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Research Article

Use of the Recovery-Stress Questionnaire - Sport (RESTQ-Sport) and King-Devick Test to Monitor Changes During Recovery of Concussion in an Amateur Women's Rugby Union Team

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Abstract

Objective: To monitor the stress and recovery of players with a concussion in amateur women's rugby union team over recovery timelines utilising the Recovery-Stress Sport (RESTQ-Sport) questionnaire, King-Devick (K-D) test and Post-Concussion Symptom Scale (PCSS).

Methods: A prospective observational study was undertaken following an amateur women's domestic rugby union club-based team over two years. A K-D test was conducted for any suspected concussion and confirmed concussions were monitored with the RESTQ-Sport, K-D test and PCSS during the concussion recovery.

Result: One training related and nine match related concussions were recorded over the study resulting in a concussion injury rate of 0.3 per 1,000 training hrs and 16.1 per 1,000 match hrs. The post-injury K-D test score was significantly slower than the baseline scores of players with a concussive injury (44.2 ±7.1 s vs. 49.0 ±7.3 s; $\chi^2_{(1)}$=6652.4; p<0.0001; $t_{(8)}$=-8.0; p<0.0001). There was a significant increase in the mean score of the *Fatigue* scale on day-7 when compared with baseline (2.36 ± 0.49 vs, 1.64 ± 0.88; $\chi^2_{(1)}$=4.0; p=0.0469; $t_{(8)}$=-2.8; p=0.0040).

Discussion: The K-D test recorded a mean slowing (worsening) of reading time of -4.7 ±1.8 s increasing to -8.8 ±2.6s on day-3 post injury. Players reported fewer symptoms before the K-D test was equal to, or faster than, the individual players baselines.

Conclusion: The RESTQ-Sport and K-D tests were useful tools for the monitoring of individual players stress and recovery and changes of an initial cohort of amateur women's rugby union participants following a mild traumatic brain injury.

INTRODUCTION

Originally designed to systematically monitor the complexities of recovery-stress states (RSS) of athletes in training or competition, the multidimensional Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) [1] comprises of 76, 52 and 36 question versions. The RESTQ-Sport has been utilized for individual players as part of a recovery program [2], and in the training environment [3-5]. More recently the RESTQ-Sport has been used to monitor sports team members' overall RSS during competition in basketball [6], rugby league [7,8], rugby union [9] and soccer (football) [10]. The RESTQ-Sport evaluates the frequency of both current stress symptoms and recovery-associated activities/states of the previous three days and nights addressing both nonspecific and sport-specific areas of RSS [11]. A unique feature of the RESTQ-Sport is the simultaneous assessment of subjective RSS-associated aspects and the ability

to provide precise starting points to enable individualised management [3]. Although the RESTQ-Sport has been utilised for overtraining and the monitoring of RSS in sport, it has never been reported to have been utilised in the monitoring of players during injury recovery. One such injury that is receiving a lot of media and medical attention is concussion [12].

Concussion, or mild traumatic brain injury (mTBI), is defined as a complex pathophysiological process affecting the brain, induced by traumatic biomechanical forces [13]. A common result of a concussion occurring are cognitive impairments such as difficulty concentrating, memory deficiencies and lapses in attention [14,15]. Concussion comprises both a physiological and psychological stressor [16], that can result in attention-related deficits and this may be an underlying factor that leads to more general deficits in cognitive function [17,18]. As a result, the affected person is forced to cope with changes to the various abilities that were available to them pre-injury [19].

The impact of a concussion on the individual can vary from a mild physical or cognitive disability through to a pervasive set of physical, behavioural, emotional, and cognitive deficits that can disrupt normal functioning throughout their lifetime [20]. The impact of stressful life events, including those related to an injury (e.g., inability to return to sport or work, changes in academic capabilities, financial hardships), are reported as important factors in the eventual outcome of a person with a concussive injury [21]. It has been reported that there is a relationship between the level of stress, and incidence of a variety of physical, emotional, and psychological symptoms related to concussion [22]. For example, the anxiety/mood clinical profile after concussion is characterized by emotional disturbance such as experiencing anxiety, feelings of depression, hypervigilance of somatic complaints, and sleep dysregulation [23]. In order to help identify and address these changes, several tools and behavioural therapies [20,24] have been developed but as yet no single tool has been able to directly address both the stress and recovery aspects of a concussive injury.

Therefore, the objective of this study was to monitor the stress and recovery of players with a concussion in an amateur women's rugby union team over a competition season utilising the RESTQ-Sport, King-Devick (K-D) test and Post-Concussion Symptom Scale (PCSS).

METHODS

A prospective observational study was undertaken following an amateur women's domestic rugby union club-based team (69 players; 26.5 ± 7.4 yr.; 1.65 ± 0.72 m; 86.6 ± 15.9 kg) over two years (2018-2019) in the Wellington Rugby Union women's domestic competition (nine teams playing in a home and away format from April to July). All players were amateur and did not receive match payments. Prior to the competition season commencing, all players provided informed written consent to participate in the research and all procedures were approved by the institutional ethics committee. Only those players with an identified concussive injury were enrolled in this study.

The RESTQ-Sport-52 version is a psychometrically-based designed to assess a player's recovery-stress state [3, 4,25], Consisting of twelve basic scales (seven stress scales: General Stress, Emotional Stress, Social Stress, Conflicts/Pressure, Fatigue, Lack of Energy, Physical Complaints; and five recovery scales: Success, Social Recovery, Physical Recovery, General Well-Being, Sleep Quality) with seven additional sport-specific scales (three sport-specific stress scales: Disturbed Breaks, Emotional Exhaustion, Injury; and four sport-specific recovery scales: Being in Shape, Personal Accomplishment, Self-Efficacy, Self-Regulation), the questionnaire uses a self-report approach to player's physical, subjective, behavioural, and social aspects of stress and recovery (Table 1) [1,5]. Each of these scales consist of items that require the player's response using a seven-point Likert scale ranging from 0 (never) to 6 (always). Each item response indicates how often the player participated in stress- or recovery-associated activities during the previous three days and nights. The stem of each item is "In the past 3 days/nights…" Examples of these are "I felt anxious or inhibited" (emotional stress), "I was tired from work" (fatigue), and "I was convinced that I performed well" (self-efficacy). The internal consistency and reliability of the RESTQ-Sport have been previously reported with Cronbach's α (0.67 to 0.88) and test-retest reliability (r=0.51 to 0.81) (see Table 1) [1,3]. The internal consistency reportedly [1] increases with the participant's familiarity with the RESTQ-Sport as occurs with any other questionnaire. The RESTQ-Sport scores were provided to players as individual and grouped theme scale scores: General Stress (mean of the seven general stress scales); Sport-specific Stress (mean of the three sport-specific stress scales); General Recovery (mean of the five general recovery scales) and Sport-specific Recovery (mean of the four sport-specific recovery scales). An Overall Stress score (mean of the ten general stress and sport-specific stress areas) and an Overall Recovery score (mean of the nine general recovery and sport-specific recovery) were calculated.

