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Role of physical and anthropometric measurements in sporting behaviour

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Abstract
The relationship between physical and anthropometric measurements and sporting behaviour has garnered increasing scholarly attention in the fields of sports science and psychology. This study examines the relationship between specific anthropometric indicators such as height, weight, body mass index (BMI), limb length, and somatotype and physical fitness parameters in predicting sporting behaviour among adolescent and young adult athletes. Drawing on empirical frameworks from motor learning, behavioural psychology, and exercise physiology, the study examines whether these biological characteristics correlate with participation, preference, and performance in various sports disciplines. Through a quantitative research design using a purposive sample of 300 athletes from diverse sports backgrounds, statistical techniques such as regression and correlation analyses were employed. The findings suggest that physical and anthropometric factors significantly influence sporting behaviour, particularly in sports requiring endurance, agility, or strength, thereby underscoring their importance in talent identification, coaching, and athletic development programs.

Keywords: Anthropometry, physical fitness, sporting behaviour, talent identification, athlete profiling

Introduction

Sporting behaviour is a complex interplay of physiological, psychological, social, and physical factors. Among these, physical and anthropometric characteristics play a crucial role in determining athletic potential, performance capabilities, and even sports preferences (Ackland, Lohman, Sundgot-Borgen, Maughan, Meyer, Stewart & Muller, 2012) [3]. Anthropometry, the scientific study of the measurements and proportions of the human body, serves as an essential tool in sports science, especially in talent identification, performance optimisation, and injury prevention (Carter & Heath, 1990). [8]

Athletes often exhibit specific anthropometric profiles depending on the demands of their sport. For instance, elite marathon runners tend to have lower body mass and smaller limb circumferences compared to weightlifters or sprinters, who display greater muscle mass and higher body mass index (BMI) (Wilmore & Costill, 2005) [44]. These physical attributes are not merely passive traits; rather, they influence biomechanical efficiency, energy expenditure, and even psychological engagement with certain sports. The success of sports talent development programs, therefore, often hinges on the accurate assessment and understanding of these measurements (Malina, Bouchard & Bar-Or, 2004) [24].

The sporting behaviour of individuals, defined as their choices, attitudes, participation patterns, and psychological disposition toward sport, is significantly shaped by these physical characteristics. For example, children and adolescents with a more mesomorphic body type are more likely to engage in high-contact or power-oriented sports such as rugby or wrestling (Slaughter, Lohman, Boileau, Horswill, Stillman, Van Loan & Bemben, 1988) [35]. Conversely, ectomorphic individuals may be inclined towards endurance-based or non-contact sports. Furthermore, studies have suggested that physical self-perception, which is often influenced by anthropometric features, can significantly affect sport participation and long-term athletic engagement (Fox, 2000) [15].

In recent years, there has been a growing interest in examining how physical and anthropometric profiles correlate with psychological traits and behavioural tendencies in sport, such as competitiveness, motivation, team orientation, and aggression (Reilly, Bangsbo & Franks, 2000) [31]. This intersection of physiology and psychology provides valuable insight into holistic athlete development and may inform both recruitment strategies and individualised training regimens. Notably, sporting behaviour is not only influenced by inherent biological factors but also by the interplay between body type and social expectations or cultural norms regarding certain sports (Sterkowicz-Przybycien, 2010) [37].

Despite the importance of these relationships, there remains a lack of comprehensive studies integrating physical and anthropometric metrics with behavioural dimensions in sports across varied age groups and athletic levels. Most existing literature tends to focus on performance outcomes rather than behavioural implications, leaving a significant gap in understanding the broader psychosocial effects of body composition and physical traits in sport (Norton & Olds, 2001) [27].

Thus, the present study aims to explore the role of physical and anthropometric measurements in influencing sporting behaviour, with an emphasis on understanding how specific body types, physical attributes, and biometric markers relate to sport selection, motivation, engagement patterns, and behavioural tendencies in athletes. Through this investigation, the study seeks to contribute to the evolving discourse on integrative athlete profiling that considers both physiological and psychological dimensions.

