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Cervical Range of Motion in School Age Rugby Union Players: A cross sectional study.

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Abstract

Objectives: Provide normative values for cervical range of motion and describe trends in school age rugby union players.

Design: Cross-sectional study

Setting: National 3 level club

Participants: 59 school age rugby union players across under 8 (n=8), under 9 (n=9), under 10 (n=15), under 13 (n=13) and under 15 (n=15) categories.

Main outcome measures: Cervical range of motion using a cervical range of motion device (CROM) to determine values for active range of motion.

Results: This study established mean ranges of motion for each age group. Pooled mean ranges with standard deviations for each direction were, flexion 66° (±11), extension 73° (±17), left rotation 69° (±9), right rotation 74° (±10), left lateral flexion 53° (±10) and right lateral flexion 49° (± 12). No statistically significant differences were observed between the age groups, however, downward trends in lateral flexion were observed as age increased. School age rugby players had greater range of motion than senior playing counterparts.

Conclusions: No statistically significant differences in ranges of motion were observed between the age groups of under 8 through to under 15. However, downward trends in some ranges of motion highlight the need for age specific monitoring for potential adaptations to continued playing and comparison to age matched non-rugby players. Inclusion of other risk factors such as head re-positioning sense should also be evaluated to help guide injury risk reduction strategies.

Key words: Rugby Union; School age; Cervical range of motion

1. Introduction

Rugby union is a vigorous contact sport and has become the third most widely played team sport in the world (Freitag et al. 2015). Like other contact sports (i.e. American Football, Rugby League, Ice Hockey and Australian Rules football), the physical nature of the game exposes players to a high frequency of contact events. Consequently, rugby union is a sport which possesses a high risk of injury (Bottini et al. 2000). Around 1.2 million children in England play the game in schools and clubs (Haseler, Carmont and England 2010), with injuries in youth rugby union occurring less frequently than at senior level, particularly at the under 9 to under 11 age groups (Haseler, Carmont and England 2010). Overall injury incidence in community level youth rugby union is reported at 24 per 1000 hours (Haseler, Carmont and England 2010) whilst senior rugby incidence at the community level has been reported as 46.8 per 1000 hours (Yeomans et al. 2018) and between 30 - 91 per 1000 hours at elite level (Jean-François Kaux et al. 2015). However, epidemiological studies find that as school age increases so does the injury frequency (Archbold et al. 2015, Bleakley, Tully and O'Connor 2011, Freitag et al. 2015, Haseler, Carmont and England 2010). Injury frequency appears to peak between the ages of under 13 to under 15**,** with incidence increasing from 43.3 per 1000 player-hours at under 13, to 56.2 per 1000 player-hours at under 15 (Haseler, Carmont and England 2010)**.** The reasons for this rise are reported to be multifactorial, with maturation, period in the match and playing season and positional elements all contributing factors (Palmer-Green et al. 2013).

The sites and types of injuries seen in school age (under 18) rugby player are similar to those at senior level. However, in some studies (Bleakley, Tully and O'Connor 2011, Haseler, Carmont and England 2010, Leung, Franettovitch Smith and Hides 2016, Mcmanus and Cross 2004), the patterns of injury differ in terms of distribution between the upper and lower limbs when compared to those seen in senior rugby. For senior players at premiership level, in the 2017-18 season, the greatest incidence of injury is concussion (17.9 per 1000 hours), followed by hamstring (6.4 per 1000 hours) and medial collateral ligament (4.1 per 1000 hours) injury (Kemp et al., 2018). In contrast, the most frequently injured sites in youth (Under 18) rugby are the head (20.2 per 1000 hours), shoulder (14.3 per 1000 hours), neck (8.3 per 1000 hours), followed by the knee (7.1 per 1000 hours). (Bleakley, Tully and O'Connor 2011, Haseler, Carmont and England 2010, Mcmanus and Cross 2004), with incidence of all injuries ranging from 6.0 incidents per 1000 player hours (Haseler, Carmont and England 2010), to 28.5 incidents per 1000 player hours (Mcmanus and Cross 2004).

Analysis of match injuries to the neck region in senior rugby union players, shows a significant association between playing position and greatest incidence of injury to this region (Mcintosh et al. 2010). Front row players had the greatest incidence of neck injury, when compared with the rest of the forwards. Whereas backs had a significantly lower incidence of neck injuries when compared to the forwards as a group (Mcintosh et al. 2010). Recurrent injury incidences in senior rugby seem to predominantly involve the neck region, particularly within two months of the player returning to full training and competition (Williams et al. 2017). Initial data drawn from seven schools in England suggests that around 11% of injuries sustained in a single season are recurrent (Palmer-Green et al. 2013), but this in not broken down into specific anatomical regions. Both new and recurrent injuries to the cervical region typically occur because of the frequent contact events, such as scrums, rucks, mauls and tackles, which take place during a game (Davies et al. 2016).

