©Journal of Sports Science and Medicine (2013) **12**, 542-550
http://www.jssm.org

Research article

Can a Specific Neck Strengthening Program Decrease Cervical Spine Injuries in a Men's Professional Rugby Union Team? A Retrospective Analysis

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Abstract
Cervical spine injuries in Rugby Union are a concerning issue at all levels of the game. The primary aim of this retrospective analysis conducted in a professional Rugby Union squad was to determine whether a 26-week isometric neck strengthening intervention program (13-week strengthening phase and 13-week maintenance phase) was effective in reducing the number and severity of cervical spine injuries. The secondary aim was to determine whether at week five, where the program had been the similar for all players, there was increased isometric neck strength. All 27 players who were common to both the 2007-2008 and 2008-2009 seasons were included in this analysis and data was extracted from a Sports Medicine/Sports Science database which included the squad's injury records. Primary outcome variables included; the number of cervical spine injuries and the severity of these injuries as determined by the total number of days lost from training and competition. Secondary outcome variables included isometric neck strength in flexion, extension and left and right lateral flexion. Using non-parametric statistical methods, no significant differences were evident for the total number of cervical spine injuries (n = 8 in 2007-2008, n = 6 in 2008-2009) or time loss due to these injuries (100 days in 2007-2008, 40 days in 2008-2009). However, a significant (p = 0.03) reduction in the number of match injuries was evident from 2007-2008 (n = 11) to 2008-09 (n = 2). Non-significant increases in isometric neck strength were found in all directions examined. A significant reduction in the number of match injuries was evident in this study. However, no other significant changes to primary outcome variables were achieved. Further, no significant increases in isometric neck strength were found in this well-trained group of professional athletes.

Key words: Rugby Union, cervical spine, injury, isometric, neck strength.

Introduction

Rugby Union is a sport that has high levels of participation worldwide (Kuster et al., 2012). Due to the large number of collisions (Fuller et al., 2010; McIntosh et al., 2010) and fatiguing nature of the game (Bathgate et al., 2002; Brooks et al., 2005a; Swain et al., 2010) cervical spine injuries are common at all levels of the game (Swain et al., 2011). While disabling cervical spine injuries that result in paralysis are a major concern (Quarrie et al., 2002) non-disabling cervical spine injuries such as: cervical facet joint sprain or dislocation, neck muscle strain, and cervical nerve root neuropathy are more common (Kuster et al., 2012; Swain et al., 2011). At the professional level of the game these injuries are experienced more by forwards than in backs (Swain et al., 2011) and this is likely due to the roles of the these players (McIntosh et al., 2010).

Cervical spine injuries commonly occur at the; scrum, ruck and maul, as well as in tackles (Brooks et al., 2005a; Quarrie et al., 2007; Scher, 1998). Cervical spine injuries in the scrum could be due to forces greater than two-thirds of a tonne being spread across the front row (Milburn, 1993) and these forces may contribute to the neck being forced into a hyper-flexed or hyper-extended position (Fuller et al., 2007a; Shelly et al., 2006). At the ruck and maul, cervical spine injuries may be caused by the neck being forcefully positioned into flexion whilst the player is in a vulnerable position such as being on the ground (Fuller et al., 2007a). Finally, with reference to tackling, both the ball carrier and tackler are at risk of cervical spine injury. High force tackles, and/or those that involve direct contact to the head or neck have been implicated in the cause of cervical spine injury (Fuller et al., 2010).

Different approaches may be considered to reduce the incidence of cervical spine injuries in Rugby Union. For example, rule changes (Bohu et al., 2009; Quarrie et al., 2007) and correct tackling technique (Hendricks and Lambert, 2010; McIntosh et al., 2010) have been suggested to reduce the risk of cervical spine injury. Another approach that has been suggested to decrease these injuries is strengthening the neck musculature (Brooks et al., 2005a; Brooks and Kemp, 2010; Frounfelter, 2008; Highland et al., 1992; Peek and Gatherer, 2005; Swain et al., 2011). This seems a logical approach as a common characteristic of these injuries seems to be the application of high levels of force. Specific neck strengthening exercises that target the cervical musculature (Conley et al., 1997) may be added to a player's usual strength and conditioning program. It may be postulated that increased muscle strength may help to dampen the deceleration of the neck into the end-range positions that cause damage to soft tissues. It has been suggested that individualised, position-specific, injury prevention programs are required in Rugby Union (Brooks and Kemp, 2010) as forwards have higher levels of neck strength when compared to the backs (Olivier and DuToit, 2008). This is probably due to a combination of their larger physique (Brooks et al., 2005a) and an adaptation to higher neck-loads in training

Received: 24 April 2013 / Accepted: 18 June 2013 / Available (online): 12 August 2013 / Published: 01 September 2013

and matches.

