Original Article

Anthropometric profiles of elite athletes

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ABSTRACT

Quantifying body composition is central to monitoring performance and training in athletes, however limited sport-specific anthropometric reference data, assessed and reported in a standardised manner, is available. This study provides anthropometric profiles in elite male athletes from different sports. Elite male athletes (n = 73) from National squads of boxing (n = 10), cricket (n = 21), swimming (n = 23), hockey (n = 10) and eventing (n = 9) were assessed for body mass, height, eight skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and medial calf), body circumferences (arm, waist, hip, thigh and calf) and muscle circumferences (arm, thigh, calf) using ISAK standardised guidelines. For all athletes, large variability exists for measures of skinfold thickness at each skinfold site. Swimming (64.6 ± 16.1 mm) and boxing (63.5 ± 16.1 mm) were similar for the sum of eight skinfolds (∑8SKF) but swimming had lower ∑8SKF compared to cricket (86.1 ± 21.3 mm; p = .011) and eventing (89.9 ± 30.7 mm; p = .028). Hockey (81.9 ± 26.3 mm) and eventing had the most varied ∑8SKF. Thigh body (p=.006) and muscle circumferences (p = .005) were significantly reduced in boxing compared to hockey. No differences were seen between sports for arm (p = .346; ES = .06) and calf (p = .382; ES = .06) muscle circumferences. The anthropometric profiles for elite athletes from various sports during pre-season training will be a useful resource for sports professionals when monitoring and interpreting body composition data. Large variation exists in anthropometric profiles between the different athletes and different sports, highlighting the necessity to have sport-specific normative ranges available to allow optimal monitoring of individual athletes particularly varying across sports as well as age, training status and position.
Keywords: Sport; Body composition; Anthropometry; Skinfold thickness; Circumferences; Bodyfat.

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INTRODUCTION

Quantifying body composition plays a central role in monitoring performance and training in all athletes, particularly in gravitational, weight class and aesthetic sports in which body composition may influence performance or adjudication (Thomas, Erdman and Burke, 2016). Enhanced body composition in athletes has been associated with improvements in cardiorespiratory fitness Hogstrom, Pietila, Nordstrom and Nordstrom, 2012) and strength (Silva, Fields, Heymsfield, Sardinha, 2010). A high proportion of body fat mass has been shown to be related to a low power to weight ratio, reduced acceleration and increased energy expenditure (Svantesson, Zander, Klingberg, Slinde, 2008). While an excess of fat mass may have a negative impact on sports performance (Malina, 2007), a lower fat mass may be related to several health complications (Ackerman, Holtzman, Cooper, Flynn, Bruinvels, Tenforde et al., 2019; Sundgot-Burgen and Garthe, 2011). The amount and distribution of muscle is also recognised as having a central role in determining sports performance, particularly in sports involving speed, strength and power (Thomas et al., 2016; Kendall, Fukada, Hyde, Smith-Ryan, Moon and Stout, 2017).

While many methods are available for the assessment of body composition, there is still no criterion methodology identified in athletes (Aragon, Schoenfield, Wildman, Kleiner, VanDusseldorp et al., 2017; Meyer, Sungot-Gorgen, Lohman, Ackland, Stewart, Maughan et al., 2013). Some methods are not practical or reliable for a coach or practitioner who want to track changes in body composition through a season (Kendall et al., 2017). Anthropometric techniques, namely skinfold thickness, are the most frequently used method to describe body composition in athletes (Meyer et al., 2013), with circumferences commonly used too. Regression equations are commonly used to estimate percentage bodyfat from skinfold thickness which introduces inherent error (Lohman, 1984) and presents huge variability in results (Suarez-Arrones, Petri, Maldonado, Torreno, Munguia-Izquierdo, Di Salvo and Mendez-Villanueva, 2018). It has been suggested that a range for “optimal” body composition presenting raw data should be determined for athletes, given the variability between individuals and the errors inherent in body fat assessment (Sundgot-Borgen, Meyer, Lohman, Ackland, Maughan, Stewart and Muller, 2013). This should account for the variation in athletes over the season as well as over the athlete’s career allowing individualised and periodized ranges for all athletes (Thomas et al., 2016).

