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Maturation and Physical Performance in National Level Youth Basketballers: Implications for Strength and Conditioning Coaches

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ABSTRACT

The purpose of this study was to (i) describe the anthropometric and performance characteristics of New Zealand national level youth basketballers and (ii) examine the relationship between maturation and these characteristics. One hundred and eighty-nine Under 14 and U15 basketball players, boys (n=100; age=14.1±0.5 years; height=178.3±9.0 cm; body mass=70.0±16.0 kg) and girls (n=89; age=14.1±0.7 years; height=169.8±7.6 cm; body mass=65.2±12.3 kg) participated in the study. Anthropometric variables were measured to determine maturity timing and status. Horizonal and vertical jumps, change of direction agility and speed were assessed for physical performance. Differences in performance tests between the boys and girls were assessed via independent samples T-test and linear regression analyses were performed to assess if %PAH (predictor) was associated with each anthropometric or performance variable (outcome). There were significant differences between boys and girls for all anthropometric and performance tests favouring boys (ES = 0.33 to 1.47; $p < 0.001$). Girls were significantly more mature (greater %PAH) than boys (ES = 1.85; $p < 0.05$). In boys, for every 1% increase in %PAH there was a moderate (ES = 0.63 to 0.71) increase in anthropometric measures and mostly small (ES = 0.24 to 0.33) increases in performance measures. In girls, the increase in anthropometric measures was moderate to large (ES = 0.59 to 0.82). These findings demonstrate that maturation was significantly associated with anthropometric and performance variables in boys but only anthropometric variables in girls. Strength and conditioning coaches should be aware of these differences and consider the practical implications that maturation can have in long-term athlete development planning of young basketball players.

Keywords: Growth, development, testing, performance standards, anthropometry, LTAD.

INTRODUCTION

Basketball is a complex team sport where physical, technical, tactical, and psychological attributes contribute to players performance and overall team success.[1] Game demands combine explosive movement patterns, such as short sprints, rapid acceleration and deceleration, fast changes in direction, and vertical jumps.[2] Successful on-court performance in basketball depends on a variety of factors, among which, physical attributes such as anthropometric (i.e., stature, body mass, arm span, and body composition)[3] and cardiovascular fitness are suggested to be key determinants.[4,5] Studies in youth basketball players have emphasised the significance of anthropometric and fitness (i.e. speed, agility, upper body strength and jumping ability) characteristics in the performance of young players.[6-8] In under 14 boys and girls basketball players, height, agility, countermovement jump (CMJ) peak power, and handgrip strength were found to be predictors of individual performance.[9] Furthermore, significant correlations between performance and anthropometric attributes of players (i.e., body mass, stature, and arm span) were identified, suggesting that taller and heavier players perform better in games than smaller and shorter players.

Physical performance differences among youth male basketballers are frequently linked to biological maturation,[10-12] with players in different phases of maturity showing large anthropometrical and physiological differences.[13] Players with advanced maturity outperform their late maturing peers in static strength, endurance, sprint, agility, jump, and throwing activities.[14] According to Hoare,[15] elite junior basketball players grow substantially taller and reach their peak height velocity (PHV) at a younger age than sub-elite players. Interestingly, the results of studies conducted with young Portuguese basketball players are somewhat contradictory. Some authors report the significant influence of maturity status on physical performance,[14] while others reported that functional capabilities were largely independent of maturity status.[13] The maturity-related discrepancies suggest that other factors, such as years of practice, may also play an important role in young athletes´ physical performance and technical skills development, since skill development and performance show systematic improvements with training.[16] These differences may impact how coaches evaluate player performances. Understanding the maturation-performance relationship is an important consideration, especially for strength and conditioning coaches, particularly when designing individualized training programs.

