ORIGINAL ARTICLE

Stress and recovery changes of injured and non-injured amateur representative rugby league players over a competition season

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INTRODUCTION

Overload adaptation requires adequate recovery to enable the body to both adapt to the increased demand and then to recuperate from the increased stimulus.[1,2] Failure to provide adequate recovery periods between increasing the training stimuli before adequate rest exposes the player to overtraining and performance decline.[3] Unfortunately it is difficult to quantify the exact amount required and imbalances may result in over-reaching of the player who may burnout, suffer over-training syndrome and be at an increased risk of injury.[4]

The stress-injury model[5] and the overtraining and recovery model[6] are used to describe the balance between physical and psychosocial stress and recovery. Changes, or disturbances, in the physical and/or psychosocial aspects, such as increased muscle tension resulting in disturbed motor coordination and reduced flexibility and narrowing of the visual field,[5] can contribute to the development of attentional changes that may result in overload of the body increasing the risk of an injury occurring.[5] The response to the attentional changes is moderated by individual coping resources, personality and history of stressors but may physically result in increases in muscle tension and distractibility, placing the player at increased risk of injury.[5] Previous authors[5,6] have only

ABSTRACT

Objective To monitor amateur representative rugby league players stress and recovery utilising the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) and the Recovery-Cue to identify which tool could differentiate which players were at a higher risk of an injury occurring during rugby league match and training activities.

Methods Thirty male rugby league players in a premier division representative rugby league team participated in this study. The multidimensional RESTQ-Sport with 52 items (10-12 minutes completion) and the Recovery-Cue tool were used to measure the complexities of stress and recovery states in players at the selection of the team and following every scheduled match.

Results During the 9 week study period (25 training sessions and 9 matches) 13 training injuries (13 per 1,000 training hours) and 39 match injuries (188 per 1,000 match hours) occurred for 30 amateur players. Over the matches, players who were subsequently injured in a match or training activity had significantly higher general- and sport-specific stress scale scores and lower general and sport-specific recovery scale scores of the RESTQ-Sport than non-injured players.

Discussion The development of a shortened version of the RESTQ-Sport specifically related to the scales of Social Stress, Success, Personal Accomplishment, Fatigue, Emotional Exhaustion, Injury and Self-Efficacy may be beneficial in the identification of players at risk of injury and would be quicker to complete, limiting time away from the training environment. The study results support sports medicine practitioners utilising the RESTQ-Sport to systematically monitor stress and recovery of players.

investigated the use of these models for evaluating training frequency and life event stress at the commencement of a playing season.

A tool developed for coaches to systematically monitor over a period of training or matches the complexities of stress and recovery states in players is the multidimensional Recovery-Stress Questionnaire for Athletes (RESTQ-Sport).[7] There are three versions of the RESTQ-Sport, consisting of a 76, a 52 and a recently published 36 question version. The main differences are the number of questions in each of the scales with the RESTQ-Sport-52 having fewer in the general stress and recovery scale sections of the questionnaire when compared with the 76 question version, whereas the RESTQ-Sport-36 also contains a reduced number of scales. Previous studies have utilised the RESTQ-Sport on individual players in the training environment[3,8,9] and as part of a recovery programme.[10] More recently the RESTQ-Sport has been used to monitor sports team members overall stress and recovery during competition in rugby

union,[11] rugby league[12] and soccer.[13] In rugby league[12] the RESTQ-Sport results allowed identification of players with an undisclosed injury and was utilised to monitor injured player's rehabilitation progress as they returned to competition participation. Although this study[12] used the RESTQ-Sport-52 (52 items) it did not assess the players for a risk of injury prior to matches or training activities.

As the RESTQ-Sport takes ten to twelve minutes to complete a monitoring tool that is quicker to complete is desirable as it could provide more timely feedback to both the player and the coach. Similar to the RESTQ-Sport, the Recovery-Cue has been developed to monitor for warning signs of possible overtraining but on a more continual basis.[14] The seven-item tool takes only 30 s to complete. Designed to provide visual feedback on the players' current stress and recovery states, the Recovery-Cue can also be used as a visual tool for improving the player's knowledge and awareness of their own stress and recovery by allowing the results to be

plotted over a timeline for each of the seven items utilised.[14] The Recovery-Cue has been previously used in the monitoring of sports players in basketball,[15] rowing and cycling[16] but no published studies have reported the use of both the RESTQ-Sport and the Recovery-Cue for monitoring individual players or team sports players. Therefore the purpose of this study was to monitor amateur representative rugby league players' stress and recovery utilising the RESTQ-Sport and the Recovery-Cue to identify which tool could differentiate whether players were at a higher risk of an injury occurring from rugby league match and training activities.

METHODS

Participants and Ethical Approval

A prospective observational study was undertaken following one premier division rugby league team (30 male players; mean ±SD 23.3 ±4.3 yr., 1.80 ±0.05 m, 93.6 ±14.4 kg) in the 2010 New Zealand regional representative competition season (six teams from around New Zealand playing in a home and away competition format over seven weeks from August to October). This team was utilised as the lead researcher was involved in the management of these players directly. The team consisted of players selected from their region as part of the national representative completion in New Zealand. All players were amateur as they derived their main source of income from other means and did not receive match payments. Ethics approval was provided (AUTEC 09/282).

