The influence of training age on the annual development of physical qualities within academy rugby league players

ABSTRACT

Previous research in academy rugby league players has evaluated the development of physical qualities according to chronological age. However, no study has considered the training age, defined as the number of formalized years of strength and conditioning training, of these players. Therefore, the purpose of this study was to present and compare the annual changes in physical qualities of academy rugby league players according to training age. Sixty-one academy players undertook a fitness testing assessment including anthropometric (height, body mass, sum of four skinfolds) and physical (10 and 20m sprint, 10m momentum, vertical jump, Yo-Yo intermittent recovery test level 1 [Yo-Yo IRTL1], one-repetition maximum [1-RM] squat, bench press and prone row) measures at the start of pre-season on two consecutive annual occasions. Players were categorized into one of three training age groups (i.e., 0, 1 or 2 years) and were analyzed using magnitude-based inferences. Almost certain, very likely or likely annual improvements were identified for body mass, 10m momentum, Yo-Yo IRTL1, vertical jump and all strength measures for the three training age groups. When training age groups were compared, 1 years showed possibly or likely lower strength increases than 0 years training age. However, the 2 years training age group demonstrated possibly or likely increased strength changes compared to 1 years. These findings suggest that training age is an important consideration for strength and conditioning practitioners but it is likely to be a combination of chronological age, biological maturity and training experience alongside dynamic inter-player variability that influences the physical development of academy rugby league players.

Key Words: Anthropometry, strength, fitness, training experience, magnitude-based inferences

INTRODUCTION

Rugby league is an intermittent, collision team sport played worldwide across various junior and senior levels (11, 17). The sport consists of high-intensity work periods (e.g., sprinting, tackling) interspersed with low-intensity activity (e.g., repositioning, jogging; 8, 17, 34). Due to the high physical game demands, players are required to have highly developed physical qualities including body composition, speed, power, strength and endurance to successfully compete in the sport (11, 17, 18, 31). Therefore, the physical enhancement of adolescent rugby players is a major concern for the strength and conditioning coach and rugby practitioner in the development of the next generation of talented rugby league players (32).

A plethora of cross-sectional research is available within the United Kingdom (UK; 19, 28, 33) and Australia (7, 9, 10) that presents the physical qualities of adolescent rugby players. This research demonstrates that the physical characteristics generally increase with chronological age. In recent years, this cross-sectional methodology has been progressed by incorporating longitudinal research designs that evaluate the seasonal (30) and annual (32) changes in physical qualities. Recently Till and colleagues (32) demonstrated greater magnitudes of annual improvement were apparent in physical characteristics within younger (16-17 years) compared to older (18-19 years) academy players (e.g., body mass U16-17 = 7.2 ± 4.1% vs. U18-19 = 2.1 ± 2.4%; one-repetition maximum [1-RM] squat U16-17 = 22.5 ± 19.5% vs. U18-19 = 4.8 ± 6.4%). The authors (32) suggested that greater physical performance changes occurred at younger ages when players were closer to maturation and more likely to have less training experience.

Although longitudinal research designs (29, 30, 32) have enhanced the quality of data available within academy rugby league players, by allowing player development to be monitored over time compared to ‘one-off’ cross-sectional research designs, the current research only considers physical development in relation to chronological age. Therefore, this research fails to consider the influence of training age or training experience of academy rugby league players. Recent guidelines for working with young athletes (21) suggested that the strength and conditioning coach should understand and consider the training age of their athletes. Lloyd & Oliver (21, p. 68) defined training age as the "*number of years an athlete has been participating in formalized training''*. Training age is an important consideration as previous research has evidenced the relative ease in which training induced adaptations can be increased in novice participants (13) compared to more diminishing positive gains within more advanced athletes (e.g., 1, 2). This has been termed the law of diminishing return, whereby as training age increases, the magnitude of training adaptations decrease (22, 25). Therefore, training age should be considered in addition to chronological age to fully understand the physical development of youth athletes. However, training age has yet to be considered in any research study within academy rugby league players.

