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Posture of rugby league players and its relationship to non-contact lower limb injury: A prospective cohort study

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ABSTRACT

Objective: This study aimed to identify posture deviations in rugby league players, and to observe relationships between posture and the incidence of non-contact lower limb injury.
Design: Prospective cohort.
Setting: Laboratory and on-field.
Participants: Junior representative, semi-professional and professional rugby league players ($n = 207$).
Main outcome measures: Static posture scores from photographs (Watson and MacDonncha tool) in pre-season; non-contact lower limb injury surveillance and exposure data.
Methods: Chi-square and logistic regression analyses were used to observe relationships between postural components and the incidence of non-contact lower limb injury.
Results: 8.7% of players sustained a quadriceps injury; 7.2% sustained a calf injury. Semi-professional and professional players had the highest injury rates. The most common posture deviations were having a forward shoulder position (46.9%), a forward head position (33.3%), a varus knee interspace (32.9%) or a lumbar lordosis (30.9%). A moderate C-scoliosis deviation was associated with a decrease in injury risk (OR 1.57 95% CI 1.00-2.46 $p = 0.052$). Included in the model was player weight, which was associated with an increased risk of injury (OR 1.04 95% CI 1.01-1.07 $p = 0.010$).
Conclusions: Although postural deviations are common in rugby league players, given the lack of association with injury, they may not warrant intervention.

1. Introduction

Rugby league is a high intensity contact sport, played from the junior level to the professional level. Given the frequent collisions, and constant changes in speed and direction, injuries are common (Gabbett, 2004). The overall incidence of injury in rugby league players has been reported to be as high as 346 injuries per 1000 player hours in professional players (Estell, Shenstone, & Barnsley, 1995), 824 injuries per 1000 player hours in semi-professional players (Gabbett, 2003), and 160.6 injuries per 1000 player hours in amateurs (Gabbett, 2000). Musculoskeletal injuries to the lower limb (knee, ankle, thigh and calf) are common (Gabbett, 2000, 2003, 2004; Orr & Cheng, 2016). Up to 30% of injuries result in five or more missed matches (Gabbett, 2004). In addition to loss of playing time, these injuries may also have long-term consequences outside of the sport. These include work or study limitations, medical costs, loss of income and physical conditions such as arthritis, chronic low back pain and joint stiffness (Gabbett, 2001; Meir, McDonald, & Russell, 1997). Given the considerable impact of injuries in rugby league, a greater understanding of factors predisposing players to injury is warranted.

Optimal posture is a state where the centres of gravity of all body segments are vertically aligned (Components, 1995; Kritz, 2008). Optimal posture results in a mechanical advantage, where tissues are at the most appropriate length to generate maximum force production (Horsley, Pearson, Green, & Rolf, 2012). Efficient postural control results in the body's centre of mass being ideally positioned over its base of support to maintain balance and prevent falling (Paillard, 2017). Deviations in static posture have been proposed as intrinsic risk factors for lower limb injury (Murphy,

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Connolly, & Beynnon, 2003). A number of studies have demonstrated this in physically active populations (Hennessey & Watson, 1993a; Shambaugh, Klein, & Herbert, 1991; Soderman, Alfredson, Pietila, & Werner, 2001), using measures such as Q-angle (Shambaugh et al., 1991), knee hyperextension (Soderman et al., 2001) and static lumbar posture (Hennessey & Watson, 1993a). Deviations in posture were found to be predictors of lower limb injury in soccer, Gaelic football and hurling (Hennessey & Watson, 1993a; Watson, 2001a). Alternatively, some postural deviations may be advantageous for sporting performance, as common static postural deviations have been observed in specific sporting populations (Kritz, 2008). For example, increased lumbar lordosis has been observed in athletes participating in American and Australian football (Kritz, 2008; Paillard, 2017), rugby and soccer (Kritz, 2008). These sports are similar to rugby league in that they are contact sports requiring frequent acceleration, deceleration and change of direction (Wilson, Caffrey, King, Casey, & Gissane, 2007). Consequently, we hypothesised that relationships between posture and non-contact lower limb injury may exist in rugby league.

Several studies have prospectively investigated risk factors for injury in rugby league (Inglis et al., 2015; Orr & Cheng, 2016; Thornton, Delaney, Duthie, & Dascombe, 2017), but no studies investigating risk factors for injury have included static posture as a variable. It is unclear which common postural deviations are present in rugby league players and whether these deviations predispose the player to injury. Therefore, the aim of this study was to identify postural deviations in rugby league players and determine relationships between pre-season static posture and non-contact lower limb injuries sustained over a subsequent competitive season.