The current study was stimulated by the cervical spine injury statistics over a two-year period (2005-2006 to 2006-2007) at a men's professional Rugby Union team. Data from the 2005/2006 rugby season revealed a total of three neck injuries with a total of 110 days of associated missed training and competition. In the following season, four neck injuries resulted in 118 days of missed training and competition. Consequently, specific neck strengthening exercises were added to the overall strength and conditioning program. The primary aim of this retrospective analysis was to determine whether the 26-week specific neck strengthening intervention program consisting of two phases; a 13-week pre-season phase and a 13-week maintenance phase had decreased the number of cervical spine injuries, and the severity (defined in relation to the number of associated missed training or match days) of these injures. The secondary aim was to determine whether acute increases in isometric neck strength were evident during the initial five weeks of the neck strengthening intervention. We hypothesized that 1) the program would lead to a significant decrease in the number and severity of cervical spine injuries and 2) that there would be significant increases in isometric neck strength.

Methods

Participants

This retrospective pre-test, post-test cohort study involved the analysis of two years of data (2007-2008 and 2008-2009) from a Sports Medicine/Sports Science database. This database was from a professional Rugby Union squad who played in the Super 14 competition in the southern hemisphere. In the 2007-2008 and 2008-2009 seasons there were 36 and 35 players in the playing squad respectively. However, at the conclusion of the 2007-2008 season, seven players had moved to other clubs and there were also two retirements. These nine players were replaced by eight new players. Hence, 27 players (mean ±SD age = 25.2 ±3.9 years, height 187.1 ±6.3 cm and mass, 102 ± 11.9 kg) consisting of 15 forwards and 12 backs were common to both seasons. Ethical clearance to conduct this study was provided an Institutional Human Research Ethics Committee whose procedures comply with the principles laid down by the Declaration of Helsinki. As this was a retrospective analysis, informed consent was not provided by the players.

The neck strengthening intervention program

A progressive and supervised isometric neck strengthening intervention program was added to the overall strength and conditioning program at the beginning of the 2008-2009 pre-season period. This 26-week program consisted of two phases; 1) a 13-week strengthening phase followed by 2) a 13-week maintenance phase. Isometric neck strengthening exercises were selected as it was believed that the absence of movement was likely to be of less risk to the cervical disc, facet and neural structures. This was especially the case in players who may have had underlying neck pathology. The exercise variations were selected based on the directions and angles of force replicating a variety of game-specific positions that require neck strength in rugby union players. However, exercises that involved producing an isometric contraction directed in axial rotation were not included as firstly, we did not have the specific equipment to produce a rotational isometric contraction or secondly, the means to assess axial rotation in an isometric manner. Besides routine neck stretching exercises undertaken by the players as part of their warm-up, no structured stretching program was implemented in this program. A description of the resistance training exercises used and program parameters are provided in Tables 1 and 2 respectively.

Once players had completed the exercises in the upright position in Weeks 1-5 (Figure 1a-c), more advanced rugby-specific exercises were provided. These exercises included features such as: modifying the angle of pull (Figure 1d) and incorporating isometric cable holds in a bent over position in; neck extension (Figure 1e) and left and right lateral flexion (Figure 1f). These

