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Morphological and physical fitness profile of young female sprint kayakers

Physical profile of female kayakers

Daniel López-Plaza[1], Fernando Alacid[2], Jacobo Ángel Rubio[2], Pedro Ángel López-Miñarro[3], José María Muyor[4], Pedro Manonelles[1].

[1] Sport Medicine Chair, Catholic University of San Antonio, Murcia. Spain.

[2] Department of Physical Activity and Sports Sciences. UCAM Research Center for High Performance Sport. Faculty of Sport. Catholic University of San Antonio, Murcia. Spain.

[3] Department of Physical Education. University of Murcia, Murcia, Spain

[4] Faculty of Education Sciences, Nursing and Physiotherapy. Laboratory of Kinesiology, Biomechanics and Ergonomic (KIBIOMER), University of Almería, Almería, Spain.

Corresponding author

MSc Daniel López-Plaza[1]

Email: dlopez4@alu.ucam.edu

Telephone number: +34 968 278 824

UCAM, Universidad Católica San Antonio de Murcia

Campus de los Jerónimos s/n.

30107 Guadalupe, Murcia. Spain.

Abstract

Traditionally, physical and anthropometrical profiles of the most successful kayak athletes have been identified in male kayakers. This study attempted to identify the differences in morphology and fitness level of two performance-based groups of young elite female paddlers. Eighty-six female kayakers, aged 13.62 ± 0.57 years (mean ± SD) were allocated in two groups (Top-10 and Rest) depending on their ranking in the three Olympic distances (200, 500 and 1000 meters). All subjects underwent a battery of anthropometrical (heights, weight, girths and sum of skinfolds), physical fitness (overhead medicine ball throw, countermovement jump, sit-and-reach test and 20-m multistage shuttle run test) and specific performance assessments (200, 500 and 1000 meters). Best paddlers presented significantly greater anthropometrical values in muscle mass percentage, maturity status and chronological age ($p < 0.05$) whereas physical fitness comparison only revealed significant differences in countermovement jump ($p < 0.05$). Furthermore, aerobic power and muscle mass percentage appear to be crucial in achieving optimal performances at long (1000-m) and short duration races (200 and 500-m). These findings confirm the importance of a larger and compact morphology, as well as superior fitness level, for success in female kayakers. The current results not only identify the weak areas on body composition and physical fitness depending on the maturity status but also the development of specific training programs for females.

Key words: body composition, performance, maturity status, talent identification, fitness level.

INTRODUCTION

Sprint canoeing became an Olympic sport for men in Berlin in 1936 but female kayaking was not introduced at the Olympic program until 1948 in London. Nowadays, only three distances are performed by paddlers at the Olympics (200, 500 and 1000-m) in two modalities, kayaking and canoeing (20). First studies have traditionally focused on the physiological characteristics of both genders, specifically the aerobic and anaerobic metabolic contribution (28, 34). However, a complex blend of different parameters determines optimal kayak performance (10, 14). In recent decades, studies on anthropometric characteristics and their relationship with performance revealed an increasing robust and compact somatotype in the most successful kayakers regardless of gender (2, 17, 26, 40).

Each sport is related to singular anthropometric and physical characteristics that suit the particularities of a specific sport or discipline (15, 38). For the determination of an optimal performance profile, predictive tests have typically been used as a measure of power, speed, aerobic fitness or flexibility (15, 18). Although most of these tests are only representative of a non-specific capacity, significant correlations have been observed with specific performance in team sports (18, 21). Nevertheless, the few investigations that have conducted studies on individual water sports have revealed contradictory results about the relationship between performance and physical fitness (11, 16, 17, 26).

In addition, the study of physical and anthropometric variables and their relationship with certain disciplines or playing positions have been undertaken in several sports (15, 18, 22) and have become paramount in the determination of a typical athlete profile (37). Similarly, in male sprint kayaking and canoeing, different disciplines and events seem to be optimally performed by athletes with certain morphology and physical attributes (14, 40). Previous studies have revealed taller and heavier somatotypes, lower skinfolds values and superior upper body girths and isokinetic force in the most successful senior paddlers (1, 14, 38). Furthermore, age group kayakers appear to show greater body mass, size and physical capacities than canoeists (4, 25).