Whilst many injuries occur because of traumatic impact, there is a suggestion that the cumulative effect of rugby playing also has a significant impact on gradual onset conditions such as disc and facet joint degeneration and cervicogenic headaches (Budelmann, Piekartz and Hall 2016). It has been hypothesised that the prolonged loading from the physical demands of the game leads to a reduction in the range of motion of the cervical spine, which has been identified in senior players who present with similar cervical symptoms to those experiencing whiplash (Lark and Mccarthy 2010). Cervical range of motion has been shown to decline with age, but this decline starts earlier and finishes later in males (Pan et al. 2018). Females also show greater range of motion than males, although the differences in range of motion between genders in young subjects are less significant

(Pan et al. 2018). Motion of the cervical spine in one plane requires complementary motion(s) in other planes from other cervical segments (Swartz, Floyd and Cendoma 2005). This is particularly the case with lateral flexion, which is associated with rotation to the same side (Swartz, Floyd and Cendoma 2005). An understanding of the kinematics and movement relationships of the cervical spine are important for clinicians to evaluate both range and quality of movement as part of a clinical assessment and re-evaluation of a treatment plan.

Whilst there have been studies into the range of motion of rugby union players, most of the projects address senior grade, or older age groups (Under 15 to 18). Studies which have examined youth rugby union players have also pooled the lower age groups together when reporting values making it difficult to determine potential trends and identify normative values within specific age groups.(Budelmann, Piekartz and Hall 2016, Davies et al. 2016, Lark and Mccarthy 2007). Therefore, the aim of this project was to determine values for cervical range of motion in under 8, 9, 10, 13 and 15-year-old rugby players to establish normative data and provide an idea of baseline parameters for coaches and clinicians to aid in monitoring player recovery. A secondary aim of the study was to observe for any associations between playing experience and range of motion and associations between the different movement directions in the cardinal planes.

1. Methods

Following ethical approval and parental written informed consent, a total of 59 players were recruited from a single Rugby Football Union (RFU) level 3 club playing in the English National 3 North division. Only male athletes were tested to eliminate variation between genders (Lark and Mccarthy 2007) with participants drawn from the under 8, under 9, under 10, under 13 and under 15 age groups. Age groups were selected to capture those not extensively evaluated in the literature, and the transition from non-contact to contact elements of the game. Anthropometric data for each age group are presented in Table 1. None of the players in any of the squads were playing up an age group.

Table 1. Anthropometric data for all players by age group.

Age Group	n	Mean age, years (SD)	Height, cm (SD)	Mass, Kg (SD)	BMI (SD)	Months Playing Experience (SD)
Under 8	8	7.5 (0.5)	132.6 (4.6)	32.1(4.1)	18.2(1.8)	23.3 (15.1)
Under 9	9	8.5 (0.5)	135.2 (7.6)	31.3 (7.4)	16.9(2.3)	33 (12.4)
Under 10	15	9.5 (0.5)	141.6 (6.7)	37.6 (4.8)	18.8(2.7)	35.4 (15.5)
Under 13	12	12.5 (0.5)	161.5 (8.9)	54.4 (10.6)	20.7(2.8)	58.5 (25.2)
Under 15	15	14.9 (0.4)	174.3 (7.9)	71.8 (17.7)	23.5(4.5)	100 (18.3)

Each participant completed a questionnaire on training frequency, past and current injuries, and general health. Thus participants were screened by a clinician for current head or neck injuries, tinnitus, vertigo and dizziness which would exclude from the study; as these conditions can affect positional awareness of the head, or be exacerbated by head movement (Lark and Mccarthy 2007).

The range of motion protocol carried out was based on that set out by Capuano-Pucci et al. (1991), and used by previous studies addressing measurement of cervical range of motion (Davies et al. 2016, Hamilton et al. 2014, Lark and Mccarthy 2007, Lark and Mccarthy 2009). In brief, each participant was seated facing a blank wall to avoid the use of visual cues during movement. Movements were practised prior to the recorded measurements to pre-stretch soft tissues and familiarise participants with the movement patterns. Movements were recorded in the sagittal, frontal and transverse planes with a cervical range of motion device (CROM, Figure 2) which records displacement in 2-degree increments (Performance Attainment Associates, Minnesota, USA). The device has been shown to have a high intra and inter-tester reliability with Pearson correlation coefficients of r=0.93-0.98, and intraclass correlation coefficients of 0.89 and 0.98 depending on the plane of motion (Capuano-Pucci et al. 1991). To further avoid slippage of the device, a bandana was used where necessary on the younger age groups. Following practise movements, each participant performed three trials in each of the three planes, with a 2 second hold at the end of the participants' self-selected maximum range. Coaching on direction was limited to 'chin toward chest' for flexion, 'look up to the ceiling' for extension, 'look over your left / right shoulder' for rotation and 'take your left/right ear toward the top of your shoulder' for lateral flexion. If participants were observed using combined motions, the end head position was corrected before taking the measurement. Participants were instructed to maintain the position of the torso, with correction given if required by the researcher and the trial repeated if necessary. Measurements were taken within a 2-week window for each age group in mid-season by the same clinician each time.

Fig. 1 Cervical Range of Motion Device (CROM) and magnetic yoke.