The Recovery-Stress Questionnaire for Athletes (RESTQ-Sport)

The RESTQ-Sport-52 version is a psychometrically paper based questionnaire that assesses a player's recovery-stress state.[3,8,17] 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 of players physical, subjective, behavioural, and social aspects of stress and recovery (see table 1).[7,9,18] 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.

The mean of each scale indicates the player's stress-associated subjective strain for the stress-associated scales. This is similar for the player's recovery process for the recovery-orientated scales. As such, the results of these scores indicates the player's stress-associated subjective strain and recovery process for the recovery scales. To compensate high states of stress equivalent recovery processes need to be initiated.[7] Chronic imbalances, such as high stress and low recovery, may place the participant at a high risk of chronic stress, burnout, performance decrements and possible health problems.[7]

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).[7,8] The internal consistency reportedly[7] 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.

The Recovery-Cue

The Recovery-Cue[14] is a seven item paper based questionnaire that can provide immediate feedback regarding current stress and recovery states to the reviewer. Players who report low score (0) can be easily identified from those reporting high scores (6). Each of the seven items (questions) in the self-monitoring tool is related to how the player felt about their recovery in the last week and required the player to respond using a seven-point Likert scale.

Table 1: RESTQ-Sport scales, scale orientation (o), number of items (n) and sample item, Cronbach's α, and test-retest reliabilities[7]

No	RESTQ-Sport scale	o	n	Example: "In the last 3 days…"	α	Test-Retest
1	General Stress	S	2	…I felt down	0.76	0.71
2	Emotional Stress	S	2	…I was in a bad mood	0.71	0.72
3	Social Stress	S	2	…I was angry with someone	0.85	0.77
4	Conflicts/pressure	S	2	…I felt under pressure	0.68	0.73
5	Fatigue	S	2	…I was overtired	0.78	0.81
6	Lack of Energy	S	2	…I was unable to concentrate well	0.72	0.68
7	Physical Complaints	S	2	…I felt uncomfortable	0.71	0.76
8	Success	R	2	…I finished important tasks	0.67	0.70
9	Social Recovery	R	2	…I had a good time with my friends	0.80	0.74
10	Physical Recovery	R	2	…I felt at ease	0.85	0.79
11	General Well-Being	R	2	…I was in a good mood	0.84	0.61
12	Sleep Quality	R	2	…I had a satisfying sleep	0.83	0.70
13	Disturbed Breaks	S	4	…my coach demanded too much of me during the breaks	0.79	0.64
14	Emotional Exhaustion	S	4	…I felt I wanted to quit my sport	0.71	0.72
15	Injury	S	4	…my performance drained me physically	0.78	0.59
16	Being in Shape	R	4	…I was in good condition physically	0.88	0.71
17	Personal Accomplishment	R	4	…I dealt very effectively with my team-mates' problems	0.80	0.81
18	Self-Efficacy	R	4	…I was convinced that I had trained well	0.89	0.82
19	Self-Regulation	R	4	…I prepared myself mentally for performance	0.83	0.77

S = Stress; R = Recovery

For example, the item for Rest asked the question "How successful were you at rest and recovery activities last week?" and the player rated their response from 6 (successful) to 0 (not successful at all). Three items (Perceived Exertion, Perceived Recovery and Recovery Effort) monitor for early warning signs of possible overtraining effects[6] while the other four items (Physical Recovery, Sleep Quality, Social Recovery and Self-Regulation) represent scales in the RESTQ-Sport important for the recovery process.[6] The Recovery-Cue utilised in this study was adapted from the original design[14] to ensure players could not duplicate the previous weeks score (see Appendix I).

Testing Schedule for RESTQ-Sport and Recovery-Cue

The study period of nine weeks included 25 training sessions, and nine matches. Similar to a previous study,[12] the RESTQ-Sport was undertaken prior to the competition starting (baseline establishment) and then on the first training session (a recovery pool session) following each match and the Recovery-Cue was included in the recovery assessments. Baseline assessment using the RESTQ-Sport and the Recovery-Cue was conducted on weeks 1 and 2 to enable capture of all players. This assessment also assisted in identification of injured players and provided a baseline to gauge the recovery against. Subsequent assessments (T1-T6) were conducted on the first Monday of each week of the competition irrespective of whether the player participated in the previous match and was injured or not. This was a planned recovery session from the previous weekend match. The RESTQ-Sport took approximately 10 to 12 minutes to complete while the Recovery-Cue took approximately 30 s to complete. This assessment time was programmed into the recovery programme and did not prolong the player's from undergoing their planned session. The team coach did request to see the Recovery-Cue immediately after completion and implemented changes to the recovery session for players with lowered Recovery-Cue scores such as low intensity activities and non-contact activities for the training session.

Injury definitions, data collection, match and training exposure and injury rate calculations

Over the competition, all training and match injuries were recorded by the team medic on a standardised injury reporting form regardless of severity.[19] All 25 training sessions were 90 minutes in duration and all matches were 80 minutes in duration. The injury definition utilised for this study was "any physical complaint or disability that occurs during participation in rugby league match or training activities that is sustained by a player, irrespective of the need for match or training time loss or for first aid or medical attention."[20]

Injury rates were expressed as the number of injuries sustained per 1,000 hours.[20-22] Match injury rates were calculated on the premise that there were 13 player positions on the field, regardless of any substitutions for 80 minutes (1.33 hours) per game. Training injury rates were reported as a function of total training exposure time.