2. Materials and methods

2.1. Study design

In this prospective cohort study, participating players attended pre-season screening where static posture was assessed. Over the course of the following competitive season these players were monitored for non-contact lower limb injury and exposure to training and matches to determine the predictive risk of static posture.

2.2. Participants

Male rugby league players (n = 207) from a regional NSW sporting organisation were recruited for this study prior to the 2008 and 2009 seasons. Players ranged from junior representative (under 16 years of age: U16, under 18: U18) to semi-professional (under 20: U20) and professional (National Rugby League: NRL) competition levels. All players associated with the organisation were invited to participate, regardless of playing level or injury history.

2.3. Human ethics registration

This study was approved by the Institution's Human Research Ethics Committee (H-252-0706). Informed consent was provided by all players (guardians of those under the age of 18 y) prior to participation.

2.4. Assessments

At the pre-season screening, data were collected on player age, height, weight, playing position, competition level and previous non-contact lower limb injury.

2.5. Static posture

Static posture was assessed with four digital photographs (Pentax, Optic M30) taken 3.1 m from the camera from the following views: 1) anterior, 2) lateral, 3) lateral (arms across chest), 4) posterior. Players stood on a small box (5.5 cm high) to allow better visualisation of the feet. Players were asked to stand normally; looking straight ahead, feet together if possible, and arms by the sides (with the exception of the lateral view with arms across chest). Players stood centrally aligned to the camera, and rotated to the left for lateral views. One researcher assessed posture using a modified version detailed in the following two paragraphs of the scale developed by Watson and MacDonncha, which has demonstrated reliability (Watson & Mac Donncha, 2000).

Ten components of posture were assessed. For each component, a score was awarded according to the degree of deviation: a score of 5 was awarded was for no deviation (normal posture), 3 for moderate deviation, and 1 for marked deviation from normal posture. Ankle posture was assessed by the degree of deviation of the Achilles tendon from a vertical line through the calcaneus. Knee interspace posture was assessed by the distance between the most medial points of the femoral condyles. Lateral knee posture was assessed by the sagittal angle of the tibia estimated by viewing its anterior aspect relative to the greater trochanter and lateral malleolus. Lumbar lordosis was assessed by the degree of hyperextension present in the lumbar spine. Kyphosis was assessed by the degree of flexion present in the thoracic spine. S and C-shaped scoliosis were assessed by the degree of thoracic deviation to the left or right, as well as the position of the shoulders and hips. Forward shoulder position was assessed by position of the shoulder girdle relative to the upper chest. Shoulder symmetry was assessed by using a horizontal marker to observe if one shoulder was higher or lower than the other. Forward head position was assessed by the degree of forward flexion of the cervical spine and degree of head protraction.

The Watson and MacDonncha (Watson & Mac Donncha, 2000) scale does not differentiate the direction of postural deviation (i.e., extension vs. flexion). For the purposes of this study, when assessing lateral knee posture, a negative value was assigned for hyperextension and a positive value assigned for increased knee flexion. For anterior knee interspace assessment, and posterior ankle assessment, a negative value was assigned for valgus alignment and a positive value for varus alignment. Intra-rater reliability was determined by one assessor scoring a random selection of 20 postures twice.

2.6. Injury and exposure monitoring

Injuries were monitored throughout the season following static posture assessment so that relationships between posture and the incidence of injuries could be evaluated. Sports training staff and team physiotherapists were responsible for injury monitoring. If a player was injured at training or in a competitive game, a standard form was completed documenting the location of injury, and whether it was the first injury to that body part or a recurring injury. Lower limb injuries were categorised as: ankle, calf, knee, quadriceps, hamstring or groin, and were not further subgrouped by limb or limb dominance. Data were collected for non-contact injuries, and injuries were only included in the analysis if they caused the player to miss at least one training session or game.

Exposure was recorded by the respective team's strength and conditioning coaches from the beginning of the pre-season through to the end of the competitive season. Training diaries were used in electronic or paper format. Average exposure values were calculated for each team. Each team's training exposure was calculated by multiplying the number of players in attendance by the length and number of training sessions throughout the entire season. Game exposure was calculated by multiplying the number of matches played, the duration of matches and number of players. Total exposure per player within each team was calculated as the average exposure per player across the season by the dividing the total team exposure by the number of players. Individual players were assigned a value for exposure based on the corresponding exposures per player value for their team.