2. Statistical analysis

All statistical analysis was performed on SPSS version 25 (SPSS Inc. Chicago, USA). Data are expressed as mean and standard deviation. Mean of the three trials in each plane was used for subsequent analysis. Tests for normality using Shapiro-Wilk were undertaken. Where data was found to be not normally distributed, non-parametric equivalent tests were used. Differences in range of motion between age groups were examined using analysis of variance (ANOVA). Where significance was achieved ($p=<0.05$), a Scheffé post-hoc test was undertaken. Cohen's d was used to calculate effect size. Pearson correlations between the range of motion in each plane of motion and playing experience (in months) were also carried out within each age group.

3. Results.

Anthropometric data for each age group are presented in Table 1. The active cervical ranges of motion for each age group in each plane of motion are presented in Figures 2-7. With the exception of flexion, a comparison across age groups for each movement (e.g. flexion, extension) revealed no statistically significant differences. Post hoc analysis of flexion revealed a difference between the under 9 and under 10 age groups ($F(4,54)=2.5, p=0.049$, Cohen's effect (d) = 1.3). The under 10 age group showing reduced flexion (59° ± 9°) when compared to the under 9 age group (71° ± 12°). When the mean active cervical range of motion in each plane was compared with the mean number of months played, no significant correlations were observed. However, there was a positive correlation (Figures 8-13) between available extension range and the subsequent availability of left ($r=0.397, p=0.004$) and right ($r= 0.376, p=0.007$) rotation and left ($r= 0.377, p= 0.006$) and right ($r = 0.281, p = 0.045$) lateral flexion. Positive correlations were also observed between Left rotation and left lateral flexion ($r = 0.345, p= 0.013$), and right rotation and right lateral flexion ($r = 0.39, p= 0.005$). There was also a positive correlation between right rotation and left lateral flexion ($r=0.334, p= 0.017$), but not for left rotation and right lateral flexion.

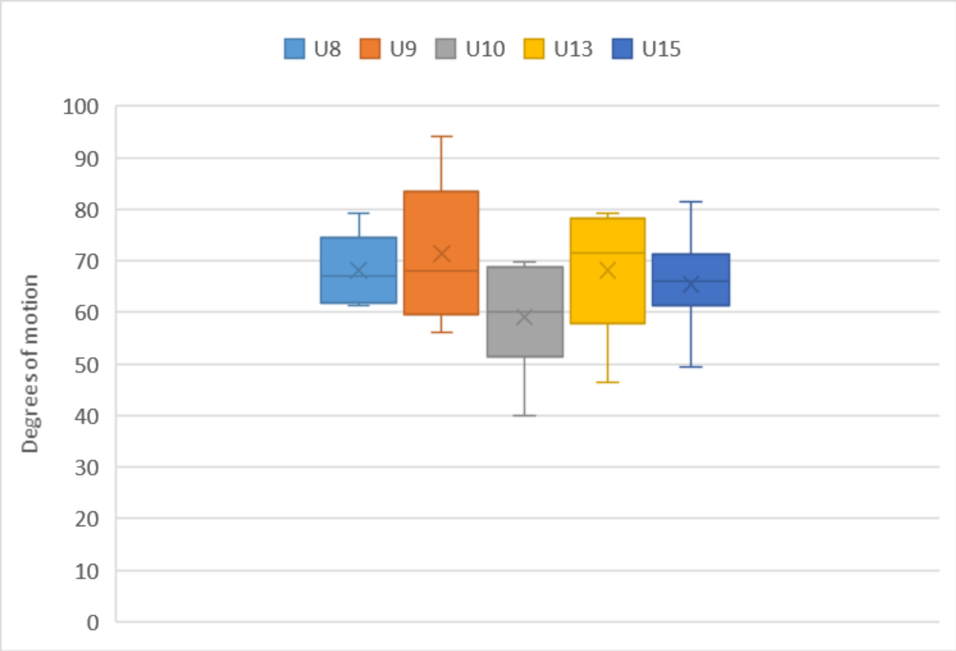

Fig. 2. Mean flexion range of motion for each age group of junior rugby players (n=59). Pooled mean 65° (±11).

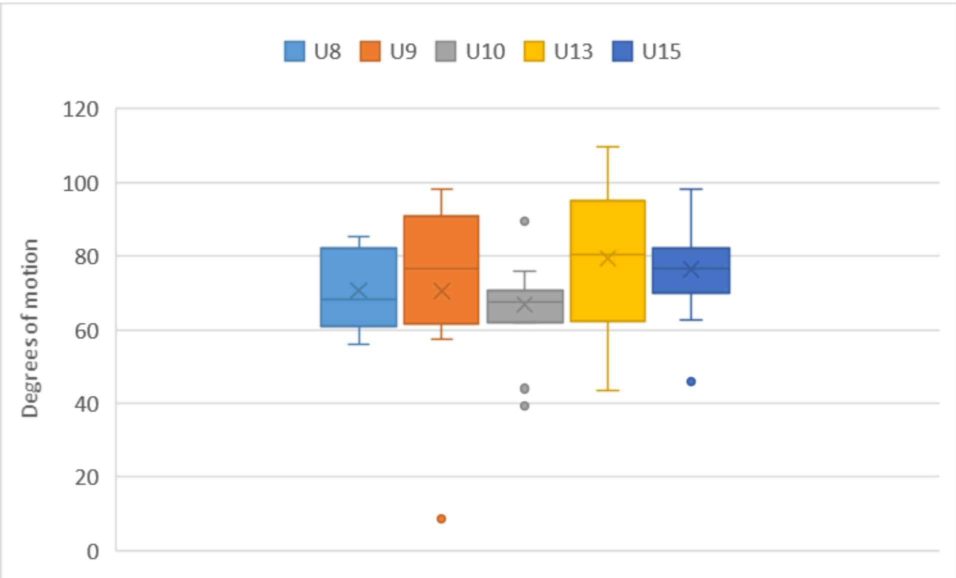

Fig. 3. Mean Extension range of motion for each age group of junior rugby players (n=59). Pooled mean 73° (±17).