Developed in the 1970's by Alan King and Steven Devick to evaluate children suspected of dyslexia or impaired saccadic eye movements [26], the K-D Test in association with Mayo Clinic is a rapid number naming task that takes < 2 min to administer [27]. The participant reads aloud a sequence of single digit numbers from the left to the right of the screen that includes one demonstration card and three visually distinct test cards that increase in difficulty [28]. Utilised in the assessment for concussion in a variety of sports at amateur [28-30] and professional [31] levels of participation, the K-D test has been reported to have a high sensitivity (0.86; 95% CI: 0.79 to 0.92), specificity (0.90; 95% CI: 0.85 to 0.93) and an Inter Class Correlation (ICC) of 0.91 (95% CI: 0.85 to 0.97) [32,33]. In addition, the K-D test has been reported to have significant correlations (p<0.0001) with the visual motor speed (VMS), reaction time (RT), verbal memory (VEM) and visual memory (VIS) of the Immediate Post-concussion Assessment Cognitive Test (ImPACT®) [34] computerised concussion evaluation system. The K-D test relies upon comparing the differences between baseline and post-injury results to provide an insight into a potential concussive injury [35] and has been utilised by parents and non-health care professionals [36]. The K-D test has not been recommended for use as a standalone diagnostic tool [32,37], rather the K-D should be utilised in conjunction with other concussion assessment tools as a side-line screening tool [37,38].

All players were tested pre-season with a tablet (iPad;

Table 1: Number of scales, scale of orientations (o), number of items per scale (n), example sample item of scale, Cronbach's α, and test-retest reliabilities [1] and scale values for the results for the Recovery-Stress Questionnaire – Sports.

No.	RESTQ-Sport Scale	o	n	Example	α	Test-Retest	Scale Summary
1	General Stress	S	4	…I felt down	0.76	0.71	High values = frequently mentally stressed, depressed, unbalanced, and listless
2	Emotional Stress	S	4	…I was in a bad mood	0.71	0.72	High values = frequent irritation, aggression, anxiety, and inhibition
3	Social Stress	S	4	…I was angry with someone	0.85	0.77	High values = frequent arguments, fights, irritation concerning others, general upset, lack of humour
4	Conflicts/Pressure	S	4	…I felt under pressure	0.68	0.73	High values = conflicts unsettled, unpleasant things done, goals not reached, certain thoughts could not be dismissed
5	Fatigue	S	4	…I was overtired	0.78	0.81	High values = time pressure in job, training, school, life; constantly disturbed during important work, over-fatigue, lack of sleep characterize this are of fatigue
6	Lack of Energy	S	4	…I was unable to concentrate well	0.72	0.68	High scores = ineffective work behaviour, inability to concentrate, lack of energy and decision making.
7	Physical Complaints	S	4	…I felt uncomfortable	0.71	0.76	Physical indisposition and physical complaints related to the whole body characterized by this scale.
8	Success	R	4	…I finished important tasks	0.67	0.70	High scores = success, pleasure at work, creativity during past few days.
9	Social Recovery	R	4	…I had a good time with my friends	0.80	0.74	High values = frequent pleasurable social contacts and change combined with relaxation and amusement.
10	Physical Recovery	R	4	…I felt at ease	0.85	0.79	High values = physical recovery, physical well-being, and fitness.
11	General Wellbeing	R	4	…I was in a good mood	0.84	0.61	High values = frequent good moods, high well-being, general relaxation, contentment
12	Sleep Quality	R	4	…I had a satisfying sleep	0.83	0.70	High values = enough recovering sleep, absence of sleep disorders when falling asleep, sleeping through the night = recovery sleep
13	Disturbed Breaks	S	4	…my coach demanded too much of me during the breaks	0.79	0.64	High values = recovery deficits, interrupted recovery, situational aspects that get in the way during periods of rest
14	Emotional Exhaustion	S	4	…I felt I wanted to quit my sport	0.71	0.72	High values = burnt out, wanting to quit
15	Injury	S	4	…my performance drained me physically	0.78	0.59	High values = acute injury / vulnerability to injuries
16	Being in Shape	R	4	…I was in good condition physically	0.88	0.71	High values = perception as fit, physically efficient, vital
17	Personal Accomplishment	R	4	…I dealt very effectively with my team-mate's problems	0.80	0.81	High values = feel integrated into team, communicate well with team-mates, enjoy sport
18	Self-Efficacy	R	4	…I was convinced that I had trained well	0.89	0.82	High values = how convinced player is that they trained well and optimally prepared.
19	Self-Regulation	R	4	…I prepared myself mentally for performance	0.83	0.77	High values = use of mental skills to prepare, push motivate, set goals for themselves.

Apple Inc., Cupertino, CA) according to the developer's recommendations (v4.2.2; King-Devick technologies Inc.). All baseline testing was completed at training to mimic the sideline playing field environments. Players were asked to read card numbers from left to right as quickly as they could without making any errors using standardized instructions. Time was kept for each test card, and the entire test K-D summary score was based on the cumulative time taken to read all three test cards [39]. The number of errors made in reading test cards was recorded. The best time (fastest) of two trials 5-minutes apart without errors became the established baseline K-D test time [30].

Originally developed in the late 1980's, the Post-Concussion Symptom Scale (PCSS) is a 22-item scale designed to measure the types and the severity of symptoms experienced following concussion during the acute phase of recovery [40,41]. The PCSS utilises a self-reported assessment based on a 7-point Likert scale with anchors at 0 (no symptom) to 7 (most severe). Participants

Table 2: Player age, height, and body mass for Forwards, Backs, and total players with a recorded concussion in an amateur domestic women's rugby union team in New Zealand over two years. Data reported by number of players and mean with standard deviation.