Within the UK, talented academy-aged rugby league players are recruited to train within the national governing bodies talent development programme between 13 and 16 years (27, 28) and within professional clubs academy programmes between 16 and 20 years of age (30, 33). A purpose of the academy programmes at 16-20 years of age is to develop the anthropometric and physical qualities of academy rugby league players required to meet the increasing training and game demands at progressing levels (8). This is the stage when formalized strength and conditioning training commences. However players can be recruited to a professional academy anytime between 16 and 19 years of age and therefore between these ages players may have large variations in their formalized strength and conditioning training experience. Therefore, a rugby league academy provides a training squad comprising of a range of formalized training ages, but similar chronological age, that would allow differences in the annual development of physical qualities to be examined. Such information would be advantageous for rugby league practitioners to understand the impact training age may have upon the physical development of players and potentially inform training programme design and long-term athlete development pathways.

Therefore, the primary purpose of the present study was to present the annual changes in physical qualities of academy rugby league players according to training age (i.e., 0, 1 or 2 years). The secondary purpose was then to compare the magnitude of difference in the annual change in physical qualities according to training age group. It was hypothesized that annual changes in physical qualities would occur, with increased changes associated with players of a lower training age.

METHODS

Experimental Approach to the Problem

Rugby league players from an UK Super League club's academy (Under 17s-20s) performed a testing battery at the start of each pre-season. Players were assessed on anthropometric (height, body mass and sum of four skinfolds) and physical (10 and 20 m sprint, 10 m momentum, vertical jump, Yo-Yo intermittent recovery test level 1 [Yo-Yo IRTL1], 1-RM back squat, bench press and prone row) characteristics. Players that were assessed on two consecutive pre-season periods (e.g., Under 17s and Under 18s) were included for analysis. All players were then grouped according to their training age, defined as the number of formalized years of strength and conditioning training within a rugby league academy (i.e., 0, 1 or 2 years). The change in physical qualities pre and post the annual period were examined for each group and the differences in the change in qualities, controlling for chronological age, between the groups were compared.

Subjects

A total number of 61 subjects (age = 17.3±0.7 years, range 16.4-19.1 years) were used in the study. Subjects were categorized by training age (i.e., 0 years, n=16; 1 year, n=33; 2 years, n=12). Subjects categorized into the 0 years group had not previously been involved in a professional club's academy programme and had no formalized strength and conditioning experience. Subjects in the 1 year and 2 year groups had that many years experience within a professional club academy, respectively.

Subjects at the Under 17-20 age categories within the rugby league academy only trained and played at the professional club. Training included three gym and two field sessions in the pre-season period (November – March) and two gym and three field sessions alongside one game per week during the season (March – September). Subjects not selected for matches would undertake an additional conditioning training session. All experimental procedures were approved by the institutional ethics committee with assent and parental consent provided along with permission from the rugby league club.

Procedures

All testing was completed across two testing sessions in November each year at the start of pre-season. The testing was undertaken by the lead researcher in the same location throughout the 6-year period and all players were familiarized with the testing protocol. Prior to testing, a standardized warm up including jogging, dynamic movements and stretches was conducted. Testing session one incorporated field based assessments of speed (10 and 20 m sprint) and endurance (Yo-Yo IRTL1). Testing session two incorporated gym based testing including anthropometric (height, body mass and sum of 4 skinfolds), vertical jump and 1-RM strength (back squat, bench press and prone row) measures. The intraclass correlation coefficient (ICC) and coefficient of variation (CV) for all methods have been described in previous research (30, 32) and all indicate acceptable reliability based on established criteria ($r > 0.80$; 15).

Anthropometry: Height was measured to the nearest 0.1 cm using a Seca Alpha stand (Seca, Birmingham, UK). Body mass, wearing only shorts, was measured to the nearest 0.1 kg using calibrated Seca alpha (model 770) scales. Sum of four site skinfolds (biceps, triceps, subscapular, suprailliac) were determined using calibrated skinfold callipers (Harpenden, British Indicators, West Sussex, UK) in accordance to Hawes and Martin (14).

Lower body power: A countermovement jump was used to assess lower body power via a just jump mat (Probotics, Huntsville, AL, USA). The countermovement was performed with both hands positioned on the hips and subjects instructed to squat to a desired depth and then jump explosively as high as possible. Each subject performed three jumps separated by 60 s rest with jump height measured to the nearest 0.1 cm.