Maturity status (pre, circa or post PHV) refers to an individual's biological maturation at the time of observation, whereas maturity timing refers to the ages at which specific maturational events occur, for example ages at peak height velocity (APHV) and menarche.[17] Many non-invasive methods for assessing maturity have become common practice in youth sports.[18] Measuring the current percentage of predicted adult height (%PAH)[19] and the progress towards this %PAH can be used to estimate maturity timing and status. Recent studies have indicated greater accuracy when adopting the %PAH method compared to the maturity offset method.[18] Based on PHV occurring between 88-95% of %PAH, percentages below 88% indicate pre-PHV and above 95% post-PHV.[20] Identifying the timing of PHV and maturity status of athletes allows strength and conditioning coaches to identify possible time-periods of rapid growth, consider selection biases and modify training sessions and programs to enhance performance and reduce the risk of injury. Therefore, in the context of New Zealand national-level youth basketball players the aim of this study was to (i) quantify anthropometric and performance traits; (ii) describe relationships between maturation and performance characteristics; and (iii) outline the practical implications and programming considerations for strength and conditioning coaches.

METHODS

Experimental approach to the problem

A cross-sectional study design was used to investigate the physical performance measures and maturation of national-level youth male and female basketball players. Testing was conducted during the Basketball New Zealand age-group national selection camps prior to the International Basketball Federation (FIBA) qualifying window. All testing was conducted on day one of the national selection camp.

Subjects

A total of 189 male and female under 14 (U14) and under 15 (U15) national-level youth players (Boys: n=100, age=14.1±0.5 years, height=178.3±9.0 cm, body mass=70.0±16.0 kg; Girls: n=89, age=14.1±0.7 years, height=169.8±7.6 cm, body mass=65.2±12.3 kg) participated in the study. Entry criteria included the following (i) players had to be invited to the national selection camp; (ii) players had at least 1 year of playing experience at regional representative level; and (iii) were free from injury in the past 6 months. Participation in this study was voluntary and had no bearing on national team selection. The participants and parents/guardians attended an information briefing session where the aims of the study and its possible risks were outlined, after which interested players and their parents/guardians signed informed consent and assent forms (players under 16 years of age). This study was approved by the Auckland University of Technology Ethics Committee (AUTEC #20/46).

Procedures

The testing battery included anthropometric measures (body mass, wingspan, standing reach and height) and physical performance measures countermovement jump [CMJ], step in vertical jump [SVJ] and max vertical jump [MVJ], horizontal jump [HJ], change of direction [COD] lane agility drill, and 20m sprint. All tests were selected due to their relevance to common game-related activities and movements that have been identified during a game of basketball.[21] Prior to testing, all participants performed a standardized 10-minute dynamic warm-up, which included relevant activation and mobilization exercises and variations of jumps and jump landings. Familiarization for each test protocol took place at the beginning of the testing session. At each station, a demonstration for the test and standardised coaching cues were provided. Participants were allowed one practice trial for each test, following which, they completed 3 trials, with the fastest/highest used for further analyses. For all tests, participants were encouraged verbally.

Anthropometric measures and maturity estimate

Anthropometric measurements were all taken directly, with the parents' mid-parental heights being self-reported and were adjusted for overestimation.[18] Body mass was measured to the nearest 0.1 kg using flat scales (Seca 813, Hamburg, Germany), standing height to the nearest 0.1 cm using a stadiometer (Seca 213, Hamburg, Germany). Standing reach was measured to the nearest 0.1cm via fixed wall tape with the participants fully extending their dominant arm to reach as high as possible. Wingspan was measured to the nearest 0.1cm using fixed ground tape, measuring from the end of the middle fingertips on each hand with the player laying prone and their arms laterally extended as far as possible. The Khamis-Roche method was used to estimate maturity.[19] This procedure uses height, body mass, chronological age, and mid-parent height. Each player's current height was then expressed as a percentage of their predicted adult height (% PAH).

Vertical jumps

Three types of jumps were assessed. Each participant had 3 trials for each type of jump as described below using a yardstick (Swift Performance, Australia). A minimum of 2 minutes passive rest was provided between each jump type and a minimum of 30s to 1 minute passive rest was allowed between trials.