The identification of these attributes is especially important at early ages and during adolescence, not only for the development of particular capacities but also for sport and discipline specialization (2, 5, 25). In an attempt to determine the optimal kayaker profile, only males and adult female paddlers have been analyzed (1, 39).

It was hypothesized that young female paddlers would exhibit similar physical and morphological characteristics to those observed in young male paddlers depending on the performance level. Therefore, the aims of this investigation were: 1) to determine and compare the anthropometric characteristics and physical fitness level between two performance-based groups of female kayakers, and 2) to identify their relationship with performance at different events.

METHOD

Experimental Approach to the Problem

A comparative description (cross-sectional study) was conducted to assess the differences in anthropometry and physical fitness in young elite female paddlers based on their performance level. A variety of assessment test items were used as dependent variables to offer a wide description of the representative successful paddler depending on the performance level (independent variable). The Leger test (23) was used to estimate VO_{2max}, which has been shown to provide compatible values between treadmill and on water paddling tests in kayakers (30, 33). Performance tests were conducted outside, and the weather conditions were not identical from one day to the other. However, wind velocity was measured to assure values below 2 $m \cdot s^{-1}$ at the beginning of each test to guarantee a minimum influence on performance results (41). Moreover, paddling experience and training volume were not collected as variables for posterior analysis and perhaps, in future research, they might be taken into account as control variables. Based on previous studies aimed to identify typical athletes' profiles, traditional field-based physical tests were selected, as they provide valid and reliable information that can be used as normative data for further comparison using limited resources.

Subjects

Between 2006 and 2009, a total of 160-180 female kayakers per year (depending on the year) were found eligible to participate in this study. Only the top 20 to 22 paddlers based on the Spanish national championship ranking each year were pre-selected to take part in the present study, as they were chosen by the Spanish Federation to participate in National Development Camps. A total of 86 young female kayak paddlers, aged 13.62 ± 0.57 years (mean ± SD), finally were recruited and volunteered to collaborate in this study. Afterwards, subjects were ranked depending on their positions in each of the three distances performed during the Camp (200, 500 and 1000-m), where the mean ranking was subsequently used to allocate them in two groups: Top-10 (best 10 kayakers of each year) and Rest (kayakers between top 10 and top 20-22). The procedures were approved by the Institutional Ethical Committee. Written signed informed consent was obtained from all subjects and their parents before the start of the study. During the testing period, subjects under pharmacological treatment or presenting any disease were excluded from assessment. All subjects were required to avoid caffeine ingestion and hard-work sessions 48 hours prior to the measurements.

Procedures

A battery of field-based tests to measure physical fitness status and body size composition was performed on three separate days. Clear instructions about the procedures were given to all subjects before the beginning of each test. All physical fitness tests were performed 3 times, recording only the best attempt for posterior analysis. Maximum oxygen consumption estimation and the three specific race tests were measured just once due to the high physical demands required for completion. Additionally, a 15 minute warm-up consisted of 5 minutes of general aerobic activity and 10 minutes of specific joint movements and familiarization with materials and procedures was provided. To prevent any potential morphology changes and to provide sufficient rest time, the order of the assessments were as follows: 1) Anthropometry (early morning of the first day); 2) Physical fitness (midday of the three separate days); 3) Specific performance on water for the three specific distance (afternoon of the three separate days).

Anthropometric parameters

All anthropometric measurements were taken following the procedures of the International Society for the Advancement of Kinanthropometry (ISAK) by a fully certified level-2 ISAK anthropometrist (27). The parameters analyzed included body mass (kg), 2 heights (cm), 8 skinfolds (mm) and 6 breadths (cm). Body mass was measured using a SECA 862 scale (SECA, Germany); stretch stature and sitting height with a GPM anthropometer (Siber-Hegner, Switzerland); girths with a metallic non-extensible tape Lufkin W606PM (Lufkin, USA) and skinfolds with a Harpenden skinfold caliper (British Indicators, UK). Each parameter was measured two or three times, if the difference between the first two measures was greater than 5% for the skinfolds and 1% for the rest of the dimensions. The mean values (or median in the last case) were used for further analysis. Body mass index (BMI) was calculated by the equation: body mass (kg) / stretch stature^2 (m) whereas muscle mass percentage (%MM) was determined using corrected arm, thigh and calf girths values following the anthropometric formula defined by Poortmans et al. (31). For the determination of fat mass percentage (%FM) triceps and subscapular skinfolds were used according to the equation described by Slaughter et al. (35).

