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Physical, anthropometric and athletic movement qualities discriminate development level in a rugby league talent pathway

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Running Title: Physical anthropometric and movement qualities between RL development level

ABSTRACT

This study compared the physical, anthropometric and athletic movement qualities of talent identified rugby league (RL) players within a development pathway. From a total of 174 players, three developmental levels were defined: under 18 (U18; n = 52), under 20 (U20; n = 53), and state league (SL; n = 69). All players performed a test battery that consisted of five physical assessments, two anthropometric measurements and an athletic movement assessment. A multivariate analysis of variance modelled the main effect of developmental level (Three levels: U18, U20 and SL) on test criterion variables. Receiver operating characteristic (ROC) curves were then built for the criterion variables that showed a significant developmental level effect. A significant effect was noted (V = 0.775, F = 5.43, P <0.05), with the SL players outperforming their U18 and U20 counterparts for measures of body mass, peak and average lower limb power, double lunge (left side), single leg Romanian deadlift (left and right sides), the push up, and total athletic ability assessment score (P <0.05; d = 0.35 – 1.21). The ROC curves generated an area under the curve of greater than 65% for each test criterion, indicating greater than chance discrimination. These results highlight the physical, anthropometric and athletic movement qualities discriminant of development level within a rugby league talent pathway. Practitioners are encouraged to consider the thresholds from the ROC curves as an objective guide to assist with the development of physical performance qualities that may augment player progression in Australian rugby league.

Key words: developmental benchmarking, athletic movement competency, long term athlete development

INTRODUCTION

In an attempt to acquire sporting excellence, it is common practice for sporting organisations to integrate evidence-based learning environments to assist with talent development (19). The fundamental goal of these learning environments, typically referred to as 'academies', is to accelerate the development of performance qualities deemed critical at the elite senior level, thus expediting the elite junior-to-senior transition (19). Examples of these talent development academies have been reported in team invasion sports such as Australian football (AF) (31), soccer (17) and field hockey (6). Within each of these examples, 'developmental benchmarks' (herewith defined as reference values that discriminate developmental levels) have been identified, and utilised as a basis for orienting training interventions purported to expedite the junior-to-senior transition.

Similar to the aforementioned sports, rugby league (RL) is a multidimensional team invasion sport. It requires players to demonstrate physical qualities such as agility, acceleration, power, speed and the capacity to execute repeated bouts of high intensity activity (25), in addition to technical (passing and tackling) and perceptual (decision-making) qualities (14). Conceivably, identifying physical fitness and anthropometric qualities explanatory of developmental level would therefore likely offer practitioners with an initial framework to orient developmental interventions and guide talent development.

Given the importance of developmental benchmarking for talent development and player progression, several studies have examined performance differences between developmental levels in RL. For example, comparisons between senior elite and semi-elite RL players with similar anthropometric attributes, suggested that upper body strength discriminated the two groups with elite players being significantly stronger and more powerful against external forces (2). Others have identified differences in physiological characteristics between junior elite and sub-elite players with the elite group faster, more agile, and possessing superior lower limb power and maximal aerobic capacity compared to the sub-elite junior players (9). Additionally, Ireton et al. (12) compared the athletic movement skill and physical performance of elite senior and junior (academy representatives) English RL players. Their results revealed that elite senior RL players possessed superior athletic movement skills (as defined via the athletic ability assessment) (32), had greater body mass and lower body power relative to their academy counterparts. Further work has recently investigated the anthropometric, physical and psychological performance of older adolescent RL players to predict junior elite selection (26). The authors suggested that the U18 players whom were selected to development programs were superior in muscular endurance and acceleration; had greater body mass and were chronologically older compared to non-selected players (26).

It is important to note that these comparisons have not to date, examined the same variable results across multiple RL clubs competing in the same competition. The results of these comparisons may provide coaching staff, and those responsible for talent development, benchmarks for each developmental level, which may provide a basis for interventions to minimize performance gaps, and contribute to talent identification processes. Additionally, the results may contribute to a coherent philosophy for athlete talent development across RL and its stakeholders, positively impacting athlete transition and club resources.