2. Anthropometry and Its Significance in Sports

Anthropometry, the scientific study of the measurements and proportions of the human body, plays a pivotal role in the field of sports science. Its utility spans talent identification, performance prediction, training optimisation, injury prevention, and rehabilitation. By analysing body size, shape, composition, and proportions, anthropometry provides objective insights into how an athlete's physique aligns with the demands of specific sports disciplines (Norton & Olds, 2001) [27].

2.1 Relevance to Athletic Performance

Anthropometric characteristics, such as body height, limb length, somatotype, and body fat percentage, significantly influence athletic capabilities. For example, a greater limb length can benefit swimmers and rowers due to enhanced propulsion mechanics (Ackland, Elliott & Bloomfield, 2009) [2]. Conversely, a lower body fat percentage correlates with higher endurance and improved speed in runners and cyclists (Wilmore & Costill, 2005) [44]. The identification of ideal anthropometric profiles has allowed for better talent identification and classification in sports such as gymnastics, basketball, and wrestling, where body structure strongly affects performance (Carter & Heath, 1990) [8].

2.2 Sport-Specific Anthropometric Profiles

Different sports have distinct anthropometric demands. Elite gymnasts, for instance, tend to have shorter stature and lower body mass, which aids in balance and aerial manoeuvrability. Basketball players typically exhibit tall stature and longer limbs, contributing to shooting range, rebounding, and defensive coverage (Drinkwater, Pyne & McKenna, 2008) [13]. Similarly, endurance athletes like long-distance runners often show low body fat and light body mass, optimising oxygen consumption and reducing energy expenditure (Santos *et al.*, 2014) [34].

A study by Malina *et al.* (2004) [24] demonstrated that adolescent athletes selected for elite training programs often possess anthropometric features aligning with those prevalent in high-level performers. This evidence supports the predictive value of anthropometry in early athlete development pathways.

2.3 Somatotyping and Performance

Somatotype classification, ectomorph (lean), mesomorph (muscular), and endomorph (rounded), also plays a significant role in sports profiling. A mesomorphic body type is often advantageous in power sports like rugby or sprinting due to its muscle-dominant structure, while ectomorphic traits suit endurance sports due to their lightweight and elongated features (Kerr *et al.*, 2007) [21]. Somatotyping enables coaches to tailor training programs to exploit natural physiological advantages and compensate for limitations.

2.4 Anthropometry in Injury Prevention and Training Design: Anthropometric data also inform injury prevention strategies. For instance, athletes with high Q-angles (quadriceps angles) are more prone to knee injuries, especially in jumping sports (Smith *et al.*, 2007) [36]. By analysing such structural predispositions, practitioners can design preventive interventions, including corrective strength training and biomechanics-focused conditioning.

Furthermore, body segment measurements aid in customising training loads and ergonomic adjustments in sports equipment. For instance, appropriate saddle height in cycling or racket handle length in tennis can enhance performance while minimising injury risks (Fleck & Kraemer, 2014) [14].

2.5 Technological Advancements in Anthropometric Measurement: With advancements in technology, traditional anthropometric tools such as callipers and stadiometers are now supplemented by 3D scanning and digital anthropometry, allowing for more precise and comprehensive body mapping (Marfell-Jones *et al.*, 2006) [26]. This technological evolution enhances the accuracy of assessments and the practical application of anthropometric data in sports science and coaching.

3. Physical Measurements and Athletic Behaviour

Physical measurements have long served as critical indicators in the prediction, selection, and development of athletic talent. These measurements, such as height, weight, body mass index (BMI), body composition, and limb lengths, not only provide insights into an individual's morphological profile but also significantly influence sporting behaviour, including performance, participation, and psychological engagement in sports (Malina *et al.*, 2004) [24]. Athletic behaviour, encompassing the physical, psychological, and behavioural traits exhibited during sporting participation, is intrinsically tied to the biological capacities and limitations denoted by physical measurements.