STATISTICAL ANALYSES

Data was entered into a Microsoft Excel spreadsheet enabling weekly assessment scores to be graphed automatically. Data were analysed with the Statistical Package for Social Sciences for Windows (SPSS; V23.0.0). Comparisons of the data between injured and non-injured players were undertaken in two-ways; (1) For the non-injured players, the RESTQ-Sport and Recovery-Cue scores were taken as a mean across all of the assessment weeks; (2) For the injured players their scores were taken from the assessment prior to the match in which they were injured.

A Generalised Linear Model was utilised for all the scales of the RESTQ-Sport and the Recovery-Cue, for the mean of the individual scales and the total stress and recovery scores utilising the injured player as the dependent variable. If differences were detected a post-hoc two-tailed paired t-test was utilised to determine if any significant differences existed. A Bonferroni-type adjustment was applied to maintain the Type-1 error probability at the 0.05 alpha level. Total recovery and stress scores were obtained by calculating the mean of all recovery and stress scales as previously described.[17] Overall weekly recovery and stress scores were obtained by calculating the mean of all recovery and stress scales.[17] The risk ratio (RR) of injury (injured players: non-injured players) was calculated with the Generalised

Linear Model for all the scales of the RESTQ-Sport and the Recovery-Cue, for the mean of the individual scales and the total stress and recovery scores utilising the injured player as the dependent variable. Changes in match and training injuries were compared using a one sample Chi-squared ($\chi 2$) test.

RESULTS

Match, training exposure and injury rates

Over the duration of the representative competition there were 25 training sessions resulting in 1004 hours of training exposure. Not all players were present at every training session resulting in a mean (±SD) of 23 ±3 players present at trainings over the study period. Thirteen training injuries were recorded over the study period giving a training injury rate of 13 (95% CI: 8 to 22) per 1,000 training hours. The team participated in nine matches (three trial matches and six representative matches) resulting in 207.5 match exposure hours. There were 39 match injuries recorded over the study period giving a match injury rate of 188 (137 to 257) per 1,000 match hours.

RESTQ-Sport and Recovery-Cue over the Competition

Injured players recorded a significantly higher pre-injury stress-score over the duration of the study when compared with the non-injured amateur rugby league players (see Table 2). Injured players recorded a significantly higher overall stress score than non-injured players at baseline ($\chi 2(1)=33.25$, p<0.0001; t(19)=-3.69, p=0.0016), T1 ($\chi 2(1)=17.44$, p<0.0001; t(12)=-6.45, p<0.0001) and T4 ($\chi 2(1)=65.33$; p<0.0001; t(12)=-5.88, p=0.0011) assessments.

Injured players recorded higher scores in the general ($\chi 2(1)=117.8$, p<0.0001; t(72)=-10.63, p<0.0001) and sport-specific ($\chi 2(1)=92.2$, p<0.0001; t(72)=-9.86, p<0.0001) stress scales and lower scores in the general ($\chi 2(1)=59.57$, p=<0.0001; t(72)=5.45, p<0.0001) and sport-specific ($\chi 2(1)=62.36$, p<0.0001; t(72)=5.35, p<0.0001) recovery scales before an injury was recorded (see Table 3). As a result, injured players recorded higher total stress scores ($\chi 2(1)=117.67$, p<0.0001; t(72)=-12.85, p<0.0001) and lower total recovery scores ($\chi 2(1)=65.97$, p<0.0001; t(72)=5.95, p<0.0001) than non-injured players over the duration of the study. Of the 17 players that

Table 2: Mean and standard deviations for scores in the different scales of the RESTQ-Sport-52 and the Recovery-Cue for players who recorded an injury and non-injured players in the week following the assessment corresponding to the seven measurements during the study period, players present at training, training injuries, total match injuries and match results of the 2010 regional representative amateur rugby league team.

