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Anthropometric and Physical Fitness Comparisons Between Australian and Qatari Male Sport School Athletes

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Abstract

Background: The increasing focus on international sporting success has led to many countries introducing sport schools and academies. Limited empirical evidence exists that directly compares student-athletes from different continents. This study investigated whether male Australian and Qatari student-athletes differ in anthropometry, physical fitness and biological maturity.
Methods: 150 male student-athletes (72 Qatari, 78 Australian; age = 11.8 - 18.6 y) completed a fitness testing session involving anthropometric (standing height, sitting height, leg length, body mass, peak height velocity (PHV) measures) and physical capacity (40 m sprint, countermovement jump (CMJ), predicted maximal oxygen uptake (VO_2 max) tests. Differences were assessed using a one-way multivariate analysis of variance (MANOVA), effect size (Cohen's d) and regression coefficients.
Results: The Australian student-athletes possessed a greater standing height and body mass ($P < 0.01$) at their age at PHV (APHV) and had an increased rate of leg length development ($P < 0.05$) in contrast to the sitting height of the Qataris ($P < 0.01$). The Qatari student-athletes had significantly ($P < 0.01$) faster 40 m sprint times (mean ± SD: 5.88 ± 0.53 vs 6.19 ± 0.44 s) and greater CMJ heights (36.9 ± 7.2 vs 34.0 ± 6.0 cm) than their Australian counterparts. Although not statistically different, the Qatari student-athletes also matured earlier (APHV: d = 0.35) and had greater aerobic power results (predicted VO_2 max: d = 0.22).
Conclusions: Despite lower stature and body mass values, Qatari student-athletes exhibited physical fitness ascendancy over their Australian counterparts.

Keywords: Student-Athlete, Body Size, Physical Fitness, Biological Maturity, Sport

1. Background

A sport school or academy is a specialised schooling environment, allowing young talented athletes to pursue their secondary education, while fostering specific sporting development through planned training and competition scheduling. They have proliferated over recent decades, subsequent to the increasing focus on national and international sporting success across many countries. Currently, over 200 sport schools and academies exist, spanning every continent (1).

Athletic performance typically requires a specific combination of biomechanical, metabolic, morphological and physiological components, which may manifest as physical capacities such as speed, power or endurance (2). Robust talent identification and development pathway programs such as sport schools often incorporate the testing of all the aforementioned components, thereby helping to determine athletic potential and subsequent sporting selection (3).

Since talent identification programs are traditionally conducted on adolescent athletes, growth and maturation are projected to be the main confounders in predicting performance (4). Growth is ascribed to the size increase from conception to adulthood while maturation reflects the tempo and timing of progress approaching the mature biological state (5). The peak height velocity (PHV) is the period whereby an individual experiences their greatest rate of growth and maturation, hence it serves as a vital timepoint for referencing physical fitness gains (5, 6). Boys of the same chronological age can vary up to three years in maturity with the difference primarily occurring at the age of peak height velocity (APHV) (normally 13 - 15 y) (7). Due to the fact that biological and chronological maturation rates are not homogeneous, large individual differences can appear leading many coaches to mistake early physical maturation for physical talent (5). Previous research has also shown that genetics, the environment, nutrition and socioeconomic status can attribute to maturity rate and timing distinctions between populations (8, 9).

Fitness determinants, biological maturity and sport selection affect all student-athletes. However, the cultural influence of the country an athlete is raised in may lead to performance advantages in specific areas such as speed, power or endurance and determine which sports are pursued during adolescent years. Numerous studies have been conducted on student-athletes from areas such as Europe (10, 11), however little research has been undertaken on Middle-Eastern or Australian populations. This study aims to compare student-athletes from two continents and assess whether male Australian and Qatari sport school athletes differ in body size, physical fitness and biological maturity as well as the rates of development of these measures.