1. *Countermovement Jump (CMJ)*
   The CMJ was assessed via the stand and reach CMJ protocol executed from a stationary position with arm swing to propel the body upwards reaching the yardstick. The CMJ is reported to be a reliable field test (ICC = 0.96, CV = 3.0%).[22]
2. *One-step Vertical Jump (SVJ)*
   This SVJ required the athlete to approach the yardstick with one step into a vertical jump using an arm swing before transitioning into a maximal vertical jump. This is considered one of the most important abilities in basketball, where players are often required to execute a maximal jump from a stepping motion.[23]
3. *Max Vertical Jump (MVJ)*
   With a running start, the participant jumped as high as possible and tapped the yardstick. The number of steps were self-selected so long as the approach distance was within a 4.6 m arc from the yardstick. The participant could choose either a 1- or 2-foot take-off.

Horizontal jump (HJ)

Participants were asked to stand with their feet hip-width apart behind a take-off line (0 cm mark). They were asked to jump forward maximally using arm swing and were cued to "stick the landing" in each trial. If the participants stepped backward or forward during landing the trial did not count and was repeated. The distance from the take-off line to the back of the participant's heel was recorded to the nearest 0.1 cm using a tape measure. High reliability for standing long jump distance is reported in female youth, with a CV of 3.4%.[24]

COD (Lane Agility Drill)

The lane agility test is a multidirectional test administered as part of the NBA Draft Combine protocol.[25] Participants start at the top left corner of the key at the free-throw line and sprint 5.8 m to the baseline. Then they side shuffle/defensive slide 4.9 m to the right across the baseline before back pedalling to the top right corner of the free-throw line. Participants then side shuffle/defensive slide 4.9 m to the left where they touch the floor with their foot at a designated point, and then immediately complete the same circuit in the opposite direction. The agility times were collected via timing gates

(Speedlight Duo, Swift Performance Australia). A minimum of 2 minutes of passive rest was provided between each trial to ensure participants were sufficiently recovered and participants were given the instructions "when you are ready, you can go". The reliability of the lane agility test has been reported previously (ICC = 0.99 and CV = 8.7%).[26]

Speed (20m sprint)

Participants performed a maximal sprint over a 20-m distance on an indoor court through wireless timing gates (Speedlight Duo, Swift Performance Australia) set at a height of 1 m and placed at 0m, 5m, 10m, and 20m. A minimum of 2 minutes passive rest was provided between each trial to ensure participants were sufficiently recovered and participants were given the instructions "when you are ready, you can go". The sprint distance of 20 m reflects the specific demands of basketball21 with research reporting maximal sprint speed typically achieved in youth players between 15 m and 30 m.[27] Overground sprinting among youth has been shown to be reliable, with mean CV ranging from 0.83% to 2.07%.[27]

Statistical analyses

The data obtained was imported into Jamovi (Version 2.3; The Jamovi Project, 2022) statistical software for analysis. The Kolmogorov-Smirnov test demonstrated a normal distribution of the variables assessed. Descriptive statistics including means and standard deviations (separately for boys and girls) were reported for age, maturity status (%PAH), anthropometric and performance variables. Differences in performance tests between the boys and girls were assessed via independent samples T-test with outcomes reported as mean difference and 95% confidence interval (CI). Separate linear regression analyses were performed to assess if %PAH (predictor) was associated with each anthropometric or performance variable (outcome). Outcomes are presented as coefficients (95% CI) representing the average change in each outcome variable for every 1% change in %PAH. Effect sizes (ES) were calculated to determine the magnitude of all estimates and interpreted using the following thresholds: < 0.2, trivial; 0.2-0.49, small; 0.5-0.79, moderate; and ≥0.8, large.28 The threshold for statistical significance was set at $p<0.05$ for all analyses.

RESULTS

Descriptive statistics, separated by gender are reported in Table 1. There were significant differences between boys and girls for all anthropometric and performance tests favouring boys (ES = 0.33 to 1.47; $p < 0.05$). However, girls were significantly more mature (greater %PAH) than boys (ES = 1.85; 95% CI = 1.45 to 2.24; $p <0.05$).

Maturity status (%PAH) was associated with all anthropometric and performance variables in boys (Table 2) but only with anthropometric variables in girls (Table 3). In boys, for every 1% increase in %PAH there was a moderate (ES = 0.63 to 0.71) increase in anthropometric measures and a mostly small (ES = 0.24 to 0.33) increase in performance measures. In girls the increase in anthropometric measures was also moderate to large (ES = 0.59 to 0.82).