Speed: Sprint speed was assessed over 10 and 20 m using timing gates (Brower Timing Systems, IR Emit, Draper, UT, USA). Players started 0.5 m behind the initial timing gate and were instructed to set off in their own time and run maximally past the 20 m timing gate. Times were recorded to the nearest 0.01 s with the quickest of the three times used for the sprint score.

10 m Momentum ($kg \cdot s^{-1}$): Momentum was calculated using estimated velocity ($m \cdot s^{-1}$) from 10 m sprint velocity (distance / sprint time) multiplied by body mass (kg^{-1}; 3).

Endurance: Endurance was assessed via the Yo-Yo IRTL1 (20), commonly used to assess endurance performance in rugby league players (12, 33). Keeping to a series of beeps, players were required to run 20 m shuttles, followed by a 10 s rest interval. The test's running speed increased progressively throughout until the players reached volitional exhaustion or until players missed two beeps, resulting in the test being terminated. Total running distance was recorded.

Strength: Strength was assessed via the 1-RM back squat, bench press, and prone row exercises. All players were accustomed to these exercises prior to testing, and any player who did not demonstrate competent technique (e.g., ability to squat to parallel) was not assessed on these measures. A warm-up protocol of 8, 5, and 3 repetitions of individually selected loads before 3 attempts of 1-RM with 3-minute rest between attempts was used. For the 1-RM squat, all players had to squat until the top of the thigh was parallel with the ground, which was visually determined by the lead researcher (3) and then return to a standing position. For the bench press, players lowered the barbell to touch the chest and then pushed the barbell until elbows were locked out (33). For the prone row, also known as a bench pull, the players lay face down on a bench. The bench height was determined so player's arms were locked out at the bottom position and then had to pull the barbell towards the bench. The 1-RM lifts were only included if both sides of the barbell touched the bench (33). After all strength assessments, player's 1-RM scores were divided by body mass to provide a strength score relative to body mass.

Statistical Analyses

Data are presented as means ± standard deviations (*SD*) physical qualities at each training age group and the percentage change in physical qualities, controlling for chronological age, between training age groups (i.e., 0, 1 and 2 years training). Analyses were conducted following log-transformation of the data to reduce bias arising from non-uniformity error and analysed for practical significance using magnitude-based inferences (4). The threshold for a change to be considered practically important (the smallest worthwhile difference, SWD) was set at 0.2 x between subject *SD*, based on Cohen's *d* effect size principle. The probability that the magnitude of change was greater than the SWD was rated as <0.5 %; *almost certainly not*, 0.5-5 %; *very unlikely*, 5-25%; *unlikely*, 25-75 %;

possibly, 75-95 %; *likely*, 95-99.5 %; *very likely*, >99.5 % *almost certainly*. Those that were less than the SWD (ES≤0.2) were described as trivial (4). Where the 90% Confidence Interval (CI) crossed both the upper and lower boundaries of the SWD (ES±0.2), the magnitude of change was described as unclear.

To investigate the effect of chronological age upon the change in physical qualities between 0, 1 and 2 years training age, covariate adjustment for chronological age was applied in the following manner; 1) the individual pre-post difference in physical quality observed in an annual period (i.e., 0, 1, and 2 training years) was plotted against each players age at pre-test; 2) linear trendlines were fitted for each group for pairwise comparison; 3) mean chronological age of all participants was then applied to the following equation to calculate an adjusted group-mean difference.

$$\text{Adjusted physical quality} = slope \times x + intercept$$

with *slope* as the slope of the trendline, x as mean chronological age of all participants in the pairwise comparison, and $intercept$ where the trendline crossed the *y* axis. Adjusted values were then compared to assess the effect of chronological age upon change in physical qualities between each group (16). The adjusted values were then compared using magnitude based inferences between 0 vs. 1 and 1 vs. 2 years training age.