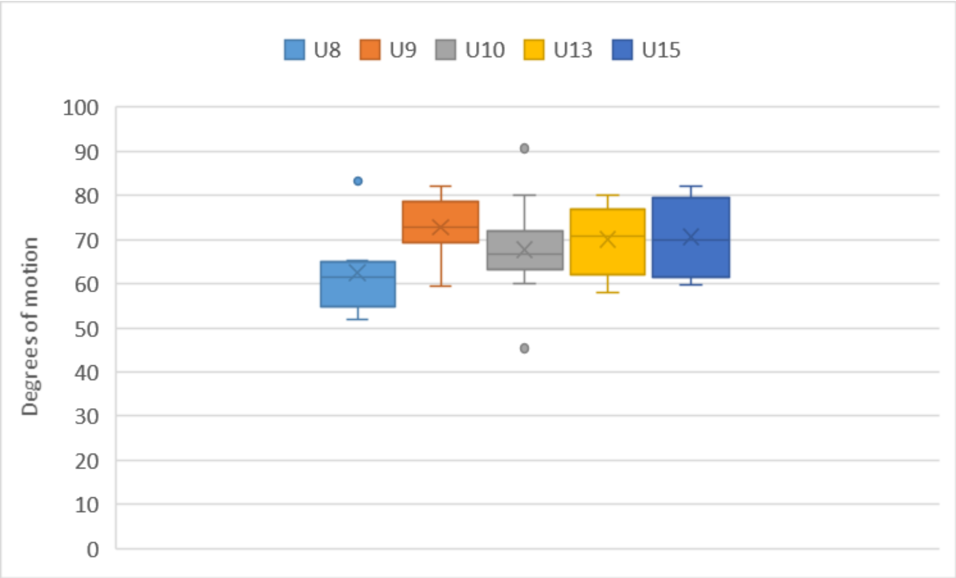

Fig. 4. Mean Left Rotation for each age group of junior rugby players (n=59). Pooled mean 69° (±9).

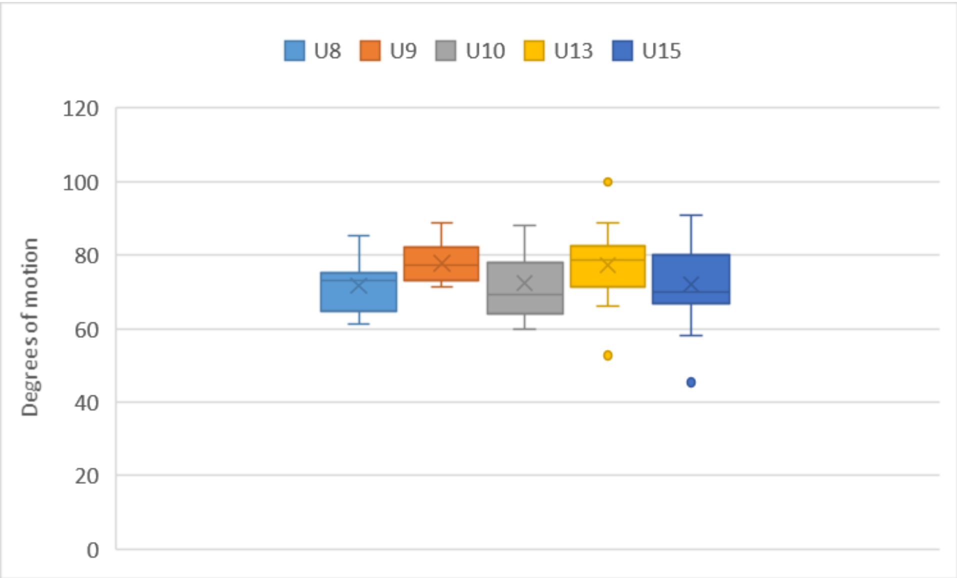

Fig. 5. Mean Right rotation for each age group of junior rugby players (n=59). Pooled mean 74° (±10).

