Title: Physical demands of representative match-play in adolescent rugby union

ABSTRACT

The purpose of this study was to quantify the physical demands of representative adolescent rugby union match-play and investigate the difference between playing positions and age groups. Players (*n*=112) were classified into 6 groups by playing position (forwards and backs) and age group (U16, U18, U20). The physical demands were measured using microsensor-based technology and analysed using magnitude based inferences to assess practical importance. Backs had a greater relative distance (except U16s) and a greater high-speed running distance per minute than forwards, with the magnitude of difference between the positions becoming larger in older age groups. Forwards had higher values of PlayerLoad™ per minute (accumulated accelerations from the three axes of movement) and PlayerLoad™ slow per minute (accumulated accelerations from the three axes of movement where velocity is <2 $m.s^{-1}$) than backs at all age groups. Relative distance, low- and high-speed running per minute all had a trend to be lower in older age groups for both positions. PlayerLoad™ per minute was greater in U18 than U16 and U20 for both positions. PlayerLoad™ slow per minute was greater for older age groups besides the U18 and U20 comparisons, which were unclear. The contrasts in physical demands experienced by different positions reinforce the need for greater exposure to sprinting and collision based activity for backs and forwards, respectively. Given PlayerLoad™ metrics peak at U18 and locomotor demands seem to be lower in older ages, the demands of representative adolescent rugby union do not seem to be greater at U20 as expected.

Key Words:

Performance analysis; microsensor technology; running demands; player load; team sports

INTRODUCTION

Quantifying the physical demands of a sport is vital for various aspects of sports science. Further understanding the physical demands experienced by players during match-play allows practitioners and researchers to appropriately replicate competition demands during training or develop interventions with the ultimate aim of improving performance (6). This information can help inform talent identification (21), and allow practitioners to understand any differences between age groups (17) and competitions (40). Furthermore, such data can support injury rehabilitation (5) and injury prevention strategies by identifying relationships between running loads and injuries (19). Despite these applications and the acknowledgment that adolescence represents a key phase in athlete development (22), research specific to this population is limited for many sports, including rugby union.

Rugby union is an intermittent contact sport including high-intensity movements (e.g., sprinting, jumping and tackling), combined with low-intensity actions (e.g., walking and jogging) (10,38). The locomotive demands of senior professional players have recently been quantified using global positioning systems (GPS) technology (4,5,30). Cahill *et al*. (4) found that in senior players, backs covered greater total (6545 ± 1055 *vs*. 5850 ± 1101 m) and relative (71.1 ± 11.7 *vs*. 64.6 ± 6.3 $m.min^{-1}$) distances than forwards in addition to recording a higher maximum velocity (8.4 ± 0.9 *vs*. 7.3 ± 1.1 $m.s^{-1}$) during sprinting. In contrast, the physical demands of adolescent rugby union are yet to be fully understood, despite adolescent players of different ages training and competing in their own respective competitions.

Within other sports, such as rugby league, studies have compared senior professional and adolescent players (16,34). Substantial differences were identified for various physical metrics including distance covered sprinting (413 ± 60 *vs.* 237 ± 48 m) during match-play (34). These types of data allow practitioners to manipulate training exposures to adequately prepare adolescent players for the progression to senior rugby. However, due to the differences between rugby codes (league and union), and the increased emphasis on set pieces such as the scrum in rugby union and the consequent fatigue (32), research is warranted to assist in the development of adolescent rugby union players. Adolescence is identified as a key period of physical growth, biological maturation and psychological development (39); and therefore not only should the differences between senior and adolescent athletes be considered but also adolescent athletes of different ages.

The existing literature for adolescent rugby union (9,22,41) is limited by methodological issues or only within one age group (i.e., U20 international players) (7). Backs have been found to cover significantly more distance during match-play than forwards (5640 ± 371 *vs.* 4240 ± 381 m) (9), however, these findings are yet to be replicated using microsensor technology as Venter *et al*. (41) presented data from only the first 30 minutes of each half. Furthermore, Hartwig *et al*. (22) collected data from various age groups (U14 – U18) in adolescent Australian rugby union but all observations were grouped together. Therefore, the demands for different age groups within the same playing standard are unknown.

England currently has the greatest number of rugby union players in the world (15) with numerous playing pathways available. For example, players who are not selected for national squads (post 16 years of age) are eligible to trial for a *representative* team within their respective county, which forms part of the Aspirational Pathway (14). Despite rugby union players competing in concurrent playing standards in England during their adolescent years, no attempt has been made to investigate the physical demands of match-play. Therefore, the purpose of the current study was to quantify the physical demands (locomotor and accelerometer metrics) of adolescent rugby union match-play at the *representative* level. Moreover, this study aimed to explore the magnitude of difference between playing positions and age groups within adolescent *representative* rugby union in England.