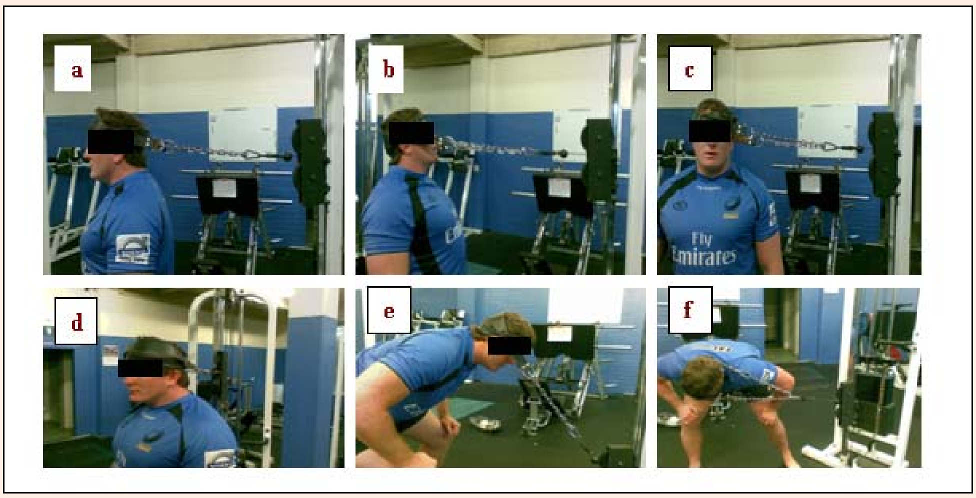

Figure 1. Exercises used in the neck strengthening intervention program. a) Isometric cable hold- neck flexion b) Isometric cable hold - neck extension c) Isometric cable hold – lateral neck flexion d) Isometric cable hold – 45 degree neck flexion left and right e) Isometric cable hold – Bent over neck extension f) Isometric cable hold – Bent over lateral neck flexion.

Table 1. Exercises used in the neck strengthening intervention program.

Name of Exercise	Description of Exercise
Isometric cable hold - neck flexion (Figure 1a)	In standing, a head harness is placed around the forehead with the cable at the level of the occiput. Player faces away from the weight stack and retracts the neck by "tucking in" the chin. Player takes the weight then steps and leans forward to lift the weight stack using the neck flexors. Weight is held for 5s.
Isometric cable hold - neck extension (Figure 1b)	In standing, a head harness is placed around the forehead with cable at the level of the forehead. Player faces toward the weight stack and retracts the neck by "tucking in" the chin. Player takes the weight then steps and leans backward to lift the weight stack using the neck extensors. Weight is held for 5s.
Isometric cable hold - right and left lateral flexion (Figure 1c)	In standing, a head harness is placed around the forehead so the cable is just above the left/ right ear. Player faces side-on to where the weight stack is located. Player then takes a sideways step away from the weight stack and leans laterally using the lateral neck muscles. Weight is held for 5s.
Isometric cable hold - 45 degree neck flexion left and right (Figure 1d)	In standing, place the head harness so it is located between the occiput and the left/ right ear. Step away from the weight stack on an angle so that the resistance is pulling the neck into extension on one side (left or right) at a 45 degree angle. Weight is held for 5s.
Isometric cable hold - bent over neck extension (Figure 1e)	In a crouched position, hips and knees are flexed at approximately 120 degrees. Player faces towards the weight stack and retracts the neck by "tucking in" the chin, then takes the weight. The cable is directed towards the floor. The player then pulls backward using neck extensors. Weight is held for 5s.
Isometric cable hold - bent over lateral flexion (Figure 1f)	In a crouched position, hips and knees are flexed at approximately 120 degrees. Player crouches side-on to the weight stack and places the head harness around the head so the cable is positioned just above the left/ right ear. Player takes a sideways step away from the weight stack and leans sideways using the lateral neck muscles. Weight is held for 5s.
Tight head prop isometric cable hold – bent over right lateral neck flexion with shoulder/pectoral fly (Figure 2a)	Exercise is performed in a cable fly machine. In a crouched position, hips and knees are flexed at approximately 120 degrees. Head harness is placed around the forehead so the cable is at the level of the left ear. Player positions themselves side-on to the weight stack then takes a sideways step to the right away from the weight stack and leans laterally using the right lateral neck muscles. At the same time, the player uses their arm right to pull the other cable positioned on the floor into the chest. Weight is held for 5s.
Loose head prop isometric cable hold – bent over lateral neck flexion with shoulder latissimus dorsi pull-down (Figure 2b)	Exercise is performed in cable fly machine. In a couched position, hips and knees are flexed at approximately 120 degrees. Head harness is placed around the forehead so the cable is just above the level of the left ear. Player positions themselves side-on to the weight stack and takes a sideways step to the right away from the weight stack and lean laterally using the right lateral neck muscles. At the same time, the player uses their left arm to pull the other cable positioned on the floor to perform a horizontal latissimus dorsi pull-down. Weight is held for 5s.
Scrum truck simulation - lateral neck flexors and extensors (Figure 2c)	Exercise is performed in the scrum-simulating machine. While loading the pads with leg drive, the player's neck muscles resist a load applied to the head by the physiotherapist or strength and conditioner. This exercise can be performed at all angles with feedback provided by a sphygmomanometer placed between the hands of the person creating the load and the player's head. The isometric load is created for 5s.