2. Methods

2.1. Subjects

Student-athletes were recruited from the Rowville sports academy (Australian sample) and aspire academy (Qatari sample) sport schools. The Australian student-athletes trained and competed in the sports of soccer, Australian football or golf whereas the Qatari student-athletes trained and competed in soccer, athletics, fencing, squash, table tennis, golf or multi-sports (i.e., student-athletes participating in a broad sport development program). Subject inclusion was based upon gender (i.e., males only) and secondary sport school attendance (age = 11.8 - 18.6 y; year level = 7 - 12).

2.2. Study Design

The study was approved in Australia by the university human ethics advisory group and department of education in Victoria and by the anti-doping lab Qatar ethics committee in Qatar. Student-athletes and parents were informed of the protocol through a plain language statement with subsequent consent obtained prior to the commencement of testing.

Test sessions were conducted at either the Rowville sports academy (Australian sample) or the aspire academy (Qatari sample). All testing was administered by qualified staff in a controlled environment. The same test protocols were adhered to in both samples. With the exception of the 20 m multi-stage fitness test (MSFT), all Qatari student-athletes performed their fitness tests on an indoor athletics track with a Mondo surface. The MSFT completed by the Qatari student-athletes and all testing on the Australian student-athlete cohort were conducted on multipurpose indoor basketball courts with sprung wooden floors. All student-athletes undertook one fitness testing session, conducted during their normal sport class times.

All student-athletes were familiarised with the standardised protocols and procedures prior to completing the 90 to 120 minute testing session (12) and were required to wear their appropriate training uniform.

2.3. Anthropometry

Loose items and shoes were removed for the anthropometric measures. Date of birth and test date were recorded for each student-athlete and transformed into a continuous number, allowing for APHV calculations. Standing height and body mass were measured to the nearest 0.1 cm and 0.1 kg using a stadiometer (PE27, Sportsforce, Australia; Holtain, UK in Qatar) and electronic scales (UC-321 Series Precision Scale, A&D Mercury Pty Ltd, Australia; ADE Electric Column Scales, Hamburg, Germany in Qatar) respectively. Sitting height was measured with each student-athlete sitting on a 50 cm block with their buttocks and shoulders against the stadiometer (12). Leg length was calculated as the difference between standing and sitting height (12).

2.4. PHV Measures

Using a standardised predictive equation for boys (13), years to and from peak height velocity (YPHV) was calculated via anthropometric measurements (standing height, sitting height, leg length, body mass) and age. This approach is ideal for student-athletes as biological maturity can be assessed non-invasively, practically and reliably. The prediction of YPHV has previously had a reported coefficient of determination (r^2) of 0.92 and the standard error of estimate of 0.49 y (13). The APHV was assessed by subtracting the YPHV from each student-athlete's chronological age.

2.5. Performance Tests

To measure speed and leg power, all student-athletes completed a 40 m sprint and countermovement jump (CMJ) three times with the best trial recorded (12). The 40 m sprint was performed from a standing start 50 cm behind the line, recorded via dual beam timing gates (Speedlight, Swift, Australia) and has been validated to elicit maximum speed (14). CMJ height was assessed using a jump mat (Swift, Australia) with the student-athletes instructed to stand centrally (hands on hips) on the mat, dip, jump without any horizontal direction and land on their forefeet. The jump mat has been documented as a valid and accurate method when a force platform is inaccessible (15).

The MSFT (Multi-stage fitness test, Australian coaching council, Australian Sports commission, 1999) and Vam-Eval maximal incremental running test (Qatari soccer players) (16) scores were converted to predicted VO_2 max scores (aerobic power) to allow meaningful comparisons. Both tests are incremental field running tests which measure peak aerobic speed to predict VO_2 max. These tests terminated when the student-athlete could not adjust their running speed and reach two successive 20 m line/cones in time (12, 16).