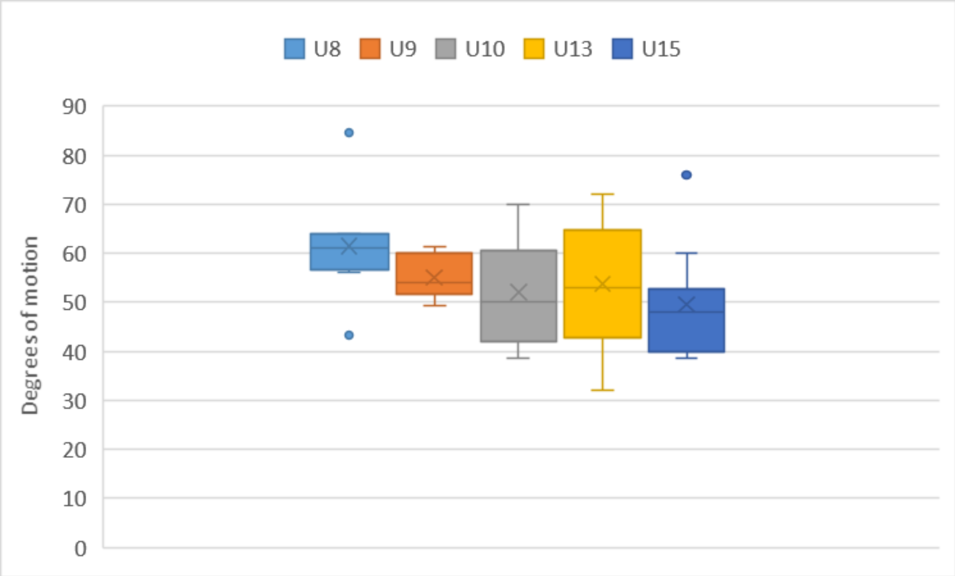

Fig. 6. Mean Left lateral-flexion for each age group of junior rugby players (n=59). Pooled mean 53° (±11).

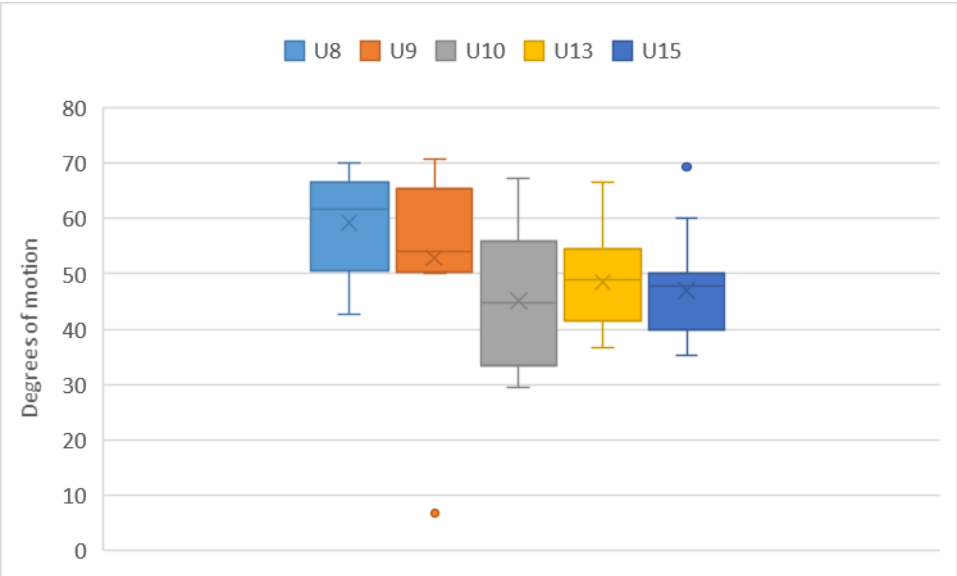

Fig. 7. Mean Right lateral-flexion for each age group of junior rugby players (n=59). Pooled mean 49° (±12).