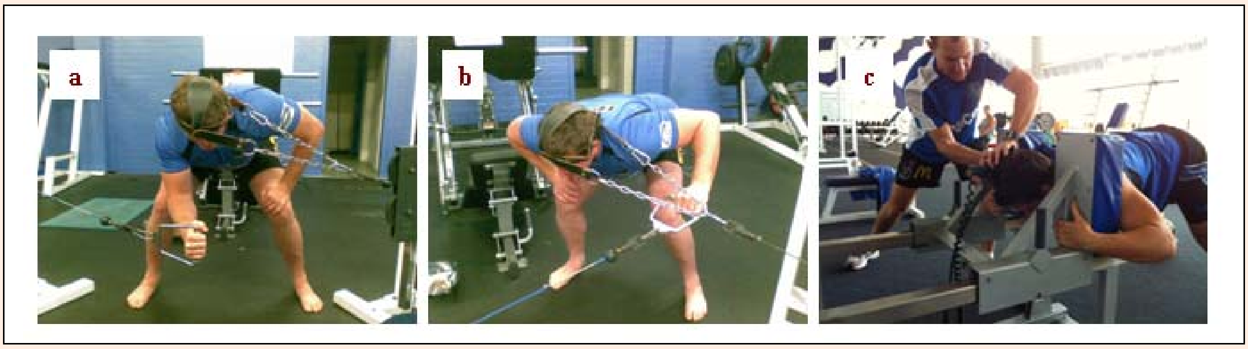

Figure 2. Exercises used for front rowers only in the neck strengthening intervention program. a) Tight head prop isometric cable hold – bent over right lateral neck flexion with shoulder/pectoral fly b) Loose head prop isometric cable hold – bent over lateral neck flexion with shoulder latissimus dorsi pull-down c) Scrum truck simulation with external force applied to lateral neck flexors and extensors.

exercises were included to mimic forces that may act on players when reaching for the ball around the ruck and maul during actual match play.

The intervention program differed slightly for those with asymmetries in strength as identified from strength testing at baseline. Players with strength imbalances (flexion/extension as well as left/right lateral flexion) were prescribed an extra set of each exercise for the

Table 2. Outline of the neck strengthening intervention program.

Week(s)	Name of Exercises	Program Parameters (Frequency, Sets x Reps, Loading)
	PRE-SEASON PHASE:	
	All Players (N=27)	
1	1) Isometric cable hold - neck flexion	2 sessions/week, 2 sets x 12 reps, 70% 1RM
	2) Isometric cable hold - neck extension	
	3) Isometric cable hold - right and left lateral flexion	
2	Same as Week 1	2 sessions/week, 3 sets x 10 reps, 70% 1RM
3	Same as Week 1	2 sessions/week, 3 sets x 8 reps, 70% 1RM
4	Same as Week 1	2 sessions/week, 2 sets x 12 reps, 70% 1RM
5	Same as Week 1	2-3 sessions/week, 3 sets x 4-6 reps, Max. weight for reps
6-13	***PRE-SEASON PHASE:***	
	Non-Front Row Players	
	1) Isometric cable hold - 45 degree neck flexion left and right	2 sessions/week, 3 sets x 6-8 reps, 70% 1RM
	2) Isometric cable hold - bent over cable extension	
	3) Isometric cable hold - bent over lateral flexion	
6-13	***PRE -SEASON PHASE:***	
	Front Row Players Only	
	1) Tight Head Prop Isometric cable hold – bent over right lateral neck flexion with right shoulder/pectoral fly	2 sessions/week, 3 sets x 6-8 reps, 70% 1RM
	2) Loose Head Prop Isometric cable hold – bent over lateral neck flexion with shoulder latissimus dorsi pull-down	2 sessions/week, 3 sets x 6-8 reps, 70% 1RM
	3) Scrum truck simulation with external force applied to lateral neck flexors and extensors	1 session/week, 2 sets x 5 reps, 70% 1RM
	MAINTENANCE PHASE	
14-26	***Non Front Row***	
	1) Isometric cable hold - neck flexion	1-2 sessions/week, 3 sets x 4 reps (3 sec hold)
	2) Isometric cable hold - neck extension	
	3) Isometric cable hold - right and left lateral flexion	
	MAINTENANCE PHASE	
	Front Row	
	1) Isometric cable hold - 45 degree neck flexion left and right	1-2 sessions/week, 2 sets x 3 reps (3 sec hold) (Note: Overall load was set by taking scrummaging sessions into account and games)
	2) Isometric cable hold - Bent over cable extension	
	3) Isometric cable hold - Bent over lateral flexion	