RESTQ-Sport	Baseline Injured	Baseline Non-Injured	T1 Injured	T1 Non-Injured	T2 Injured	T2 Non-Injured	T3 Injured	T3 Non-Injured	T4 Injured	T4 Non-Injured	T5 Injured	T5 Non-Injured	T6 Injured	T6 Non-Injured
Overall stress score	1.87 ±0.48a	1.15 ±0.44	1.94 ±0.41a	0.95 ±0.37	1.92 ±0.53	0.90 ±0.41	1.78 ±0.38a	0.95 ±0.15	1.64 ±0.47a	0.83 ±0.38	1.61 ±0.30	0.67 ±0.28	1.54 ±0.38a	0.82 ±0.31
General stress	1.73 ±0.57a	1.07 ±0.52	2.03 ±0.73a	0.85 ±0.37	1.74 ±0.61	0.83 ±0.60	1.67 ±0.44a	1.07 ±0.26	1.56 ±0.44a	0.79 ±0.43	1.54 ±0.32a	0.61 ±0.34	1.60 ±0.59a	0.74 ±0.33
General Stress	1.05 ±0.56	0.82 ±0.84	1.55 ±1.00a	0.50 ±0.50	1.43 ±0.83	0.33 ±0.58	1.14 ±0.50	0.86 ±0.90	1.04 ±0.57a	0.36 ±0.48	1.10 ±0.57a	0.19 ±0.37	1.11 ±0.93	0.38 ±0.46
Emotional Stress	1.68 ±0.59a	1.11 ±0.58	2.23 ±1.25a	0.92 ±0.49	1.79 ±0.73	0.67 ±0.76	1.18 ±0.51	1.07 ±0.67	1.54 ±0.50a	1.00 ±0.41	1.35 ±0.34a	0.50 ±0.53	1.56 ±0.63a	0.62 ±0.42
Social Stress	1.55 ±0.71a	0.86 ±0.66	1.55 ±0.87a	0.73 ±0.48	1.50 ±0.92	0.83 ±0.29	1.36 ±0.55	0.71 ±0.70	1.25 ±0.64a	0.57 ±0.61	1.15 ±0.63a	0.25 ±0.38	1.28 ±0.57a	0.42 ±0.49
Conflicts/Pressure	2.15 ±0.92a	1.34 ±0.68	2.56 ±0.88a	1.23 ±0.63	2.07 ±0.68	0.67 ±0.58	1.86 ±0.55	1.57 ±0.61	1.75 ±0.55	1.07 ±0.89	1.45 ±0.72	1.00 ±1.13	1.61 ±0.82	0.96 ±0.69
Fatigue	2.43 ±1.16a	1.23 ±1.03	2.31 ±1.15a	1.12 ±0.77	2.07 ±1.02	1.00 ±0.50	2.36 ±1.00a	1.50 ±1.04	2.36 ±1.35a	1.00 ±0.82	2.25 ±1.27a	1.00 ±0.93	2.11 ±1.69	1.23 ±0.97
Lack of Energy	1.88 ±0.78a	1.34 ±0.76	2.37 ±0.71a	1.00 ±0.58	1.79 ±0.61	1.00 ±1.00	1.86 ±0.64a	0.93 ±0.79	1.57 ±0.55a	0.79 ±0.49	1.60 ±0.46a	0.56 ±0.42	1.67 ±0.56a	0.96 ±0.32
Physical Complaints	1.40 ±0.88a	0.80 ±0.78	1.63 ±0.86a	0.46 ±0.48	1.54 ±0.82	1.33 ±1.53	1.91 ±1.04	0.86 ±0.48	1.43 ±0.87	0.71 ±0.81	1.90 ±0.94	0.75 ±0.80	1.89 ±1.47a	0.58 ±0.57
Sport-specific stress	2.17 ±0.47a	1.32 ±0.40	1.72 ±0.56a	1.18 ±0.54	1.78 ±0.76	1.06 ±0.13	2.05 ±0.55a	0.65 ±0.37	1.80 ±0.76a	0.92 ±0.37	1.76 ±0.44a	0.80 ±0.32	1.38 ±0.40	1.01 ±0.41
Disturbed Breaks	1.88 ±0.77a	1.45 ±0.85	1.65 ±0.66	1.13 ±0.71	1.64 ±0.95	0.92 ±0.14	1.82 ±0.60a	0.68 ±0.61	1.63 ±0.78	1.18 ±0.95	1.63 ±0.44a	0.53 ±0.49	1.31 ±0.74	0.94 ±0.66
Emotional Exhaustion	1.60 ±0.71a	0.80 ±0.54	1.46 ±0.78a	0.73 ±0.57	1.27 ±1.10	0.50 ±0.25	1.48 ±0.95	0.32 ±0.19	1.18 ±0.81a	0.32 ±0.31	0.98 ±0.32a	0.44 ±0.68	0.72 ±0.44	0.50 ±0.48
Injury	3.03 ±0.94a	1.69 ±0.56	2.04 ±0.56	1.67 ±0.78	2.45 ±0.63	1.75 ±0.66	2.84 ±1.06a	0.96 ±0.70	2.61 ±1.10a	1.25 ±0.99	2.68 ±0.84a	1.44 ±0.50	2.11 ±0.67	1.60 ±0.91
Overall recovery score	3.64 ±0.40a	4.16 ±0.77	3.35 ±0.32a	4.20 ±0.45	3.70 ±0.43	4.14 ±0.10	3.80 ±0.69	4.28 ±0.66	3.53 ±0.67	4.43 ±0.61	3.89 ±0.70	4.21 ±0.68	4.02 ±0.76	4.29 ±0.79
General recovery	3.75 ±0.43	4.16 ±0.84	3.33 ±0.81	4.28 ±0.39	3.55 ±0.75	4.10 ±0.20	3.83 ±0.73	4.17 ±0.75	3.66 ±0.69	4.41 ±0.53	4.16 ±0.61	4.29 ±0.20	3.81 ±1.09	4.38 ±0.79
Success	3.35 ±0.78	3.82 ±1.17	2.96 ±1.16	3.65 ±0.80	3.29 ±1.20	3.17 ±1.26	3.41 ±1.18	3.64 ±0.99	3.07 ±1.16	3.71 ±0.70	3.35 ±1.18	3.19 ±1.07	3.28 ±1.48	3.54 ±1.45