METHODS

Experimental Approach to the Problem

The study used an observational research design where data were collected from two matches for three age groups (U16, U18, U20) between October 2014 and January 2015, totalling 6 matches. The matches were part of the annual competitive fixtures between *representative* county teams and produced the following results; U16 (39-12, win; 22-72, loss), U18 (41-22, win; 10-22, loss) and U20 (34-7, win; 47-13, win). The U16 and U18 matches had an official playing time of 70 min, whereas the U20 matches were 80 min.

Subjects

A total of 112 male *representative* rugby union players were recruited during the 2014 / 2015 playing season from three different age groups (U16, U18 and U20) and split into two playing positions (forwards [F] and backs [B]). Consequently, players were classified into 6 independent groups (see Table 1 for characteristics). There were no repeated measures for individual players and therefore all observations were treated as independent samples. Ethics approval was granted from the University's ethics board and all players provided written consent with a parent or guardian providing this for all players under 18 years.

***** INSERT TABLE 1 NEAR HERE *****

Procedures

During the matches, each player wore a microsensor-based technology unit (Optimeye S5, Catapult Innovations, Melbourne, Australia) that contained a GPS and a tri-axial accelerometer capturing data at a sampling frequency of 10 and 100 Hz, respectively. The units were placed within a pocket in the vest provided by the manufacturer and worn so it was situated between the scapulae. All participants wore the unit during a training session prior to the match as a familiarisation exercise. The mean ± standard deviation number of satellites during all data collection were 14.7 ± 0.7, whilst the horizontal dilution of precision were 0.77 ± 0.13.

The 10 Hz GPS units used in this study have previously been shown to be more reliable than 5 and 15 Hz GPS (25, 36). The GPS units used have a typical error (expressed as coefficient of variation; CV) of 1.9, 4.7 and 10.5% for total distance, high-speed running (>4.7 $m.s^{-1}$) and very high-speed running (>5.56 $m.s^{-1}$), respectively (36). The accelerometer in the unit has also been shown to have an acceptable CV for within (0.91–1.05%) and between (1.02–1.10%) unit reliability (3).

Following the match, all data were downloaded and analysed using the software provided by the manufacturer (Catapult Sprint 5.17, Catapult Innovations, Melbourne, Australia). Each file was trimmed so only data from actual playing time were analysed and players who played less than 20 min were excluded from the study.

The physical demands of match-play were assessed using a combination of locomotor and accelerometer metrics. Total distance covered were analysed into velocity zones specific to adolescent rugby union players (22); low speed running (LSR; 0 – 3.33 $m.s^{-1}$) and high speed running (HSR; >3.33 $m.s^{-1}$). Player Load™ (PL) represents the accumulated accelerations in the three axes of movement and is not dependent on distance, and therefore were downloaded to quantify the additional external load that rugby players experience (11). Player Load™ slow (PL_{slow}), which only contains data from velocities <2 $m.s^{-1}$ were also analysed due to the static exertions involved in rugby union (11). All measures were analysed relative to the amount of time spent on the field due to differences in actual playing time between the age groups and were therefore relative distance ($m.min^{-1}$), $LSR.min^{-1}$, $HSR.min^{-1}$, $PL.min^{-1}$ and $PL_{slow}.min^{-1}$.

Statistical Analyses

Descriptive data are presented as the mean ± standard deviation. Prior to analysis all data were log-transformed to reduce bias arising from non-uniformity error and analysed for practical importance using magnitude-based inferences (2). Percentage differences are presented with 90% confidence limits (24). The chances of the physical demands being lower, similar or greater than the smallest worthwhile difference (0.2 x between-subject standard deviation) were calculated using a spreadsheet (23) and assessed qualitatively as follows: <0.5%, *most unlikely*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, *possibly*; 75-95% *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly* (24). Where the chances of both lower and greater performance measures were >5% the magnitude of difference was reported as *unclear*.

RESULTS

The differences between forwards and backs within the same age group for physical demands relative to time are shown in Figures 1 and 2. The differences between age groups and within the same position for physical demands relative to time are shown in in Table 2.