movement direction showing lower levels of strength. For those who played in the front row, additional strengthening exercises in a bent-over position were added to simulate scrummaging specific to the tight head prop (Figure 2a) and loose head prop (Figure 2b). Front rowers also performed an exercise in a scrum-simulating device where an external resistance applied to the head was provided at varying angles (Figure 2c). During this exercise, players were encouraged to maximally contract against an applied resistance for a period of five seconds. This period of time was selected to simulate previous studies that had successfully improved neck pain (Strimpakos et al., 2004; Ylinen et al., 1999).

Data collection and analysis

Primary outcome variables

The primary outcome measures in this study included: the number (and type) of cervical spine injuries as well as the severity of these injuries, as measured by the number of days players were considered unavailable in matches and in training. Cervical spine injuries that did not result in time-loss from training or matches were not examined in this study. Diagnosis of any cervical spine injury was made via clinical examination by two senior physiotherapists. Where necessary, radiological investigation (such as MRI) were utilised to support and/or confirm clinical observation. After a cervical spine injury had been recorded, injury details were entered into the database using the Orchard Sports Injury Classification System (OSICS) (Orchard et al., 2010). Due to the nature of the cervical spine injuries recorded, only four Orchard codes were utilised, they being: cervical spine facet joint injury (NJXX), cervical disc prolapse (NCLP), cervical facet joint pain / chronic inflammation (NJPX) and cervical disc sprain (NCLX). Definitions relating to injury-related terms used in this study (see Table 3) were adapted from previous work (Bathgate et al., 2002; Fuller et al., 2007b; Orchard et al., 2010; Swain et al., 2010).

Secondary outcome variables

Isometric neck strength

Isometric neck strength testing was conducted at the start of the 2008-2009 season (baseline), and at week five of the intervention program. Retesting at week five of the program was decided upon as strength and conditioning staff wanted to know whether acute increases in neck strength in this squad of well-conditioned, professional players were possible within this period. Based on favourable data obtained from this period, a decision was made to continue the program.

Table 3. Injury-related definitions used in the study.

Term	Definition
Cervical spine injury	The loss of cervical spine range of motion with associated pain that limited the ability of a player to fully play or train after a 24h period.
Training-related cervical spine injury	An injury that prevented a player's training activities typically planned for that day for a period of greater than 24h from midnight at the end of the day the injury was sustained.
Match-related cervical spine injury	An injury that prevented a player's match play activities typically planned for that day for a period of greater than 24h from midnight at the end of the day the injury was sustained
Recurrent cervical spine injury	An injury of the same type and at the same site as an index injury and which occurs after a player's return to full participation from the index injury
Cervical spine facet joint injury (Orchard Code: NJXX)	Described an injury to the zygapophyseal joint including both its ligamentous capsule, meniscus and cartilage surface.
Cervical disc prolapse (Orchard Code: NCLP)	These were divided into more serious disc injury where a frank disc bulge confirmed by radiologists may have been identified.
Cervical facet joint pain/chronic inflammation (Orchard Code: (NJPX)	Described a condition where players that had an inflamed and already degenerative cervical spine whereby poor architecture and osteophytic formation have a low threshold to mild trauma causing pain and joint hypomobility.
Cervical disc sprain (Orchard Code: NCLX)	A sprain of the disc where fissures and small tears developed from trauma in the outer layers of the annulus fibrosis.

After a familiarisation session, isometric neck strength was measured in four directions they being; flexion (Figure 3a) extension (Figure 3b) and left and right lateral flexion (Figure 3c). As senior players were absent due to international playing commitments, these measurements were taken from a sub-group of 20 players (mean ±SD age = 26 ± 3 years, height 1.88 cm ± 0.08 m and mass, 104kg ± 11kg).