RESULTS

Table 1 shows the physical qualities for players who had 0, 1 and 2 years training age, pre and post the annual period. Players with 0 years training age demonstrated *almost certainly*, *very likely* or *likely* annual increases in body mass, 10 m momentum, vertical jump, and all absolute and relative strength measures. Annual change in height and sum of skinfolds were *possibly* increased and *unclear*, respectively. Change in 10 and 20 m sprint performance was *very likely* and *likely* trivial, and there was a *possible* increase in Yo-Yo IRTL1. Players with 1 years training age demonstrated *almost certainly, very likely* or *likely* annual increases in height, body mass, 10 m momentum, Yo-Yo IRTL1, vertical jump, and all absolute and relative strength measures. There was *likely* trivial changes for sum of skinfolds and *possibly* decreased 10 and 20 m sprint time, suggesting improved performance. Players with 2 years training age demonstrated *almost certainly, very likely* or *likely* increases for Yo-Yo IRTL1 and all absolute and relative strength measures. There were *likely* trivial changes for height and body mass; *possibly* decreased sum of skinfolds, and 10 and 20 m sprint time, with *possible* increased 10 m momentum and vertical jump.

Insert Table 1 near here

Table 2 shows the percentage annual change for physical qualities (adjusted for controlling chronological age) according to 0 vs. 1 and 1 vs. 2 years training age. Figure 1 and Figure 2 show the magnitude of the comparisons of the annual percentage change between 0 vs. 1 year training age, and 1 vs. 2 year training ages respectively. For 0 vs. 1 years training age, *trivial* or *unclear* effects were shown for height, body mass, sum of skinfolds, 10 m momentum, Yo-Yo IRTL1 and vertical jump. For 10 and 20 m sprint, sprint time change was *possibly* lower for 1 year training age compared to 0 years, suggesting greater performance improvements for the 1 years training age group. For all absolute and relative strength measures, the annual percentage change was *possibly* or *likely* lower for 1 years compared with 0 years training age.

For 1 vs. 2 years training age, *trivial* or *unclear* effects were found for body mass, sum of skinfolds, Yo-Yo IRTL1, vertical jump, 1-RM and relative bench press, and 1-RM prone row. *Possibly* lower annual percentage change for 2 years compared to 1 years was shown for height and 10 m momentum. *Likely* lower changes for 10 and 20 m sprint performance, indicating greater improvements in 1 years training age, were also shown. *Likely* greater percentage annual changes were shown for 1-RM and relative squat and *possibly* greater percentage annual changes were found for relative prone row favouring the 2 years training age group.

Insert Table 2, Figure 1 and 2 near here

DISCUSSION

The purpose of this study was to present the annual changes in physical qualities of academy rugby league players according to training age (i.e., 0, 1 or 2 years) and then compare the magnitude of difference in the annual change in physical qualities according to training age. This study progressed on previous research examining the physical qualities (33), the seasonal (30) and annual (32) change in physical qualities of academy rugby league players according to chronological annual-age groups. As hypothesized, most physical qualities, especially strength characteristics, improved within each training age group over an annual period. Also, as hypothesized, players with no formalized strength and conditioning training experienced increased annual changes for body mass and strength measures compared to players with a training age of 1 year. However, when 1 year training age was compared with a training age of 2 years, the group with 2 years training age increased absolute and relative squat strength and relative prone row strength more than the 1 year training age group, respectively. These findings suggest that training age is an important consideration for strength and conditioning practitioners but it is likely to be a combination of chronological age, biological maturity and training experience alongside dynamic inter-player variability that influence the physical development of academy rugby league players.

Annual changes in anthropometric characteristics for each training age group showed varying changes for each group. For height, 0 and 2 years training age showed *possibly* and *likely* similar values pre and post the annual period, whilst 1 years training age demonstrated *likely* increases in height. Therefore, height should be monitored into late adolescence regardless of training age as academy players may not have attained adult height, which continues to develop into early adulthood due to chronological and maturational age (23). For body mass, *very likely* and *likely* increases were found for 0 and 1 years, whilst 2 years showed *likely* similar values pre and post the annual period. A possible explanation for this may be the reduction in sum of four skinfolds for the 2 years training age group compared to *unclear* and *likely* similar values for 0 and 1 years respectively. Therefore, although lean mass was not directly assessed, gains in lean mass may be evident in academy rugby league players regardless of training age, which is most likely due to the normal adaptations related to growth and maturation alongside the inclusion of resistance training and nutritional interventions in academy rugby league players (26, 32, 33).

