - Logical Memory (Immediate Recall)	53.16	43.11	739.000	0.087
WMS-IV - Logical Memory (Delayed Recall)	48.18	45.65	893.500	0.667
WMS-IV - Logical Memory (Recognition)	52.60	41.95	687.000	0.064
RAVLT - Total	47.15	46.17	925.000	0.869
RAVLT - Delayed recall	43.84	47.12	863.000	0.572
RAVLT - Recognition	45.69	46.16	920.500	0.934
Boston Naming Test	48.50	45.48	883.500	0.602
Categorical Fluency Test	45.76	46.88	922.500	0.849
Phonological Fluency Test	49.34	45.06	857.500	0.466
WAIS III - Digit Span	51.06	44.18	804.000	0.238
WAIS III - Arithmetic	52.98	41.34	630.500	0.047
WAIS III - Letter-number sequencing	46.05	44.49	839.500	0.787

	Absence of immediate reported symptoms	Presence of immediate reported symptoms	U	p
	Mean rank	Mean rank		
WAIS III - Digit Symbol-Coding	44.29	46.07	849.500	0.760
WAIS III - Symbol Search	40.34	47.25	735.000	0.231
Trail Making A (seconds)	48.50	44.71	852.500	0.516
Trail Making B (seconds)	49.21	49.21	799.500	0.328
Beck's Depression Inventory - amount of symptoms	38.35	50.64	693.000	0.027
Beck's Depression Inventory - total score	38.66	50.48	702.500	0.032

Note: Statistical Significance ($p \leq 0.05$).

Linear regression analyses indicated that primary/acute signs and symptoms of concussion (t = 4.48; p < 0.001), Beck's Depression Inventory Score (t = 2.83; p = 0.006), as well as attentional composite score (t = –2.13; p = 0.036) were significantly predictive of post-concussion symptoms within the first 72 h following concussion.

Discussion and Conclusions

Sports concussion has captured consideration in the scientific literature and journalistic media over recent years (Ahmed & Hall, 2017). One of the biggest concerns connected to concussion is the short and long-term effects of head impacts on brain functioning. Despite ongoing interest in the diagnosis, rehabilitation, and prevention of sports concussion and the link with CTE, the concussion spectrum of disorders has yet to be fully understood.

We present the Arg-SCARS protocol, a longitudinal study of active and retired rugby players in Buenos Aires, Argentina, to collect data both on short and long-term impact of concussion and characterize the negative results in neurological and cognitive functions in this population. Our aim in this paper was to share the study design and the preliminary results about clinical profile in rugby union players following sports concussion.

A considerable part of players with concussion had previous history concussion injuries (66.3%), with an average number of clinical concussions of 1.94 (SD: 3.04; range: 0 – 15). In this study, only 22.7% of athletes were not removed from game after a confirmed or uncertain concussion. The tackle was the main contact situation for concussion, being the tackler the one at greatest risk.

Many researches have showed a significant independent association between history of sports concussions and unfavorable outcomes (Iverson et al., 2017) and subsequent concussion risk (Guskiewicz et al., 2003; Hollis et al., 2009). Recent reports suggest a link between the presence and severity of symptoms post-concussion and a history of sports concussions (Register-Mihalik et al., 2009).

While almost 75% of the athletes were removed from play after a concussion, the number of players immediately returning to the game was still high. Although in our setting the Graduated Return-to-Play Protocol is being implemented, its use is still not widespread in amateur rugby.

These findings highlight that extensive training programs to players, referees, managers, relatives, coaches, and healthcare providers should be expanded to train everyone in identifying and removing players with concussion and to emphasize the potential effects of repetitive mild traumatic brain injuries (Lee & Garraway, 1996; Marshall & Spencer, 2001). Going forward, it would be tempting to assess the impact of implementing national and international guidelines (McCrory et al., 2017; Russo et al., 2020; World Rugby Organization-WR, 2021) in our setting, and their influence on sports concussion management.

Most concussions occurred from tackle situation. Given that tackle appears to be a consistent contact situation in several papers (Gardner et al., 2015; Lopez et al., 2016), it would be pertinent also to implement recommendations on tackling technique in this population (Cross et al., 2019) as a strategy to prevent concussion.

The clinical presentation can vary greatly, from significant changes in balance to less obvious changes such as cognitive or sleep disturbances. Somatic (e.g., balance problems), cognitive (e.g., concentration difficulties), sleep (e.g., drowsiness), and/or emotional (e.g., anxiety) symptoms may present. Headache was the most frequently described symptom at the time of injury, featuring 43.3% of concussions. More than one symptom was reported by 64.1% of players. Similar results were reported by other authors (Cosgrave & Williams, 2019; Merritt et al., 2015).

Concussion is immediately presumed with a Loss of Consciousness (LOC). Health care professionals know that most concussions do not result in LOC (Kelly, 2001), with a rate between 5 and 12% reported in earlier reports (Hinton-Bayre et al., 2004; Meehan et al., 2010). The high proportion of LOC (40%) in our sample requires attention. One possible explanation is that LOC may be considered an appropriate concussion severity marker in our setting, and the players were specifically referred for evaluation for that reason. The latest consensus statement from the International Concussion Conference in Berlin (McCrory et al., 2017) emphasized that there have been uncertain data concerning whether LOC or post-traumatic amnesia should be considered specific injury severity characteristics. The strongest and most consistent predictor of clinical recovery after a sports concussion is the higher acute symptom severity after injury (Fuller et al., 2015; McCrory et al., 2017).

Although the predictors of clinical recovery were not the focus of this research, it is a key point that requires further study.. Nevertheless, our findings join a few numbers of studies (Makdissi et al., 2010; Merritt et al., 2019) reporting that athletes who endorse immediate/acute concussion symptoms showed greater observed concussion signs, greater and more severe post-concussion symptoms within the first 72 h following a concussion, including worst emotional symptoms (based on Beck's Depression Inventory) and lower arithmetic performance in the cognitive assessment.

Next, with respect to the sign- and symptom-related variables, the total immediate/acute signs and symptoms of concussion, total Beck's Depression Inventory Score, and attentional composite score were the only variables that showed to reliably predict the severity of athletes' symptoms within the first 72 h after a concussion.

In the absence of a readily available biomarker to assist in diagnostic and prognostic assessment, a pattern of acute and subacute symptoms following sports concussion can be used as an useful indicator of the severity of the traumatic injury and a beneficial method to determine individualized patient care after a concussion and to improve the design of research studies.

It is essential that the full spectrum of concussed athletes and all stages following a concussion are recognized and understood. The information obtained can be used to monitor recovery adequately and tailor personalized interventions for specific athlete settings.

The findings of Arg-SCARS will provide us with better understanding of the link between repetitive mild traumatic brain injury and subsequent decline in neurological functioning in rugby union players. Ultimately, the Arg-SCARS will provide data to design player-centered intervention strategies in our setting.

Conflicts of Interest

Authors reports no conflicts of interest to report in relation to this study.

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