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An Objective Case Controlled Study: Does Cervical Muscle Adaptation in Male Rugby Players Aged 13-18 Occur When Compared to Controls?

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Abstract

Purpose: Rugby is a physical game causing injuries, the most catastrophic of which is the cervical spine injury (CSI), resulting in tetraplegia or even death. Currently the Rugby Football Union (RFU) differentiates players on age alone and not strength. The primary outcome goal is to investigate the cervical strength of adolescent rugby playing individuals versus age match controls.

Methods: Forty four 14-18 year olds were evaluated for their cervical strength in flexion and extension using repetition maximum. Repetition maximum was established by measuring isometric contraction until the onset of eccentric failure with the use of a dynamometer. Neck girth was measured directly superior to the thyroid cartilage and cervical range of movement using a goniometer. These three parameters were compared against football playing controls.

Results: Cervical circumference and strength is significantly stronger in rugby players versus age matched controls and also in 17-18 year old rugby players compared with their 14-16 year old counterparts P<0.05. The difference in strength is not just age related but also sport specific as cervical extension strength to body weight ratio is stronger in rugby players versus football players P<0.05.

Conclusion: Urgent RFU regulations need to be addressed before the coming season to make sure U16 players are not playing for U18 teams unless having both sufficient strength and skill. Further still novice or beginners should not be introduced into the team without adequate conditioning and training.

Keywords: Rugby; Spine; Strength; Cervical; Injury; Rugby Football Union (RFU)

Introduction

Rugby is a popular sport played at all levels from juniors through to club national and international level. Since the game turned professional after the second world cup in South Africa in 1995; there is ever more publicity and people taking part; with rugby now being played in over 100 countries worldwide [1]. It is a physical game causing injuries; the most catastrophic of which is the cervical spine injury (CSI); resulting in tetraplegia or even death.

Cervical spine injury (CSI) in children can have catastrophic consequences. In children older than 10 years of age the common causes of spinal injuries occurs more frequently from sports than from motor vehicle accidents; this is the reverse in children less than 10 years of age [2-5]. In the 1980s New Zealand and Australia noticed increase incidence of CSI within the adolescent rugby players; and in a 10 year review between 1986 and 1996 rate of occurrence was 2.4/100;000 players- year [6].

Rugby is increasing in popularity in the school age group; where it is being played from the age of seven upwards. Any cervical injury in this population is obviously more worrying and devastating; with one study by Bottini et al there was a 3 times increase risk of SCI in children compared to adults [4].

CSI has a high personal and economic cost to both the individual and society. Lifetime cost for tetraplegia has been estimated to be in the region of $5 million [7]; This figure is likely to be higher still in the adolescent population.

The adolescent cervical spine is affected in 60-80% of spinal cases compared to only 30-40% in adults [8]. With childhood cervical injuries associated with up to a 75% mortality [9]. The biomechanics of children may also play a role in the incidence of CSI. This may explain why the cervical spine is more commonly affected in paediatric and adolescent population than compared with adults. The biomechanical differences found in the cervical spine of children compared to adults; include incomplete ossification of the vertebrae; shallow angulations of the facet joints; increased ligamentous laxity causing hypermobility of the cervical spine and immature development of the musculature [8,9].

In Rugby the rules of “crouch-hold-touch-engage” has been used to decrease the chance of CSI in the rugby scrum. With all of this in mind catastrophic cervical injuries still continue to occur during the rugby football game; with the introduction of new rules several series have reported no further decrease in injuries [6,10-12]; and when this occurs amongst the paediatric population the associated morbidity and mortality appears to be higher [9].

The evolving nature of the game and introduction of rule changes has resulted in the reduction of CSI in the scrum and ever increasing occurrence in the tackle [13]; thus exposing the whole team to this risk. Further still a mismatch in physical size often found in adolescent rugby; and differences in ability and skill creates situations conductive to injuries [14].

This novel research project will look into cervical muscle strength in the adolescent rugby playing population versus controls; which has never been carried out before. This is to see if rugby players at a junior level undergo cervical muscle adaptation while playing rugby when compared to controls. This is to evaluate if muscle adaptation is the response to a specific type of physical activity.