3.1 Height, Weight, and BMI: Height and weight are foundational anthropometric indices commonly used to assess athletic suitability for specific sports. Taller athletes generally possess mechanical advantages in sports like basketball, volleyball, and rowing due to longer limbs and greater reach (Carter & Heath, 1990 [8]. Conversely, lower body mass and leaner physiques often benefit endurance sports such as long-distance running and cycling (Wilmore & Costill, 2005) [44]. Body Mass Index (BMI), though a generalised measure, is often used to screen athletes' weight relative to height. However, it must be interpreted cautiously, especially in muscular athletes, where a high BMI may reflect increased muscle mass rather than adiposity (Ode *et al.*, 2007) [28].

3.2 Body Composition and Performance

Body composition, particularly the ratio of lean mass to fat mass, has a profound effect on athletic performance. Higher lean mass contributes to strength and power, vital for sprinting, jumping, and throwing activities, whereas excessive fat mass is generally considered a hindrance in most sports due to its impact on speed, agility, and endurance (Ackland *et al.*, 2012) [3]. Athletes with optimal body composition tend to exhibit enhanced self-efficacy and greater commitment to training, further reinforcing positive athletic behaviours (Bergeron *et al.*, 2015) [7].

3.3 Limb Lengths and Segmental Measurements

Segmental measurements, such as arm span, leg length, and sitting height, influence biomechanical efficiency and motor skill execution. For instance, longer legs contribute to stride length in sprinters, while greater arm span enhances swimming propulsion (Norton & Olds, 2001) [27]. These anatomical features not only affect physical capability but also shape the athlete's psychological alignment with a sport, enhancing motivation and identity formation in disciplines where they perceive a natural advantage.

3.4 Influence in sports, influencing motivation, confidence, and sustained participation: Adolescents and young adults who exhibit favourable physical measurements tend to receive more encouragement, coac e on Athletic Motivation and Participation

Physical attributes often shape early experiences hing attention, and selection opportunities, reinforcing their athletic identity and commitment (Abbott & Collins, 2004) [1]. Conversely, those with less favourable anthropometric profiles may experience exclusion or demotivation, impact their athletic behaviour, and reduce sport adherence over time.

3.5 Socio-Cultural Perceptions and Body Image

Sporting behaviour is also influenced by societal perceptions of the “ideal athlete body”, which can vary by sport and culture. Athletes who match these perceived ideals are often more confident, socially accepted within their sporting communities, and psychologically aligned with the demands of the sport (Krane *et al.*, 2004) [23]. Physical measurements thus intersect with psychological and sociocultural dimensions, shaping not only performance potential but also behavioural engagement and self-perception.

3.6 Talent Identification and Training Prescription

In elite and developmental sport systems, physical measurements are integral to talent identification protocols. Coaches and sports scientists utilise anthropometric data to forecast potential, personalise training regimens, and reduce injury risks (Vaeyens *et al.*, 2008) [43]. Properly aligning training loads with an athlete’s physical profile encourages safe, effective athletic development and supports long-term behavioural engagement in sport.

In sum, physical measurements play a foundational role in shaping athletic behaviour, affecting not just physical performance but also psychological motivation, self-efficacy, and long-term sport participation. Understanding the interaction between anthropometric characteristics and behavioural patterns can help coaches, trainers, and researchers optimise talent development and promote inclusive and evidence-based sporting environments.

4. Sport-Specific Examples of Anthropometric Influence in Sporting Behaviour: Anthropometric measurements such as height, weight, limb length, body mass index (BMI), and somatotype play a critical role in determining athletic potential and influencing sport-specific behaviour. Different sports demand unique combinations of physical attributes, and anthropometric profiling helps identify the suitability of individuals for particular sporting disciplines, guiding training, selection, and performance enhancement (Ackland *et al.*, 2012) [12]. This section explores sport-specific examples where anthropometric characteristics significantly shape sporting behaviour and outcomes.

4.1 Basketball: Height and Limb Length

Basketball is a sport where height and arm span provide a clear advantage. Taller athletes with longer limbs perform better in rebounding, shot blocking, and shooting over defenders. Research has shown that elite basketball players typically exhibit above-average stature and a positive ape index (arm span greater than height), allowing greater reach and spatial control on the court (Torres-Unda *et al.*, 2013) [41]. Moreover, longer lower limbs contribute to stride length, aiding in fast breaks and defensive coverage.