In Australia, and particulary the dominant RL region of Queensland, the development pathway for talented RL players is initiated at the U18 level, with players recruited to regional or state league (SL) representative clubs (18). Based upon talent and chronological age, these players progress to the U20 level and finally to the SL level with different training regimes at each level. The U18 representative players train three times a week (technical skill and compound strength training) throughout the RL preseason (November to March). The U18 competition season is eight weeks in duration (March to April), and during competition season the U18 squad train two days and play one game each week. Progression of representative RL selection is to the U20 level. The U20 group commonly train three days each week throughout pre-season, strength, conditioning and technical skill training. The U20 group were also an eight week competition season (March to April), and similar to U18, the training regime during competition season was reduced to two training days and one game played each week. If the players are deemed capable, they may be selected to join the SL squad. The SL squad preseason generally includes three strength sessions, three field conditioning sessions and four technical skills sessions each week. The competition season is 25 weeks duration and training during competition season is generally training three days and one game each week. The fundamental goal of the multi-level pathway is to develop RL players capable of competing within the elite senior competition, the NRL.

To contribute to the development of talented RL players for elite competition, the knowledge of developmental level RL qualities, both the benchmark and discriminative attributes, may contribute toward evidence based, developmental level specific, RL training programs. Therefore, the aim of this study was to compare the physical, anthropometric and athletic movement qualities of talent identified RL players in an Australian development pathway. Given the work of others (12, 21), it was hypothesized that the SL athletes would possess superior athletic movement skills and lower body power characteristics relative to their U18 and U20 counterparts.

METHODS

Experimental Approach to the Problem

To test the study hypothesis, an observational cross-sectional research design was implemented. All participants undertook a test battery that consisted of physical, anthropometric and athletic movement skill assessments. The test battery construction was in accordance with prior research in RL (8, 12). Testing was performed at the end of the participant's preseason phase of training in an effort to standardize training related adaptations.

Subjects

The total sample consisted of 174 participants from eight RL football clubs, who were registered within the same state-based RL association. Each participant was categorized according to their developmental level (U18, U20 or SL), resulting in 52 U18 (17.2 ± 0.5 years), 53 U20 (18.9 ± 0.6 years) and 69 SL (23.8 ± 2.4 years) representatives. Playing position was standardized across each developmental level to ensure potential positional attributes did not impact the study observations.

Specifically, an approximately equal number of forwards and backs were utilised within each developmental level. Ethical approval was granted from the relevant institution, and participants were informed of the risks and benefits of the study. Participants <18 years of age also provided written informed consent from parents/guardians prior to data collection.

Procedures

Each participant undertook a standardised warm-up followed by a battery of assessments, previously applied for RL studies, in the following order: standing height and body mass, stationary vertical jump height (13), athletic movement skill (32), linear acceleration (28), repeated sprint ability (20), agility (10), and maximal aerobic capacity (1). The standardised warm-up consisted of jogging for two minutes followed by dynamic flexibility exercises of leg swings flexion/extension and abduction/adduction, overhead squats, walking lunges and A-skips. The warm up was completed with a stretching routine including calves, hamstring, quadriceps, gluteal groups, lumbar and thoracic spine, and shoulders for six minutes. Prior to the AAA, sprint and agility assessments, a single familiarisation repetition of each test was performed at 50% of maximal ability. A brief procedural description of each assessment is provided below.

Standing height was measured using a stadiometer and recorded to the nearest 0.1cm. Participants were required to remove footwear and were placed in the Frankfort plane prior to measurement.

Body mass was measured using a set of calibrated digital scales (Tanita BC545N Segmental Body Composition Monitor Scales BC-545N, Victoria, Australia). Participants were required to remove their footwear; with body mass being recorded to the nearest 0.1 kg. Training shorts and a singlet were permitted.

Stationary vertical jump height was measured using a Vertec jump device (Swift Performance Equipment, Lismore, Australia). The participants performed three bilateral countermovement jumps at a self-selected depth with the best of three jumps recorded for analysis. At the highest point of each jump, the inside hand was used to displace the vanes of the Vertec apparatus. The jump height was recorded as the difference between the standing reach height and the highest vane displaced whilst jumping. The maximum jump height (cm) was used as the criterion value for analysis. Additionally, peak lower limb power and average lower limb power generated by participants was estimated using the equation *78.5 x vertical jump cm + 60.6 x mass kg-15.3 x height cm – 1308*; and *41.4 x vertical jump cm + 31.2 x mass kg-13.9 x height cm + 431*, respectively (13).