2.6. Statistical Analyses

The Kolmogorov-Smirnov and Levene's test were performed to determine whether data for each independent group met the assumptions of normality and homogeneity of variances. As age, YPHV, CMJ and predicted VO_2 max were not normally distributed ($P < 0.05$), all were subsequently log transformed prior to inclusion in further analyses. Results showed that heterogeneous variances were noted for YPHV between Qatar and Australia groups. Due to the YPHV's non-Gaussian distribution, a non-parametric (Kruskal-Wallis) test was conducted on age, YPHV and APHV for comparisons between the two countries. Age, YPHV and APHV were screened to ascertain whether both independent groups were similar in age. Due to multiple comparisons being made (n = 3), the Bonferroni adjustment was implemented, altering the critical P-value to 0.016.

A one-way multivariate analysis of variance (MANOVA) was used to analyse standing height, body mass, 40 m sprint, CMJ and predicted VO_2 max according to country. Due to multiple comparisons being made (n = 5), the Bonferroni adjustment was implemented, altering the critical P-value to 0.01. Descriptive statistics were obtained for all variables and used to calculate effect sizes (Cohen's d) between the Australian and Qatari student-athletes. The magnitude of the effects were interpreted as small ($d \geq 0.20$), medium ($d \geq 0.50$) or large ($d \geq 0.80$) (17).

The relationship between anthropometric or physical fitness variables and YPHV (independent variable) were assessed using regression analyses. The Australian and Qatari regression coefficients were compared and the gradient and intercept (YPHV = 0) were calculated. The gradient represents the rate of development in the body size and physical fitness variables throughout adolescence, whereas the intercept represents the performance results at the APHV. The exploratory data, MANOVA and regression analyses were conducted using a statistical package (SPSS Inc., version 23, Chicago, IL, USA). Effect sizes were calculated using Microsoft Excel (Microsoft, 2013, USA).

3. Results

150 male student-athletes, comprising of 72 and 78 from Qatar and Australia respectively were included in the final analyses. The age (14.5 ± 1.4 y, mean ± standard deviation (SD)), YPHV (-0.42 ± 1.30 y) and APHV (14.9 ± 0.5 y) of the Qatari student-athletes were not different to the Australian student-athletes (age: 14.4 ± 1.4 y; YPHV: -0.67 ± 1.07 y; APHV: 15.1 ± 0.5 y) ($P = 0.018$).

Descriptive statistics, F statistics, critical P-values and effect sizes for the student-athletes in this study are reported in Table 1. Qatari student-athletes compared to their Australian counterparts were significantly faster over the 40 m sprint (mean ± SD: 5.88 ± 0.53 vs 6.19 ± 0.44 s; $P < 0.001$) and achieved a superior CMJ height (36.9 ± 7.2 vs 34.0 ± 6.0 cm; $P < 0.01$). The magnitude of the difference, shown as the effect size, has been classed as medium to large for the 40 m sprint and near medium for the CMJ. Although the predicted VO_2 max yielded no significant difference, the small effect size showed the Qataris recorded slightly higher values. The Qatari and Australian student-athletes were not statistically different from each other in body size (standing height, body mass). However, the small effect sizes for standing height and body mass highlighted that the Australians had a slightly greater body size. The two groups showed no significant differences in their APHV. Nonetheless, the Qatari student-athletes tended to mature earlier than the Australians, as shown by the small to medium effect size.

The gradient, intercept, F statistic and critical P-values for each variable of the regression analyses between the two countries are reported in Table 2. The Qatari student-athletes' sitting height (i.e., upper body) developed at a significantly greater rate than the Australians ($P < 0.01$). Conversely, the Australians' leg length (i.e., lower body) developed at a significantly greater rate than the Qataris ($P < 0.05$). The rate of growth between the student-athletes from each country did not differ for all other body size and physical fitness variables ($P < 0.05$).

At the APHV, the Australian student-athletes possessed a significantly greater body size (standing height, body mass) than the Qataris ($P < 0.01$) (Figure 1). However, the Qatari student-athletes significantly exceeded the Australians in the 40 m sprint ($P < 0.001$) and CMJ ($P < 0.01$) performances at their APHV (Figure 2). Predicted VO_2 max did not differ between the two countries at their APHV.