***** INSERT FIGURE 1 NEAR HERE *****

***** INSERT FIGURE 2 NEAR HERE *****

***** INSERT TABLE 2 NEAR HERE *****

DISCUSSION

The purpose of the current study was to quantify the physical demands experienced by adolescent rugby union players during *representative* match-play and investigate the magnitude of difference between playing positions (i.e., forwards and backs) and age groups (i.e., U16, U18 and U20). The results of the present study showed relative distance and HSR.min^{-1} were greater for backs, while PL.min^{-1} and PL_{slow}.min^{-1} were greater for forwards. The main findings were comparisons between age groups, where a decreasing trend as age increased was identified for relative distance and HSR.min^{-1} in both positions. PL.min^{-1} was *possibly* higher in U18 when compared to U16 for both forwards and backs. Interesting, PL.min^{-1} was *likely* to *almost certainly* higher for U16 and U18 than U20 for forwards and backs. These data suggests that some physical aspects of U20 *representative* rugby union may be lower than the U16 and U18 age groups. However, PL_{slow}.min^{-1} is the only performance measure that seems to be greater in older age groups and indicates that there becomes a greater amount of activity from collisions and static exertions in *representative* adolescent rugby union as players get older. PL_{slow}.min^{-1} has been correlated with collisions (r = 0.79) in adolescent rugby union players (18), and thus provides a proxy measure for this aspect of the game in rugby union. The observed differences between age groups have implications for how practitioners design rugby training and conditioning sessions for players in preparation for the older age group, which this study shows may not be simply an increase in all the physical demands.

When comparing between positions, U18 and U20 backs covered a *likely* and *very likely* greater relative distance than forwards with similar trends highlighted in professional senior players (4,5). Interestingly, at U16 an *unclear* difference in relative distance was observed and shows that the differences between forwards and backs become more pronounced as age increases. This could be explained by the lower standard of skill level at younger age groups (20) and the impact this has shown to have on the physical demands of match-play in team sports (13). In addition, if superior defensive structures are in place during rugby at older ages this may explain the greater low-velocity activity ($PL_{slow}.min^{-1}$) and drop in running demands. The between position differences for rugby union players suggests that backs and forwards should prepare differently for match-play with further research required for positional development at younger age groups.

When analysing the physical demands by low or high speed running, $LSR.min^{-1}$ was *likely* and *possibly* higher in U16 and U18 forwards than backs, while *unclear* between U20s. However, $HSR.min^{-1}$ was greater in backs for all age groups. $HSR.min^{-1}$ is likely greater in backs due to them possessing a higher maximum velocity sprint (4) and the roles they undertake during the game including repositioning for and carrying the ball (35). In contrast to the locomotor metrics, the accelerometer variables ($PL.min^{-1}$ and $PL_{slow}.min^{-1}$) were *possibly* to *almost certainly* greater in forwards than backs at all age groups. The greater $PL_{slow}.min^{-1}$ suggests forwards accumulate a greater load from low-velocity activities such as collisions (31). Similar relationships for HSR and PL metrics have been shown between forwards and backs for senior professional players (33).

These observed differences between forwards and backs can be likely attributed to inherent difference in the roles between positions during match-play, that involves forwards winning possession of the ball at set pieces and breakdowns and backs involved in more open field play (12,31). The concurrent physical preparation of players for the locomotor and collision (determined via accelerometer) demands is key, as these have been shown to impact upon markers of muscle damage (29) and the time course for recovery (26) following match-play. In addition to this, practitioners preparing adolescent rugby union players for match-play should consider how the technical and tactical requirements of the sport influence the physical demands at different age groups, which warrants further investigation.

In addition to the between position group comparisons, practitioners should consider how the demands change with age, which was previously unknown. The comparison of physical demands between age groups indicates that relative distance; LSR.min^{-1} and HSR.min^{-1} may decrease with age. It should be noted that the within player variability in HSR.min^{-1} has previously been established in senior rugby union players as 23-33% (33) and therefore it is possible that the match-to-match variability may exceed the between group differences although this has yet to be established for adolescent players. The magnitude of change between age groups for relative distance is largest when progressing from U18 to U20, despite this, the values for U20 *representative* players are similar to those reported from international U20 players (forwards: 65.3 ± 3.2 vs. 61.5 ± 8.0 m.min^{-1}; backs: 70.9 ± 8.7 vs. 69.1 ± 7.6 m.min^{-1}) (7). In contrast, the relative distance of U16 and U18 players in this study are more comparable to senior players (forwards: 71.6 ± 10.1; backs: 81.0 ± 10.2 m.min^{-1})

(37). This finding seems to be contrary to other sports (e.g., soccer) where total distance and high speed running covered during match-play increased with age in academy players (U11 – U16) (21), highlighting important implications for physical preparation and progressions during adolescence. This may be due to the inverse relationship between HSR and physical contact, which have been previously observed during small-sided games (27,28). $PL_{slow}.min^{-1}$ showed a *likely* to *very likely* difference between U16 and U18 but *unclear* between U18 and U20, for both forwards and backs. This may suggest that the static component (e.g., scrums, mauls, rucks) of *representative* rugby union plateaus at U18. This implies that the contact element of rugby union may be a key consideration when preparing players for the progression from U16 to U18 age groups.