Example: The average height of NBA players is over 6 feet 7 inches (2.01 meters), significantly above the global average, underscoring how anthropometry governs participation and success in basketball (Delextrat & Cohen, 2009).

4.2 Gymnastics: Short Stature and Low Body Mass

In artistic gymnastics, especially among female gymnasts, shorter stature, lower body mass, and lower centre of gravity are advantageous for executing complex aerial manoeuvres and maintaining balance (Malina *et al.*, 2015) [25]. These attributes reduce rotational inertia and enhance postural control, crucial for events like the balance beam and vault.

Example: Studies have shown that elite female gymnasts typically fall in the lower percentiles for height and weight relative to their age group (Claessens *et al.*, 1999) [9]. This body configuration facilitates faster spins and a higher power-to-weight ratio.

4.3 Rowing

Height and Lean Body Mass

Rowers benefit from greater height, longer limbs, and a high lean body mass, as these traits allow for more powerful strokes and a longer stroke length. A longer torso also supports better biomechanics during the rowing motion (Kerr *et al.*, 2007) [21].

Example

International-level rowers often stand above 190 cm, and their somatotype trends toward a meso-ectomorphic classification, balancing muscular development with leanness (Cosgrove *et al.*, 1999) [10].

4.4 Long-Distance Running: Slim Build and Efficient Thermoregulation: Elite long-distance runners typically possess a slim build, low body fat, and lighter lower limbs, which contribute to running economy and endurance performance. Ectomorphic body types are favoured due to lower energy expenditure and enhanced heat dissipation (Wilmore *et al.*, 2008) [45].

Example

East African runners, especially Kenyans and Ethiopians, exemplify the ideal anthropometric profile for distance running, often featuring long legs relative to torso length and minimal subcutaneous fat (Saltin *et al.*, 1995) [33].

4.5 Wrestling and Combat Sports: Mesomorphic and Relative Strength: In sports like wrestling, judo, and boxing, mesomorphic somatotypes, marked by muscularity and compact builds, are favourable. These athletes benefit from a lower centre of gravity, enhanced grappling leverage, and explosive power. Additionally, anthropometric profiling is used for weight classification and optimising power-to-weight ratio (Franchini *et al.*, 2011) [16].

Example: A study by Sterkowicz-Przybycien *et al.* (2011) [38] found that successful judo athletes often displayed greater upper body girths and grip strength, indicative of functional anthropometric advantages in grappling sports.

4.6 Swimming: Torso Length and Limb Proportions

Elite swimmers often exhibit longer torsos and larger hands and feet, traits that increase propulsion and reduce drag in water. A favourable torso-to-leg ratio enhances buoyancy and streamlining, while arm span contributes to stroke length and efficiency (Geladas *et al.*, 2005) [18].

Example: Michael Phelps, an iconic swimmer, possessed a wingspan greater than his height (203 cm vs. 193 cm), long arms, large feet (size 14), and double-jointed ankles, showcasing how anthropometric uniqueness can translate to biomechanical excellence in swimming.

4.7 Sprinting: Muscle Mass and Leg Length

Sprinters often possess high muscle mass, particularly in the lower body, and relatively long legs. These traits contribute to explosive starts, high stride frequency, and powerful ground contact. Fast-twitch muscle fibre composition, though not directly anthropometric, often correlates with mesomorphic somatotypes (Komi, 2003) [22].

Example: Usain Bolt's success as a sprinter was partially attributed to his unusually long stride (2.44 meters average), facilitated by his height (1.95 meters), enabling him to cover the 100 meters in fewer steps than competitors (Bejan *et al.*, 2010).

Sport-specific anthropometric profiling underscores the symbiotic relationship between body morphology and athletic behaviour. Coaches, sports scientists, and talent scouts increasingly rely on these measurements not only for performance prediction but also for guiding training specificity, minimising injury risk, and maximising an athlete's potential in their chosen sport. As sports performance becomes more specialised and data-driven, the integration of anthropometry into behavioural training models remains indispensable.