For speed, findings showed *likely* similar or *possibly* improved performance for each of the training groups. These findings are similar to previous cross-sectional (5, 33) and longitudinal (32) comparisons of sprint performance by chronological age. Therefore, training age does not seem to impact upon the development of speed with previous research suggesting speed improvements predominantly occur pre-16 years (29, 30). However, when 10 m momentum was considered, combining 10 m sprint performance and body mass, *likely* annual improvements were evident. This provides support that momentum is also an important physical characteristic to monitor within academy rugby league players (3, 32). In addition, findings for vertical jump, Yo-Yo IRTL1 and all absolute and relative strength measures demonstrated improvements in performance for each of the three training age groups supporting the initial hypothesis. This suggests that academy rugby league players will improve power, high-intensity running performance and strength regardless of training age corresponding with adaptations with chronological age (32, 33).

Previous longitudinal research (32) demonstrated enhanced physical improvements in body mass, 10m momentum, vertical jump and strength performance for younger (i.e., 16-17 years) compared to older (i.e., Under 18-19) rugby players. Potential explanations for this adaptation was that Under 16 players were closer to maturation and that players had a lower training age (30, 32). When 0 and 1 years training age were compared, findings demonstrated *possibly* greater improvements for 1 years training age for 10 and 20 m speed. However, for all absolute and relative strength measures, 0 years demonstrated *possibly* or *likely* greater strength improvements in comparison to 1 years. Therefore, for strength, these findings support the hypothesis that a reduced training age would enhance the annual change in physical performance. Such differences in strength changes may have been experienced due to greater neuromuscular (e.g., intermuscular co-ordination, muscle fibre activation and recruitment) or morphological (e.g., muscle cross-sectional area, myofibrillar size, muscle pennation angle, etc.) adaptations to training with players of a lower training age, therefore enhancing the training response (6, 25). It is also likely, that the neuromuscular adaptation interplays with improvements in technical or movement efficiencies. Despite this, all subjects were competent with the testing battery, when athletes engage in a structured training programme for the first time (i.e., 0 years training age), they are exposed to specific movements, of which they likely become more efficient at. This may explain the initial improvements in performance for a specific test. Due to the study examining annual changes in performance it is difficult to understand the exact mechanisms for the training responses. Previous research (25) suggests neuromuscular adaptations occur within 2-4 weeks of training commencement and morphological adaptations within 2-16 weeks (25) and therefore it is likely to be a combination of mechanisms that results in an increased training adaptation.

However, when the 2 years training age were compared with 1 years respectively, opposite findings were apparent for strength measures. The 2 years training age group demonstrated *possibly* or *likely* enhanced improvements for 1-RM squat, relative squat and relative prone row in comparison to the 1 years training age group. Such findings, negate the study hypothesis and the law of diminishing returns suggested by McMaster (25), whereby as training age increases, positive training adaptations diminish. Instead, the current findings suggest that an advanced training age, within adolescent rugby players, may be advantageous for developing strength, specifically in the lower body and upper back. Potential explanations for this finding may include the 2 years training age group maximizing strength development due to an increased training load (intensity or volume), reduced time spent on technical competence and lifting technique, especially for the squat, and enhanced neuromuscular adaptations (25). Although these factors were not controlled in the current study it may be the training stimulus that impacted upon the strength development. Another potential reason for this finding may include the use of chronological age as a covariate; the 2 year training age group demonstrated little variation in chronological age, with a range of 0.64 years, whereas the 1 year training group demonstrated a range of 2.91 years between the youngest and older players. This influenced the slope of the trendline applied to each group with 2 years training age being steeper, therefore when adjustment was calculated the group-mean difference was larger in comparison to 1 years training age. Alternatively, such findings demonstrate the complexity in understanding performance adaptations based upon chronological age, training age and the training stimulus but findings do provide evidence to the strength and conditioning coach that a lower training age does not always result in advanced adaptation and increased performance gains.