Peak isometric neck strength was measured using a slight adaptation of a previously published method which demonstrated excellent between-day reliability (ICC = 0.94-0.98) (Ylinen et al., 1999). A head harness made of seat belt webbing and velcro was firmly attached to the forehead of the participants. The harness was then attached by a stiff wire cable to a load cell (HBM 2007 S40 100kg) that was then in turn, attached to an immovable metal frame. The load cell measured peak force at 40 Hz and these data were saved to a file for later analysis.

Prior to evaluation of neck strength in each direction, participants were requested to perform three submaximal (75% effort) isometric contractions and were requested to hold these contractions for a period of five seconds. Peak isometric neck strength was then assessed by undertaking three, five-second contractions. Encouragement was provided to all participants during testing to ensure maximal effort. To minimise the effect of fatigue a rest period of 30 seconds was provided between each attempt. The highest score from the three repetitions was recorded. The testing order was block randomised.

During neck strength measurement, participants sat in an incline bench press chair with its back positioned vertically and participants positioned their head/neck in a neutral posture so that an imaginary line between and nasion and opisthion was horizontal (Strimpakos et al., 2004; Ylinen et al., 1999). The back of the chair reached the level of the mid-cervical region (Rezasoltani et al., 2008). An 8mm solid plastic sheet was placed between the participants and the upright of the chair (Figure 3) to

Figure 3. Experimental set up for testing of neck strength in a) flexion b) extension and c) right lateral flexion

Table 4. Injury statistics for the 2007-2008 and 2008-2009 seasons.

	2007-2008	2008-2009	p-value
Players injured [N (%)]	8 (29.6)	6 (22.2)	.75
Injuries - Total [N]	12	6	
Mean (SD)	.44 (0.89)	.22 (.42)	
Median (IQR)	0 (1)	0 (0)	.34
Injuries – Training [N]	1	4	
Mean (SD)	.44 (0.19)	.15 (.36)	
Median (IQR)	0 (0)	0 (0)	.18
Injuries - Matches [N]	11	2	
Mean (SD)	.41 (0.89)	.07 (.27)	
Median (IQR)	0 (0)	0 (0)	.03
Time Loss – Total [days]	100	40	
Mean (SD)	3.7 (8.0)	1.5 (4.2)	
Median (IQR)	0 (5)	0 (0)	.40
Time Loss - Training [days]	21	17	
Mean (SD)	.8 (4.0)	.6 (1.6)	
Median (IQR)	0 (0)	0 (0)	.20
Time Loss - Matches [days]	79	23	
Mean (SD)	2.9 (7.3)	.8 (4.0)	
Median (IQR)	0 (3)	0 (0)	.14

eliminate possible body movement (Ylinen et al., 1999). Air-inflated balance discs were also placed under the subject's feet to minimise the possibility that force was created at the feet to increase neck strength values.

Match and training time

Training time measured in minutes per week and sessions per week was determined for the team as a whole during pre-season and in-season in each year of the study. These data were collated by the lead author (RN) from training records held by strength and conditioning staff. The amount of match time was calculated as the total time of practice matches and during competition itself. Due to the retrospective nature of the study, it was not possible to attain match and training time for individual participants.

Statistical analysis

Descriptive statistics were calculated for all primary and secondary outcome variables. Given the relatively small sample sizes and the presence of positive skew in the distributions, non-parametric Wilcoxon signed rank tests for paired data were used to determine whether significant differences were evident over time. Further, an exact McNemars test was used to determine whether the proportion of injured players changed over time. Due to the unique and experimental nature of this study no adjustment was made for multiple comparisons therefore, the alpha level was set at 0.05 and all tests were two tailed. All statistical analyses were performed by a Biostatician (SB) using Stata V12 (Statacorp LP, College Station, TX). A power analysis was not performed given that the sample size was determined by factors beyond the investigators control i.e. the cohort was restricted to players who were in the team for both seasons.

Results

Table 4 outlines the detail relating to the number of cervical spine injuries and the time loss related to those injuries for the two seasons spanned by this retrospective analysis. Table 5 provides the detail pertaining to neck injury type and time loss related to each neck injury type.