Sprint time was obtained via a 30m maximal sprint. Timing lights (Swift Performance Equipment, Lismore, Australia) were used to record the time with gates being placed at the start line and the 30m line similar to a previous study in RL (28). Three trials with two minute rest intervals were conducted with the best time used for analysis.

Repeated sprint ability was measured via a 6x30m maximal sprinting effort on a 30s cycle (20) using timing lights (Swift Performance Equipment, Lismore, Australia). Participants commenced each sprint in a stationary up-right position, placing their lead foot on the start line approximately 30cm behind the timing gate. Participants were given a five second warning prior to the commencement of each sprinting effort. The total time for all six sprints was used as the criterion for analysis.

Agility was assessed via the *L-run agility test* (10). The L-Run test takes approximately 5 to 6 seconds to complete and has similar lateral movement patterns to those used in RL game play by athletes (10). The test required participants to move as quickly forward and around 1.1m high poles placed in a pre-planned inverted capital 'L' design. Timing lights (Swift Performance Equipment, Lismore, Australia) were placed 2.5m apart at the start/finish line with the fastest time of three trials separated by three minutes used for analysis.

Aerobic capacity was measured using the Yo-Yo Intermittent Recovery Level 1 (IR1) test, similar to previous research (1). The test concluded when the participant either: (a) reached volitional exhaustion, or (b) was unable to keep their running performance in time with the tones on two successive occasions. The total distance reached (in metres) by each participant was used as the criterion value for analysis.

Athletic movement skill was measured via the modified version of the athletic ability assessment (AAA) (32). The AAA is a reliable movement assessment protocol that associates the relationship between foundational athletic movement capability, and the movement patterns of physical performances specific to RL such as sprinting and leg drive (32). This assessment included five trials each of an overhead squat, double lunge, single-leg Romanian deadlift (RDL) (movement completed on left and right legs), and an attempt to complete 30 push-ups (32). Due to feasibility considerations, we were unable to include the chin up movement within the AAA and thus used the modified AAA in line with previous research (11). Feedback was not provided to participants whilst performing the protocol in order to prevent a potential scoring bias. Each movement was video recorded using standard two-dimensional cameras (Sony CX405 Full HD Handycam, Singapore), placed in the sagittal and frontal positions. Each movement was demonstrated by the primary investigator prior to the assessment. Participants used a wooden dowel to simulate a barbell for the overhead squat, single leg RDL and double lunge movements, and scoring was conducted retrospectively using the video footage and criterions described elsewhere (32). A greater description of each movement and its subsequent scoring criteria is provided in Table 1.

******INSERT TABLE 1 ABOUT HERE******

Statistical Analysis

To confirm the measurement properties of the AAA scoring procedure, the intra-rater reliability was assessed. The primary investigator assessed ten randomly chosen SL participants on two occasions separated by seven days. Given the categorical nature of the scoring criteria, the level of agreement between the two sessions was assessed using the weighted kappa statistic (k) (16). Agreement levels were defined as follows: <0 less than chance agreement, 0.01-0.20 slight agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 substantial agreement, and 0.81-0.99 almost perfect agreement (16). The level of agreement for scoring the athletic movement skill assessment ranged between 'substantial' to 'almost perfect' for each movement.

Descriptive statistics (mean ± standard deviation) were calculated for all physical, anthropometric, and athletic movement skill criterion variables according to developmental level. A multivariate analysis of variance (MANOVA) modelled the main effect of development level (Three levels: U18, U20 and SL) on each criterion variable, with the Type-I error rate set at $P \leq 0.05$. Additionally, effect sizes with 90% confidence intervals (CI) were calculated relative to the main effect using Cohen's *d* statistic, where d = <0.20 was considered trivial, d = 0.20-0.60 small, d = 0.61-1.20 moderate, d = 1.21-2.00 large and d = >2.00 very large (3). All between group comparisons were performed using SPSS (version 21, SPSS Inc., USA).

Receiver operating characteristic (ROC) curves were then built for the variables that were significantly different according to the main effect using the *pROC* package (22) in the computing environment, *R* (*R* Core team, Vienna). For each ROC curve, the area under the curve (AUC) was calculated with an AUC of 1 (100%) representing perfect discriminant power. The point on the curve of each variable that generated the highest AUC was considered the 'cut-off' value acceptable for discriminating between developmental levels.