DISCUSSION

The aims of this study were (i) quantify anthropometric and performance traits; (ii) describe relationships between maturation and performance characteristics; and (iii) outline the practical implications and programming considerations for strength and conditioning coaches. The main findings demonstrated that male and female youth athletes of similar ages are significantly different in anthropometric and performance measures, and that maturity status was associated with anthropometrics and physical performance in males but not females.

There was a significant association between %PAH and the anthropometric variables in both boys and girls. Previous research in adolescent boys indicated that biological maturation is significantly related to anthropometric and fitness variables.[29] Higher values of stature, body mass and wingspan were found in more mature boys, consistent with our findings.[14,30] Previous research in adolescent girls has also demonstrated similar results.[31,32] The differences in anthropometric factors reported between maturation phases could be due to hormonal changes that occur around APHV.[17] Sex hormones and growth hormone concentrations have been found to increase substantially during this stage and are linked to the accumulation of adipose tissue and lean tissue.[33]

Previous research has indicated that more mature

Table 1. Descriptive statistics reported by gender for anthropometric characteristics and performance tests.

	Boys (n=100)	Girls (n=89)	Boys & Girls (n=189)					
Variable	Mean±SD [95%CI]	Mean±SD [95%CI]	Mean±SD [95%CI]	Mean Difference	[95% CI]	Effect Size	[95% CI]	*p*
Age (years)	14.1±0.5 [14.0 to 14.2]	14.1±0.7 [13.9 to 14.2]	14±0.6 [13.9 to 14.1]	-0.04	[-0.22 to 0.14]	-0.07	[-0.36 to 0.21]	0.625
Height (kg)	178.3±9.0 [176.5 to 180.1]	169.8±7.6 [168.2 to 171.4]	174±9.3 [172.9 to 175.6]	-8.46	[-10.87 to -6.05]	-1.01	[-1.33 to -0.68]	< .001*
Body Mass (kg)	70.0±16.0 [66.8 to 73.2]	65.2±12.3 [62.6 to 67.8]	65.2±14.6 [65.6 to 69.8]	-4.79	[-8.95 to -0.63]	-0.33	[-0.62 to -0.04]	0.024
Wingspan (cm)	183.6±10.3 [181.6 to 185.7]	174.3±8.2 [172.5 to 176.0]	178±10.4 [177.7 to 180.7]	-9.38	[-12.08 to -6.68]	-0.99	[-1.32 to -0.67]	< .001*
Max Reach (cm)	231.7±13.0 [229.1 to 234.3]	219.9±10.4 [217.7 to 222.1]	225±13.2 [224.2 to 228.1]	-11.83	[-15.26 to -8.40]	-0.99	[-1.31 to -0.67]	< .001*
Countermovement Jump (cm)	53.9±8.2 [52.2 to 55.5]	43.76±7.0 [42.2 to 45.2]	49±9.2 [47.8 to 50.4]	-10.17	[-12.38 to -7.95]	-1.32	[-1.66 to -0.97]	< .001*
Step Vertical Jump (cm)	59.9±8.7 [58.4 to 61.7]	48.3±7.6 [46.7 to 49.9]	54±10.0 [53.0 to 55.9]	-11.66	[-14.03 to -9.29]	-1.41	[-1.77 to -1.06]	< .001*
Max Vertical Jump (cm)	66.1±10.0 [64.1 to 68.1]	52±9.0 [50.1 to 53.9]	59±11.8 [57.8 to 61.2]	-14.04	[-16.79 to -11.29]	-1.46	[-1.82 to -1.11]	< .001*
Horizontal Jump (cm)	216.0±26.4 [210.7 to 221.6]	187.7±19.5 [183.6 to 191.8]	204±27.3 [198.7 to 206.6]	-28.27	[-35.02 to -21.52]	-1.20	[-1.53 to -0.87]	< .001*
Agility (s)	12.8±0.8 [12.6 to 13.0]	14.1±0.9 [13.9 to 14.3]	13.25±1.1 [13.2 to 13.6]	1.29	[1.02 to -1.55]	1.39	[1.04 to 1.75]	< .001*
20m Sprint (s)	3.3±0.2 [3.2 to 3.3]	3.5±0.2 [3.5 to 3.6]	3.43±0.2 [3.4 to 3.4]	0.23	[0.17 to 0.3]	0.99	[0.67 to 1.32]	< .001*
Percentage of PAH (%)	94.5±2.6 [94.0 to 95.0]	98.7±1.7 [98.4 to 99.1]	97.02±3.1 [96.0 to 96.9]	4.25	[3.59 to 4.91]	1.85	[1.45 to 2.24]	< .001*