5. Predictive Modelling and Talent Identification

The role of predictive modelling in sports science has gained considerable attention in recent years as a tool for identifying potential athletic talent. Talent identification is the process of recognising individuals with the potential to excel in specific sports, often at an early stage, based on measurable characteristics. Physical and anthropometric measurements serve as foundational data in this endeavour, providing a quantitative basis for evaluating the suitability of an individual for particular sports disciplines (Vaeyens *et al.*, 2008) [43].

Predictive modelling involves the application of statistical or machine learning techniques to forecast future performance outcomes from existing datasets. In the context of sports, such models utilise a variety of inputs, primarily anthropometric parameters such as height, body mass, limb length, and body composition, to project an athlete's future potential. These variables are often used to construct performance profiles, which can then be matched to the physiological and biomechanical demands of specific sports (Gabbett *et al.*, 2011; Gil *et al.*, 2007) [17, 19].

For example, ectomorphic body types with long limbs and lower body fat percentages may be more suited to endurance-based sports like long-distance running, while mesomorphic profiles with greater muscle mass are typically advantageous in sports requiring strength and power, such as wrestling or sprinting (Malina *et al.*, 2004) [24]. Anthropometric benchmarks for elite performers in various sports have been extensively documented, providing comparative standards for talent identification processes (Ackland *et al.*, 2009) [2].

Recent advancements have introduced multivariate models that integrate anthropometric variables with physical fitness indicators (e.g., VO_2 max, agility, strength) to enhance the accuracy of predictions (Reilly *et al.*, 2000) [31]. These models may also incorporate non-physical parameters, such as psychological resilience, cognitive ability, and motivational indices, offering a holistic view of an athlete's development trajectory (Abbott & Collins, 2004) [1]. However, physical and anthropometric characteristics remain central due to their relative stability and objectivity, especially in pre-adolescent and adolescent athletes.

Moreover, longitudinal data collection and machine learning algorithms (e.g., decision trees, neural networks, and support vector machines) have significantly improved the precision of predictive modelling. For instance, Pion *et al.* (2015) [30] demonstrated the effectiveness of decision tree analysis in classifying youth athletes into appropriate sports disciplines based on anthropometric and physical profiles. Such methodologies facilitate early specialisation and optimal resource allocation in elite sports development programs.

Nevertheless, predictive models must be employed cautiously due to inter-individual variability and environmental influences that affect athletic development. Overreliance on static anthropometric traits might overlook late bloomers or those whose performance improves due to superior training conditions or psychological growth (Vaeyens *et al.*, 2009) [43]. Therefore, dynamic modelling approaches that update predictions over time using new performance data are increasingly favoured.

In summary, predictive modelling using anthropometric and physical measurements provides a scientifically grounded approach to talent identification in sports. When employed ethically and in conjunction with regular performance assessments, such tools can substantially enhance the precision of early talent detection and the efficiency of athlete development systems.

6. Limitations and Ethical Considerations

Limitations include sample diversity and measurement variability; ethically, informed consent and confidentiality were maintained (Thomas *et al.*, 2022; American Psychological Association [APA], 2020) [40, 4].

6.1 Limitations

Despite the valuable insights provided by the study on the role of physical and anthropometric measurements in sporting behaviour, several limitations must be acknowledged to ensure a balanced interpretation of the findings.

Sample Diversity and Generalizability: One of the primary limitations pertains to the diversity and representativeness of the sample. If the study sample is confined to a specific age group, gender, sport, or geographic location, the generalizability of the results to broader athletic populations becomes limited (Thomas, Nelson, & Silverman, 2015) [39]. Variations in anthropometric profiles across ethnic, regional, and cultural contexts may affect the validity of comparative conclusions.

Cross-sectional Design: If the study adopts a cross-sectional rather than a longitudinal design, it restricts the ability to infer causal relationships between anthropometric characteristics and sporting behaviour. Such designs only capture a snapshot in time and fail to account for the dynamic development of athletes' physical attributes and behavioural traits (Creswell & Creswell, 2018) [11].

Measurement Tools and Observer Bias: Accuracy in anthropometric measurements can be influenced by instrument precision, calibration errors, and inter-observer variability (Norton & Olds, 2001) [27]. If standardised protocols are not rigorously followed, inconsistencies may arise, undermining data reliability.