RESULTS

There was a significant effect of developmental level (V = 0.775, F = 5.43, P <0.05) with the SL group superior to their U20 and U18 counterparts, demonstrating large effect sizes for measures of body mass, peak and average lower limb power, double lunge (left side), single leg RDL on both left and right sides, the push up and total AAA score (d = 0.68 – 1.21; Table 2). Additionally, the SL group outperformed their U20 counterparts in the score for overhead squat (Table 2), while the U18 group performed the double lunge movement with a significantly lower proficiency relative to both the U20 and SL levels (Table 2).

******INSERT TABLE 2 ABOUT HERE******

Given the results from the MANOVA, the ROC curves compared two groups: the combined U18 and U20s (referred to as juniors), and the SL group. The variable expressing the greatest between-group discrimination was the AAA total score (Figure 1H). The 'cut-off' score for this was 39.6 (from a possible 54 arbitrary units) with the AUC being 85%. For the junior group, 79% of the participants scored ≤39.5, whilst 78% of the SL group scored >39.5. The single leg RDL left leg produced an AUC of 79.7%, with a score of 5.5 (out of a possible 9 points) discriminating 77.4% of the junior group and 74% of the SL group (Figure 1F). The double lunge left leg demonstrated a AUC 72.4%, successfully discriminating 77.4% of the juniors and 58% of SL group with a score of 7.5 (Figure 1D). Body mass produced an AUC of 68.3% at a score of 85.5kg, discriminating 69.4% of the juniors and 61.5% of SL group. Of the physical fitness assessments, peak lower limb power discriminated 76.6% of the juniors and 55.8% of the SL group at a score of 5635 watts (AUC = 70.1%; Figure 1B), while average lower limb power discriminated 70.2% of the juniors and 65.4% of the SL group at a score of 3040 watts (AUC = 70.8%; Figure 1C).

******INSERT FIGURE 1 ABOUT HERE******

DISCUSSION

The current study demonstrated that SL players outperformed their U18 and U20 counterparts in nine of the 17 criterion variables. Specifically, SL players were heavier, generated greater peak and average lower limb power, scored higher on the double lunge, single leg RDL and push up movements, and subsequently had a higher AAA total score relative to the U18 and U20 players. These results provide coaches at the U18 and U20 with objective insights into the physical and athletic movement qualities that differ between developmental levels in an Australian talent pathway. Accordingly, our observations could generate practical utility for coaches responsible for the physical development of talent identified U18 and U20 RL players within an Australian development system.

It was of interest to note that the athletic movement skills of the U18 and U20 groups were considerably worse than what was observed for their SL counterparts. Most apparent were the single leg RDL and double lunge movements, where the U18 and U20 players performed at a lower standard to their SL representatives. This may be due to SL players having both greater playing experience and exposure to athletic movement, strength programs and screenings by appropriately qualified professionals for longer periods wherein any weaknesses may have been addressed. In contrast to the current study, a previous study of the English rugby league system, did find significant differences between junior groups (under 16 (U16) and under 19 (U19)) (12). Ireton et al. (12), stated that the U19 group demonstrated superior athletic movement ability for push ups, single leg RDL and double lunge right compared to the U16 group (12). However, the only significant differences between groups were that the senior group performed right side lunge and right side RDL, better compared to U19 group (12). Differences between these results and the current study may be due to RL academy training differences and/or the different player groups (U16 and U19 vs. U18 and U20) with the U16 group potentially biologically immature relative to the U18 group used in the current study.

The implications of the differences in developmental levels for the current study are important to consider in talent development. The single leg RDL is often prescribed to assist with hamstrings and lumbar spine strength and motor control via eccentric loading (4). Additionally, the double lunge assists with the acquisition of lower body loading during acceleration and deceleration (15). The importance of athletic movement skill for physical performance outcome has recently been demonstrated in AF (30). Specifically, Woods et al. (30), noted that junior AF players with relatively superior athletic movement were able to generate faster linear acceleration times, jump higher and produce a greater score on a 20m multistage fitness test. Thus, our results indicate that the majority of the U18 and U20 players may see augmented improvements with the continued refinement of their athletic movement capabilities.