Social Recovery	4.58 ±0.86	4.36 ±1.03	3.76 ±1.04a	4.58 ±0.64	3.89 ±1.04	3.83 ±0.76	4.68 ±0.46	4.21 ±0.86	4.04 ±1.34	4.71 ±0.57	4.65 ±0.75	4.75 ±1.20	4.39 ±0.96	4.85 ±1.05
Physical Recovery	3.03 ±0.77	3.68 ±1.21	2.92 ±0.57a	3.77 ±0.83	3.07 ±0.85	3.83 ±1.26	3.14 ±0.84	4.29 ±0.91	3.25 ±0.94	3.93 ±1.59	3.60 ±0.74	4.13 ±0.99	3.33 ±1.27	4.38 ±0.94
General Well-Being	4.10 ±0.85	4.52 ±1.05	3.38 ±1.00a	4.77 ±0.53	3.68 ±1.07	4.50 ±0.50	4.32 ±0.75	4.43 ±0.93	3.96 ±0.60	5.00 ±0.50	4.70 ±0.71	4.94 ±0.90	4.17 ±1.03	4.85 ±0.77
Sleep Quality	3.68 ±0.82a	4.43 ±1.17	3.63 ±1.23a	4.65 ±0.88	3.82 ±0.91	5.17 ±1.04	3.59 ±1.45	4.29 ±1.35	3.96 ±1.01	4.71 ±1.22	4.50 ±1.11	4.44 ±1.27	3.89 ±1.75	4.31 ±1.11
Sport-specific recovery	3.51 ±0.54a	4.15 ±0.89	3.38 ±0.69	4.09 ±0.78	3.75 ±0.79	4.19 ±0.44	3.76 ±0.76	4.42 ±0.64	3.36 ±0.75a	4.44 ±0.82	3.55 ±0.88	4.12 ±0.92	4.28 ±0.93	4.18 ±0.87
Being in Shape	3.23 ±0.91a	4.50 ±0.97	3.65 ±0.89	4.37 ±0.75	3.79 ±1.00	4.67 ±0.14	3.64 ±1.17	4.54 ±0.76	3.52 ±0.85	4.54 ±1.51	3.83 ±1.01	4.38 ±1.02	4.33 ±0.90	4.56 ±0.87
Personal Accomplishment	3.35 ±0.61	3.73 ±0.98	3.04 ±0.63a	3.65 ±0.77	3.32 ±0.80	3.42 ±1.15	3.27 ±0.88	3.79 ±0.62	3.05 ±0.74	4.04 ±0.82	2.93 ±0.96	3.44 ±1.08	3.19 ±1.22	3.83 ±1.11
Self-Efficacy	3.43 ±0.77a	4.02 ±1.02	3.29 ±0.78a	3.92 ±0.85	3.89 ±0.79	3.67 ±0.29	3.86 ±0.98	4.43 ±0.72	3.23 ±1.02	4.04 ±0.68	3.48 ±0.98	3.97 ±0.91	4.69 ±1.00	3.98 ±1.06
Self-Regulation	4.04 ±1.01	4.36 ±1.21	3.54 ±0.92a	4.40 ±1.19	4.00 ±0.89	5.00 ±0.66	4.27 ±0.68	4.93 ±1.01	3.64 ±0.82a	5.14 ±0.79	3.95 ±0.86	4.69 ±1.15	4.89 ±0.99	4.35 ±1.23
Recovery-Cue														
Effort	2.94 ±1.34	2.94 ±1.09	3.31 ±0.95	3.69 ±1.18	2.93 ±1.00	3.33 ±1.15	3.18 ±1.60	2.43 ±0.79	3.42 ±0.90	2.71 ±0.95	3.10 ±0.88	2.63 ±1.41	3.67 ±1.32	2.62 ±1.26
Recovery	3.82 ±1.59	4.00 ±1.00	3.69 ±0.95a	4.92 ±0.86	4.21 ±0.70	4.33 ±0.58	4.36 ±0.50	4.71 ±0.95	3.83 ±0.58	3.71 ±1.98	4.00 ±0.94	4.00 ±1.41	4.33 ±1.50a	5.31 ±0.75
Rest	3.94 ±1.14	3.76 ±1.09	3.62 ±0.87a	5.15 ±1.07	4.14 ±0.95	5.00 ±1.00	3.82 ±0.40a	5.00 ±1.00	4.08 ±0.67	4.71 ±1.25	4.20 ±0.92	4.13 ±1.81	4.89 ±1.36	5.00 ±0.91
Physical	3.88 ±1.41	4.18 ±1.01	4.00 ±0.82a	5.31 ±0.75	4.29 ±1.20	4.33 ±0.58	4.00 ±1.26	5.14 ±0.90	4.25 ±0.87	4.86 ±1.35	4.30 ±1.16	4.13 ±1.36	4.56 ±1.42	5.46 ±0.66
Sleep	3.76 ±1.71	4.53 ±1.07	4.31 ±1.18	4.92 ±1.04	4.50 ±1.16	4.67 ±1.15	4.09 ±1.22	5.14 ±1.07	4.33 ±1.23	5.00 ±1.41	4.70 ±1.16	4.50 ±1.51	4.78 ±1.30	4.85 ±1.41
Fun	4.76 ±0.66	4.76 ±1.30	4.00 ±0.91a	5.46 ±0.52	4.93 ±1.07	4.33 ±1.53	4.82 ±0.75	5.14 ±1.07	4.33 ±0.78	5.57 ±0.53	4.90 ±0.74	5.13 ±0.99	4.56 ±1.24	5.31 ±1.03
Achievement	4.12 ±1.05	4.41 ±1.18	4.08 ±0.76	4.62 ±0.96	4.79 ±0.70	4.33 ±0.58	4.36 ±0.92	5.29 ±0.76	3.83 ±1.19	5.00 ±0.82	4.70 ±0.67	5.00 ±1.20	5.11 ±1.05	5.00 ±1.15
Mean ±SD players at trainings	20.8 ±2.8		28.8 ±5.8		25.3 ±7.4		20.0 ±7.0		20.3 ±4.0		20.3 ±4.2		23.3 ±2.8	
Training Injuries (No.) 1,000 training hrs	(2) 25.0		(8) 23.2		(0) 0.0		(0) 0.0		(0) 0.0		(0) 0.0		(2) 29.0	
Total match injures (No) 1,000 match hrs	-		(0) 0.0		(4) 231.3		(8) 404.9		(4) 231.3		(9) 520.5		-	
Results (W=Win ;L=Loss; H=Home; A=Away)	-		22-8 (W; H)		24-18 (W; A)		74-0 (W; H)		18-10 (W; A)		30-34 (L; A)		Bye	