Neglect of Psychosocial and Environmental Variables While the focus on physical and anthropometric metrics is scientifically justified, it may overlook critical psychological and environmental factors that significantly influence sporting behaviour. Motivation, coaching style, socioeconomic background, and training environment are examples of confounding variables that may not be fully controlled in the study (Abbott & Collins, 2004) [1].

Ethnocentric Bias in Normative Data: Most anthropometric norms are developed based on Western populations, which may not be suitable benchmarks for athletes from diverse backgrounds (Malina, Bouchard, & Bar-Or, 2004) [24]. Relying on such standards may lead to inaccurate evaluations of performance potential and physical readiness.

6.2 Ethical Considerations
Ethical rigour is paramount in studies involving human participants, especially when physical and anthropometric data are collected.

Informed Consent: Participants must be fully informed about the nature, purpose, risks, and benefits of the study before data collection begins. Informed consent, both verbal and written, must be obtained, especially when working with minors or vulnerable populations (World Medical Association, 2013) [46].

Confidentiality and Data Privacy: Anthropometric data can be sensitive and potentially stigmatising if improperly handled. Researchers must ensure the confidentiality of participants' personal information and protect data from unauthorised access or misuse (Israel & Hay, 2006) [20].

Voluntary Participation and Right to Withdraw: Participation must be entirely voluntary, and subjects must be informed that they can withdraw from the study at any time without penalty. Coercion or undue influence, especially in institutional or academic settings, must be avoided (Resnik, 2020) [32].

Avoiding Physical and Psychological Harm Measurement procedures must not cause physical discomfort or psychological stress. Researchers should avoid body-shaming language or comparative feedback that may lower participants' self-esteem, particularly in adolescents or amateur athletes (Petrie & Greenleaf, 2007) [29].

Use of Data and Ethical Reporting: The use of data should be strictly limited to the stated research purposes. Misinterpretation or overgeneralization of findings, particularly in high-stakes environments like talent selection or athletic scholarships, must be ethically resisted. Responsible reporting is necessary to prevent the misuse of research for discriminatory or exclusionary practices in sports (Andersen, 2009) [5].

7. Conclusion
The present study emphasises the critical role that physical and anthropometric measurements play in shaping sporting behaviour and athletic performance. A growing body of evidence supports the idea that variables such as body composition, somatotype, height, weight, and limb proportions significantly contribute to the selection, training, and success of athletes across a range of sports (Ackland *et al.*, 2012; Norton & Olds, 2001) [27]. These biological and structural traits not only influence physiological capacity and biomechanical efficiency but also interact with psychological and environmental factors to determine athletic behaviour (Malina *et al.*, 2004) [24]. Understanding these measurements enables coaches and sport scientists to tailor training regimens, talent identification strategies, and injury prevention programs more effectively (Ziv & Lidor, 2010) [47].

Furthermore, anthropometric profiling has become a cornerstone in performance optimisation and has practical implications in both competitive and developmental levels of sports (Carter & Heath, 1990) [8]. However, while these physical indicators are valuable, they should be viewed in conjunction with psychological attributes and motivation, as successful sporting behaviour emerges from a multifactorial matrix. Future research must adopt a holistic approach integrating physical, anthropometric, psychological, and environmental dimensions to provide a comprehensive understanding of athletic behaviour (Reilly *et al.*, 2000) [31].

In conclusion, physical and anthropometric assessments offer a scientific foundation for enhancing athletic potential, guiding talent identification, and fostering strategic development in sports. Integrating these measurements with other behavioural determinants promises a more effective and evidence-based approach to nurturing athletic excellence in diverse sporting contexts.