	Total	Age (yr.)		Height (m)		Mass (kg)	
	n=	Mean ±SD	Range	Mean ±SD	Range	Mean ±SD	Range
Forwards	5	30.0 ±11.4	18 - 48	1.61 ±0.04	1.54 - 1.65	84.6 ±14.8	60.0 - 98.0
Backs	5	24.6 ±7.3	19 - 34	1.62 ±0.10	1.52 - 1.74	83.4 ±7.4	76.0 - 95.0
Total	10	27.3 ±9.5	18 - 48	1.62 ±0.08	1.52 - 1.74	84.0 ±11.0	60.0 - 98.0

SD = Standard Deviation

Table 3: Mean and standard deviation scores of the different scales of the RESTQ-Sport(52) for General Stress, General Recovery, Sports-Specific Stress and Sport-Specific Recovery; King-Devick test times and self-reported concussion symptoms of players in an amateur domestic women's rugby union team in New Zealand with a medically diagnosed concussion.

		Baseline	Sideline	Day-3	Day-7	Day-14	Day-21	Day-28
		Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
RESTQ-Sport(52)								
General Stress								
1	General stress	0.81 ±0.61	-	-	2.61 ±1.38^{g}	1.75 ±1.58	1.03 ±0.79	0.86 ±0.65^{d}
2	Emotional stress	0.97 ±0.63	-	-	2.17 ±1.43	1.86 ±1.09	1.33 ±0.72	0.94 ±0.51
3	Social stress	1.00 ±0.40	-	-	2.14 ±1.38	1.86 ±1.16	1.17 ±0.52	0.94 ±0.58
4	Conflicts/pressure	1.42 ±0.77	-	-	2.39 ±1.82	1.64 ±1.49	1.72 ±1.32	1.14 ±0.75
5	Fatigue	1.64 ±0.88^{d}	-	-	2.36 ±0.49^{a}	1.97 ±0.86^{g}	1.69 ±1.26	1.19 ±0.82^{e}
6	Lack of energy	1.08 ±0.68	-	-	2.03 ±1.60	1.75 ±1.32	1.25 ±0.56	0.83 ±0.63
7	Physical complaints	1.14 ±0.76	-	-	2.22 ±1.58	2.03 ±1.27	1.44 ±1.08^{g}	0.47 ±0.48^{f}
General Recovery								
8	Success	1.56 ±0.50	-	-	1.39 ±0.55	1.42 ±0.83	1.83 ±0.67	2.14 ±1.05
9	Social recovery	2.14 ±0.70	-	-	1.92 ±0.80	1.97 ±0.79	2.81 ±1.04	2.94 ±1.01
10	Physical recovery	1.42 ±0.35	-	-	0.94 ±0.60^{g}	1.53 ±0.86	1.56 ±1.16	2.06 ±1.08^{d}
11	General well-being	2.00 ±0.48	-	-	1.50 ±0.71	1.53 ±0.88	2.56 ±1.25	2.83 ±1.39
12	Sleep quality	1.58 ±0.60	-	-	1.61 ±0.93	1.81 ±0.58^{f}	2.72 ±1.00^{e}	2.56 ±1.59
Sport Stress								
13	Disturbed breaks	1.50 ±0.47	-	-	1.75 ±0.53	1.56 ±0.62	1.28 ±0.54	1.33 ±0.31
14	Emotional exhaustion	1.92 ±0.93	-	-	2.08 ±0.70^{f}	2.97 ±1.29^{fg}	1.22 ±0.36^{de}	1.28 ±0.69^{e}
15	Injury	2.14 ±0.56^{e}	-	-	3.89 ±0.99^{g}	3.83 ±0.73^{afg}	2.19 ±1.53^{e}	2.03 ±0.85^{de}
Sport Recovery								
16	Being in shape	2.64 ±0.70^{d}	-	-	1.56 ±0.85^{ag}	1.81 ±0.39^{g}	2.61 ±1.18	3.39 ±1.05^{de}
17	Personal accomplishment	3.36 ±0.97^{de}	-	-	2.58 ±1.02^{a}	2.17 ±0.57^{a}	3.06 ±1.22	2.86 ±0.69
18	Self-efficacy	3.25 ±0.94	-	-	1.97±1.23^{g}	1.78 ±1.00	2.78 ±1.41	2.97 ±0.23^{d}
19	Self-regulation	3.25 ±1.09	-	-	2.89 ±0.99	2.39 ±0.70	3.64 ±1.02	3.06 ±0.61
Total Stress		1.46 ±0.44^{e}	-	-	2.36 ±1.00^{g}	2.12 ±0.80^{ag}	1.43 ±0.62	1.10 ±0.24^{de}
Total Recovery		2.35 ±0.50^{d}	-	-	1.82 ±0.45^{a}	1.82 ±0.62^{f}	2.62 ±0.77^{e}	2.76 ±0.80
Difference		0.89 ±0.69	-	-	-0.55 ±1.27	-0.30 ±1.03	1.18 ±0.99	1.65 ±0.83
King-Devick Test								
Time (s)		44.2 ±7.1^{bcdef}	49.0 ±7.3^{acdfg}	53.0±7.6^{abdefg}	51.2 ±6.9^{abcefg}	47.8 ±6.3^{acdfg}	45.9 ±7.1^{abcdeg}	44.0 ±7.3^{abcdef}
Concussion Symptom Scale								
Score (22)		0.9 ±1.4^{bcde}	19.0 ±2.5^{adefg}	17.1 ±2.5^{adefg}	11.3 ±2.6^{abcefg}	6.9 ±1.8^{abcdfg}	1.7 ±1.7^{bcdeg}	0.0 ±0.0^{bcdef}
Severity (132)		0.9 ±1.4^{bcde}	65.1 ±23.6^{acdefg}	34.3 ±13.1^{abefg}	24.0 ±6.2^{abefg}	13.7 ±3.6^{abcdfg}	2.8 ±2.9^{bcdeg}	0.0 ±0.0^{bcdef}
Distress (6.0)		0.3 ±0.5^{bcde}	3.3 ±0.9^{acdfg}	2.0 ±0.6^{abg}	2.0 ±0.7^{abg}	2.0 ±0.6^{abfg}	1.0 ±1.0^{adeg}	0.0 ±0.0^{bcde}

SD = Standard Deviation; Significant difference (p<0.05) then (a) = Baseline; (b) = Sideline; (c) = Day-3; (d) = Day-7; (e) = Day-14; (f) = Day-21; (g) = Day-28

completed the PCSS in paper version as a baseline, at the ground post-match and when reviewed post-injury). The PCSS has been reported to be a reliable test with a high internal consistency (r=0.89 to 0.94) [41]. In addition to recording symptom score (number of symptoms reported) and severity (sum of symptom scores reported), the symptom distress score was calculated (symptom severity divided by symptom score) to provide symptom intensity [42].