T=Testing; SD: Standard deviation; Significant difference (p<0.05) with (a)=Non-Injured

recorded an injury, there was an observable increase in the test scores for the RESTQ-Sport scales Conflict/Pressure (RR: 1.9 [95% CI: 1.3 to 2.9]; p=0.0009), Social Recovery (RR: 3.6 [95% CI: 1.8 to 7.1]; p=0.0004), Disturbed Breaks (RR: 2.0 [95% CI: 1.1 to 14.1]; p=0.0188) and Injury (RR: 2.4 [95% CI: 1.1 to 5.5]; p=0.0342) scales (see Table 3) before the following match when they recorded the injury.

There were differences observed in scores for the Recovery ($\chi2(1)=78.52$, p=<0.0001; t(72)=2.74; p=0.0080) and Physical ($\chi2(1)=70.25$, p<0.0001; t(72)=3.54, p=0.0008) items of the Recovery-Cue for all players

over the duration of the study (see Table 3). Significant differences (p<0.0001) occurred between all the scales of the Recovery-Cue between the injured and non-injured players over the duration of the study (see Table 3). Although injured players recorded a similar mean Effort score ($\chi2(1)=68.36$, p=<0.0001; t(72)=-0.70, p=0.4839) prior to recording an injury, they had a lower mean score in all other areas of the Recovery-Cue when compared with non-injured players.

An example of injury risk potential can be seen in the RESTQ-Sport and Recovery-Cue profile of player A (see Table 4) who had a shoulder injury from club participation

prior to baseline assessment and was stood down from training and match activities until rehabilitated. He was monitored and following rehabilitation his RESTQ-Sport profile scores altered (baseline). At T1 his general (1.29 vs. 2.14; $\chi2(1)=10.33$, p<0.0013; t(9)=-2.30, p=0.0615) and total (1.50 vs. 1.80; $\chi2(1)=6.80$; p=0.0091; t(9)=-0.77, p=0.4600) stress scale score had risen, while his general (3.90 vs. 2.60; $\chi2(1)=33.75$; p<0.0001; t(9)=3.47, p=0.0255) and total (3.72 vs. 2.36; $\chi2(1)=9.20$; p=0.0024; t(9)=5.29; p0.0007) recovery scores had lowered when compared with his baseline. He self-recorded a high level of Recovery, Rest, Physical, Sleep,

Table 3: Mean and standard deviation (±SD) of the RESTQ-Sport-52 scale and Recovery-Cue scale scores and Risk Ratio's with 95% confidence intervals of injured (n=17) and non-injured (n=13) amateur representative rugby league players.