CI = confidence interval, SD = standard deviation, %PAH = percentage of predicted adult height, p < .05, ES classification: <0.2: trivial; 0.2-0.49: small; 0.5-0.79: moderate; >0.8: large*

Table 2. Association between maturity status (%PAH) and anthropometric and performance variables in boys.

Anthropometric Variables	Estimate (95% CI)	*p*	Effect Size (95% CI)
Height (cm)	2.56 (2.12 to 2.99)	< .001*	0.761 (0.63 to 0.89)
Body Mass (kg)	3.77 (2.83 to 4.7)	< .001*	0.627 (0.47 to 0.78)
Wingspan (cm)	2.78 (2.24 to 3.31)	< .001*	0.721 (0.58 to 0.86)
Max reach (cm)	3.43 (2.73 to 4.12)	< .001*	0.703 (0.56 to 0.84)
Physical Performance Variables	**Estimate (95% CI)**	***p***	**Effect Size (95% CI)**
Countermovement Jump (cm)	1.02 (0.434 to 1.60)	< .001*	0.33 (0.14 to 0.52)
Step Vertical Jump (cm)	0.94 (0.31 to 1.56)	0.004*	0.29 (0.09 to 0.48)
Max Vertical Jump (cm)	1.19 (0.46 to 1.91)	0.002*	0.31 (0.12 to 0.50)
Horizontal Jump (cm)	2.89 (0.99 to 4.78)	0.003*	0.29 (0.10 to 0.48)
Agility (s)	-0.05 (-0.11 to 0.01)	0.113	-0.16 (-0.35 to 0.04)
20m Sprint (s)	-0.02 (-0.04 to -0.004)	0.015*	-0.24 (-0.43 to -0.05)

Note. p < .05, ES classification: <0.2: trivial; 0.2-0.49: small; 0.5-0.79: moderate; >0.8: large*

Table 3. Association between maturity status (%PAH) and anthropometric and performance variables in girls.

Anthropometric Variables	Estimate (95% CI)	*p*	Effect Size (95% CI)
Height (cm)	2.77 (2.07 to 3.47)	< .001*	0.643 (0.481 to 0.80)
Body Mass (kg)	5.70 (4.85 to 6.55)	< .001*	0.817 (0.695 to 0.94)
Wingspan (cm)	2.76 (1.96 to 3.56)	< .001*	0.591 (0.42 to 0.76)
Max reach (cm)	3.77 (2.8 to 4.74)	< .001*	0.637 (0.47 to 0.80)
Physical Performance Variables	**Estimate (95% CI)**	***p***	**Effect Size (95% CI)**
Countermovement Jump (cm)	0.175 (-0.65 to 1.02)	0.679	0.044 (-0.16 to 0.25)
Step Vertical Jump (cm)	-0.0339 (-0.94 to 0.88)	0.942	-0.008 (-0.22 to 0.20)
Max Vertical Jump (cm)	-0.727 (-1.8 to 0.35)	0.183	-0.142 (-0.35 to 0.068)
Horizontal Jump (cm)	-0.744 (-3.14 to 1.65)	0.538	-0.066 (-0.27 to 0.14)
Agility (s)	0.0597 (-0.06 to 0.18)	0.330	0.104 (-0.10 to 0.31)
20m Sprint (s)	0.0012 (-0.03 to 0.03)	0.936	0.009 (-0.20 to 0.22)

Note. p < .05, ES classification: <0.2: trivial; 0.2-0.49: small; 0.5-0.79: moderate; >0.8: large*

athletes have more fat free mass than their peers.30 Girls who mature early are heavier and taller than their peers.[17] However, this increase in body mass is primarily attributed to adipose tissue, with proportionally smaller gains in lean mass than boys. Muscle mass has been found to be extremely important in athletic performance[34] and closely linked to biological maturation, with testosterone levels during adolescence reported to be up to 30 times above baseline levels in male populations.[33] This likely explains the differences found in body mass between genders. In contrast, height is significantly influenced by growth hormone,[35] which could explain the greater stature of more mature individuals of both sexes.