2.7. Data analysis

A convenience sample was used for this study where we aimed to recruit the maximum number of eligible players available, as we expected posture to vary among individuals. Our sample size is considerably larger than other studies that have measured posture using observational methods in sporting groups (Hennessey & Watson, 1993b; Watson, 2001b). Frequencies and percentages were calculated to summarise the proportions of players with the following postural deviations: varus or valgus ankle alignment, varus or valgus knee interspace, lateral knee flexion or hyperextension, lumbar lordosis, forward shoulder position, shoulder asymmetry, S and C-shaped scoliosis, kyphosis, and forward head position.

Descriptive analysis was used to calculate the median and interquartile range (IQR) or mean and standard deviations (SD) of player age, height and weight for injured and non-injured players, as well as the total sample. Frequencies and percentages were calculated for player position and competition level for injured players, non-injured players, and the total sample. Frequency and percentages were calculated for previous and current non-contact lower limb injury for injured and non-injured players. Independent t-tests were used to examine differences in characteristics between injured and non-injured players.

To determine relationships between injury (previous, first during the season and recurrent injury for ankle, knee, calf, groin, hamstrings and quadriceps) and having normal vs. deviated posture, Chi-square or Fisher's Exact (for categories with frequencies less than five) tests were used. Binary logistic regression was used to determine whether there were associations between sustaining an injury during the season and having one or more of the postural deviations listed above. The following potential confounders were accounted for in the analysis: player age, height, weight, position (backs vs. forwards), competition level (U16 and U18 vs. U20 and NRL) and previous non-contact lower limb injury. Due to the large number of variables, univariate regressions were first performed, with only those variables achieving a $p \leq 0.25$ in univariate analysis being included in the multivariate models. Final regression models were determined using the backwards Wald method. All analyses were performed in IBM SPSS Version 24.0 (IBM Corp., Armonk, NY, USA).

3. Results

Player characteristics are shown in Table 1. Injured players were significantly ($p = 0.005$) older than uninjured players. The highest percentages of injury were seen in the U20 (47.2%) and NRL (41.1%) competition levels. Table 2 outlines the numbers of each type of injury at each competition level. The quadriceps and calf muscles were the most common injury site (Table 1); 8.7% of all players sustained a quadriceps injury and 7.2% of all players sustained a calf injury. Intra-rater reliability of posture scores was high (Kappa ranged from 0.762 to 1.0).

Posture characteristics are shown in Table 3. Forward shoulder (46.9%), forward head (33.3%), varus knee interspace (32.9%) and lumbar lordosis (30.9%) represented the highest proportions of moderate deviation across all players. Lumbar lordosis (5.8%) represented the highest proportion of marked deviation.

There were no significant relationships between having normal or deviated posture for each postural component and sustaining a lower limb injury (previous, first during the season and recurrent injury for ankle, knee, calf, groin, hamstrings and quadriceps). Univariate regression analyses indicated that player age (OR 1.12; 95% CI 1.03, 1.22; $p = 0.011$), weight (1.04; 1.01, 1.07; $p = 0.004$), competition level (3.27; 1.75, 6.13; $p \leq 0.001$), and previous injury (1.95; 1.05, 3.61; $p = 0.034$) were associated with sustaining a lower limb injury. These variables, along with lateral knee posture, S-scoliosis and C-scoliosis met the criteria for inclusion in the multivariate analysis. As competition level was based on the age of a player, these two variables were closely related and age was selected for the multivariate analysis to avoid collinearity. The final multivariate model indicated that having a moderate C-shaped scoliosis was associated with being non-injured (OR 1.57 95% CI 1.00–2.46, $p = 0.05$). In the injured population, 13% ($n = 9$) of players had a moderate C-scoliosis whereas in the non-injured population, 29% ($n = 40$) of players had a moderate C-scoliosis. The model was adjusted for player weight, with greater weight significantly associated with being injured (OR 1.04 95% CI 1.01–1.07, $p = 0.010$). No other player factor remained in the final regression model as significant.

4. Discussion

This study is the first to investigate postural characteristics of junior and adult representative/elite rugby league players, as well as the relationships between posture and the incidence of non-contact lower limb injuries. Previous studies prospectively investigating risk factors for injury in rugby league have used measures of physical performance (Gabbett & Domrow, 2005) and body structure and movement (O'Connor, 2004). Using comprehensive assessment of static posture, the current study identified a number of common postural deviations, including forward head position, forward shoulder position, lumbar lordosis, and varus knee interspace. However, there was little association between posture and the incidence of non-contact lower limb injury. These results suggest that correction of postural deviations may not be warranted as an injury prevention measure.