Maturity status was estimated taking into consideration the age at peak height velocity (APHV) following the guidelines described by Mirwald et al. (29). Since APHV was considered a maturational benchmark (0 value), the difference in years between APHV and each measurement (described as years from PHV) was considered as a value of maturity offset.

Physical fitness and performance assessment

According to the procedures described by Lager & Lambert (23) maximum oxygen consumption (VO_{2max}) was estimated using the multistage shuttle run test (mp3 version, Coachwise, UK). Subjects were required to run 20-m shuttles progressively in speed and in time with an audible “beep” until reaching volitional exhaustion. The test was concluded if two consecutive shuttles were completed out of time, considering the last successful repetition for subsequent VO_{2max} estimation by the regression equations described by Ransbottom et al. (32).

For the determination of upper and lower body power, Countermovement Jump test (CMJ) and Overhead Medicine Ball Throw test (OMBT) were used, respectively. CMJ test was performed on a Bosco platform (Bosco System, USA) to record athlete's contact time ($m \cdot s^{-1}$) in accordance to the recommendations described by Temfemo et al. (36). During the action, a countermovement of approximately 90º of knee flexion was permitted. The OMBT test was evaluated using a 3-kg medicine ball (15). Subjects were requested to throw the ball over the head as far forward as possible from a standing and arm-relaxed position, registering the distance to the nearest centimeter. Countermovements were allowed during the act of throwing since the feet remained motionless.

To determine hamstring flexibility, sit-and-reach test (SR) was used according to the procedures described by López-Miñarro et al. (24). Subjects were instructed to sit with no shoes, keep the legs together and the knees extended while the heels were flat against the bottom of a testing board (Richflex System, Sportime, USA). The maximum distance reached and maintained for 3 seconds by sliding the hands together along the testing board was then registered to the nearest centimeter. A tape measure placed on the top of the board, with the zero mark representing the plantar surface, was used for that purpose.

Specific performance tests were performed over 200, 500 and 1000 meters on separate days. Subjects were required to complete the three distances at maximum effort on a measured flatwater course under race conditions. All tests were laterally recorded by a JVC Everio MG-135 (Victor Company, Japan) at 30 frames per second from a motorboat, following each paddler and leaving at least 5-m of separation. Race times were obtained throughout the calculation of the frames from the first traction movement to the finish line using the Virtualdub software 1.8.8 (Avery Lee).

Statistical analysis

All statistical analyses were conducted using SPSS v22.0 (SPSS Inc. Chicago IL, USA). The hypotheses of normality and homogeneity of variance were analyzed using the Kolmogorov-Smirnov test and Levene's test, respectively. The difference between the mean values between groups was analyzed using t-test for independent samples when statistical tests revealed no violations of the assumptions of normality and homogeneity. When normality supposition of data was rejected, the Mann-Whitney nonparametric test was used. Statistical significance was set at the $p < 0.05$ level of probability. To measure the effect size of observed differences Cohen's d analysis was used, considering small effect between 0.2 and 0.5, moderate between 0.5 and 0.8, and large when it was > 0.8 (12). The relationships between anthropometric characteristics and performance and between physical fitness and performance were investigated using Pearson's correlation coefficient (*r*) or Spearman correlation coefficient (r_s) when the assumption of normality was violated. The magnitude of the correlations was assessed according to Hopkins et al. (19). Stepwise multiple linear regression analysis was conducted using the significant variables from the linear correlation to determine which ones could predict performance times. In addition, collinearity was analyzed using the variance inflation factor (VIF). When VIF values were greater than 10 predictor variables were excluded from the model.