Wingspan measures were also higher in both more mature boys and girls. From infancy to childhood, children experience cephalo-caudal and proximal-distal development in the early phases of development.[17] During adolescence, growth occurs first in the lower extremities, then the trunk, and finally the upper extremity from distal to proximal.[17] This distal-proximal developmental order could explain the differences observed between more and less mature youth. Anthropometrics are an important consideration in basketball as the association between anthropometric characteristics, body composition and successful competition have been observed in adults.[36] Further, the anthropometry of basketball athletes has been linked to team and individual success.[13,15] Anthropometric and performance characteristics of young basketball players are important, as parameters like body height, body mass, and wingspan, positively contribute to their physical performance or fitness characteristics.[37]

There were significant associations between %PAH and physical performance in boys but not in girls. Importantly, it should be noted that the increases in performance measures would be greater if expressed, for example, per 5% difference in %PAH. Jump height significantly increased in boys as %PAH increased but not in girls. Explosive lower-body power (i.e., jumping), is an important characteristic in basketball.[38] It has previously been reported that biological maturation may influence power performance.[39] The general agreement is that short term muscle power increases during growth and maturation and is significantly higher in boys than in girls during and after the adolescent growth spurt.[40] Radnor et al.,[41] reported significantly higher jump performances in more mature boys and attributed these differences to increased muscle thickness compared to younger boys. Emmonds et al.,[42] found unclear changes in lower-body power (CMJ height) between maturity groups of youth female soccer players and suggested players may experience a reduction in relative peak force and consequently lower-body power at 0.5 Years to PHV (YPHV). Reduced jump height in females maybe explained by a potential increase in fat mass after PHV.[17]

Our results show that sprint performance significantly improved as %PAH increased in boys but not in girls. These results support previous research found in boys and girls.[43-46] Differences in speed development between genders become noticeable at the onset of puberty. Boys can make significant gains while girls make limited speed gains throughout adolescence.[47] Throughout the process of maturation, sprint performance naturally improves as a result of factors such as increased muscle size, longer limbs, adaptations in musculotendinous tissue, improved neural and motor development, and enhanced movement quality and coordination.[48] Potential mediators of sprinting velocity development around PHV could be increased stride length, alongside better stride frequency and ground contact time stabilisation.[49] Reported increases in sprint performance in males appears at Mid and Post-PHV in accordance with maturation-related sprint development.[43,49] Increases in sprinting speed in girls slow significantly after the age of 12 compared to boys.[50] Nagahara et al.,[46] found that girls >12.7 years became slower every year compared to girls <12.7 years. Jakovljević et al.,[51] found a significant negative correlation between the sum of skinfolds and the running speed of young basketball players. As mentioned earlier, body mass is a limiting factor of speed in running. Heavier athletes who have more fat mass have greater inertia, which requires greater force per kilogram of lean mass to obtain a change in speed.[52] Therefore, excess body fat significantly impedes locomotion efficiency.

The association between %PAH and COD was not statistically significant for boys or girls. The point estimate for boys and associated uncertainty suggests our findings are more compatible with an association (improved agility with increased %PAH) than not and the lack of statistical significance may just be due to sample size. Boys and girls tend to have similar abilities for agility-related tasks during the prepubescent years.[53] Previous findings have found significant differences in agility between genders with boys outperforming girls in youth tennis[54] and badminton.[45] Sex-associated differences begin to appear around the onset of puberty with reports indicating that peak rate of development in COD performance occurs around 13–14 years of age in male youths, which corresponds with the timing of PHV.[55] These results are similar to previous findings indicating that following PHV, sex-associated differences in COD continue to emerge because of continued physical performance enhancement in males and performance plateaus or declines in females.[53] As already mentioned above, these differences may be due to neural adaptations and increases in hormone concentrations and/or structural adaptations (i.e., increase in the muscle cross-sectional area) during and after PHV.[56] Speed and agility are considered crucial attributes of basketball performance in both adult[57] and in youth teams.[15]