4. Discussion

Previous research has investigated student-athlete populations from the countries of Australia and Qatar,

Table 1. Student-Athlete Characteristics (M ± SD), F Statistic and Critical P-Values and Effect Sizes

	Qatar	Australia	F Statistic	Critical P	Effect Size[+]
Age (y)	14.5 ± 1.4	14.4 ± 1.4	0.1	0.752	0.05
YPHV (y)	-0.4 ± 1.3	-0.7 ± 1.1	1.9	0.174	0.21
APHV (y)	14.9 ± 0.5	15.1 ± 0.5	4.9	0.028	-0.35
Standing height (cm)	162.4 ± 10.1	164.8 ± 10.0	2.2	0.138	-0.24
Body mass (kg)	51.2 ± 10.9	53.9 ± 9.5	2.6	0.107	-0.26
40 m sprint (s)	5.88 ± 0.53	6.19 ± 0.44	14.7	< 0.001	-0.64
CMJ (cm)	36.9 ± 7.2	34.0 ± 6.0	7.5	0.007	0.45
VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$)	50.2 ± 6.6	48.9 ± 6.0	1.8	0.179	0.22

Abbreviations: [+]; Cohen's d, APHV; age of peak height velocity, CMJ; countermovement jump, YPHV; years to and from peak height velocity, VO_2 max; maximal oxygen uptake.

Table 2. Regression Coefficient Gradient and Intercept Comparisons

	Gradient				Intercept (YPHV = 0)			
	Qatar	**Australia**	**F Statistic**	**Critical P**	**Qatar**	**Australia**	**F Statistic**	**Critical P**
Standing height (cm)	6.80	7.38	0.67	0.414	167.0	169.7	8.39	0.004
Sitting height (cm)	4.15	3.28	10.02	0.002	87.1	86.0	N/A	N/A
Leg length (cm)	2.66	4.10	6.26	0.013	79.9	83.8	N/A	N/A
Body mass (kg)	6.99	6.62	0.21	0.646	55.7	58.5	9.67	0.002
40 m sprint (s)	-0.28	-0.29	0.03	0.855	5.69	6.00	33.48	< 0.001
CMJ (cm)	3.92	3.08	1.53	0.217	39.3	36.2	10.89	0.001
VO_2 max ($mL \cdot kg^{-1} \cdot min^{-1}$)	1.98	2.22	0.09	0.765	51.5	50.3	2.01	0.16

Abbreviations: CMJ; countermovement jump, N/A; not applicable due to the gradients being significantly different, VO_2 max; maximal oxygen uptake, YPHV; years to and from peak height velocity.

yet these studies have only examined the specified populations in isolation (18-21). This study is the first to directly compare student-athletes from Australia and Qatar. The similar age (d = 0.05) between the two independent groups allows appropriate comparisons as differences in age can drastically alter body size and physical fitness values within adolescent populations (19).

At the predicted APHV, which represents a normalised maturity-based time-point comparison for all student-athletes in the study, the Australians were 2.7 cm taller and 2.8 kg heavier than the Qataris. Although not significant overall, these differences may have implications for talent identification and development pathway programs within sport schools or academies. This is due to body size differences being known to influence sport/level selection and/or positional role in conjunction with an athlete's physical fitness profile (22-24).

Standing height is a fixed characteristic (25). The larger Australian standing height may be explained by differences in living standards, nutrition, healthcare and social equality. The frequency of certain genetic lineages has also been suggested to account for the increased standing height of males from particular countries over others (26).

The body mass differences were anticipated as results from two previous isolated studies on elite soccer players found that Australians weighed on average 3.5 kg more than Qataris (18-20). Muscular hypertrophy training is known to increase body mass (27) and may be implemented to a greater extent in the Rowville sports academy than the aspire academy. alternatively, Australian student-athletes may consume more energy than they expend (28). Genetics may also contribute to body mass differences (29). Unfortunately, data related to body composition, diet, detailed training program adherence and genetics were not collected in this study. Future research to help explain the body mass difference between the Australian and Qatari student-athletes is recommended.