RESULTS

The results of the anthropometric characteristics for both groups of kayakers, depending on their performance level, are presented in Table I. Significant differences ($p < 0.05$) between the Top-10 and the Rest groups were identified in chronological age, %MM and maturity status. Cohen's *d* analysis revealed moderate effect sizes in these parameters, with *d* values ranging from 0.50 to 0.80.

Table I near here

Table II summarizes the physical fitness and race parameters of the two performance-based groups of kayakers. The independent t-test analysis revealed significant differences in CMJ (0.30 ± 0.05 vs 0.27 ± 0.03 cm for Top 10 and Rest kayakers, respectively) whereas OMBT, SR and estimated VO_{2max} presented no significant differences between means. Although moderate effect size was only identified in CMJ (0.73), OMBT and estimated VO_{2max} showed meaningful small effect sizes of 0.41 and 0.44, respectively. Highly significant lower race times ($p < 0.001$) were observed in the Top-10 group compared to the Rest group in all three distances performed (1000, 500 and 200-m). Additionally, Cohen's *d* calculations revealed large effect sizes with values not lower than 1.25 for any distance.

Table II near here

Pairwise correlations between the anthropometric, physical fitness variables and race times in all three distances are presented in Table III. Furthermore, Table IV shows the stepwise linear regression models to identify the determining factors that predict race times over 200, 500 and 1000-m. Chronological age, sitting height, %MM and maturity status were negatively and significantly associated with all distances ($p < 0.01$), except for sitting height with 200-m race time. Several and substantial relationships were also observed between physical fitness and race times. SR and OMBT revealed negative and significant correlations with race time over 1000 and 500-m ($p < 0.05$) whereas over 200-m only OMBT presented a significant correlation ($p < 0.01$). Conversely, no significant associations were observed for the rest of parameters analyzed apart from estimated VO_{2max} with 1000-m ($r = 0.31$; $p < 0.01$) and CMJ with 200-m race time ($r = 0.23$; $p < 0.05$). Chronological age, sitting height, estimated VO_{2max} and %MM significantly contributed as predictor variables of 1000, 500 and 200-m time, observing r^2 values not greater than 0.47.

Table III near here

Table IV near here

DISCUSSION

The main objectives of this study were to determine the differences in anthropometry and physical fitness and to identify their relationship with race times between the more successful (Top-10) and the rest (Rest) of the young elite female paddlers. Additionally, other findings revealed the importance of chronological age, maturity status, upper body strength and muscle mass in obtaining optimal results over the three Olympic distances.

Traditionally, the typical morphology of the more successful kayakers involved superior anthropometric parameters than their opponents, mainly in weight, height and lean mass, resulting in larger and heavier somatotypes (1, 14, 40). Over the last decades these differences in somatotype have been intensified, especially for female athletes competing not only in paddling (1) but also in rowing (9). Although, in the current research only significant differences were discovered in chronological age, %MM and maturity, the greater values observed in most parameters for the Top-10 kayakers support the affirmations of a more solid and robust somatotype in the best paddlers. Similar results in the basic anthropometric attributes were observed by Alacid et al. (3, 6), except for the greater sum of 6 and 8 skinfolds (above 88 and 110 mm, respectively) in a group of young female kayakers. Prior investigations with senior female competitors reported heavier and taller morphology but similar fat mass percentage values than those observed here (1, 2, 10, 34). Previous analysis of proportionality of the sum of 8 skinfolds revealed that young female kayakers presented higher levels of adiposity in comparison with Olympic paddlers (ranging from -0.6 to -0.7 vs -2.2 in the Phantom Z-score, respectively) (1, 3).

One of the main anthropometric differences between both performance-based groups was identified in %MM. The significantly greater muscularity in the more successful kayakers (41.3 vs 40.1% of MM) has traditionally been stated in prior research with male competitors (10, 14, 40). Despite the fact that no data about muscle mass in female paddlers was found in the literature, greater levels of certain variables that are typically associated with greater muscularity such as relaxed and contracted arm girths were observed in the more successful female competitors (1, 2). In addition, the higher ratings of mesomorphy exhibited by the Olympic and international kayakers in comparison with younger and national paddlers may be mainly explained by larger %MM (1, 3, 40). In recent years, more resistance workouts have been added to female training programs (10) contributing, perhaps, to the observed increases in muscle mass increases.