Concussions were classified as witnessed (a concussive injury that met the definition of a concussion [13], that was identified during match activities resulting in removal from match activities and had >3 s for pre to post-match K-D, and later confirmed by a health professional's clinical assessment) or witnessed (changes >3 s for pre to post-match K-D with associated changes, and later confirmed by a physician's clinical assessment). The 3 s threshold for changes in post-match K-D is identical to studies reporting K-D test use [43,44]. In accordance with the International Consensus Conference on Concussion in Sport, the definition of a concussion utilised for this study was "any disturbance in brain function caused by a direct or indirect force to the head. It results in a variety of non-specific symptoms and often does not involve loss of consciousness. Concussion should be suspected in the presence of any one or more of the following: (a) Symptoms (such as headache), or (b) Physical signs (such as unsteadiness), or (c) Impaired brain function (e.g., confusion) or (d) Abnormal behaviour" [13]. An 'unwitnessed' concussion was defined for the purpose of this study as "any disturbance in brain function caused by a direct, or indirect force, to the head that does not result in any immediate observable symptoms, physical signs, impaired brain function or abnormal behaviour but had a delay in the post-match K-D score of >3 s and associated changes in the post-match SCAT5" [29].

Similar to previous studies [7,8], the RESTQ-Sport was undertaken at the approximately one month prior to the competition starting in April. All players completed the RESTQ-Sport at the end of each month following a match activity through to the last match (semi-final) where assessment was completed approximately two days following the final match [45]. The questionnaire took approximately 10 minutes to complete, and players typically completed this prior to the training session commencing. Internal consistency was checked at the completion of each testing utilising Cronbach's alpha (α).

During matches, the team medic (and lead researcher), observed players for any signs of direct contact to the head, or being slow to rise from a tackle or collision, or being unsteady on their feet following a collision. If this occurred, players were assessed on-field. If any signs of delayed answering, incorrect answers to questions, or if the player appeared to be impaired in any way, the player was removed from match activity and rested on the sideline. Players who reported any signs of a concussion, who were suspected to have received a concussion, or who were removed from match participation were initially assessed with the sideline K-D test after a 15-minute rest period; not allowed to return to play on the same day; and, referred for further medical assessment. The test was administered once using the same instructions, and time and errors were recorded and compared to the participant's baseline. Worsening time and/or errors identified on the sideline, or post-match K-D have been associated with concussive injury [28,30,31]. The K-D test performance has been shown to be unaffected in various noise levels and testing environments [46].

No player who had been identified with delayed (worsening) post-match K-D times, were allowed to return to training or match activities without a full medical clearance. If players were identified with a loss of consciousness, they would be treated for a cervical spine injury and managed accordingly. All suspected concussive injuries were evaluated by the player's own health professional. All players that were identified with a delay (worsening) of the K-D test from their baseline were reviewed by their health professional for a formal concussion evaluation (n=9). For those players with a delay in their K-D at the sideline and had been diagnosed as having a concussion (n=1), this was repeated on day-3, 7, 14, 21 and 28 post-concussion. These players were also asked to complete a PCSS at the same time on day-3, 7, 14, 21 and 28 post-concussion. The RESTQ-Sport was completed as part of the concussion recovery monitoring process with players completing the questionnaire on day-7, 14, 21 and 28 post-concussion and compared with their baseline questionnaire. This was undertaken to identify any areas that may have impeded the concussion recovery process and to assist the player's individual rehabilitation program. No player was allowed to return to full match activities until they were medically cleared and, had returned to their baseline K-D score.

Data were entered into a Microsoft Excel spread sheet enabling assessment scores to be graphed automatically. Data were analysed with the Statistical Package for Social Sciences for Windows (SPSS; V25.0.0). Data were checked for normality and homogeneity of variance using a Shapiro-Wilk's test of normality. If tolerances were not met, equivalent non-parametric tests were utilised. To check for internal consistency of the RESTQ-Sport, a Cronbach's α test was conducted after each testing session [47]. The mean of the individual scales and the total stress and recovery scores of the RESTQ-Sport, K-D test scores were compared utilising a Generalised Linear Model. A Bonferroni-type adjustment was applied to maintain the Type-1 error probability at the 0.05 alpha level. When differences were detected a post-hoc two-tailed paired t-test was utilised to determine if any significant differences existed. Total recovery and stress scores were obtained by calculating the mean of all recovery and stress scales as previously described [25]. The CSS was analysed with a Friedman repeated measures ANOVA on ranks. If notable differences were observed, a Wilcoxon signed-rank post-hoc test was conducted with a Bonferroni correction applied. The level of significance was set at $p \leq 0.05$, and all data are expressed as means and standard deviations.

RESULTS

Over the duration of the study players undertook 114 training sessions for an exposure of 3,339.5 training hrs and 29 match activities for an exposure of 558.6 match hrs. One training related and nine match related concussions were recorded over the study resulting in a concussion injury rate of 0.3 (95% CI: 0.0 to 2.1) per 1,000 training hrs and 16.1 (95% CI: 8.4 to 31.0) per 1,000 match hrs. Although forwards were older (3.0 ±11.4 vs. 24.6 ± 7.3 yr.; $t_{(4)}$=0.9; p=0.4059), had a lower stature (1.61 ±

0.04 vs. 1.62 ± 0.10 m; $t_{(4)}$=-0.3; p=0.8067) and had a higher mean body mass (84.6 ±14.8 vs. 83.4 ±7.4 kg; $t_{(4)}$=0.2; p=0.8543) these were not significant (Table 2).