Variable	Injured Mean ±SD	Non-Injured Mean ±SD	RR (95%CI)
General Stress	**1.71 ±0.56**	**0.88 ±0.43**	**1.8 (1.2 to 2.7)***
General Stress	1.20 ±0.72	0.55 ±0.67	1.3 (0.9 to 1.8)
Emotional Stress	1.64 ±0.75	0.89 ±0.56	1.5 (0.9 to 2.4)
Social Stress	1.40 ±0.72	0.65 ±0.58	1.2 (0.8 to 1.9)
Conflicts/Pressure	1.97 ±0.81	1.18 ±0.75	1.9 (1.3 to 2.9)*
Fatigue	2.29 ±1.19	1.18 ±0.91	2.3 (1.6 to 3.2)*
Lack of Energy	1.83 ±0.67	1.02 ±0.65	1.8 (1.2 to 2.7)*
Physical Complaints	1.62 ±0.96	0.71 ±0.71	1.3 (0.9 to 2.0)
General Recovery	**3.70 ±0.73**	**4.26 ±0.67**	**1.3 (0.9 to 2.0)**
Success	3.24 ±1.11	3.62 ±1.09	3.1 (1.7 to 5.8)*
Social Recovery	4.27 ±1.00	4.53 ±0.93	3.6 (1.8 to 7.1)*
Physical Recovery	3.16 ±0.85	3.96 ±1.09	3.1 (1.7 to 5.8)*
General Well-Being	4.01 ±0.92	4.71 ±0.83	4.1 (1.7 to 10.1)*
Sleep Quality	3.84 ±1.14	4.49 ±1.11	4.0 (2.1 to 7.6)*
Sport Specific Stress	**1.85 ±0.61**	**1.07 ±0.45**	**2.0 (1.1 to 3.7)***
Disturbed Breaks	1.68 ±0.73	1.08 ±0.77	2.0 (1.1 to 3.7)*
Emotional Exhaustion	1.29 ±0.81	0.59 ±0.52	1.3 (0.7 to 2.6)
Injury	2.58 ±0.91	1.53 ±0.74	2.4 (1.1 to 5.5)*
Sports Specific Recovery	**3.62 ±0.76**	**4.20 ±0.81**	**1.3 (0.7 to 2.6)**
Being in Shape	3.64 ±0.98	4.49 ±0.92	2.8 (0.5 to 14.1)
Personal Accomplishment	3.18 ±0.80	3.72 ±0.92	3.6 (0.8 to 15.6)
Self-Efficacy	3.63 ±0.96	4.02 ±0.89	2.5 (1.1 to 6.0)*
Self-Regulation	4.00 ±0.94	4.56 ±1.13	3.1 (1.2 to 7.9)*
Total Stress	**1.75 ±0.47**	**0.94 ±0.38**	**1.3 (0.9 to 1.8)**
Total Recovery	**3.66 ±0.64**	**4.23 ±0.66**	**1.5 (0.9 to 2.4)**
Recovery-Cue			
Effort	3.19 ±1.15	2.93 ±1.18	3.4 (2.6 to 4.6)*
Recovery	4.01 ±1.06	4.49 ±1.20	4.2 (3.1 to 5.8)*
Rest	4.06 ±0.97	4.59 ±1.25	3.8 (2.7 to 5.2)*
Physical	4.15 ±1.16	4.81 ±1.08	4.2 (3.0 to 5.9)*
Sleep	4.30 ±1.32	4.78 ±1.20	4.0 (2.9 to 5.5)*
Fun	4.62 ±0.91	5.15 ±1.03	4.8 (3.4 to 6.6)*
Achievement	4.38 ±0.98	4.78 ±1.05	4.8 (3.5 to 6.6)*

RR = Risk Ratio; CI = Confidence Interval; (*)=Significant difference (p<0.05); Non-injured players RESTQ-Sport and Recovery-Cue scores were taken as a mean across all of the assessment weeks; Injured players RESTQ-Sport and Recovery-Cue scores were taken from the assessment prior to the match in which they were injured

Fun and Accomplishment in the Recovery-Cue at T1. He played in the next game despite the observed changes in the RESTQ-Sport scales and his self-reported Recovery-Cue scores but subsequently re-injured his shoulder. The subsequent RESTQ-Sport and Recovery-Cue profile (T2) again changed reflecting the effects of the injury with an increase in total stress (2.35 vs. 1.50; $\chi2(1)$=4.34; p=0.0.0372; t(9)=-2.13, p=0.0625) and a slight increase in total recovery (3.78 vs. 3.72; $\chi2(1)$=3.96, p=0.0467; t(9)=-0.11, p=0.9120) scores when compared with his baseline. As a result of the injury he subsequently withdrew from the team and did not participate in any other match or training activities in the representative competition.

DISCUSSION

In undertaking this study the RESTQ-Sport-52 and Recovery-Cue were utilised to monitor the stress and recovery of amateur rugby league team players. The Recovery-Cue was also selected to provide immediate visual feedback. The visual feedback was obtained by reviewing the scores to see where they were in relationship to the scale provided and did not require being calculated. While monitoring players it was identified that there were specific characteristics recorded for players who subsequently recorded an injury compared with non-injured players.

The training cycle for the rugby league competition consisted of activities involving aerobic and anaerobic endurance activities, skills, and drills, undertaken in an intermittent fashion mimicking match activities.[23,24] As the season progressed, the intensity increased to reflect the ensuing matches. Increases in training requirements and harder matches may lead to higher fatigue, stress, physical complaints, injuries and lower recovery scores. A surprising result was that following the bye (no match played), players (n=8) who recorded injuries in the subsequent match had a greater increase in the general stress and decrease in the general recovery scores than the mean of the non-injured players. Further research is warranted to identify if byes in the middle of competitions do place higher stress and decrease the recovery process.

Team management were keen to utilise the RESTQ-Sport questionnaire to assist with monitoring the players, even though immediate feedback was not possible. Alternative recovery monitoring tools may be more appropriate for feedback (i.e. Total Quality Recovery (TQR) scale,[6] or the Daily Analysis of Life Demands for Athletes (DALDA) scale[25]). The immediate visual identification of where the players were at in their recovery from the previous week's activities, via the Recovery-Cue, allowed

Table 4: Mean and standard deviation (SD) of scales of RESTQ-Sport scores and score of Recovery-Cue of player A pre injury and following a competition ending injury for amateur representative rugby league.representative amateur rugby league team.