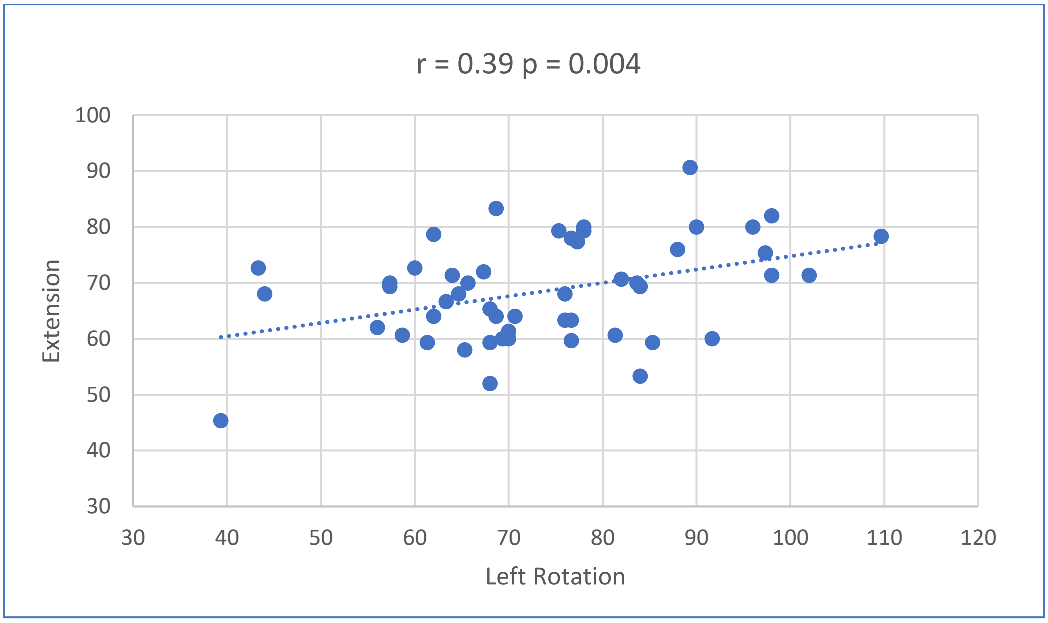

Figure 8. Extension vs. Left Rotation Correlation

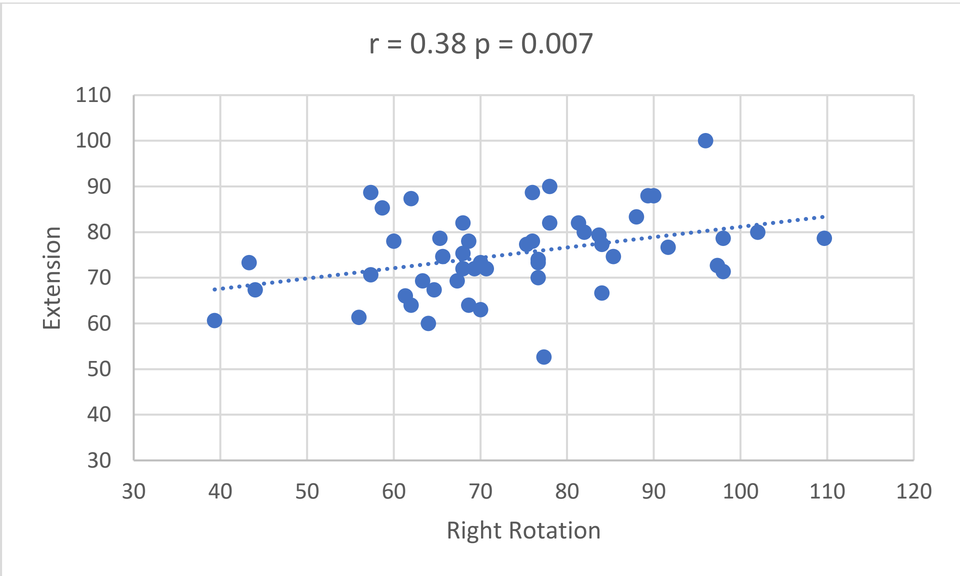

Figure 9. Extension vs. Right Rotation Correlation

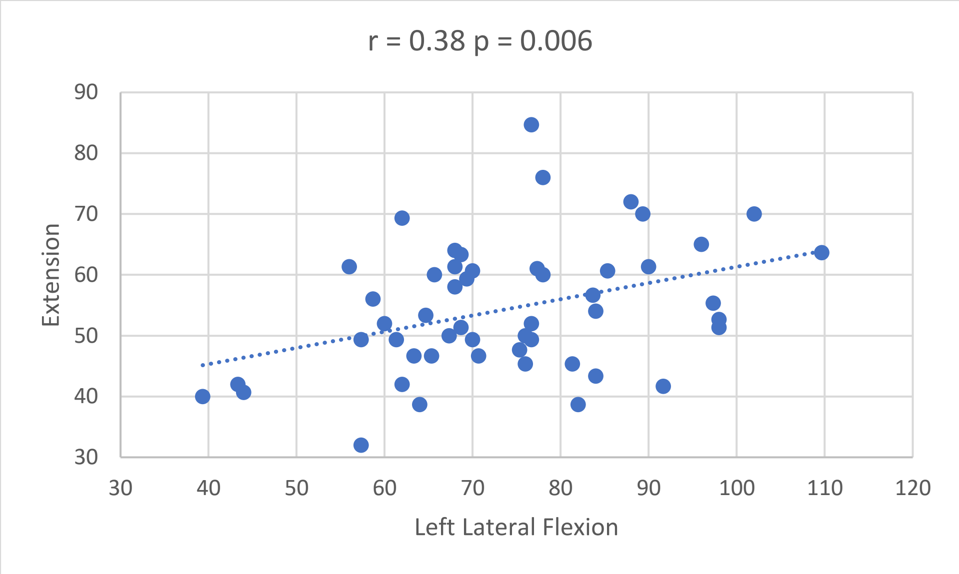

Figure 10. Extension vs. Left Lateral Flexion Correlation

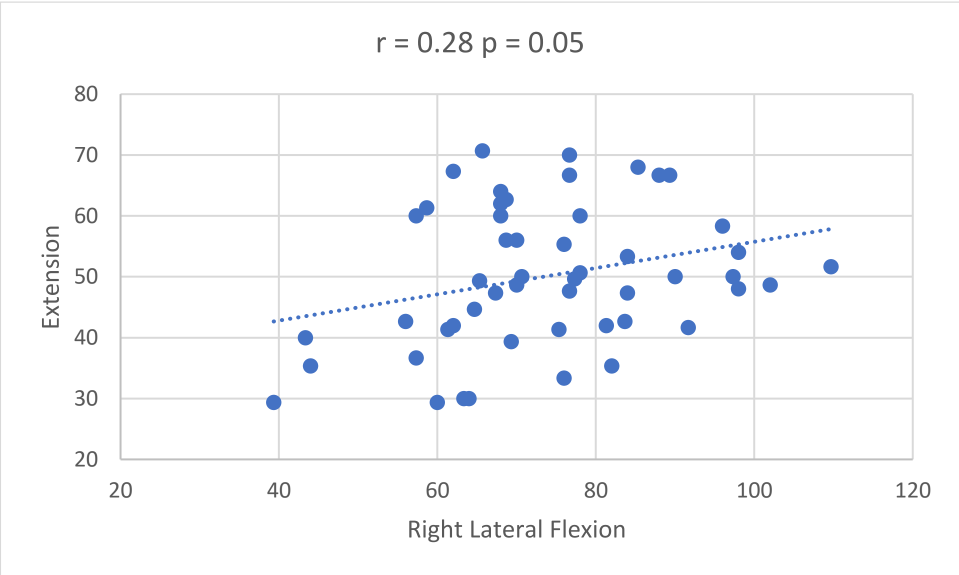

Figure 11. Extension vs Right Lateral Flexion Correlation

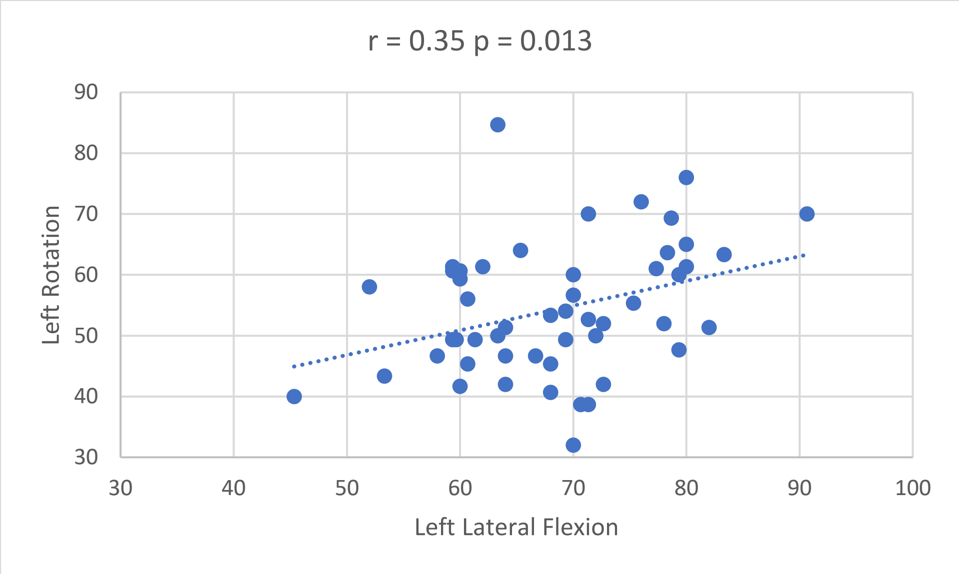

Figure 12. Left Rotation vs Left Lateral Flexion Correlation

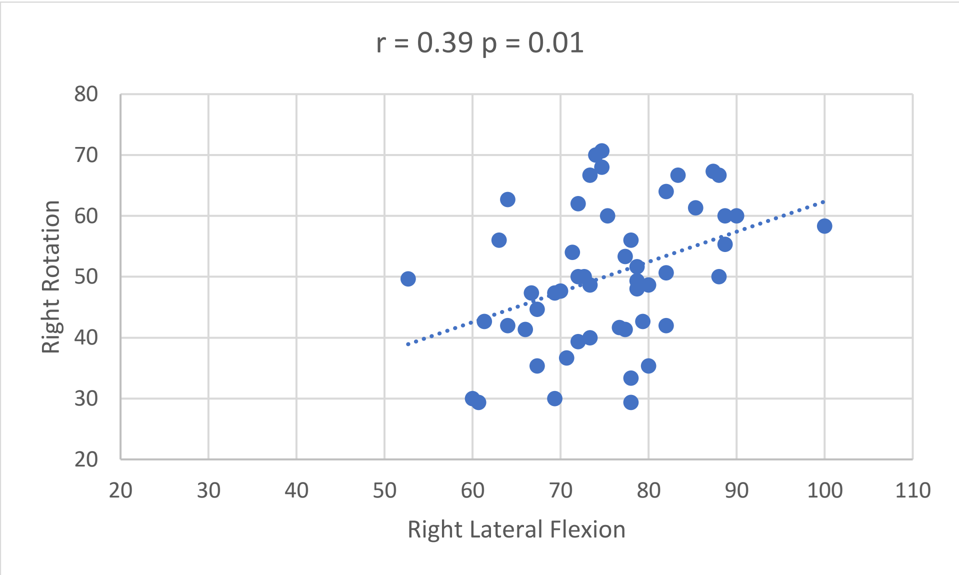

Figure 13. Right Rotation vs. Right Lateral Flexion Correlation

4. Discussion

To the author's knowledge, this is the first study to address cervical range of motion in a range of age groups representing school age rugby union players. The findings suggest that, with the exception of flexion between the under 9 and under 10 age groups, there are no statistically significant differences in ranges of motion between the age groups. This study also found no correlation between available range of motion and playing experience in terms of months played.