Along with these morphological differences, Top-10 kayakers also showed significantly higher levels of maturation than the Rest, partially explained by the significantly greater chronological age observed in the first group. In most sports, the improvements in physical attributes and morphology as a result of maturation have been well documented (13, 29). In water sports, the few investigations in analyzing athletes' physical fitness reported superior results in the most mature male paddlers (26) and the most experienced female rowers (9). In the current investigation, Top-10 paddlers were also those who showed superior results in all physical parameters but only significantly in CMJ. Best paddlers seem to have greater power and strength since better results were obtained in the OMBT and CMJ tests traditionally used as upper and lower limb power predictors (15, 36). In both tests, overall moderate effect sizes were also observed between performance groups. This suggests that not only meaningful power and strength levels are essential for talent identification at early ages but also for optimal long-term development in young female paddlers. Additionally, there is some evidence supporting these affirmations when comparing the isokinetic strength between different level male paddlers (14, 40). Perhaps, these superior levels of power production may be related to the larger muscularity shown above in the most successful female kayakers.

To date, the association between performance at different events and physical and anthropometric characteristics has only been investigated in elite male kayakers (14, 26, 38). The performance of the female kayakers in all distances were significantly related to chronological age and maturity, especially in 200-m. Nevertheless, only chronological age was identified as a predicting factor of 1000 and 200-m perhaps due to the fact that all kayakers had already reached PHV a long time before and/or as a consequence of maturity status calculations from other anthropometric parameters. Regarding prior studies with female paddlers, Aitken & Jenkins (2) found no correlation between anthropometry and 500-m performance. Male kayak research has revealed contradictory results in morphology, except for chest and arm girths correlations with performance (14, 17, 38). In addition, as distance decreases, there is an increasing association of %MM with performance which is consistent with the high relationship between mesomorphy and short events observed by van Someren et al. (38, 40) and the presence of %MM in the 500 and 200-m predictive equations. Along with the significant associations of the power tests with 200-m time (r = -.289; $p < 0.05$ and r = -.231; $p < 0.05$ for OMBT and CMJ, respectively) observed in the current investigation, it appears that muscular factors seem to be a determinant for optimal sprint performance irrespective of gender.

The analysis of maximum oxygen consumption has usually been used to evaluate the aerobic power in sprint canoeing (28, 34). Prior research comparing different male paddlers' level reported contradictory results when VO_{2max} was analyzed. Fry & Morton (14) determined greater values in the best 1000-m adult kayakers while van Someren & Palmer (40), conversely, identified slightly lower peak VO_2 levels in 200-m sprinters, perhaps due to the larger anaerobic metabolic contribution in this event. In the current investigation, the effect size observed in the estimated VO_{2max} would suggest that the enhancement and monitoring of this capacity during adolescence would be important in the development process of successful female kayakers. Furthermore, the estimated values of both groups were consistent with those identified in previous research for female kayakers, ranging from 44 to 49 $ml \cdot kg^{-1} \cdot min^{-1}$ (10, 34).

Concerning the relationship between maximum oxygen consumption and performance, Bishop (10) reported significant correlations between 500-m race time and VO_2 in female kayakers (r = 0.72), finding even greater correlations for relative peak VO_2 (r = 0.82) that suggests a significant influence of body mass on this variable. In addition, the presence of estimated VO_{2max} in the predictive equation for 1000-m might suggest a greater importance of aerobic power over long distances than that previously revealed by the linear correlation analysis (*r* = -.307; $p < 0.01$). The results from the current investigation are in agreement with previous research that identified greater aerobic contribution at longer distances (14). On the contrary, van Someren & Howatson (38) revealed no significant relationships between peak VO_2 and 200, 500 or 1000-m race times. Nevertheless, the fact that some evidence only found meaningful associations in absolute and threshold VO_2 (38) may indicate the importance of not only the achievement of high VO_{2max} levels but also of the maintenance of maximal and supramaximal intensities. Unfortunately, most investigations on young paddlers have focused on male kayakers, limiting the possibility for further comparisons.