There was a significant increase in the mean score of the *Fatigue* scale on day-7 when compared with baseline (2.36 ±0.49 vs, 1.64 ±0.88; $\chi^2_{(1)}$=4.0; p=0.0469; $t_{(8)}$=-2.8; p=0.0040) (Table 3). This was similar for the mean scores of the *Being in Shape* (1.56 ±0.85 vs. 2.64 ±0.70l; $\chi^2_{(1)}$=27.8; p<0.0001; $t_{(8)}$=3.5; p=0.0076), *Personal Accomplishment* (2.58 ±1.02 vs. 3.36 ±0.97; $\chi^2_{(1)}$=8.0; p=0.0047; $t_{(8)}$=2.3; p=0.0499) and *Total Recovery* (1.82 ±0.45 vs. 2.35 ±0.50; $\chi^2_{(1)}$=5.7; p=0.0167; $t_{(8)}$=2.9; p=0.0214) scales on day-7 when compared with baseline scores. There was a significant difference in the mean score of the *Injury* scale on day-14 (3.83 ±0.73) when compared with day-21 ($\chi^2_{(1)}$=7.7; p=0.0057; $t_{(8)}$=3.3; p=0.0111) and day-28 ($\chi^2_{(1)}$=13.0; p=0.0003; $t_{(8)}$=4.1; p=0.0035). The mean *Total Stress* was higher on day-7 (-0.55 ±1.27; $\chi^2_{(1)}$=2.4; p=0.1233; $t_{(8)}$=1.3; p=0.2319) and day-14 (-0.30 ±1.03; $\chi^2_{(1)}$=0.0; p=0.9151; $t_{(8)}$=0.9; p=0.4053) when compared with *Total Recovery* but this was not significant. The internal consistency of the RESTQ-Sport over the duration of the study ranged from α = 0.72 to 0.93.

The post-injury K-D test score was significantly slower than the baseline scores of players with a concussive injury (44.2 ±7.1 s vs. 49.0 ±7.3 s; $\chi^2_{(1)}$=6652.4; p<0.0001; $t_{(8)}$=-8.0; p<0.0001) (see Table 3). The K-D test times were slower on day-3 post-concussion (53.0 ±7.6 s) when compared with day-7 ($\chi^2_{(1)}$=116.7; p<0.0001; $t_{(8)}$=2.6; p=0.0324); day-14 ($\chi^2_{(1)}$=64.7; p<0.0001; $t_{(8)}$=5.5; p=0.0006), day-21 ($\chi^2_{(1)}$=54.2; p<0.0001; $t_{(8)}$=7.4; p<0.0001) and day-28 ($\chi^2_{(1)}$=35.6; p<0.0001; $t_{(8)}$=7.8; p<0.0001). The ICC for the K-D test was 0.96 [0.85-0.99]. Concussed players reported a significantly higher mean concussion symptom score (0.9 ±1.4 vs. 19.0 ±2.5; $\chi^2_{(1)}$=9.0; p=0.0027; z=-2.7; p=0.0076), severity (0.9 ±1.4 vs. 65.1 ±23.6; $\chi^2_{(1)}$=9.0; p=0.0027; z=-2.7; p=0.0077) and distress (0.3 ±0.5 vs. 3.3 ±0.9; $\chi^2_{(1)}$=9.0; p=0.0027; z=-2.7; p=0.0076) on the day of the injury when compared with baseline concussion symptom severity.

Although there was no significant difference observed for symptom score ($\chi^2_{(1)}$=3.6; p=0.0588; z=-1.6; p=0.1020) on day-3 when compared with the sideline assessment, there was a significant difference observed in the symptom severity ($\chi^2_{(1)}$=9.0; p=0.0027; z=-2.7; p=0.0076) and symptom distress ($\chi^2_{(1)}$= 9.0; p=0.0027; z=-2.6; p=0.0077) (Table 3). There was a significant difference observed in the symptom severity on day-3 when compared with day-14 ($\chi^2_{(1)}$=5.4; p=0.0196; z=-2.5; p=0.0108) but not symptom distress ($\chi^2_{(1)}$=0.1; p=0.7389; z=-0.6; p=0.9527).

DISCUSSION

The purpose of this study was to utilise the RESTQ-Sport, K-D test, and CSS to assess concussion and monitor recovery, in players from an amateur women's rugby union team. In particular, the RESTQ-Sport was utilised to monitor for stress and recovery changes that occur during concussion recovery. The principal findings were: 1) Player's *Total Stress* increased in the first 14 days post-injury; 2) The K-D test recorded a mean slowing (worsening) of reading time of -4.7 ±1.8 s increasing to -8.8 ±2.6 s on day-3 post injury; and 3) Players reported fewer symptoms before the K-D test was equal to, or faster than, the individual players baselines.

As can be seen in Table 3, the RESTQ-Sport was not utilised on the day of the concussion injury and on day 3 following the concussion injury. This was done to ensure the player with the concussive injury undertook a period of cognitive rest as recommended by the Concussion in Sports Consensus group, before the recommencing of any graduated return to sport strategy [13]. It has been recommended that cognitive rest be undertaken by limiting activities that require attention and concentration such as performing school or academic work, working online, text messaging and reading [48]. As the RESTQ-Sport was a questionnaire that was undertaken online it was decided to not complete this over this period as increasing cognitive activity during the initial stages of a concussion occurring has been associated with a prolonged symptom duration [48].

The RESTQ-Sport has been reported to be useful for a review of lowered performance and for the identification of current stress and recovery, but not for the prediction of future performance and injury [49]. The RESTQ-Sport can be utilised to assess for the identification of group changes but when analysed on an individual basis it has been reported to more beneficial than on a group level [9,49]. This was noticeable when the RESTQ-Sport was utilised for the assessment of injury recovery for individual players. For example, there were noticeable differences for Player A across most of the RESTQ-Sport scales, specifically in the General Recovery, Sport-Specific Stress and Sport Specific Recovery aspects throughout the recovery period and this would be reflective of the effects of a mild traumatic brain injury on an individual (Figure 1). Compared with her baseline, Player A's Injury scale went from 2.25 to 4.75 day-3 post injury and declined to 2.75 at day-21 when she was medically cleared to return to sporting activities. This was similar for her *Fatigue* scale rising from 1.25 to 2.75 day-3 post-injury before declining to 0.50 at day-21. Whilst not previously reported, the RESTQ-Sport may be another useful tool for the monitoring of amateur sports participants following a mild traumatic brain injury.

The RESTQ-Sport has been utilised for the monitoring of players in rugby league [7,8], rugby union [9] and soccer [10] and has also been reported [8] to be able to identify amateur players at risk of injury. Similar to previous studies [7,8,50], when the scores for all aspects of the RESTQ-Sport were retrospectively reviewed, injured players had lower recovery-related scores and higher stress-related scores than non-injured players. However, the cohort of players enrolled in this study only completed the RESTQ-Sport monthly as part of their competition monitoring. It was not until the players were identified with a concussion that they were asked to complete the questionnaire on a more regular frequency. It has been recommended [8,50] that a shorter version of the RESTQ-Sport specifically for injury risk assessment may be useful for sports participants. As previously identified [8,50], this would mean a shortened version of the current questionnaire enabling less disruption to the individual participants.