The Qatari student-athletes predominately outperformed the Australians in many areas of physical fitness such as speed (40 m sprint), power (CMJ) and endurance (Predicted VO_2 max). Furthermore, at their predicted APHV, it was estimated that the Qatari student-athletes' ran 0.31

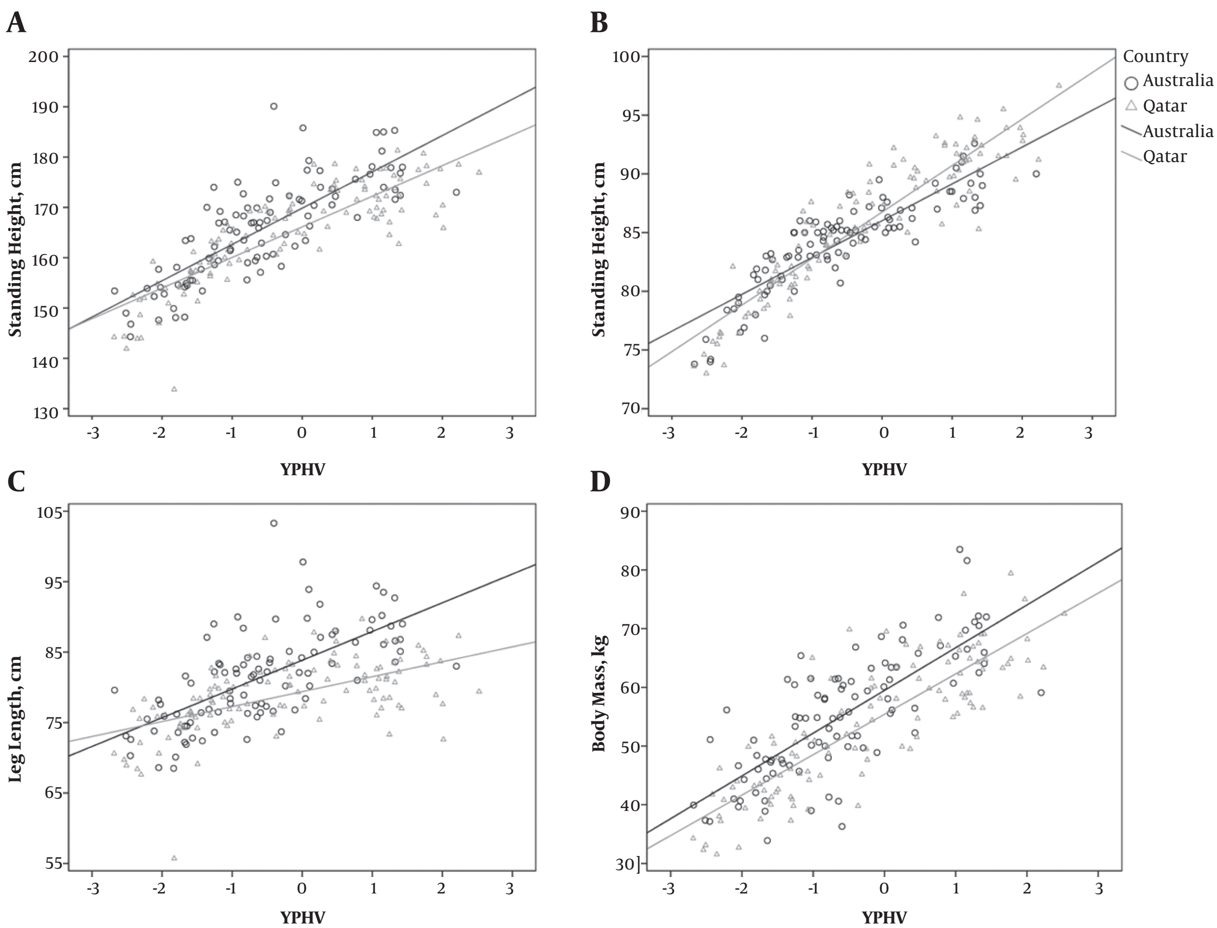

Figure 1. The relationship between years to and from peak height velocity (YPHV) and (A) standing height, (B) sitting height, (C) leg length and (D) body mass between Australian and Qatari student-athletes

seconds faster and jumped 3.1 cm higher than the Australians in the 40 m sprint and CMJ respectively.