As for the relationship among all these parameters, especially at early ages, performance and aerobic power seems to be largely influenced by morphology, therefore, VO_2 parameters were typically normalized for body mass (10). Although the improvement of aerobic power during puberty is difficult to predict due to maturational changes (37), biological and chronological age plays an important role in its development (13). Interestingly, aerobic power in pubertal athletes may not be as influential on performance as other physiological parameters (8). The metabolic specialization into aerobic or anaerobic that occurs late in the maturity process may be responsible for the secondary role of this parameter (13). Additionally, best kayakers performed equally better ($p < 0.001$) over the three Olympic distances (200, 500 and 1000-m) compared with the Rest, suggesting that specific distance specialization observed in elite adult paddlers arises likely as a result of this posterior metabolic specialization.

The results of the current investigation demonstrated the importance of physical and morphological parameters for success in young female kayakers. Best paddlers exhibited a significantly greater %MM but only slightly larger body sizes than less successful competitors. Additionally, chronological age, muscle mass and physical fitness level appears to be associated with better performances at the three Olympic distances. All these findings may be explained by the superior maturity status also identified in the best competitors. Therefore, assuming that there is an influence of biological age on performance, this parameter should be taken into consideration as critical factor in the talent identification programs. Currently the parameters used in the selection process of future talents among age-group paddlers are mainly race-time based tests (26). To date, this is the first research conducted with female paddlers that provided normative data regarding the optimal profile of successful kayakers, which may be useful for early talent identification.

PRACTICAL APPLICATIONS

For coaches, this is the first study to analyze the anthropometric and physical fitness profile of young female paddlers based on field tests. The anthropometric characteristics of the current female kayakers are consistent with those previously reported for both male kayakers and canoeists (3, 7, 26). Thus, the findings presented here provide valuable information about the characteristics of the paddlers depending on their level and may be a useful tool and guide for talent identification among young athletes. The physical fitness results may allow for identification of the weak areas of the strength and conditioning programs that might need to be reinforced for optimal athlete performance depending on individual maturity status. Currently, most specific training programs followed by female paddlers are based on prior male scientific knowledge or on coach training experience. Therefore, these results may also help to improve individual program designs for females, developing specific paddler training to allow for a smooth transition to the professional field. In addition, all test and assessments could be performed with little equipment by following the procedures defined in the methods, making it accessible for teams and athletes with limited resources.

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Table I. Mean values of the anthropometric parameters

	Top 10 (n = 40)		**Rest** (n = 46)		*P* values	Effect size (Cohen's *d*)
	Mean ± SD	95% CI	Mean ± SD	95% CI		
Chronological age (years)	13.86 ± 0.53	13.69 - 14.03	13.42 ± 0.54	13.26 - 13.58	**< 0.001**	0.80
Body mass (kg)	55.39 ± 7.88	52.87 - 57.91	54.56 ± 8.18	52.13 - 56.99	0.63	0.12
Height (cm)	163.48 ± 4.99	161.89 - 165.07	162.16 ± 6.10	160.35 - 163.97	0.27	0.25
Sitting height (cm)	87.87 ± 2.22	86.84 - 88.90	86.97 ± 3.44	85.95 - 88.00	0.22	0.31
BMI (kg · m^{-2})	20.65 ± 2.16	19.96 - 21.34	20.70 ± 2.46	19.97 - 21.43	0.93	0.02
Sum of 6 skinfolds (mm)	72.76 ± 19.70	66.46 - 79.06	72.91 ± 20.10	66.95 - 78.88	0.97	0.01
Sum of 8 skinfolds (mm)	98.13 ± 27.87	87.72 - 108.54	98.76 ± 25.91	89.57 ± 107.95	0.93	0.02
FM (%)	23.00 ± 4.28	21.63 - 24.37	22.95 ± 4.33	21.66 - 24.24	0.96	0.01
MM (%)	41.31 ± 1.87	40.72 - 41.71	40.14 ± 2.02	39.54 - 40.74	**0.01**	0.60
Maturity status (years from APHV)	1.82 ± 0.47	1.67 - 1.97	1.56 ± 0.56	1.39 - 1.72	**0.02**	0.50

Notes: Means ± SD and the lower and upper bound 95% confidence intervals for the means.
Significant differences are highlighted in bold text.
Abbreviations: BMI = Body Mass Index; FM = Fat Mass; MM = Muscle Mass; APHV = Age at Peak Height Velocity.