There were no significant differences evident between-season for the number of players with cervical spine injury (8 players in 2007-2008, 6 players in 2008-2009, $p = 0.75$) or the total number of cervical spine injuries (12 and 6 for the 2007-2008 and 2008-2009 seasons respectively, $p = 0.34$). Two players had one or more recurrent disc injuries. While there was no significant difference ($p = 0.18$) evident between-years for the number of training injuries (1 in 2007-2008 and 4 in 2008-2009) there was a significant reduction ($p = 0.03$) in the

Table 5. Details of neck injury type (including Orchard Codes) and related time loss in training and games. Data are provided for the 2007-2008 and 2008-2009 seasons.

	2007-2008				2008-2009			
	Injuries Training (N)	Injuries Training (days)	Injuries Games (N)	Injuries Games (days)	Injuries Training (N)	Injuries Training (days)	Injuries Games (N)	Injuries Games (days)
Cervical Spine Facet Joint Injury (NJXX)	0	0	5	20	3	11	1	2
Cervical Disc Prolapse (NCLP)	1	21	1	21	0	0	1	21
Cervical Facet Joint Pain / Chronic Inflammation (NJPX)	0	0	4	32	0	0	0	0
Cervical Disc Sprain (NCLX)	0	0	1	6	1	6	0	0
Total	1	21	11	79	4	17	2	23

Table 6. Mean (SD) data from for isometric neck strength testing during the pre-season phase of the 2008-2009 season.

	Baseline		End Week 5		
	Mean (SD)	Median (IQR)	Mean (SD)	Median IQR)	p-value
Neck Flexion (N)	277.6 (63.0)	280.2 (99.7)	288 (64.1)	307.7 (98.1)	.271
Neck Extension (N)	367.7 (47.9)	364.4 (46.8)	372.4 (50.9)	374.9 (68.3)	.481
Neck Lateral Flexion – Left (N)	363.2 (53.9)	348.2 (67.3)	372.2 (50.6)	359.7 (85.1)	.687
Neck Lateral Flexion – Right (N)	376.4 (44.7)	374.4 (62.3)	383.6 (51.9)	371.3 (73.6)	.711

number of cervical spine injuries experienced in matches (from 11 in 2007-2008 to 2 in 2008-2009). The time loss related to these injuries was not significantly different (p = 0.40) between-season. Specifically, there was no significant difference (p = 0.20) in the days lost from training in 2007-2008 (21 days) and 2008-2009 (17 days) and there was no significant difference (p = 0.14) for the number of days lost from matches in 2007-2008 (79 days) and 2008-2009 (23 days).

As shown in Table 6, the initial 5-week neck strengthening program resulted in a non-significant increases in isometric neck strength in all four directions of movement (flexion, p = 0.271; extension, p = 0.481; left lateral flexion, p = 0.687; right lateral flexion, p = 0.711). Match time was constant between-year (1120 mins per year) and 17 of the 27 participants were considered regular players in the starting 15. There were significant decreases between-year for pre-season training time (p = 0.002) and for number of sessions per week (p < 0.001) (Table 7). No adverse effects were recorded as a result of the neck strengthening program.

Discussion

The primary aim of this retrospective analysis was to determine whether the implementation of an isometric neck strengthening program was effective in reducing the number of cervical spine injuries as well as their severity. The main finding was a significant decrease was found in the number of match-related cervical spine injuries. This is an important finding as most injuries in Rugby Union occur during actual game play (Brooks et al., 2005a; 2005b). We are unaware of any rule changes that would have influenced this finding. There was also a non-significant increase in the number of training-related cervical spine injuries. While it may be considered that training is a more controlled environment than match play, there are still many factors in training that may cause cervical spine injury. For example, the introduction of new techniques and drills, or an increase in the frequency of high-risk training methods such as wrestling, two-on-one tackling drills, and opposition clean out of the ruck area at practice are high risk activities that may result in an increase in injury. While at first appearance, there seemed to be a notable decrease in total time loss (100 days pre-intervention as compared to 40-days post intervention) there was evidence of skewing in this data therefore, non-parametric statistics were used which utilises ranks rather than means. This meant there were no significant changes in this variable.