Methods

After Ethical approval from the Queen Mary's University of London ethics board 44 boys were recruited between the ages of 13-18 inclusive; there was no drop out of participants and no loss to follow up. Data collection involved anthropometrical assessment; alongside cervical range of movement (ROM) and cervical strength. Height weight and neck circumference were measured before isometric assessment.

Prior to evaluation; informed consent was obtained and the participants were screened for prior CSI. CSI was classified as any injury to the cervical spine preventing the player from training or competing or which medical attention was sought.

Neck girth was taken directly superior to the thyroid cartilage with the subject sitting and head in the neutral position. A measuring tape was held perpendicular to the line of the neck and measured without compressing the underlying soft tissue structures [15].

The cervical range of movement was assessed using a PhysioMed Cervical Measurement System MM1303; a type of bubble goniometer was set to measure degrees of rotation within the three planes of head movement in order of flexion/extension; rotation and side flexion.

A cervical muscle warm up programme was prescribed beforehand the assessment of strength. This involved 10 sub maximal flexion/extension and rotational movements with the use of the head harness. Isometric contraction using a head harness and dynamometer until the beginning of eccentric failure produced repetition maximum. Repetition maximum by similar methods has shown to be reliable [16-18]. Cervical strength was measured in flexion and extension with the participant braced against the same chair and workbench. . Three measurements were taken with the highest reading recorded as peak strength; with a 30 second rest between each testing.

SPSS software package 16.0 was used to determine statistically significant differences between the different aged groups using either Unpaired Student's t Test or Mann-Whitney U Test for skewed data. Hypothesis was tested at the set 95% confidence interval.

Results

The population included 44 boys varying between the ages of 14-18; 27 rugby players and 17 football players. The population details included age; height and weight were taken before range of movement (ROM) analysis and isometric assessment and summarized in Table 1. The football players on average were slightly older 16.7 ± SD 0.6 years compared to 15.9 ± SD 1.68 years; taller 180 ± SD 6.83 cm versus 175 ± SD 7.42 cm and heavier 73.6 ± SD 8.06 kg opposed to 70.1 ± SD 15.1 kg. The height being the only significant difference P<0.05.

	Mean Age in Years (CI)	Mean Height in cm (CI)	Mean Weight in Kg (CI)
Rugby	15.85 (1.68)	174.9 (7.42)	70.1 (15.1)
Football	16.71 (0.6)	180 (6.83)	73.6 (8.06)

Table 1: Demographics

In summary the data followed a non-parametric distribution. There were exactly the same median flexion and extension ROM vales of 58 (IQR 12 and 20) and 80 (IQR 8 and 17) degrees respectively for both the rugby and football participants. The combined median cervical rotation differed minimally with rugby players 158 degrees (IQR 28) in comparison the football the figure was 156 degrees (IQR 24).

The extension strength for the Rugby players was 29.0% stronger than flexion; in comparison to 31.1% in footballers. The rugby playing group had significantly stronger cervical extension to body weight ratio than their football playing counterparts (p<0.05) (Table 2).

	Average weight (Kg)	Average Flexion strength (Kg)	Flexion strength to weight ratio	Average Extension Strength (Kg)	Extension strength to weight Ratio
Rugby 14-16 years olds	60.7	18.2	0.30	29.4	0.48
Rugby 17-18 years olds	82.0	26.5	0.32	40.4	0.49
Football 17-18 year olds	73.6	19.6	0.27	28.4	0.39

Table 2: Ratio of cervical strength against body weight

Validation of Testing Method

Ten participants 1 week later were re-tested to analyse the reliability of the data being collected. The systemic bias showed small standard deviation and spanned zero for both cervical circumference; range of movement and strength (Table 3a and 3b). The coefficient of variation was evaluated for random error shows high reliability with a maximum error of +/- 2.8% (Table 3c). This confirms that the testing methodology had a high degree of reproducibility.

Statistical analysis

The data was subdivided into 2 age groups 14-16 and 17-18 age groups the usual divide between junior and senior adolescent rugby. The inter rugby analysis showed significant increase in cervical circumference P<0.0001 (U score 7.5) and cervical strength P<0.01; when the older rugby group was compared to younger group (Table 4a & box and whisker plots 1-2). There is no significant difference in cervical ROM between these age groups.