The use of the K-D test for the assessment of a concussive injury was undertaken at the sideline as a screening tool only. It does not preclude a comprehensive concussion evaluation and was not utilised to diagnose concussion [35]. By utilising the baseline to post-injury (concussion) comparisons, any player with a post-injury (concussion) slowing of their K-D test time, regardless

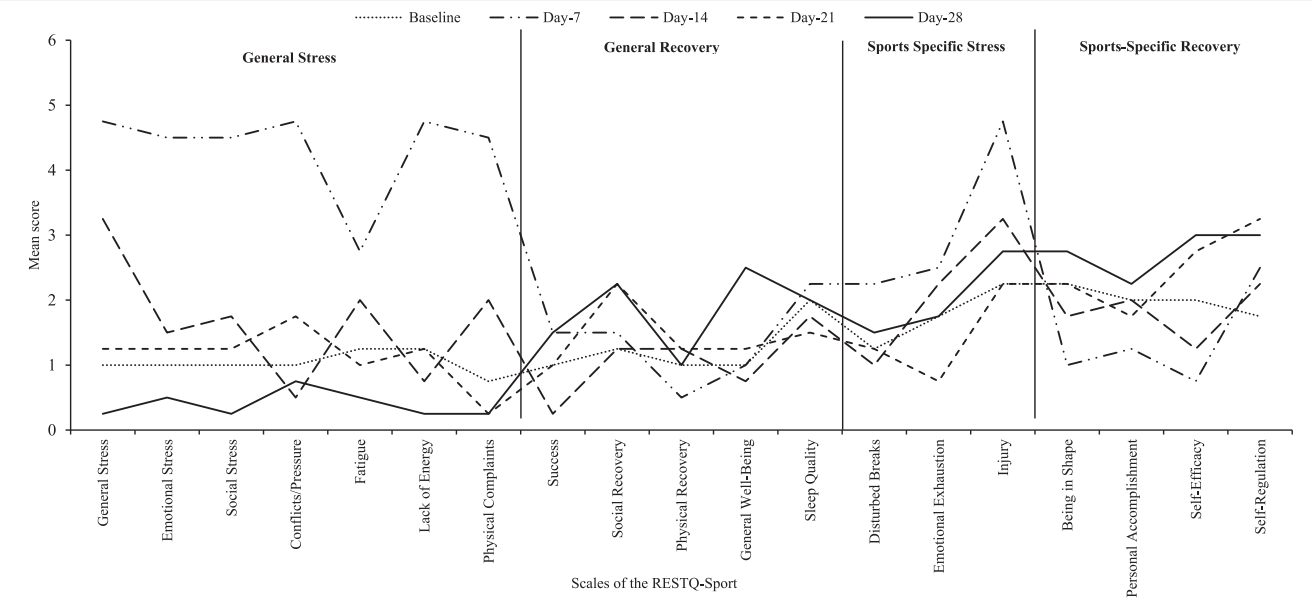

Figure 1 Scores of the different scales of the RESTQ-Sport(52) for General Stress, General Recovery, Sports-Specific Stress and Sport-Specific Recovery for player A in an amateur domestic women's rugby union team in New Zealand for assessment of concussion recovery.

of whether the player has, or has not had a witnessed insult, should be withheld from any further participation until they are evaluated by a medical professional trained in the management of concussion [51]. In accordance with the developer's recommendation [35], any slowing (worsening) of the K-D test score of >1 s was a fail and concerning for a concussive injury especially following a traumatic force to the head and brain [52]. Players tested post-injury (concussion) recorded a mean slowing (worsening) of -8.2 s (range: -19.1s to -3.4 s) and no player tested post-match or post-injury (concussion) recorded a K-D test score with >1 s and ≤ 3 s. The K-D test was utilised at every testing time to monitor the recovery process.

One concussion throughout the study was an unwitnessed concussive event that occurred in a tackling drill where the player's head connected with the other player's knee. The player continued on with tackling other players as part of the drill until another player reported her to the coaching staff. The player was removed from further training involvement and tested after five minutes rest. The players post- 'event' K-D test score had worsened (33.3 s vs. 52.4 s) when compared with her baseline. This is consistent with previous studies [28-30, 44,53] where participants tested at the side of the match venue immediately following an injury have demonstrated substantial worsening of the K-D test times when compared with their baseline scores.

The finding that the concussion incidence was 16.1 per 1,000 match-hrs. over the study was higher than previous women's rugby union match injury studies (0.55 per 1,000 playing hours) [54]. The mean missed-match duration for concussions were 28.9 ±3.7 days which was similar to a previous study [55] where the majority of concussions took 28 days to recover. This finding is in conflict with the Concussion in Sport Consensus (CISC) where it identified that 80% to 90% of all concussions recover in seven to ten days [13,56]. The New Zealand Rugby concussion guidelines are based on the CISC guidelines and outline that players can return to match activities on the 21st day post-injury with medical clearance. No players in this study with a medically diagnosed concussion were allowed to commence contact training in preparation for match participation until they had equalled or surpassed (faster) their baseline K-D test despite the presentation of a medical clearance by their own health practitioner. No player with an identified concussion returned to their baseline K-D test before 21 days post-injury. As a result, no player was allowed to return to full match participation until they had completed two contact training sessions, were symptom free and, there were no worsening (slower) time of their K-D test from their baseline.

In a recent meta-analysis [57] it was reported that male athletes tend to record concussions through player contact whereas female athletes tend to record concussions as a result of contact with equipment or the surface even for sports that have the same rules of player for both male and female participants. Women rugby union participants play under the same rules as male participants, but it has never been identified whether women's rugby union concussions occur specifically as a result of the tackle contest or through contact with the ground. Most (n=8) of the concussions recorded in this study occurred within the tackle as either the tackler (n=1) or ball carrier (n=7). Only one concussion occurred during a ruck and it was not identified as whether she was the tackler or the ball carrier. In all cases the players were taken to the ground and the concussion may have occurred from either player contact or contact with the ground. Further research is warranted to ascertain if this occurring in women's rugby union and a clearer identification of the cause of the concussive injury (if possible) be added to the data recording.

Although the players completed the RESTQ-Sport prior to a training session, the results were not able to be reviewed until later due to the time requirements for the analysis of the results.

Despite this, the results were useful for future follow-up and provided the individual players with a visual representation of their results compared to the average group results.