Results showed that peak and average lower limb power were significantly different between the U18/U20 and SL groups. These findings complement the observations of Ireton et al. (12), who demonstrated lower limb power differences between U16, U19 and senior English RL players. Taken together, as expected, it could be suggested that junior RL players may not yet possess the lower body power qualities required to match their senior counterparts. Somewhat explanatory of this, it is likely that the SL players have been exposed to the RL development pathway longer than their junior counterparts and they may have greater playing experience (7). Additionally, the SL players (20 to 30 years of age) are also experiencing the biological peak of their musculoskeletal function (27).

When coupled with the superior body mass shown by the SL players in the current study, it is possible that these power differences could negatively impact upon a U20 player's progression into the SL when engaging in tackling and collisional activities performed during game-play, such as line breaks (breaking opponents defensive line while in possession of the ball) and ball carries (running with possession of the ball) (5). To assist with training program design, practitioners could utlise the peak and average thresholds resolved from the ROC curve analysis. Notably, these values could provide reference points that coaches could use as targets for their U18 and U20 players that may assist with player progression. Pertinently however, prior to undertaking advanced movements designed to enhance power, our results suggest that coaches at the U18 and U20 levels should prioritise the development of the athletic movement skills that underpin the single leg RDL and double lunge movements (29, 30).

The relatively minor differences observed between the U18 and U20 developmental levels in all criterion variables was of note. This was in contrast to Ireton et al. (12), who observed the greatest differences in athletic movement, body mass and lower limb power between the U16 and U19 groups. These points of differences may be reflective of the age differences between the players used in both studies, with the U16 group potentially being biologically immature relative to the U18 group used in the current study. Further, the additional year of difference between the U16 and U19 group versus U18 and U20 in the current study may have impacted upon the magnitude of differences observed.

Specific to our study, it is important to note that the U18 and U20 representative season is an eight week competition opposed to the SL competition season, which is 25 weeks. This difference could impact on the activity of preseason each developmental level engages in. Thus, a potentially reduced preseason phase of training within the U18 and U20 levels may result in the targeted development of the technical and tactical qualities needed in RL, constraining the development of the physical attributes described here. Nonetheless, our work demonstrates a clear developmental gap between the U18, U20 and SL levels with regards to physical attributes. Accordingly, to accommodate the temporal constraints imposed on the U18 and U20 levels, coaches could explicitly focus on the resolved differences presented here, using the 'cut-off' scores as a guideline for developmental benchmarking.

Despite the practical implications of this work, it is important to acknowledge its limitations. Notably, RL is a multidimensional sport, requiring physical, technical and perceptual performance qualities (5, 12, 24). Given the aim of this work, it only assessed one component of effective play, the physical requisites. Future work may therefore extend these findings by comparing the technical and perceptual-cognitive skills of RL players at different stages of a talent development pathway. Further, the inclusion of data from NRL representatives would likely provide further insight into the developmental differences between the early (U18, U20) and latter stages of the RL pathway. Lastly, this study explicitly adopted a cross-sectional design to identify developmental differences, limiting its capability to ascertain the longitudinal development trajectories of these performance qualities (23, 24). Nonetheless, these limitations offer an enticing platform for which future research could progress.

In conclusion, this study has highlighted the physical, anthropometric and athletic movement skill differences between talent identified RL players within a development pathway in Australia. Results showed that SL players were heavier, possessed greater peak and average lower body power and athletic movement skill relative to their U18 and U20 counterparts. These observations are likely to provide coaches at the U18 and U20 levels with an objective framework for the establishment of physical training interventions designed to positively augment player abilities. This training direction may ultimately assist with talent development and player progression in Australian RL.

PRACTICAL APPLICATIONS

There are three primary considerations to stem from this work. Firstly, the physical, anthropometric and athletic movement skill benchmarks highlighted by the ROC curve analysis may be used by coaches to improve player progression from U20 to SL. For example, coaches at the U18/U20 level could implement programs with outcomes that each player achieves AAA scores of >5.5 and >7.5 for the single leg RDL and double lunge movement, respectively, to create a smoother progression into the SL level. Secondly, given the results of the AAA athletic movement scores for the U18 and U20 groups, coaching staff should focus on correcting bilateral and unilateral movement patterns prior to initiating a progressive-load resistance program. Finally, following the development of the aforementioned athletic movement skill, lower limb power should also be considered for U18/U20 developmental training programs, which may assist with talent development and player progression.