Previous findings demonstrate maturation is significantly correlated with physical fitness (Hand grip Strength, CMJ, Multi-stage 20 m Shuttle run test) in boys and girls but more strongly in boys.[58] Maturity timing had significant influence on physical fitness measures in female basketballers especially in jumping, endurance, and 20 m sprint tests with players closer to their PHV performing better than those who were further from PHV.[59] Likewise, older and more mature male basketball players had better results in most physical tests of speed, jumping ability, agility, and endurance than younger and average maturing players.[60] Moreover, in soccer, maturation was inversely associated with 30 m sprint time in U12 to U16 age groups, and was also positively associated with CMJ performance in U12 boys.[61] Furthermore, maturity stage influenced physical performance in a large sample of young tennis players, with results showing that post-PHV players out performed their pre-PHV peers in jumping ability, linear sprints, and COD ability tests.[44] These findings corroborate the results of our study regarding performance in youth basketball players.

This study's limitations require consideration. These include the cross-sectional research approach, which prevented the use of long-term maturation observation models and the investigation of a cause and effect between anthropometric variables and physical variables throughout the adolescent years. It was also not possible to obtain body composition data for the participants in this study, and therefore, the reason for the observed differences between sexes regarding body fat as a non-functional role or muscle mass for athletic performance is speculative and requires further research. Another limitation is the lack of strength-related measurements that could be useful to determine whether the differences found in this study are mediated by differences in strength levels.

In summary, the findings of this study demonstrate significant differences in anthropometric and performance variables between boys and girls of the same ages. Maturation was significantly associated with all anthropometric and performance variables in boys but only anthropometric variables in girls. Additionally, jump and sprint performance was significantly better in more mature boys but not girls. Strength and conditioning coaches should be aware of these differences and consider the practical implications that maturation can have in the long-term development of young basketball players.

PRACTICAL APPLICATIONS

This study confirmed significant variability in the maturational status of youth basketball players of similar age. Therefore, it is recommended that maturity status is regularly monitored and taken into consideration on a quarterly basis with young basketballers of this age. It is important for strength and conditioning coaches to understand and interpret changes in anthropometry and physical performance in youth athletes alongside maturity estimates, as typically the tallest and most mature basketball players are selected for teams.[7] Identifying the maturation status of youth athletes can ensure proper physical development related to their stage of growth. Using biological age (estimated from maturity status) instead of chronological age is more suitable for designing and individualizing training programs from a long-term athlete development point of view. Grouping youth athletes into pre-, circa- or post-PHV groups can simplify programming by focusing on specific physical qualities that are apparent during their adolescent periods of adaptation.[62]

Specifically, it appears that mature athletes benefit more from strength-specific training than pre-PHV athletes, while pre-PHV athletes benefit more from stretch shortening cycle (SSC) / plyometric-type training.[63] The risk of certain growth-related injuries may increase during circa-PHV[64,65] and thus awareness of maturity status will allow strength and conditioners to adapt training to mitigate this increased injury risk. Additionally the circa-PHV period may lead to “adolescent awkwardness” resulting in altered movement mechanics that may negatively impact performance.[66] Strength and conditioners can help youth athletes understand this temporary loss of performance and adapt training to minimise any negative impact. This strategy is particularly helpful for youth athletes training and competing in age-based environments, where they might be more vulnerable to maturation selection bias, especially if they are less mature. Due to the impact of maturity on anthropometric and performance variables, it is further recommended that strength and conditioning coaches consider this when training players at the youth level, as it will impact the evaluation and selection process.[67]

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CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

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This study received no specific funding in order to be completed.

ETHICAL APPROVAL

The participants and parents/guardians attended an information briefing session where the aims of the study and its possible risks were outlined, after which interested players and their parents/guardians signed informed consent and assent forms (players under 16 years of age). This study was approved by the Auckland University of Technology Ethics Committee (AUTEC #20/46)

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