Where comparison is possible, the cervical ranges of motion for the school age groups, show similar values to international representative rugby union players evaluated by Davies et al (2016) at the under 18-19 age group. However, the ranges of motion for flexion, extension, left rotation and right rotation planes are lower when compared to the non-rugby playing population in the under 10 age group (Budelmann, Piekartz and Hall 2016). Senior semi-professional rugby union players appear to have reduced range of motion when compared to their non-rugby playing but trained equivalent age groups (Lark and Mccarthy 2007). Results of this study suggest that school age rugby union players have a greater range of motion when compared to their senior semi-professional contemporaries; this is particularly apparent in the flexion and extension planes of motion. Whilst this study found mean range of motion across the age range for flexion to be 65°, extension 72°, left lateral flexion 51° and right lateral flexion 40°, Lark and McCarthy (2007) found values of 44°,40°, 43° and 42° respectively for semi-professional senior players. However, it does appear that school age rugby players between the ages of 9 and 15 years, have less cervical range of motion than their non-rugby playing peers at the under 10 age group (Budelmann, Piekartz and Hall 2016). Thus, as players reach the senior semi-professional level, the available flexion and extension and left and right lateral flexion are reduced, but the findings of this study suggest this does not begin in a players' early playing career. This has potential implications to force attenuation and ability to scan the field of play and prepare for collisions.

As the whiplash motion is a common mechanism encountered in contact sport, it would be expected that flexion and extension range of motion decrease the more years players participate. However, in rugby union, impacts occur from a variety of angles, so the line of force may also have a similar effect on other ranges of motion. Interestingly, the trend for left and right lateral flexion in the age groups tested shows a downward trend, although this was not statistically significant. Furthermore, although statistical analysis revealed no changes in range of motion with playing age, comparisons with non-rugby players at similar ages would suggest a reduced range of motion. However, it is not clear if this is down to rugby per se, or a combination of this and other activities the participants were taking part in. Many of the participants were also involved in other sports, such as football, which may also result in loading to the upper limb and head region through running and heading the ball.

Correlations were observed for the whole group between left rotation and left lateral flexion, and right rotation and right lateral flexion respectively. This is not surprising, as lateral flexion depends upon a degree of rotation to the ipsilateral side (Lewandowski and Szulc 2003). This is illustrated by the absence of correlation between left rotation and right lateral flexion. However, there was also a positive correlation between right rotation and left lateral flexion, but this could be accounted for by the prevalence of right sided dominance in the participants in the study (47 right sided dominant vs. 12 left dominant). This dominant side effect is perhaps also demonstrated by the stronger correlation between right rotation and right lateral flexion than between left rotation and left lateral flexion. As comparatively few of the participants were left side dominant, it was not possible to conduct any viable comparisons between dominant sides.

Elements of Rugby Union present differing risks to a player. However, as with the senior game, the tackle is consistently identified as the highest risk event in terms of injury causation in school age rugby (Haseler, Carmont and England 2010, Leung, Franettovitch Smith and Hides 2016, Mcmanus and Cross 2004, Palmer-Green et al. 2013). For the ball carrier, this is particularly the case when the tackle is made from behind, or outside of the ball carriers' peripheral vision, and the event is therefore unseen and/or unprepared for, with little or no time to use agility skills (Mirsafaei Rizi et al. 2017). From the tacklers' perspective, having good technique has been identified as reducing the propensity of head and neck injury from this aspect of the game. The ability to be able to get the 'head up and forward', and 'head placement on the correct side of the ball carrier' have been associated with fewer incidences of head injury assessment because of tackling in senior rugby (Burger et al. 2017, Fuller et al. 2010, Sobue et al. 2018). To be able to achieve this technical accuracy, enough range of motion in the cervical spine is one of the physical components required by players. Without adequate range of motion, players may not be able to effectively execute good tackling technique, or scan the field of play for opposition players, and subsequently be caught unprepared and more susceptible to injury. Lack of range of motion in one area, can lead to compensatory movements in other areas (i.e. shoulder, thoracic spine) and results in sub-optimal positioning of these areas to deal with load attenuation. This alteration of loading could result in problems in other areas of the body from traumatic events or over time due to cumulative effect.

Although this study aimed to provide a cross section of range of motion values in school age rugby union players, it has not been able to compare age matched comparisons for playing versus non-playing participants across all the individual age groups. The data was also taken in the middle of a single playing season, and it is therefore not possible to observe for any potential changes in values during a competitive season, or to track changes in a group of players range of motion profiles over several playing seasons.

The results of this study provide guidance on profiles of cervical range of motion in school age rugby union players. It also suggests that school age rugby players have greater range of motion than senior players in agreement with Lark and McCarthy (2007) and Davies et al. (2016). Correlations were also found between the cardinal planes of motion, similar to those found by Lewandowski and Szulc (2003), with positive correlations observed for lateral flexion and rotation to the ipsilateral side.

Future studies should examine comparisons for age matched groups across a broader age range, and duration, to examine for potential transient changes due to playing season variation and adaptation to number of playing years. It may also be the case that further complexity is required when identifying exposure to game events when observing for trends in range of motion. Separation of forwards and backs would perhaps allow for more detail in relation to the players exposure to aspects of the game such as scrums, rucks and tackling.

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