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Figure 1. ROC curves showing the point generating the greatest AUC discriminating the combined U18 and U20 to the SL for: A) Body mass; B) Peak lower limb power; C) Average lower limb power; D) Double lunge score; E) Single leg RDL (R) score; F) Single leg RDL (L) score; G) Push up score; and H) Total AAA score

Table 1. The AAA used to assess athletic movement competency as adapted from Woods et al. (26)

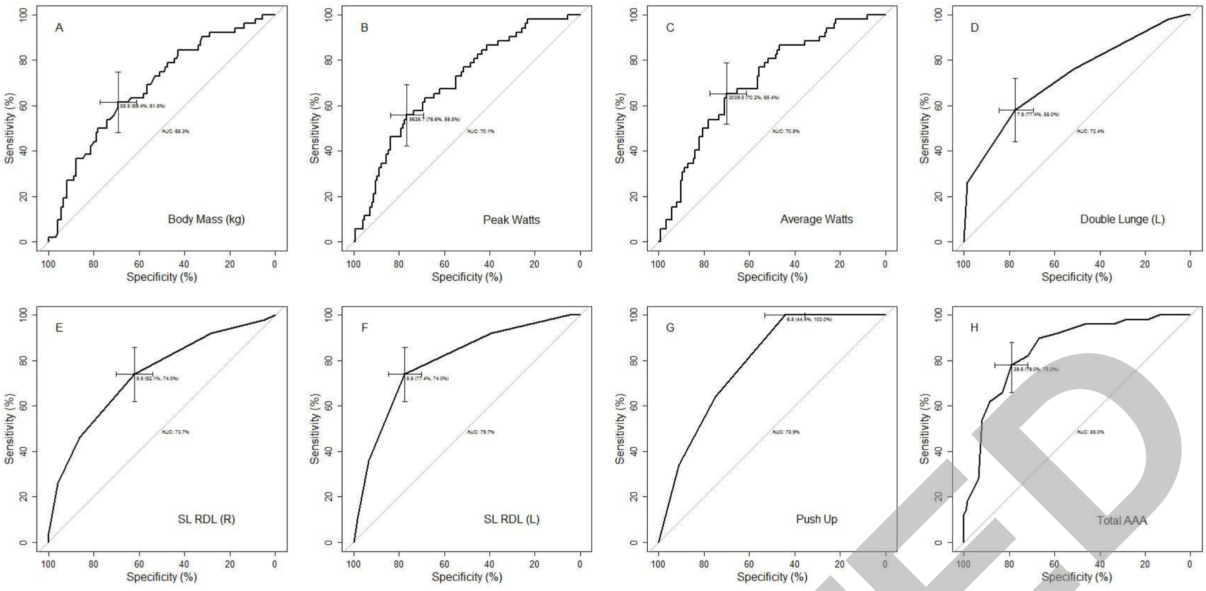
Movement	Assessment Points	3	2	1
OH SQT	Upper Quadrant	Perfect hands above head/feet	Hands above head/feet	Unable to achieve position
	Triple Flexion	Perfect SQT to parallel	SQT to parallel (compensatory)	Unable to achieve position
	Hip Control	Neutral spine throughout	Loss of control at end of range	Excessive deviation
DL	Hip, Knee, Ankle	Alignment during movement	Slight deviation	Poor alignment
	Hip Control	Neutral hip position	Slight deviation	Excessive flex/ext
	Take off Control	Control	Jerking	Excessive deviation
Push Up	TB control	Perfect control/alignment	Perfect control/alignment for some	Poor body control for all reps
	Upper Quadrant	Perfect form/symmetry	Inconsistent	Poor scap. positioning for every rep
	x30 reps	Hits target count	-	< x 30
SL RDL	Hip Control – Frontal	Maintain neutral spine	Slight flex/ext through hips	Excessive flex/ext on SL stance
	Hip Control – Sagittal	No rotation	Slight rotation at end of range	Excessive rotation
	Hinge range	Achieves parallel	Can dissociate but not reach parallel	Cannot dissociate hips from trunk

Note: OH SQT, overhead squat; DL, double lunge; SL RDL, single leg Romanian deadlift; scap, scapula; flex, flexion; ext, extension

Table 2. Between group effects for anthropometric, physical and athletic movement skill assessments