This study aimed to progress on previous cross-sectional (7, 33) and longitudinal (30, 32) research evaluating the physical development of academy rugby league players by considering training age, which has been highlighted as an important factor for strength and conditioning coaches to consider in their programme designs (21). However, this study is not without limitations. Firstly, training age (i.e., 0, 1 and 2 years) was classified by an athlete's previous experience of formalized strength and conditioning training within a rugby league academy. However, classification of training age may be much more complex than this and may potentially need to account for players individual training histories to fully understand how this may affect physical development. Second, there was no measure of maturity offset, which may have impacted upon adaptations. However, all participants were older than 16 years of age, with recent research (24) stating predicting maturity offset of boys post 16 years may be inaccurate. Thirdly, although the players involved in the study undertook a standardized training programme there may have been individual differences (i.e., training loads, injuries, etc.) in the training programme design that may have impacted upon training adaptations. However, controlling training programmes within an applied practice research is often difficult but future research should aim to monitor training loads more closely to understand the training stimuli resulting in adaptation. Lastly, the authors acknowledge that these findings are only one from rugby league academy and caution should be considered when applying within other academy programmes in other sports. However, the authors believe this is the start of consideration of training age to understand its impact upon long-term training adaptations and physical development in adolescent athletes. The varying trajectories in development are likely due to differing combination of neuromuscular and morphological adaptations, and changes in efficiency or task competency. As such, future research should differentiate between these aforementioned variables to fully comprehend the likely development rates of adolescent athletes.

In conclusion, this study presents and compares the annual changes in physical qualities according to training age within academy rugby league players. The findings demonstrated that changes in body mass, Yo-Yo IRTL1, vertical jump, and all absolute and relative strength measures were apparent across all three training age groups suggesting these characteristics improve annually regardless of training age. When training age groups were compared, greater improvements in strength were evident for 0 vs. 1 years training age as expected due to greater adaptations associated with novice athletes. However, the 2 years training age group demonstrated enhanced improvements in strength characteristics compared to the 1 years training age group. Findings suggest that training age is an important consideration for the strength and conditioning coach that may impact upon adaptations to training. However, it is more likely a combination of chronological age, biological maturity, training age and experience that impacts upon physical adaptations alongside the inter-individual differences and dynamic nature of player development.

PRACTICAL APPLICATIONS

Enhancing the physical qualities of academy rugby league players is important for long-term player development. The current findings demonstrated annual improvements in body mass, momentum, vertical jump, Yo-Yo IRTL1, and absolute and relative strength measures are expected within academy rugby league players irrespective of training age. Therefore, strength and conditioning coaches and rugby practitioners should expect annual improvements in these physical qualities of players with 0, 1 or 2 years formalized training experience within a rugby league academy.

When training age groups were compared, strength adaptations were greater in 0 vs. 1 years training age demonstrating that practitioners should expect increased strength gains upon commencing a formalized strength and conditioning programme in an academy rugby league programme. However, such gains may continue to develop, and even increase with 2 years training age, as players may be able to undertake more advanced programmes and become more competent lifters, especially in the squat exercise. However, these adaptations are likely to be a result of a number of considerations including chronological age, biological maturity, training history, movement and lifting technique competence and training volume and intensity. Such findings demonstrate the complexity of training adaptation and demonstrate that strength and conditioning coaches should understand their participant’s background in informing training programme design to maximize performance gains and long-term athlete development whilst monitoring performance over time using longitudinal methodologies.

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Figure Legends

Figure 1. Magnitude based inferences for anthropometric and physical qualities comparing 0 vs. 1 years training age groups.

Figure 2. Magnitude based inferences for anthropometric and physical qualities comparing 1 vs. 2 years training age groups.