	Cervical Circumference	Flexion ROM	Extension ROM	Rotation Right	Rotation Left	Right Side Flexion	Left Side Flexion
Paired t-Test Significance (CI)	0.974 (-.33 to 0.13)	0.924 (-191 to 0.12)	0.914 (-1.54 to 2.74)	0.94 (-1.35 to 2.95)	0.924 (-1.51 to 1.91)	0.913 (-1.08 to 1.88)	0.918 (-2.51 to 1.31)

Table 3a: Reliability of Data Collected

	Flexion Strength	Extension Strength
Paired t-Test Significance (CI)	0.976 (-0.64 to 0.54)	0.973 (-0.69 to 0.75)

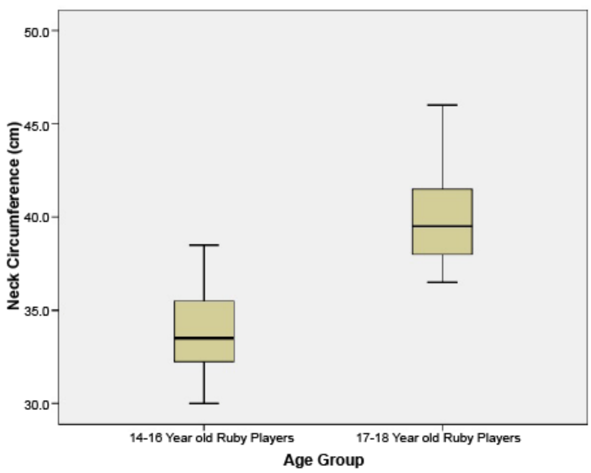
Table 3b: Reliability of Data Collected

	Mean Difference	SD	Typical (SEM)	Coefficient of variation %	Limits of Agreement +/-
Circumference	-0.1	0.32	0.1	0.55%	0.71
Flexion Strength	-0.05	0.82	0.26	2.8%	1.86
Extension Strength	0.1	1.2	0.38	2.5%	2.71

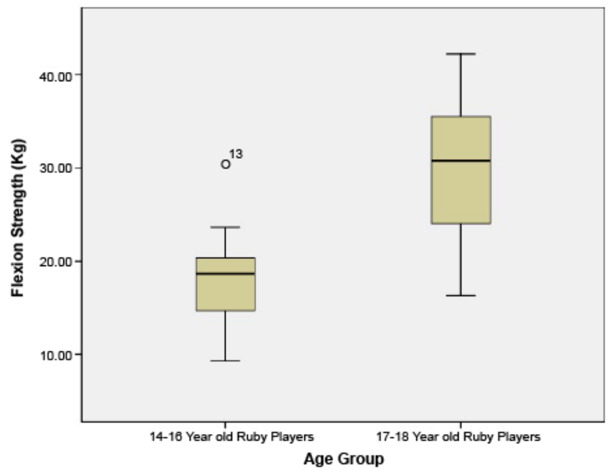
Table 3c: Reliability of Data Collected

Cervical Strength	P<0.01
Cervical Circumference	P<0.0001
Cervical ROM	P>0.05

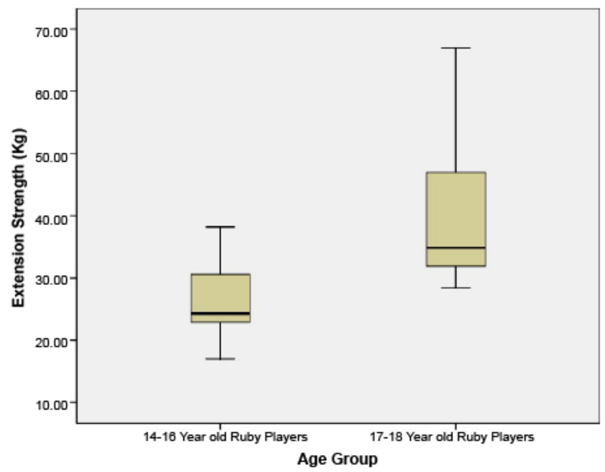
Table 4a: Younger (14-16) versus Older (17-18) Rugby players



Box and Whisker Plot 1: Showing Significant Cervical Circumference Difference Between 14-16 and 17-18 Year old Rugby Players (circumference in cm) P<0.0001