Qatari student-athletes may achieve an increased maximal speed due to an improved stretch-shortening cycle, lower limb stiffness and hip extensor activity (30). Speed can also be enhanced through a variety of assisted or resisted training techniques, aiming to increase stride length and/or frequency (31). Speed training is known to increase energy metabolism, partly mediated via increases in circulating hormones which is exaggerated during an athlete's timing of PHV (32). The 40 m sprint regression analysis shows that the Qataris were consistently quicker throughout all adolescent years.

It is possible that Qatari student-athletes may be genetically more predisposed to the development of leg power (33). This could be related to greater percentages of motor unit activation, the development of type II muscle fibres and/or increased fascicle length (34). Furthermore, greater leg power is known to correlate to enhanced sprinting speeds in adult athletes (30). Qatari student-athletes may have a greater lean muscle mass than the Australians as reduced fat proportions are known to significantly correlate to greater CMJ height and maximal sprint speed (18). Alternately, different training practices employed by the two sport schools may have impacted on the results.

A small to medium APHV difference existed between the Australian and Qatari student-athletes, indicating that the Qataris matured earlier than the Australians, with a mean difference of approximately 60 days. This can be argued to be a sizable difference as the APHV has been previously noted as the most critical adolescent time-point for maximal morphology, speed, power and endurance increases (5, 6). This is especially relevant as the mean age of both groups lies within the under 13 to 15 chronological age category, where regional and national selection opportunities often begin to arise (35).