Table 1.Anthropometric and Physical Characteristics according to Training Age across an annual period

	0 Training Years (*n*=16)				1 Training Year (n=33)				2 Training Year (n=12)			
	Pre	**Post**	***d*** **± 90% CI**	**Qualitative descriptor**	**Pre**	**Post**	***d*** **± 90% CI**	**Qualitative descriptor**	**Pre**	**Post**	***d*** **± 90% CI**	**Qualitative descriptor**
Age (years)	17.3 ± 0.7	18.3 ± 0.7			17.1 ± 0.6	18.1 ± 0.6			17.9 ± 0.2	18.9 ± 0.2		
Height (cm)	181.3 ± 6.0	182.4 ± 6.0	0.2 ± 0.1	Possibly ↑ (39/61/0)	178.8 ± 5.2	180.0 ± 5.3	0.2 ± 0.0	Likely ↑ (83/17/0)	179.8 ± 2.7	180.2 ± 2.7	0.2 ± 0.1	Likely ↔ (22/78/0)
Body Mass (kg)	83.9 ± 10	87.1 ± 10	0.3 ± 0.1	Very likely ↑ (95/5/0)	82.8 ± 8.9	84.8 ± 8.0	0.2 ± 0.1	Likely ↑ (77/23/0)	86.6 ± 9.1	88.0 ± 9.4	0.1 ± 0.1	Likely ↔ (16/84/0)
Sum of 4 skinfolds (mm)	39.7 ± 14.7	38.9 ± 10.9	0.0 ± 0.3	Unclear (10/79/11)	36.1 ± 11.6	34.5 ± 10.2	-0.1 ± 0.1	Likely ↔ (0/76/24)	38.3 ± 11.2	36.4 ± 10.4	-0.2 ± 0.1	Possibly ↓ (0/61/33)
10 m (s)	1.81 ± 0.1	1.81 ± 0.1	0.0 ± 0.2	Very likely ↔ (2/96/2)	1.79 ± 0.1	1.78 ± 0.1	-0.2 ± 0.2	Possibly ↓ (0/52/48)	1.81 ± 0.1	1.8 ± 0.1	-0.2 ± 0.3	Possibly ↓ (1/48/51)
20 m (s)	3.11 ± 0.1	3.11 ± 0.1	0.0 ± 0.2	Likely ↔ (1/94/5)	3.09 ± 0.10	3.07 ± 0.10	-0.2 ± 0.2	Possibly ↓ (0/50/50)	3.1 ± 0.1	3.1 ± 0.1	-0.2 ± 0.2	Possibly ↓ (0/68/32)
10m Mom ($kg.s^{-1}$)	464.8 ± 53.8	482.7 ± 54.0	0.3 ± 0.1	Likely ↑ (94/6/0)	461.6 ± 47.8	476.1 ± 45.7	0.3 ± 0.1	Likely ↑ (92/8/0)	479.5 ± 52.5	489.7 ± 52.2	0.2 ± 0.1	Possibly ↑ (44/56/0)

Yo-Yo IRTL1 (m)	1320 ± 242	1391 ± 223	0.5 ± 0.5	Possibly ↑ (64/32/5)	1495 ± 332	1650 ± 304	0.5 ± 0.2	Very likely ↑ (97/3/0)	1466 ± 264	1646 ± 476	0.6 ± 0.7	Likely ↑ (84/13/3)
Vertical Jump (cm)	48.3 ± 3.0	50.9 ± 6.5	0.4 ± 0.2	Likely ↑ (93/7/0)	50.9 ± 5.8	53.9 ± 5.6	0.4 ± 0.1	Almost certainly ↑ (100/0/0)	51.2 ± 6.0	52.1 ± 5.3	0.2 ± 0.3	Possibly ↑ (41/58/2)
Bench Press (kg)	93.7 ± 16.7	106.2 ± 16.0	0.7 ± 0.2	Almost certainly ↑ (100/0/0)	96.1 ± 14.1	106.3 ± 12.8	0.7 ± 0.1	Almost certainly ↑ (100/0/0)	106.6 ± 11.4	114.6 ± 17.1	0.7 ± 0.3	Very likely ↑ (99/1/0)
Relative Bench Press (kg/kg)	1.12 ± 0.2	1.22 ± 0.1	0.7 ± 0.2	Almost certainly ↑ (100/0/0)	1.16 ± 0.1	1.26 ± 0.13	0.6 ± 0.1	Almost certainly ↑ (100/0/0)	1.24 ± 0.1	1.31 ± 0.2	0.5 ± 0.3	Very likely ↑ (95/5/0)
Squat (kg)	115.7 ± 16.7	128.1 ± 16.4	0.7 ± 0.3	Very likely ↑ (99/1/0)	127.9 ± 16.7	138.8 ± 15.3	0.6 ± 0.2	Almost certainly ↑ (100/0/0)	137.2 ± 15.8	144.7 ± 15.7	0.5 ± 0.2	Very likely ↑ (98/2/0)
Relative Squat (kg)	1.38 ± 0.2	1.47 ± 0.1	0.6 ± 0.5	Likely ↑ (92/7/1)	1.55 ± 0.18	1.64 ± 0.16	0.5 ± 0.2	Very likely ↑ (99/1/0)	1.60 ± 0.2	1.65 ± 1.2	0.3 ± 0.2	Likely ↑ (82/18/0)
Prone Row (kg)	82.3 ± 11.7	93.1 ± 10.9	0.9 ± 0.2	Almost certainly ↑ (100/0/0)	86.5 ± 11.0	94.2 ± 10.9	0.7 ± 0.1	Almost certainly ↑ (100/0/0)	94.5 ± 11.0	100.8 ± 12.4	0.6 ± 0.1	Almost certainly ↑ (100/0/0)
Relative Prone Row (kg/kg)	0.98 ± 0.1	1.07 ± 0.1	0.8 ± 0.3	Almost certainly ↑ (100/0/0)	1.05 ± 0.1	1.11 ± 0.1	0.6 ± 0.2	Almost certainly ↑ (100/0/0)	1.09 ± 0.1	1.15 ± 0.1	0.5 ± 0.1	Almost certainly ↑ (100/0/0)