Box and Whisker Plot 2a: Showing Significant Flexion and Extension Strength Differences between 14-16 Year old Rugby Players (Strength in Kg) P<0.05



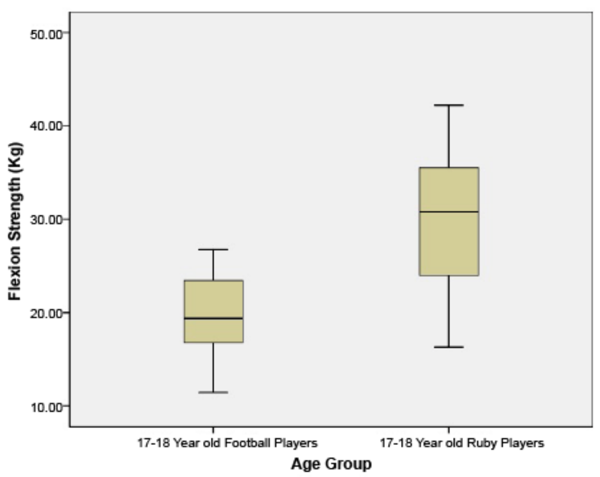
Box and Whisker Plot 2b: Showing Significant Flexion and Extension Strength Differences between 17-18 Year old Rugby Players (Strength in Kg) P<0.05

Comparison between aged matched rugby and football players; showed that the rugby players had increase in cervical circumference <0.0001 (U score 12) and neck strength in all directions P<0.005

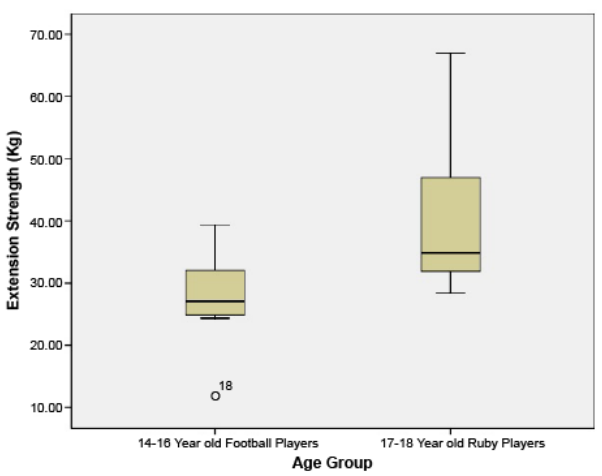
(Table 4b and box and whisker plot 3). There was no significant difference between the two groups in relation to cervical ROM.

Cervical Strength	P<0.005
Cervical Circumference	P<0.0001
Cervical ROM	P>0.05

Table 4b: Age match Rugby versus Football Controls



Box and Whisker Plot 3a: Showing Significant Flexion Strength Differences between Age Match Controls (Strength in Kg) P<0.05



Box and Whisker Plot 3b: Showing Significant Extension Strength Differences between Age Match Controls (Strength in Kg) P<0.05

Statistical review of older football players compared to younger rugby players only showed statistical significance for neck circumference; with the older football boys having larger necks (P<0.05). There was no significant difference in neck strength or cervical ROM (Table 4c).

Cervical Strength	P>0.05
Cervical Circumference	P<0.05
Cervical ROM	P>0.05

Table 4c: Younger (14-16) Rugby Players versus Older (17-18) Football players

Discussion

The results indicate that rugby players go through cervical adaptation and are stronger than age matched controls and increase in age alone does not produce increase cervical strength. In addition the increase in cervical spine girth seen in the older groups did not necessarily correlate with increase strength.

There is significantly increase strength found in 17-18 year old rugby players compared to 14-16 year old rugby players (P< 0.05) also found in age matched controls (P<0.005). This observation is important as current guidelines from the Rugby Football union (RFU) for youth rugby players states that rugby players shall play in their own age grade unless they fall within one of the following exceptions;

(a) Very talented or physically developed players in the U13; U14 and U15 age grades may play up one age grade with appropriate permission;

(b) Those in the U16 and U17 age grades may play up two age grades

This is of concern that talented younger players do not necessarily need to be physically developed or strong to be able to compete with older players. And even more worrying that 15 or 16 year olds; playing in the U16 squad; can play for the U18 team. Further still new players having not competed in rugby before may also be at risk; as subsequently they may have weaker cervical musculature when compared to the rest of the squad; having not had an opportunity for specific cervical muscular development.