CONCLUSION

This study utilised the RESTQ-Sport to monitor the stress and recovery of amateur domestic female rugby players over a competition season. Although there were some noticeable differences in the group analysis, this did not occur on all aspects of the RESTQ-Sport, and when analysed on an individual basis there were more observable differences identified. The RESTQ-Sport was a useful tool for the monitoring of stress and recovery of an initial cohort of amateur women's rugby union participants following a mild traumatic brain injury.

CONTRIBUTOR STATEMENT

The corresponding author attests that all listed authors meet authorship criteria and that no others meeting the criteria have been omitted. According to the definition given by the International Committee of Medical Journal Editors (ICMJE), the authors listed above qualify for authorship based on making one or more of the substantial contributions to the intellectual content of: (1) Conception and design [DK]; and/or, (2) Acquisition of data [DK]; and/or (3) Analysis and interpretation of data [DK]; and/or (4) Participated in drafting of the manuscript [DK, PH, TC, KH]; and/or (5) Critical revision of the manuscript for important intellectual content [DK, PH, KH,C].

REFERENCES

1. Kellmann M, Kallus K. The Recovery-Stress Questionnaire for Athletes. In: Kallus K, Kellmann M, editors. The Recovery-Stress Questionnaires: User Manual Frankfurt is Main: Pearson Assessment & Information GmbH. 2016; 86-131.
2. Tessitore A, Meeusen R, Pagano R, Benvenuti C, Tiberi M, Caprancia L. Effectiveness of active versus passive recovery strategies after futsal games. J Strength Cond Res. 2008; 22: 1402-1412.
3. Kellmann M, Günther K-D. Changes in stress and recovery in elite rowers during preparation for the Olympic Games. Med Sci Sports Exerc. 2000; 32: 676-683.
4. Kellmann M, Altenburg D, Lormes W, Steinacker J. Assessing stress and recovery during preparation for the world championships in rowing. Sports Psychol. 2001; 15: 151-167.
5. Coutts A, Wallace L, Slattery K. Monitoring changes in performance, physiology, biochemistry, and psychology during overreaching and recovery in triathletes. Int J Sports Med. 2007; 28: 125-34.
6. Morales J, Roman V, Yáñez A, Solana-Tramunt M, Álamo J, Fíguls A. Physiological and psychological changes at the end of the soccer season in elite female athletes. J Hum Kinet. 2019; 66: 99-109.
7. King D, Clark T, Kellmann M. Changes in stress and recovery as a result of participating in a premier rugby league representative competition. Int J Sport Sci Coach. 2010; 5: 223-237.
8. King D, Clark T, Kellman M, Hume P. Stress and recovery changes of injured and non-injured amateur representaitve rugby league players over a competition season. NZ J Sports Med. 2017; 43: 57-63.
9. Hartwig T, Naughton G, Searl J. Load, stress, and recovery in adolescent rugby union players during a competitive season. J Sports Sci. 2009; 27: 1087-1094.
10. Brink M, Visscher C, Arends S, Zwerver J, Post W, Lemmink K. Monitoring stress and recovery: New insights for the prevention of injuries and illnesses in elite youth soccer players. Br J Sports Med. 2010; 44: 809-815.
11. Kellmann M, Bertollo M, Bosquet L, Brink M, Coutts A, Duffield R, et al. Recovery and performance in sport: Consensus statement. Int J Sports Phys Perform. 2018; 13: 240-245.
12. King D, Brughelli M, Hume P, Gissane C. Assessment, management and knowledge of sport-related concussion: Systematic review. Sports Med. 2014; 44: 449-471.
13. McCrory P, Meeuwisse W, Dvořák J, Aubry M, Bailes J, Broglio S, et al. Consensus statement on concussion in sport - The 5th international conference on concussion in sport held in Berlin, October 2016. Br J Sports Med. 2017; 51: 838-847.
14. Van Donkelaar P, Langan J, Rodriguez E, Drew A, Halterman C, Osternig LR, et al. Attentional deficits in concussion. Brain Inj. 2005; 19: 1031-1039.
15. Van Donkelaar P, Osternig L, Chou L. Attentional and biomechanical deficits interact after mild traumatic brain injury. Exerc Sport Sci Rev. 2006; 34: 77-82.
16. Shrey D, Griesbach G, Giza C. The pathophysiology of concussions in youth. Phys Med Rehabil Clin N Am. 2011; 22: 577-602.
17. Chan RCK. Attentional deficits in patients with post-concussion symptoms: a componential perspective. Brain Inj. 2001; 15: 71-94.
18. Borgaro S, Prigatano G, Kwasnica C, Rexer J. Cognitive and affective sequelae in complicated and uncomplicated mild traumatic brain injury. Brain Inj. 2003; 17: 189-198.
19. Yehene E, Lichtenstern G, Harel Y, Druckman E, Sacher Y. Self-efficacy and acceptance of disability following mild traumatic brain injury: A pilot study. Appl Neuropsychol Adult. 2019.
20. Strom TQ, Kosciulek J. Stress, appraisal and coping following mild traumatic brain injury. Brain Inj. 2007; 21: 1137-1145.
21. Kay T, Newman B, Cavallo M, Ezrachi O, Resnick M. Toward a neuropsychological model of functional disability after mild traumatic brain injury. Neuropsychology. 1992; 6: 371-384.
22. Machulda MM, Bergquist TF, Ito V, Chew S. Relationship between stress, coping, and postconcussion symptoms in a healthy adult population. Arch Clin Neuropsych. 1998;13: 415-424.
23. Sandel N, Reynolds E, Cohen PE, Gillie BL, Kontos AP. Anxiety and mood clinical profile following sport-related concussion: From risk factors to treatment. Sport Exerc Perform Psychol. 2017; 6: 304-323.
24. Houben F, Ghysels R, Mennen D, Bosmans R, Nuyts E, Spooren A. A tool for measuring burden in activities and participation of clients with acquired brain injury: the FINAH-instrument. Brain Inj. 2020.
25. Kellmann M, Kallus K. Mood, recovery-stress state, and regeneration. In: Lehmann M, Foster C, Gastmann U, Keizer H, Steinacker J, editors. Overload Performance Incompetence and Regeneration in Sport. New York: Kluwer Academic / Plenum Publishers. 1999; 101-118.
26. Seidman D, Burlingame J, Yousif L, Donahue X, Krier J, Rayes L, et al. Evaluation of the King–Devick test as a concussion screening tool in high school football players. J Neurol Sci. 2015.
27. Dessy AM, Yuk FJ, Maniya AY, Gometz A, Rasouli JJ, Lovell MR, et al. Review of Assessment Scales for Diagnosing and Monitoring Sports-related Concussion. Cureus. 2017; 9: 1922.
28. Galetta K, Brandes L, Maki K, Dziemianowicz M, Laudano E, Allen M, et al. The King-Devick test and sports-related concussion: Study of a rapid visual screening tool in a collegiate cohort. J Neurol Sci. 2011; 309: 34-39.