The apparent reduction in the locomotor and increase in the contact components of rugby union across age groups provide practitioners with some key considerations, which can be translated into training practices. Previous research has shown that when multiple contacts are performed in a training session, a greater reduction in running intensity is found when compared to non-contact (27,28), thus this may be a strategy that coaches employ when progressing players from U16 to U18 age groups. However, the anthropometric changes that occur during adolescence should also be considered. For example, it has recently been highlighted that running test performances throughout a professional rugby union club (U16, U18, U21 and senior team) did not change with age (8), although when body mass was used as a covariate, clear differences were observed between age groups. As such, it may be advantageous for players to focus on maintaining HSR ability while increasing body mass, as this will positively influence player momentum (8), which is an important physical characteristic in rugby (1).

An unexpected finding of this study was that the U18 *representative* playing level was more physically demanding than the U20 age group. Moreover, the locomotor demands were lower in older age groups. The possible explanations for this may be reflective of the current structure of adolescent rugby union in England. If players are selected for national teams (post 16 years of age) they cannot represent their county team post 16 years of age (14). Therefore, the playing pool at the U18 and U20 ages for *representative* rugby is diluted and may be reflected in some of the findings in this study in relation to the intensity of match-play. Furthermore, it may highlight that the demands of older age groups are different due to other attributes such as the technical and tactical ability and as players develop physically they can execute those skills that are more closely associated with senior players due to biological maturity. Due to variability in physical performances during match-play (33), the number of games assessed at each age group limits the current study and a larger number of games would have provided a further breakdown of positional demands in addition to reducing the uncertainty of the current results. Further research is warranted in adolescent rugby union of different playing pathways such as academy or school rugby. Studies should also look to examine the interaction between the physical and technical performances of adolescent rugby union players, taking into account contextual factors such as weather conditions, pitch size and match result.

In summary, the current study is the first to evaluate the match demands of different age groups within adolescent English rugby union, at a *representative* level. Differences between forwards and backs exist in all age groups, with relative locomotor metrics greater in backs and PL metrics higher in forwards. $HSR.min^{-1}$ and $PL_{slow}.min^{-1}$ in particular highlight the disparity between the two positions and reflect the different positional roles. Differences between age groups shows that the locomotor demands are lower at older age groups, with the PL metrics peaking at U18. This highlights the need to prepare U16 players for this higher contact element and the greater physical demands of U18 rugby compared to U20. In conclusion, the findings of this study show all the physical demands for different age groups seem to change in a non-linear fashion during *representative* adolescent rugby union.

PRACTICAL APPLICATIONS

Practitioners working with adolescent rugby players must be aware that running performance should not be evaluated in isolation and accelerometer based metrics should be considered when examining the total external load in rugby union. Furthermore, anthropometrics such as body mass should be taken into account due to the impact it has on physical attributes such as momentum. PL metrics, in particular PL_{slow} are practical measures that can be used to quantify the impact of non-running based activities (i.e., rucks, mauls, scrums) and highlight the differences between age groups, particularly for forwards. When designing training sessions, coaches should be aware that the inclusion of contact in rugby training is likely to have a profound effect on the running intensity of players. In addition, *representative* adolescent players should continue to be exposed to high-speed running as age increases in order to maintain this physical quality.

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Figure 1. Differences between forwards and backs in relative distance (A), low speed running (B) and high speed running (C) during representative adolescent rugby union match-play

Differences are shown using magnitude based inferences and percentage differences ±90% CL.

Figure 2. Differences between forwards and backs in PlayerLoad^{TM} (A) and PlayerLoad^{TM} slow (B) during representative adolescent rugby union match-play

Differences are shown using magnitude based inferences and percentage differences ±90% CL.

Table 1. Age and anthropometrics of representative adolescent rugby union players

Data are presented as mean ± standard deviation.

Table 2. Differences between age groups in the physical demands during representative adolescent rugby union match-play for forwards and backs

Differences are shown using magnitude based inferences and percentage differences ±90% CL. LSR = Low speed running; HSR = High speed running; PL = PlayerLoad^{TM}; PL_{slow} = PlayerLoad^{TM} slow.