With respect to the secondary aim of the study, we found non-significant increases in all neck strength variables after five weeks of the neck strengthening program. This finding is similar to that of previous work (Lisman, 2009) conducted in a small sample of college-age males with previous American football or rugby playing experience. That study reported non-significant increases (7-10%) in isometric cervical strength (measured in extension and left lateral flexion) after an 8-week isoinertial cervical resistance training program conducted 2-3 times per week. While previous studies examining clinical (neck pain) populations have achieved significant increases in neck strength through the use of short term (4-8 weeks) training programs (Chiu et al., 2004; Highland et al., 1992; Ylinen et al., 1994) it should be considered that Professional Rugby players are well-conditioned athletes. This may have some bearing on the potential increases in neck strength that are possible in this group over a relatively short time period (Argus et al., 2010; Hoffman et al., 1990; Olivier and DuToit, 2008; Taylor et al., 2006). While it would have been preferable to re-assess neck strength after the completion of the strength development phase of the program (at week 13), there were other priorities in the player management schedule. It is also worth considering that even if strength testing had been re-tested at week 13, for the reasons stated above, it would be unlikely that a significant increase in isometric neck strength would have been evident in this group.

While it is difficult to attribute the decreased number of cervical spine injuries occurring in matches to the non-significant changes in isometric neck strength, there are known to be neurological adaptations that occur with resistance training. For example, improved muscle coactivation (Folland and Williams, 2007) improved proprioception, and greater stabilisation of the deep cervical flexors may result (O'Leary et al., 2007). These are all

Table 7. Details of time related to training and matches. Data are provided for the 2007-2008 and 2008-2009 seasons.

			2007-2008	2008-2009	p-value
Training – Pre Season	**Time / week (mins)**	Mean (SD)	852.3 (125.5)	615.8 (186.9)	
		Median (IQR)	845.0 (182.5)	652.5 (255.0)	.002
	Sessions / week (N)	Mean (SD)	15.5 (2.7)	9.9 (2.6)	
		Median (IQR)	15.0 (3.5)	9.5 (4.0)	<.001
Training – In Season	**Time / week (mins)**	Mean (SD)	312.0 (80.3)	265.0 (59.0)	
		Median (IQR)	324.5 (138.0)	262.5 (45.8)	.100
	Sessions / week (N)	Mean (SD)	6.2 (1.5)	5.5 (1.3)	
		Median (IQR)	6.5 (2.0)	5.0 (1.5)	.226
	Matches – Total time (mins)		1120	1120	

factors that were not examined in this study. Alternatively, it cannot be ruled out that the positive findings may have been due to chance alone.

There were several limitations to this study. Firstly, this study was a retrospective analysis rather than a randomised controlled trial using a prospective study design. However, conducting such a randomised controlled trial would not be without its problems at the professional level of the game. For example, it would be very difficult to get other professional teams in the Super 15 competition (teams are from Australia, New Zealand and South Africa) to act as controls. Related to this limitation there were a small number of players common to both years in our analysis. Secondly, the findings of this study may not be applicable to other levels of the game. The introduction of such a neck strengthening program to a rugby team requires close control and guidance by appropriately qualified strength and conditioning and medical staff. Finally, the neck strengthening program in this study only involved isometric contractions using flexion, extension and lateral flexion. It is possible that isometric contractions using axial rotation, dynamic contractions and/or plyometrics (Lisman, 2009; Mansell et al., 2005) may help to better stabilise the head upon player impact. However, it was our belief that the safest way to strengthen the neck musculature in this study was by using isometric contractions in the selected directions at various angles of pull.

Conclusion

In conclusion, a significant reduction in the number of match injuries was evident in this neck strengthening intervention study. However, no other significant changes to the primary outcome variables were achieved. Further, no significant increases in isometric neck strength were found in this well-trained group of professional athletes. Whilst it may seem that this program had limited effect, there was a reduction in match injury incidence that would be considered as a positive outcome in the professional sporting environment. Whether this change was due to strength training itself or chance alone, should be examined in future prospective study designs with larger groups of professional Rugby Union players.

Acknowledgements

We wish to thank Mr Haydn Masters for his assistance with aspects of the data extraction and Miss Andie Ma for her assistance in preparing the manuscript.

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Key points

- While many authors have proposed that neck strengthening could be an effective strategy in preventing cervical spine injuries in Rugby Union, there is currently little information in the literature pertaining to how such a study might be conducted.
- A significant decrease in the number of injuries recorded in matches can be achieved using a specific neck strengthening program at the elite level.
- In an elite rugby union team as investigated in this study a significant increase in neck strength is difficult to achieve in a short period of time such as five weeks.

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