Limited standardised normative values exist for raw data of skinfolds and circumferences due to variations in assessment methods and reporting procedures of data, which limits interpretation of body composition information amongst athletes and support teams. Reference values for anthropometric measurements in athletes of varying sports have been reported however interpretation and generalisation of the results for some sports may have been limited due to anthropometric variables reported for only one participant in some cases (Garrido-Chamorro, Sirvent-Belando, Gonzalez-Lorenzo, Blasco-Lafarga, and Roche, 2012; Santos, Dawson, Matias, Rocha, Minderico, Allison et al., 2014). More recently, there is evidence available on anthropometric profiles in open water swimming (Shaw and Mukija, 2018), Olympic race walkers (Gomez-Ezeiza, Torres-Unda, Granados, and Santos-Concejero, 2019), elite young male runners (Sanchez-Munoz, Muros, Belmonte and Zabala, 2020), Olympic mountain bikers (Sanchez-Munoz, Muros, and Zabala, 2018) and professional male basketball players (Gryko, Kopiczko, Mikolajec, Stasny and Musalek, 2018). There is a need for further sport-specific anthropometric profiles, assessed in a standardised manner and reported in line with guidelines (Aragon et al., 2017; Stewart, Marfell-Jones, Olds and de Ridder, 2011) to allow optimal monitoring and interpretation of anthropometric characteristics in athletes. The aim of this study was to provide sport-specific anthropometric reference data in elite male athletes from different sports during the pre-season training period.

METHODS

Participants

Seventy-three elite male athletes participated in this study, representing the sports of boxing (n = 10), cricket (n = 21), swimming (n = 23), hockey (n = 10) and equestrian eventing (n = 9). Athletes were recruited through the support centre for high-performance athletes in Ireland and must have been over 18 years of age and part of the high-performance or National team. Athletes currently injured or taking any drugs or medication were excluded. A power calculation was completed using data from Suarez-Arrones et al. (2018). With an 80% power requirement assumed, the 'SD' was set at 0.7 and the difference 'd' was 1, it was estimated that a minimum of 8 participants were required for each sporting category. Written informed consent was received prior to participation in the study. Ethical approval was granted by the University ethics committee.

Study design

A cross-sectional design was used. Participants were required to attend a one-off testing session during pre-season in the morning before the consumption of lunch. Athlete demographics were gathered and measurements for body mass, height, skinfold thickness and circumferences were assessed by a level 3 International Society for the Advancement of Kinanthropometry (ISAK) anthropometrist (mean %TEM of 1.6% for skinfolds and < 1% for all other measures) as per ISAK guidelines (Stewart et al., 2011).

Procedures

Body mass was assessed to the nearest 0.1 kg using a portable digital scale (Seca 877, Germany). Standing height was measured to the nearest 0.1 m using a portable stadiometer (Seca, Leicester Height Measure). Skinfolds were measured with calibrated Harpenden callipers at eight sites (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, mid-thigh, and medial calf). Individual skinfold sites and the sum of the eight skinfolds (∑8SKF) were reported in mm of bodyfat. The sum of seven skinfolds (∑7SKF) (minus iliac crest) was also reported given its common usage amongst practitioners. Waist, hip, arm, mid-thigh and calf circumferences were measured to the nearest 0.01 cm using an anthropometric tape (Lufkin W606PM). Arm, thigh and calf circumferences were converted into muscle circumferences by correcting the circumferences for the respective skinfold using formula described (Heymsfield, McManus, Smith, Stevens, Nixon, 1982): Arm Muscle Circumference = arm circumference – (π*(mean triceps and biceps skinfold)); Thigh Muscle Circumference = thigh circumference – (π*thigh skinfold); Calf Muscle Circumference = calf circumference – (π*calf skinfold).

Statistical analyses

Data were analysed using SPSS (version 23.0; IBM Corp, Armonk, NY). Normality of data distribution was tested using the Kilmogorov-Smirnov test. Descriptive statistics were expressed as mean ± standard deviation (SD) and 95% Confidence Intervals (CI) [lower limit-upper limit] were also reported. Differences between the body composition characteristics of the different athletic populations were identified using an ANOVA with Tukey's post hoc tests identifying the location of difference. Eta squared effect sizes (ES) were reported and interpreted based on the recommendations of Cohen such that ES of < 0.06 are small, 0.06 to 0.14 are medium and > 0.14 are large (Cohen, 1988). Statistical significance was set at $p \leq .05$.