The most common posture deviations identified in these rugby league players were forward head position, forward shoulders, lumbar lordosis and varus knee alignment. These findings are consistent with studies identifying similar postures in other high-intensity contact sports (Hennessey & Watson, 1993a; Watson, 2001a). A number of factors may explain these observations. These posture characteristics may be protective against injury, and therefore players who advance to higher competition levels in the sport may tend to display these posture characteristics. In addition, these postures may provide performance advantages. For example, anterior pelvic tilt is advantageous for increased sprint speed, whilst forward shoulder position may provide an advantage as players brace for front-on contact (Bloomfield, 1998). Another explanation for these postures could be adaptation as a consequence of the strength and conditioning programs these players have performed from approximately 16 years of age. There may have been a lack of emphasis on posterior muscle groups such as the rhomboids, gluteal muscles and hamstrings, and over development of the anterior muscle groups, resulting in the shoulders being drawn forward and the pelvis becoming anteriorly tilted. Given that few relationships between postural deviations and non-contact lower limb injuries were identified, it is questionable whether there is any benefit in correcting these deviations.

Table 1
Characteristics of injured, non-injured, and all players (n = 207).

	Injured	Uninjured	Total
Number of Players (%)	67 (32.4)	140 (67.6)	207 (100.0)
	Median (IQR) or Mean (SD)	**Median (IQR) or Mean (SD)**	**Median (IQR)# or Mean (SD)**
Age# (y)	19.4 (16.6, 20.7)	17.5 (15.9, 19.3)[a]	17.9 (15.9, 20.1)
Height (cm)	180.9 (6.3)	180.3 (6.3)	180.5 (6.3)
Weight (kg)	93.7 (12.4)	88.3 (12.1)[a]	90.0 (12.4)
Body mass index (kg.m^2)	28.6 (3.1)	27.0 (3.3)	27.5 (3.3)
	Number of Players (%)	**Number of Players (%)**	**Number of Players (%)**
Player Position			
Forward	41 (33.6)	81 (66.4)	122 (58.9)
Back	26 (30.6)	59 (69.4)	85 (41.1)
Player Team			
U16	16 (33.3)	32 (66.7)	48 (23.2)
U18	3 (6.0)	47 (94.0)	50 (24.2)
U20	25 (47.2)	28 (52.8)	53 (25.6)
NRL	23 (41.1)	33 (58.9)	56 (27.1)
Previous Lower Limb Injury			
Ankle	33 (15.9)	174 (84.1)	
Knee	15 (7.9)	175 (92.1)	
Hamstring	11 (5.8)	179 (94.2)	
Quads	9 (4.7)	181 (95.3)	
Groin	4 (1.9)	203 (98.1)	
Calf	4 (1.9)	203 (98.1)	
Current Lower Limb Injury			
Ankle	12 (5.8)	195 (94.2)	
Knee	8 (3.9)	199 (96.1)	
Hamstring	12 (5.8)	195 (94.2)	
Quads	18 (8.7)	189 (91.3)	
Groin	12 (5.8)	195 (94.2)	
Calf	15 (7.2)	192 (92.8)	

[a] Significant difference between injured and uninjured player, $p < 0.01$.

Table 2
Number (%) and type of lower limb injuries sustained at each competition level (U16: n = 48; U18: n = 50; U20: n = 50; NRL: n = 56).

Injury type	Competition level	Number (%) of injured players
Ankle	U16	4 (8)
	U18	1 (2)
	U20	5 (10)
	NRL	2 (4)
Knee	U16	4 (8)
	U18	0
	U20	4 (8)
	NRL	0
Hamstring	U16	1 (2)
	U18	1 (2)
	U20	5 (10)
	NRL	5 (9)
Quads	U16	3 (6)
	U18	0
	U20	8 (16)
	NRL	7 (13)
Groin	U16	3 (6)
	U18	1 (2)
	U20	3 (6)
	NRL	5 (9)
Calf	U16	1 (2)
	U18	0
	U20	4 (8)
	NRL	10 (18)

U16: under 16 years of age; U18: under 18; U20: under 20; NRL: National Rugby League (professional).

Table 3
Proportions of rugby league players (n = 207) displaying each posture characteristic.