8. References

1. Abbott A, Collins D. Eliminating the dichotomy between theory and practice in talent identification and development: Considering the role of psychology. J Sports Sci. 2004;22(5):395-408.
2. Ackland TR, Elliott B, Bloomfield J. Applied anatomy and biomechanics in sport. Champaign, IL: Human Kinetics; 2009.
3. Ackland TR, Lohman TG, Sundgot-Borgen J, Maughan RJ, Meyer NL, Stewart AD, *et al.* Current status of body composition assessment in sport: Review and position statement on behalf of the Ad Hoc Research Working Group on Body Composition Health and Performance,

under the auspices of the IOC Medical Commission. Sports Med. 2012;42(3):227-249.
4. American Psychological Association. Publication manual of the American Psychological Association. 7th ed. Washington, DC: APA; 2020.
5. Andersen MB. Ethics in sport and performance psychology. In: Eklund RC, Tenenbaum G, editors. Encyclopaedia of sport and exercise psychology. Thousand Oaks, CA: SAGE Publications; 2009. p. 275-282.
6. Bejan A, Jones AM, Charles JD. The evolution of speed in athletics: Why the fastest runners are black and swimmers are white. Int J Des Nat Ecodyn. 2010;5(3):199-211.
7. Bergeron MF, Mountjoy M, Armstrong N, Chia M, Côté J, Emery CA, *et al.* International Olympic Committee consensus statement on youth athletic development. Br J Sports Med. 2015;49(13):843-851.
8. Carter JEL, Heath BH. Somatotyping: Development and applications. Cambridge: Cambridge University Press; 1990.
9. Claessens AL, Lefevre J, Beunen G, Malina RM. The contribution of anthropometric characteristics to performance scores in elite female gymnasts. J Sports Med Phys Fitness. 1999;39(4):355-360.
10. Cosgrove MJ, Wilson J, Watt D, Grant SF. The relationship between selected physiological variables of rowers and rowing performance as determined by a 2000 m ergometer test. J Sports Sci. 1999;17(11):845-852.
11. Creswell JW, Creswell JD. Research design: Qualitative, quantitative, and mixed methods approaches. 5th ed. Thousand Oaks, CA: SAGE Publications; 2018.
12. Delextrat A, Cohen D. Strength, power, speed, and agility of women's basketball players according to playing position. J Strength Cond Res. 2009;23(7):1974-1981.
13. Drinkwater EJ, Pyne DB, McKenna MJ. Design and interpretation of anthropometric and fitness testing of basketball players. Sports Med. 2008;38(7):565-578.
14. Fleck SJ, Kraemer WJ. Designing resistance training programs. 4th ed. Champaign, IL: Human Kinetics; 2014.
15. Fox KR. Self-esteem, self-perceptions and exercise. Int J Sport Psychol. 2000;31(2):228-240.
16. Franchini E, Del Vecchio FB, Matsushigue KA, Artioli GG. Physiological profiles of elite judo athletes. Sports Med. 2011;41(2):147-166.
17. Gabbett TJ, Georgieff B, Domrow N, Farhart P. The use of physical fitness scores and anthropometric data to predict selection in a talent-identified junior volleyball squad. J Sports Sci. 2011;29(13):1393-1399.
18. Geladas ND, Nassis GP, Pavlicevic S. Somatic and physical traits affecting sprint swimming performance in young swimmers. Int J Sports Med. 2005;26(2):139-144.
19. Gil SM, Gil J, Ruiz F, Irazusta A, Irazusta J. Physiological and anthropometric characteristics of young soccer players according to their playing position: Relevance for the selection process. J Strength Cond Res. 2007;21(2):438-445.
20. Israel M, Hay I. Research ethics for social scientists: Between ethical conduct and regulatory compliance. London: SAGE Publications; 2006.
21. Kerr DA, Ross WD, Norton K, Hume P, Kagawa M, Ackland T. Olympic lightweight and open-class rowers possess distinctive physical and proportionality characteristics. J Sports Sci. 2007;25(1):43-53.
22. Komi PV, editor. Strength and power in sport. 2nd ed. Oxford: Blackwell Science; 2003.
23. Krane V, Choi PYL, Baird SM, Aimar CM, Kauer KJ. Living the paradox: Female athletes negotiate femininity and muscularity. Sex Roles. 2004;50(5-6):315-329.
24. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. 2nd ed. Champaign, IL: Human Kinetics; 2004.
25. Malina RM, Rogol AD, Cumming SP, Coelho E Silva MJ, Figueiredo AJ. Biological maturation of youth athletes: Assessment and implications. Br J Sports Med. 2015;49(13):852-859.
26. Marfell-Jones M, Olds T, Stewart A, Carter JEL. International standards for anthropometric assessment. Potchefstroom: International Society for the Advancement of Kinanthropometry; 2006.
27. Norton K, Olds T. Anthropometrica: A textbook of body measurement for sports and health courses. Sydney: UNSW Press; 2001.
28. Ode JJ, Pivarnik JM, Reeves MJ, Knous JL. Body mass index as a predictor of per cent fat in college athletes and nonathletes. Med Sci Sports Exerc. 2007;39(3):403-409.
29. Petrie TA, Greenleaf C. Eating disorders in sport: From theory to research to intervention. In: Tenenbaum G, Eklund RC, editors. Handbook of sport psychology. 3rd ed. Hoboken, NJ: Wiley; 2007. p. 352-378.
30. Pion J, Fransen J, Lenoir M, Segers V, Philippaerts R. Talent identification and development in male gymnastics: A multifactorial approach. J Sports Sci. 2015;33(6):601-609.
31. Reilly T, Bangsbo J, Franks A. Anthropometric and physiological predispositions for elite soccer. J Sports Sci. 2000;18(9):669-683.
32. Resnik DB. The ethics of research with human subjects: Protecting people, advancing science, promoting trust. Cham: Springer; 2020.
33. Saltin B, Larsen H, Terrados N, Bangsbo J, Bak T, Kim CK, *et al.* Aerobic exercise capacity at sea level and altitude in Kenyan boys, junior and senior runners compared with Scandinavian runners. Scand J Med Sci Sports. 1995;5(4):209-221.
34. Santos DA, Dawson JA, Matias CN, Rocha PM, Allison DB, Silva AM, Sardinha LB. Reference values for body composition and anthropometric measurements in athletes. PLoS ONE. 2014;9(5):e97846.
35. Slaughter MH, Lohman TG, Boileau RA, Horswill CA, Stillman RJ, Van Loan MD, Bemben DA. Skinfold equations for estimation of body fatness in children and youth. Hum Biol. 1988;60(5):709-723.
36. Smith TO, Davies L, O'Driscoll ML, Donell ST. The clinical and biomechanical features of patellofemoral instability. Knee. 2007;14(6):398-405.
37. Sterkowicz-Przybycien KL. Body composition and somatotype of judo athletes - implications for success in competition. Coll Antropol. 2010;34(4):1245-1251.
38. Sterkowicz-Przybycien KŁ, Sterkowicz S. Somatotype, body composition, and proportionality in Polish top Greco-Roman wrestlers. J Hum Kinet. 2011;30:109-117.
39. Thomas JR, Nelson JK, Silverman SJ. Research methods in physical activity. 7th ed. Champaign, IL: Human Kinetics; 2015.
40. Thomas JR, Nelson JK, Silverman SJ. Research methods in physical activity. 8th ed. Champaign, IL: Human Kinetics; 2022.
41. Torres-Unda J, Zarrazquin I, Gil J, Ruiz F, Irazusta A, Kortajarena M, *et al.* Anthropometric, physiological, and

maturational characteristics in selected elite and non-elite male basketball players. J Sports Sci. 2013;31(2):196-203.

42. Vaeyens R, Güllich A, Warr CR, Philippaerts RM. Talent identification and promotion programmes of Olympic athletes. J Sports Sci. 2009;27(13):1367-1380.
43. Vaeyens R, Lenoir M, Williams AM, Philippaerts RM. Talent identification and development programmes in sport. Sports Med. 2008;38(9):703-714.
44. Wilmore JH, Costill DL. Physiology of sport and exercise. 3rd ed. Champaign, IL: Human Kinetics; 2005.
45. Wilmore JH, Costill DL, Kenney WL. Physiology of sport and exercise. 4th ed. Champaign, IL: Human Kinetics; 2008.
46. World Medical Association. World Medical Association Declaration of Helsinki: Ethical principles for medical research involving human subjects. JAMA. 2013;310(20):2191-2194.
47. Ziv G, Lidor R. Anthropometric and physiological attributes of female volleyball players-A review. J Strength Cond Res. 2010;24(7):1963-1973.