RESULTS

Demographics of the athletes are presented in Table 1. Swimming were significantly younger than other athletes ($p = .000$; ES = .50). Eventing were competing at a National level for a significantly longer period of time compared to all other sports ($p = .000$; ES = .51). Eventing perform more training weekly to those in boxing, cricket and hockey ($p = .000$; ES = .84) with the minimum weekly training hours for eventing (28 hours) reported to be greater than the maximum for any other sport (maximum: boxing 18 hours; cricket 20 hours; swimming 24 hours; hockey 14 hours). Eventing training was inclusive of all hours spent on the horse. No significant differences exist in body mass ($p = .057$; ES = .12) and height ($p = .404$; ES = .06) between the sports.

Table 1. Athlete demographics.

	Boxing (n = 10)	Cricket (n = 21)	Swimming (n = 23)	Hockey (n = 10)	Eventing (n = 9)
Age (years)	25.2 ± 3.7[a] *[22.5-27.9]*	25.1 ± 5.5[a] *[22.6-27.6]*	20.7 ± 2.4 *[19.6-21.7]*	23.2 ± 3.4 *[20.8-25.6]*	35.7 ± 8.0[a] *[29.6-41.8]*
Years at National Level	5.3 ± 3.5 *[2.8-7.8]*	6.1 ± 2.8 *[4.8-7.3]*	3.7 ± 2.7 *[2.5-4.8]*	4.0 ± 3.2 *[1.7-6.3]*	14.8 ± 6.3[c] *[9.9-19.6]*
Weekly Training Hours	18.0[b]	14.8 ± 3.9[ab] *[13.0-16.5]*	22.4 ± 2.1 *[21.5-23.3]*	14.0[ab]	34.6 ± 4.9 *[30.8-38.3]*
Body Mass (kg)	73.8 ± 14.4 *[63.5-84.1]*	83.8 ± 8.1 *[79.8-87.8]*	78.6 ± 5.3 *[76.3-80.9]*	82.1 ± 9.6 *[75.3-89.0]*	79.0 ± 9.0 *[72.1-85.9]*
Height (cm)	179.5 ± 7.9 *[173.9-185.1]*	184.0 ± 7.8 *[180.4-187.6]*	183.5 ± 4.8 *[181.5-185.6]*	181.6 ± 6.5 *[176.9-186.2]*	181.2 ± 6.9 *[175.9-186.5]*

Data presented as Mean ± SD [95% CI]. ap ≤ .05 significantly different to swimming; bp ≤ .05 significantly different to eventing; cp ≤ .05 significantly different to all other sports.

Mean skinfold thickness for each skinfold site is presented in Table 2. Athletes in swimming presented with significantly lower mean skinfold thickness measures at selected upper body and trunk sites compared to cricket, hockey and eventing. Boxing displayed significantly reduced mean skinfold thickness measures at selected upper body, lower body and trunk sites compared to cricket and eventing. For all athletes, large variability exists for measures of skinfold thickness. Ranges for skinfold thickness for all athletes were: triceps 2.4 mm to 14.2 mm; subscapular 5.6 to 25.8 mm; biceps 1.8 mm to 8.1 mm; iliac crest 5.7 mm to 32.6 mm; supraspinal 4.0 mm to 22.0 mm; abdominal 6.0 mm to 30.0 mm; thigh 5.8 mm to 23.6 mm; calf 3.4 mm to 14.6 mm. The lowest skinfold for each site was seen within the swimming cohort, except for the lowest thigh skinfold site being recorded amongst the boxing.

Swimming had a significantly lower mean ∑8SKF compared to cricket ($p = .011$) and eventing ($p = .028$). Hockey and eventers had the most varied ∑8SKF. The lowest ∑8SKF was reported as 42.8 mm in swimming compared to the highest being in eventing (148.6 mm). Compared to cricket and eventing, mean ∑7SKF was lower in boxing ($p = .027$; $p = .045$, respectively) and swimming ($p = .004$; $p = .018$, respectively).