	Normal N (%)	Moderate deviation N (%)	Marked deviation N (%)
Knee Interspace	101 (48.8)	95 (45.9)	11 (5.3)
Varus		68 (32.9)	7 (3.4)
Valgus		27 (13.0)	4 (1.9)
Forward Head	133 (64.3)	69 (33.3)	5 (2.4)
Forward Shoulder	104 (50.2)	97 (46.9)	6 (2.9)
Kyphosis	184 (88.9)	21 (10.1)	2 (1.0)
Lordosis	131 (63.3)	64 (30.9)	12 (5.8)
Lateral Knee	191 (92.3)	16 (7.7)	0 (0.0)
Flexion		16 (7.7)	0 (0.0)
Extension		0 (0.0)	0 (0.0)
Shoulder Symmetry	155 (74.9)	52 (25.1)	0 (0.0)
S-Scoliosis	189 (91.3)	17 (8.2)	1 (0.5)
C-Scoliosis	158 (76.3)	49 (23.7)	0 (0.0)
Ankle	161 (77.8)	42 (20.3)	4 (1.9)
Varus		1 (0.5)	0 (0.0)
Valgus		41 (19.8)	4 (1.9)

However, when retiring from rugby league and for long term health, correction of postural defects may be beneficial. Increased lumbar lordosis has been found to be related to low back pain (Sorensen, Norton, Callaghan, Hwang, & Van Dillen, 2015), whilst forward head position and forward shoulders have been associated with neck pain (Yip, Chiu, & Poon, 2008).

Injured players were older and had greater body weight. These findings support those of previous studies, demonstrating a higher incidence of injury in older, heavier players (Gabbett, 2002, 2004). At higher competitions levels (e.g., U20 and NRL), the game is played at higher speeds, with greater forces and more repeated bouts of high intensity effort (Gabbett, 2013). An increase in player weight may be associated with greater muscle mass, and therefore a greater capacity for strength, power and momentum. As a result, these players are at higher risk of non-contact sprains and strains of the lower limb. Given these findings, in order to minimise non-contact lower limb injury, it may be advantageous for players in higher competition levels to maintain a lower weight. However, maintaining a lighter weight may prove to be a disadvantage in contact situations and potentially lead to more contact injuries.

When considering relationships between posture and injury, it was identified that players in the uninjured group had more moderate C-scoliosis deviations than those in the injured group. This was an unexpected finding and does not fit the previous literature suggesting that postural deviations may be associated with an increase in the incidence of lower limb injury (Cowan et al., 1996; Loudon, Jenkins, & Loudon, 1996; Powers, Maffucci, & Hampton, 1995). It is possible this is a chance finding, considering the low numbers of moderate C-scoliosis in the sample (24% of all players, $n = 49$) and the fact that none of the injured or non-injured players had a marked scoliosis. It is clear that postural deviations are common in rugby league, however given that they are not associated with an increase in non-contact lower limb injury, they may not require intervention for preventing lower limb injury. However, it is not known whether spinal posture might be related to upper limb, spinal, shoulder or contact injury, as these data were not collected in the current study.

The study is strengthened by the fact that it is the first to describe the postures that exist in the more elite levels of the sport of rugby league, and to examine relationships between posture and the incidence of lower limb injury in rugby league. However, a number of limitations must be acknowledged. Assessment of posture was limited to an observational measure requiring judgement from the assessor, and no other physical measurements were used. However, the photographic methods were carefully standardised and the Watson and MacDonncha (Watson & Mac Donncha, 2000) scale has demonstrated reliability. These methods allowed for a larger sample of individuals to be tested. Secondly, a lower incidence of injury is reported in the current study than in previous studies of players (Estell et al., 1995; Gabbett, 2003, 2004). This is probably due to the inclusion of non-contact injuries only, as contact injuries make up a large proportion of injuries in rugby league (Estell et al., 1995; Gabbett, 2003, 2004). Limb dominance was not recorded and not considered in the analyses. Future studies may investigate the relationships between posture and all types of injuries, including contact, as this may yield different results. Lastly, it was not feasible to record individual player exposure, and despite players having different degrees of involvement, exposure was recorded as an average for their respective team.

Given the large proportion of postural deviations seen in the neck, spine and shoulder, future studies should seek to examine relationships between posture and injuries to the upper limb and neck. Additionally, the inclusion of contact injuries and specific types of injury would give researchers a greater understanding of any relationships between posture and injury. Finally, given that this study measured static posture, future studies may seek to observe relationships between dynamic posture, such as postures used while running or tackling, and injury.

5. Conclusions

This prospective cohort study identified common postural deviations that exist among junior representative and adult elite rugby league players, including having a forward head position, forward shoulder position and lumbar lordosis. Although the presence of a C-scoliosis was observed more in non-injured players, no statistically significant relationships were found between posture and sustaining a non-contact lower limb injury. Unrelated to posture, but an interesting study finding, injured players were older and had greater body weight, suggesting that heavier players in the highest playing levels have the greatest risk of sustaining a non-contact lower limb injury.

Ethical approval

Ethics approval was obtained from the University of Newcastle Human Research Ethics Committee (H-252-0706). Informed consent was provided by all players (guardians of those under the age of 18) prior to participation.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2019.08.006.

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