	RESTQ-Sport						Recovery Cue						
	Stress			Recovery									
	GS	SSS	TS	GR	SSR	TR	Effort	Rec	Rest	Phy	Sleep	Fun	Accom
Baseline	1.29 ±0.86e	2.00 ±1.32	1.50 ±1.00	3.90 ±0.74ce	3.50 ±0.54c	3.72 ±0.65c	2	3	2	2	0	4	3
T1	2.14 ±0.85	1.00 ±1.00	1.80 ±1.01	2.60 ±0.22bf	2.06 ±0.52b	2.36 ±0.45bdef	3	5	5	6	6	6	6
T2 a	2.29 ±1.65	2.50 ±0.25	2.35 ±1.36	3.90 ±1.47	3.63 ±1.03	3.78 ±1.23c	3	5	5	4	4	4	4
T3	2.36 ±0.69b	1.58 ±0.58	2.13 ±0.73	4.70 ±0.76b	3.81 ±1.39	4.31 ±1.11c	3	4	3	2	2	5	2
T4	2.14 ±1.60	1.92 ±0.63	2.08 ±1.34	4.40 ±1.24c	3.13 ±0.75	3.83 ±1.20c	5	3	3	3	3	4	2

(a)= Injury occurred in next match following this assessment; GS = General Stress; SSS = Sport Specific Stress; TS = Total stress; GR = General Recovery; SSR = Sports Specific Recovery; TR = Total Recovery; Rec = Recovery; Phys = Physical; Accom = Accomplishment; Significant difference (p<0.05) than (b) = Baseline; (c) = T1; (d) = T2; (e) = T3; (f) = T4

adjustment of training intensity when required or to exclude players from certain activities if the coaching staff considered it necessary. The decision to review the Recovery-Cue once they were completed was undertaken in conjunction with the team medic as the competition rules allowed for the naming of a squad of 25 players to be named prior to the representative competition started. It was decided to add in an additional five players to be on 'active reserve' in case of injury where players were unable to further compete in the competition. If the scores, in conjunction with the injury status, indicated that the player may not be able to continue (as in the situation of player A) then there were procedures required to replace the player and the more notice to do this ensured the replacement player was available to be included in the main and travelling team squad for the next game.

In a previous study[11] the RESTQ-Sport did reflect how the players were dealing with the effects of amateur participation and other requirements in their own life (e.g., work, relationships). Although the RESTQ-Sport was able to identify current stress levels and lowered performance it may not be able to predict future performance and injury.[26] However, when the scores for all aspects of the RESTQ-Sport for the current study were retrospectively reviewed, injured players had higher stress related scores and lower recovery related scores than non-injured players in the assessment prior to the injury occurring.

Shier and Hall[27] utilised the RESTQ-Sport-76 (76-items) questionnaire at baseline before two weeks of injury data collection for circus performers', and found low levels of Self-Efficacy and high levels of Fatigue, Emotional Exhaustion and Injury were associated with a two to three-fold increase in the risk for injury.[27] The current study had methodological differences in that it utilised the RESTQ-Sport-52 (52-items) completed each week by all members of the representative team and had high scores in the scales Fatigue, Emotional Exhaustion and Injury and low scores for the scale Self-Efficacy. A suggestion Shier and Hall's[27] study reported was that a high score for scale Social Stress and low score for either the scale Success or Personal Accomplishment may be predictive of injury.[27] This was a similar

finding for the current study. Despite these findings not all injured players had similar changes in their RESTQ-Sports scale scores. Further longitudinal research is warranted to identify if any the changes in the scale scores are able to assist in prediction of an injury.

Further studies that prospectively monitor stress, recovery and injury over one or more rugby league competition seasons are required to develop a system that can indicate the risk of an injury occurring from rugby league participation. In addition, the Recovery-Cue could be utilised for the recovery monitoring of injured players. The goal would be to develop a system able to visually report on how players are coping with life outside of rugby league, recovery progress from an injury that has occurred and project modification requirements in regards to rugby league training activities that can assist in the reduction of the incidence of injuries in rugby league. The development of a shortened version of the RESTQ-Sport specifically related to the scales of Social Stress, Success, Personal Accomplishment, Fatigue, Emotional Exhaustion, Injury and Self-Efficacy may be beneficial in the identification of players at risk of injury and would be quicker to complete, limiting time away from the training environment. Further research with a shortened version of the RESTQ-Sport for rugby league is warranted.

A limitation to this study was there was only one team monitored for a short duration competition season. There were only 25 players in the competition team and they were not allowed to be substituted unless they were medically excluded from the rest of the competition. Future studies utilising the RESTQ-Sport and Recovery-Cue for player monitoring should be undertaken over more seasons with a larger player base enabling better confidence for injury prediction and injury rehabilitation monitoring.

In this study we monitored measures of stress and recovery as a result of participating in rugby league activities. We identified that there were certain characteristics of players who subsequently recorded an injury and developed a monitoring strategy for injury identification. From this point forward research is warranted to evaluate if this form of monitoring (RESTQ-Sport and Recovery-Cue) and any subsequent interventions

utilised will lead to a reduction in injuries in rugby league.

What are the new findings?

- There was a two to three-fold increase in the risk of an injury occurring with increases in the psychological factors of Physical Complaints, Emotional Exhaustion, General and Social Stress.

- Use of the Recovery-Cue can assist in the monitoring of the recovery of an injured player.

- The Social Stress, Success and Personal Accomplishment scales are most useful for predicting injury.

Competing Interests Statement

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