Table II. Mean values of the physical and performance parameters

	Top 10 (n = 40)		**Rest** (n = 46)		*P* values	Effect size (Cohen's *d*)
	Mean ± SD	95% CI	Mean ± SD	95% CI		
SR (cm)	11.73 ± 5.53	9.99 - 13.46	10.14 ± 7.33	7.96 - 12.32	0.43	0.25
OMBT (m)	4.97 ± 0.63	4.76 - 5.18	4.71 ± 0.64	4.52 - 4.91	0.07	0.41
CMJ (m)	0.30 ± 0.05	0.28 - 0.32	0.27 ± 0.03	0.26 - 0.28	**0.01**	0.73
VO_{2max} (ml · kg^{-1} · min^{-1})	46.18 ± 3.46	45.04 - 47.31	44.69 ± 3.38	43.68 - 45.71	0.05	0.44
1000-m time (s)	289.28 ± 7.99	286.73 - 291.83	304.55 ± 9.63	301.69 - 307.41	**< 0.001**	1.73
500-m time (s)	146.69 ± 6.44	144.63 - 148.75	154.93 ± 5.79	153.22 - 156.66	**< 0.001**	1.35
200-m time (s)	53.16 ± 2.24	52.44 - 53.87	56.35 ± 2.82	55.52 - 57.19	**< 0.001**	1.25

Notes: Means ± SD and the lower and upper bound 95% confidence intervals for the means.
Significant differences are highlighted in bold text.
Abbreviations: SR = Sit and reach; OMBT = Overhead Medicine Ball Throw; CMJ = Countermovement Jump.

Table III. Relationship between anthropometric and physical fitness characteristics and performance

	1000-m time	HPM	500-m time	HPM	200-m time	HPM
Anthropometry						
Chronological age (years)	-.490**	M	-.272*	L	-.640**	LA
Body mass (kg)	-.013	-	.035	-	-.083	-
Height (cm)	-.187	L	-.067	-	-.078	-
Sitting Height (cm)	-.332**	M	-.333**	M	-.183	L
BMI ($kg \cdot m^{-2}$)	-.113	L	.101	L	-.068	-
Sum of 6 skinfolds (mm)	.129	L	.100	L	.117	L
Sum of 8 skinfolds (mm)	.146	L	.081	-	.246	L
FM (%)	.075	L	.070	-	-.026	-
MM (%)	-.320**	M	-.337**	M	-.352**	M
Maturity status (years from APHV)	-.441**	M	-.267*	L	-.459**	M
Physical Fitness						
SR (cm)	-.232*	L	-.256*	L	-.149	L
OMBT (m)	-.278*	L	-.222*	L	-.289**	L
CMJ (m)	-.072	-	-.065	-	-.231*	L
VO_{2max} (ml · kg-1 · min-1)	-.307**	M	-.186	L	-.181	L

Notes: *Significant correlation ($p < 0.05$); ** Significant correlation ($p < 0.01$).
Abbreviations: BMI= Body Mass Index; FM= Fat Mass; MM= Muscle Mass; APHV= Age at Peak Height Velocity; SR= Sit and reach; OMBT= Overhead Medicine Ball Throw; CMJ= Countermovement Jump; HPM= Hopkins' magnitude; M= moderate; L= Low; LA= Large.

Table IV. Regression equations to predict performance over 1000= 500 and 200 meters.

Distance		r^2	*SEE*
1000-m	1000-m time = 525.04 - (7.93 x Chronological age) - (1.17 x VO_{2max}) - (0.42 x SR) - (0.71 x Sitting height)**	0.39	9.36 s
500-m	500-m time = 265.12 - (1.24 x %MM) - (0.73 x Sitting height)**	0.21	6.54 s
200-m	200-m time = 113.65 - (3.23 x Chronological age) - (0.36 x %MM)**	0.47	2.26 s

Note: **Significant contribution ($p < 0.01$) to the predictive model.
Abbreviations: MM= Muscle Mass