29. King D, Gissane C, Hume P, Flaws M. The King–Devick test was useful in management of concussion in amateur rugby union and rugby league in New Zealand. J Neurol Sci. 2015; 351: 58-64.

30. Galetta K, Barrett J, Allen M, Madda F, Delicata D, Tennant A, et al. The King-Devick test as a determinant of head trauma and concussion in boxers and MMA fighters. Neurology. 2011; 76: 1456-1462.

31. Galetta M, Galetta K, McCrossin J, Wilson J, Moster S, Galetta S, et al. Saccades and memory: baseline associations of the King–Devick and SCAT2 SAC tests in professional ice hockey players. J Neurol Sci. 2013; 328: 28-31.

32. Galetta K, Liu M, Leong D, Ventura R, Galetta S, Balcer L. The King-Devick test of rapid number naming for concussion detection: Meta-analysis and systematic review of the literature. Concussion. 2015; 1: CNC8.

33. Yue JK, Phelps RRL, Chandra A, Winkler EA, Manley GT, Berger MS. Sideline concussion assessment: The current state of the art. Neurosurgery. 2020.

34. Tjarks B, Dorman J, Valentine V, Munce T, Thompson P, Kindt S, et al. Comparison and utility of King-Devick and ImPACT composite scores in adolescent concussion patients. J Neurol Sci. 2013; 334: 148-153.

35. Legarreta AD, Mummareddy N, Yengo-Kahn AM, Zuckerman SL. On-field assessment of concussion: Clinical utility of the King-Devick test. Open Access J Sports Med. 2019; 10: 115-121.

36. Leong D, Balcer L, Galetta S, Liu Z, Master C. The King-Devick test as a concussion screening tool administered by sports parents. J Sports Med Phys Fit. 2014; 54: 70-77.

37. Howitt S, Brommer R, Fowler J, Gerwing L, Payne J, DeGraauw C. The utility of the King-Devick test as a sideline assessment tool for sport-related concussions: A narrative review. J Can Chiropr Assoc. 2016; 60: 322-339.

38. Marinides Z, Galetta K, Andrews C, Wilson J, Herman D, Robinson C, et al. Vision testing is additive to the sideline assessment of sports-related concussion. Neurol Clin Pract. 2014; 5: 25-34.

39. Nguyen MQ, King D, Pearce AJ. A reliability and comparative analysis of the new randomized King-Devick test. J Neuroophthalmol. 2020; 40: 207-212.

40. Lovell M, Collins M. Neuropsychological assessment of the college football player. J Head Trauma Rehabil. 1998; 13: 9-26.

41. Lovell M, Iverson G, Collins M, Podell K, Johnston K, Pardini D, et al. Measurement of symptoms following sports-related concussion: reliability and normative data for the post-concussion scale. App Neuropsychol. 2006; 13: 166-174.

42. Merritt V, Meyer J, Arnett P. A novel approach to classifying postconcussion symptoms: The application of a new framework to the Post-Concussion Symptom Scale. J Clin Exp Neuropsychol. 2015; 37: 764-775.

43. King D, Brughelli M, Hume P, Gissane C. Concussions in amateur rugby union identified with the use of a rapid visual screening tool. J Neurol Sci. 2013; 326: 59-63.

44. King D, Clark T, Gissane C. Use of a rapid visual screening tool for the assessment of concussion in amateur rugby league: A pilot study. J Neurol Sci. 2012; 320: 16-21.

45. King DA, Hume PA, Foskett A, Narnes MJ. Changes in the stress and recovery of injured versus non-injured amateur domestic women's rugby union team players over a competition season in New Zealand. NZ J Sports Med. 2020; 46: 74-83.

46. Spradley B, Wiriyanpinit S, Magner A. Baseline concussion testing in different environments: A pilot study. The Sport J. 2014.

47. Taber KS. The use of Cronbach's alpha when developing and reporting research instruments in science education. Res Sci Educ. 2018; 48: 1273-1296.

48. Brown N, Mannix R, O'Brien M, Gostine D, Collins M, Meehan III W. Effect of cognitive activity level on duration of post concussion symptoms. Pediatr. 2014.

49. Marshall J. Measuring stress and recovery in rugby union. Rugby Football Union Technical Journal. 2004.

50. Shrier I, Hallé M. Psychological predictors of injuries in circus artists: an exploratory study. Br J Sports Med. 2011; 45: 433-436.

51. Hubbard R, Stringer G, Peterson K, Vaz Carneiro MRF, Finnoff JT, Savica R. The King-Devick test in mixed martial arts: the immediate consequences of knock-outs, technical knock-outs, and chokes on brain functions. Brain Inj. 2019; 33: 349-354.

52. Oberlander TJ, Olson BL, Weidauer L. Test-Retest reliability of the King-Devick Test in an adolescent population. J Ath Train. 2017; 52: 439-445.

53. King D, Hume P, Gissane C, Clark T. Use of the King–Devick test for sideline concussion screening in junior rugby league. J Neurol Sci. 2015; 357: 75-79.

54. Gardner A, Iverson G, Williams W, Baker S, Stanwell P. A systematic review and meta-analysis of concussion in rugby union. Sports Med. 2014; 44: 1717-1731.

55. Kara S, Crosswell H, Forch K, Cavadino A, McGeown J, Fulcher M. Less than half of patients recover within 2 weeks of injury after a sports-related mild traumatic brain injury: A 2-year prospective study. Clin J Sport Med. 2020; 30: 96-101.

56. McCrory P, Meeuwisse W, Aubry M, Cantu R, Dvořák J, Echemendia R, et al. Consensus statement on concussion in sport: the 4th International Conference on Concussion in Sport held in Zurich, November 2012. Br J Sports Med. 2013; 47: 250-258.

57. Ling DI, Cheng J, Santiago K, Ammerman B, Jivanelli B, Hannafin J, et al. Women are at higher risk for concussions due to ball or equipment contact in Soccer and Lacrosse. Clin Orthop Relat Res. 2020; 478: 1469-1479.

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