Note: Mom = Momentum; Yo-Yo IRTL1 = Yo-Yo intermittent recovery test level 1

Table 2. Comparison of Annual Percentage Change in Anthropometric and Physical Characteristics According to Training Years (Adjusted for Chronological Age)

	0 vs 1		**1 vs 2**	
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**
	0 Years	**1 Years**	**1 Years**	**2 Years**
Height (%)	0.62 ± 0.68	0.64 ± 0.41	0.62 ± 0.41	0.25 ± 0.32
Body Mass (%)	3.78 ± 3.44	2.54 ± 3.73	2.30 ± 3.73	2.12 ± 2.01
Sum of four Skinfolds (%)	-1.73 ± 21.39	-4.48 ± 15.55	-5.33 ± 15.55	-8.34 ± 7.24
10 m (%)	-0.05 ± 1.81	-0.50 ± 2.14	-0.33 ± 2.14	1.97 ± 1.48
20 m (%)	-0.16 ± 1.63	-0.56 ± 1.86	-0.38 ± 1.86	1.41 ± 1.13
10 m Mom (%)	3.82 ± 3.78	3.05 ± 4.29	2.64 ± 4.29	0.14 ± 1.80
Yo-Yo IRTL1 (%)	1.73 ± 4.06	2.70 ± 4.79	2.69 ± 4.79	-5.97 ± 6.43
Vertical Jump (%)	5.48 ± 6.68	4.75 ± 4.72	4.32 ± 4.61	8.79 ± 6.27
1-RM Bench Press (%)	14.38 ± 6.57	10.92 ± 6.24	10.73 ± 6.24	16.08 ± 6.20
Relative Bench Press (%)	9.73 ± 5.10	8.17 ± 6.28	8.24 ± 6.28	13.67 ± 5.80
1-RM Squat (%)	12.34 ± 10.26	8.53 ± 8.37	7.93 ± 8.37	16.09 ± 4.48
Relative Squat (%)	8.25 ± 9.76	5.84 ± 8.29	5.51 ± 8.29	13.68 ± 5.06
1-RM Prone Row (%)	14.02 ± 6.61	8.85 ± 6.19	8.38 ± 6.19	11.30 ± 2.93
Relative Prone Row (%)	9.87 ± 6.78	6.16 ± 5.21	5.94 ± 5.21	8.99 ± 2.33

Note: Mom = Momentum; Yo-Yo IRTL1 = Yo-Yo intermittent recovery test level 1; negative changes for sum of four Skinfolds, 10 m and 20 m demonstrate an improved performance change