Significantly larger neck girth is seen in both 17-18 year old football controls and 17-18 year old rugby players when compared to 14-16 year old rugby players P<0.05 and P<0.001 respectively (box and whisker plot 1). This may be explained that with increasing age there is growth and muscular development. Additional analysis showed that there was a significant increase in neck circumference in age matched rugby versus football players P=0.0001 (U score 12). This suggests that further muscular development and growth is found in contact sport.

It is important to emphasize that increase strength was not reproduced by the older football controls (who had never participated in rugby) when compared to younger rugby players. This is in comparison to the 17-18 year old rugby players; who were stronger than their younger subgroup. It has been well documented since the 1950s by Tanner et al that majority of boys have gone through pubertal maturation and growth spurt by the age of 17[19,20]. Thus the fact that the older football boys are not significantly stronger than the younger rugby boys suggests that going through pubertal maturity alone is not sufficient for increasing cervical strength.

The most important cervical strength is extension power; as the majority of rugby spinal cord injuries (SCI) are related from hyper-flexion of the cervical spine [10,21-23]. Extension strength of the cervical muscles also aids in part stability of the scrum which has also been supported by Olivier and Du Toit [15]. The 17-18 year old rugby players had increase neck extension power P<0.001 over both the 14-16 years old rugby players and the age match football players. This observation; which has not been documented to date; is important for allowing both age and strength matched rugby players to compete against each other. The importance of neck extension alongside technique is paramount in the scrum; with scrum collapses being one of the leading causes of SCI [1,12,24]. The significant increase in extension strength to body weight ratio found amongst rugby players against football controls (table 2) may suggest a muscular adaptation found with this type of physical activity. The flexion to body weight ratio was not found to be different between footballers and rugby players; this could be explained by use of neck flexors to head a football.

The increase in extension over flexion strength has been previously documented [15,25]. However; the increase in this strength varies in both articles; In the adult paper by Oliver et al the increase in extension strength was 31% [15]; which included both forwards and backs; while in comparison du Toit et al this figure was 48% with the average age of the participants being 17 [25]. The adult data compares with the values seen in both the rugby players and football controls at 29% and 31.1% respectively during this research. The data by du Toit et al is very different; and could be explained by their older average study age of 17 and all were 1st and 2nd team school forwards; thus playing at a relatively high level. This may suggest further muscular adaptation to the cervical extensor muscles occurs in forwards.

There is no significant difference in cervical range of movement seen within any of the population groups studied. The mean rotation +/-standard deviation was 154 +/-20.3 degrees which is comparable with adult data of 148.7 +/-16.9 from Andrade et al. [26]. There have been previous reports that children have hyper-mobile cervical spine when compared to teenagers and adolescent something not supported here [3,8,9]. Although there is no normative data in the literature to analyse this further.

Cervical Rom was measured with a bubble goniometer; though this is documented not to be the best method; with the gold standard for measuring ROM is with radiographic evaluation [27]. However; subjecting children to ionising radiation is unethical and Wolfenberger et al. recently compared bubble goniometer with other forms of nonradiating instrumentation and found the results very comparable [27].

The limitations to this study include involve the imperfect matching of the rugby and football groups for height. The principle tester (JP) was not blinded to the participants. There is thus a possibility of a testing bias involved in the data collection. In future studies this could be addressed through blinding rugby players and controls to the investigator; though this can be difficult due to the physical stature of many rugby players would make the blinding virtually impossible.

Conclusion

Cervical circumference and strength is significantly stronger in rugby players versus age matched controls and also in 17-18 year old rugby players compared with their 14-16 year old counterparts P<0.05. The difference in strength is not just age related but also sport specific as cervical extension strength to body weight ratio is stronger in rugby players versus football players P<0.05.Urgent RFU regulations need to be addressed before the coming season to make sure U16 players are not playing for U18 teams unless they have both adequate skill and strength. Further still novice or beginners should not be introduced into the team without adequate conditioning and training.

Practical implications

- Neck strength values can assist in screening weaker and potentially more injury prone participants.
- Gifted younger players will need to demonstrate adequate cervical strength before they are able to participate at higher levels in the game.

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