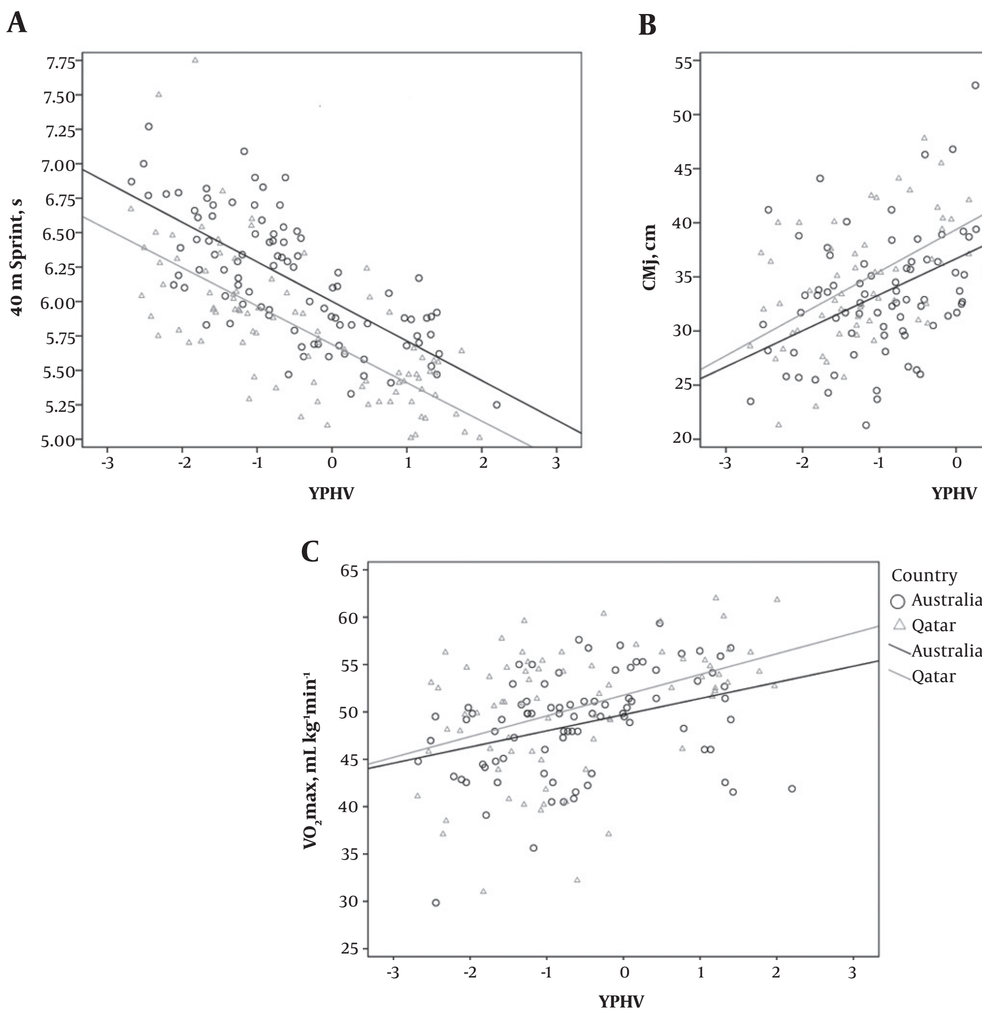

Figure 2. The relationship between years to and from peak height velocity (YPHV) and (A) 40 m sprint, (B) CMJ and (C) predicted VO_2 max between Australian and Qatari student-athletes

Previous studies have found the mean male APHV to be 13.8 y and 14.3 y for Australian and Qatari adolescent students respectively (21, 36). This study compared both population groups together and showed considerably higher APHV values of 15.1 y and 14.9 y for the Australian and Qataris respectively. Although these values are higher than previously reported, they still fall within the normal APHV range of 13 to 15 y for males (5, 7). However, these findings should be interpreted cautiously as Mirwald's predictive equation for the YPHV of adolescent males has only been validated on Canadian and Flemish populations (13) and still requires validation on Australian and Qatari populations.

The regression analyses showed the student-athletes from each country to have contrasting height proportions. This is highlighted by the Qatari upper body (sitting height) and Australian lower body (leg length) developing at significantly greater rates than their counterparts. The Qatari student-athletes sitting height exceeded the Australians from roughly one year to their APHV. Australian adolescent athletes tend to exhibit relatively shorter torsos allowing their leg length to explain their greater standing height. Their substantial rate of leg growth caused the Australians to have longer legs from early on during adolescence. The regression coefficient gradients for body mass and each physical capacity variable were not different between the two countries.

Findings from the current study add to the talent identification and development pathway program literature. Many countries are culturally diverse and the number of sport schools are increasing (1). Understanding the typical body size, physical fitness, biological maturity, and rate of development will guide practitioner decision-making. It enables talent identification and development pathway programs consisting of student-athletes from varying country and cultural backgrounds to become more individualised.

4.1. Conclusions

The Australian student-athletes possessed a greater standing height and body mass in comparison to the Qatari student-athletes. However, analysing the rate of development revealed contrasting height proportions, with the Qatari student-athletes tending to have larger torsos while the Australians possessed a greater leg length. To our knowledge, this is the first study examining anthropometric development spanning the YPHV within these population groups.

Qatari student-athletes were found to generate greater speed and leg power than the Australians. This occurred with a reduced body mass which is contradictory to previous literature on body mass and performance correlations. Including their small advantage in aerobic power, the findings suggest that the Qatari student-athletes were physically fitter than their Australian counterparts at a similar age. The Qataris were also found to mature earlier than the Australians, although Mirwald's predictive equation still requires validation on both populations. While the more objective variables related to body size may have genetic differences, differences related to fitness may also have resulted from varying development pathway programs.

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