Variables	**U18**	**U20**	**SL**	**U18 – U20** *d (90%CI)*	**U18 – SL** *d (90%CI)*	**U20 – SL** *d (90%CI)*
Height (cm)	179.9 ± 7.0	179.2 ± 6.3	180.2 ± 13.5	0.11 (-0.22, 0.43)	-0.03 (-0.33, 0.28)	-0.09 (-0.39, 0.21)
Body mass (kg)	83.8 ± 11.2	85.5 ± 11.1	96.7 ± 12.3[ab]	-0.15 (-0.47, 0.17)	-1.09 (-1.41, -0.76)	-0.95 (-1.26, -0.63)
Vertical jump height (cm)	58.5 ± 6.1	58.0 ± 7.3	60.6 ± 7.6	0.07 (-0.25, 0.07)	-0.30 (-0.60, 0.01)	-0.35(-0.65, -0.04)
Peak lower limb power (W)	5605.8 ± 672.5	5686.0 ± 698.4	6551.3 ± 828.5 [ab]	-0.12 (-0.44, 0.21)	-1.24(-1.56, -0.90)	-1.12 (-1.43, -0.79)
Average lower limb power (W)	2964.7 ± 334.5	3009.6 ± 354.3	3451.9 ± 444.3 [ab]	-0.13 (-0.45, 0.19)	-1.22(-1.54, -0.88)	-1.08(-1.40, -0.76)
30m sprint time (s)	4.31 ± 0.16	4.21 ± 0.20	4.28 ± 0.16	0.55 (0.22, 0.87)	0.19 (-0.12, 0.49)	-0.39(-0.69, -0.09)
Agility time - left (s)	8.6 ± 0.4	8.7 ± 0.4	8.7 ± 0.4	-0.25(-0.57, 0.07)	-0.25 (-0.55, 0.05)	0.00 (-0.30, 0.30)
Agility time - right (s)	8.6 ± 0.4	8.6 ± 0.4	8.8 ± 0.7	0.00 (-0.32, 0.32)	-0.34 (-0.64, -0.03)	-0.34(-0.64, -0.03)
Repeated sprints total time (RSA) (s)	27.7 ± 1.1	27.6 ± 1.3	27.9 ± 1.4	0.08 (-0.24, 0.40)	-0.16 (-0.46, 0.15)	-0.22 (-0.52, 0.08)
Yo-Yo IR1 total distance (m)	909.2 ± 313.1	893.8 ± 368.7	960.0 ± 338.8	0.04 (-0.28, 0.37)	-0.15(-0.46, 0.15)	-0.19 (-0.49, 0.11)
Overhead squat	6.1 ± 1.6	5.6 ± 1.6	6.6 ± 1.7[b]	0.31 (-0.01, 0.63)	-0.30(-0.60, 0.00)	-0.60 (-0.91, -0.29)
Double lunge right	6.6 ± 1.1	7.1 ± 1.1[a]	7.5 ± 1.1[a]	-0.45 (-0.78, -0.13)	-0.82 (-1.13, -0.50)	-0.36 (-0.66, -0.06)
Double lunge left	6.4 ±1.0	6.7 ± 1.0	7.4 ± 1.1 [ab]	-0.42 (-0.62, -0.03)	-0.94 (-1.26, -0.62)	-0.66 (-0.97, -0.35)
Single leg RDL right	4.8 ± 1.0	5.3 ± 1.1	6.3 ± 1.3 [ab]	-0.48 (-0.80, -0.15)	-1.27 (-1.59, -0.93)	-0.82 (-1.13, -0.50)
Single leg RDL left	4.7 ± 1.0	4.8 ± 0.8	6.0 ± 1.1 [ab]	-0.11(-0.43, 0.21)	-1.23 (-1.55, -0.89)	-1.22 (-1.54, -0.89)
Push up	6.2 ± 1.5	6.2 ± 1.5	7.9 ± 0.8 [ab]	0.00 (-0.32, 0.32)	-1.47 (-1.80, -1.13)	-1.47(-1.80, -1.12)

[a] SL significantly (*P* <0.05) different to U18; [b] SL significantly (*P* <0.05) different to U20; L left, R right; *d* effect size


A
Body Mass (kg)
B
Peak Watts
C
Average Watts
D
Double Lunge (L)
E
SL RDL (R)
F
SL RDL (L)
G
Push Up
H
Total AAA
Sensitivity (%)
Specificity (%)