Mean body and muscle circumferences are presented in Table 3. Hip circumference was significantly greater in cricket compared to boxing ($p = .004$) and swimming ($p = .024$). Thigh body circumference was significantly smaller in boxing compared to cricket ($p = .008$) and hockey ($p = .006$). Thigh muscle circumference was greater in hockey but only significantly so in comparison to boxing ($p = .005$). No differences were seen between athletic groups for arm body circumference ($p = .218$; ES = .08) and arm muscle circumference ($p = .346$; ES = .06) or calf body circumference ($p = .098$; ES = .11) and calf muscle circumference ($p = .382$; ES = .06).

Table 2. Skinfold thickness and mean sum of skinfolds for each sport.

Skinfold Site (mm)	Boxing	Cricket	Swimming	Hockey	Eventing	p value	Effect Size
Triceps	7.2 ± 1.3 *[6.3-8.2]*	9.7 ± 2.9[a] *[8.4-11.0]*	6.9 ± 2.1 *[6.0-7.9]*	9.5 ± 1.9[a] *[8.1-10.8]*	10.2 ± 2.3[ab] *[8.4-12.0]*	.000	.28
Subscapular	8.2 ± 1.5 *[7.1-9.2]*	10.2 ± 2.2 *[9.2-11.2]*	7.8 ± 1.2 *[7.3-8.3]*	10.5 ± 3.4 *[8.1-12.9]*	11.7 ± 6.0[a] *[7.1-16.3]*	.003	.21
Biceps	3.4 ± 0.4 *[3.1-3.7]*	4.6 ± 1.3[a] *[4.0-5.2]*	3.5 ± 1.4 *[2.8-4.1]*	4.4 ± 0.8 *[3.8-4.9]*	4.0 ± 1.1 *[3.2-4.9]*	.013	.17
Iliac Crest	11.6 ± 4.5 *[8.4-14.8]*	15.5 ± 5.2 *[13.2-17.9]*	11.8 ± 4.4 *[9.9-13.7]*	16.9 ± 9.0 *[10.4-23.3]*	17.0 ± 8.4 *[10.6-23.5]*	.039	.14
Supraspinal	6.2 ± 1.7 *[5.0-7.5]*	9.4 ± 2.9[ab] *[8.0-10.7]*	6.3 ± 1.5 *[5.6-6.9]*	8.5 ± 3.1 *[6.3-10.7]*	9.6 ± 5.4[a] *[5.5-13.8]*	.001	.23
Abdominal	11.9 ± 4.6 *[8.6-15.2]*	15.8 ± 4.6[a] *[13.7-17.9]*	10.4 ± 3.5 *[8.9-11.9]*	15.3 ± 7.0 *[10.3-20.3]*	17.0 ± 7.2[a] *[11.5-22.6]*	.002	.22
Mid-Thigh	9.5 ± 3.0 *[7.4-11.7]*	12.9 ± 4.1 *[11.0-14.8]*	11.6 ± 3.4 *[10.1-13.0]*	10.2 ± 1.3 *[9.3-11.2]*	14.0 ± 3.4[b] *[11.4-16.6]*	.021	.15
Calf	5.4 ± 1.5 *[4.3-6.5]*	8.1 ± 2.5[b] *[7.0-9.3]*	6.3 ± 2.2 *[5.4-7.2]*	6.7 ± 2.9 *[4.6-8.8]*	6.3 ± 1.8 *[4.9-7.6]*	.020	.15
∑8SKF	63.5 ± 16.1 *[52.0-75.0]*	86.1 ± 21.3[a] *[76.4-95.8]*	64.6 ± 16.1 *[57.6-71.5]*	81.9 ± 26.3 *[63.1-100.7]*	89.9 ± 30.7[a] *[66.3-113.5]*	.002	.22
∑7SKF	51.9 ± 12.2 *[43.1-60.1]*	70.6 ± 16.6[ab] *[63.0-78.1]*	52.8 ± 12.8 *[47.2-58.3]*	65.1 ± 17.6 *[52.5-77.6]*	72.8 ± 22.9[ab] *[55.3-90.4]*	.007	.25

Data presented as Mean ± SD [95% CI]. ∑8SKF, sum of eight skinfolds: triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and medial calf; ∑7SKF, sum of seven skinfolds: triceps, subscapular, biceps, supraspinal, abdominal, thigh and medial calf; [a]p ≤ .05 significantly different to swimming; [b]p ≤ .05 significantly different to boxing.

Table 3. Mean body and muscle circumferences for each sport.

Circumferences (cm)	Boxing	Cricket	Swimming	Hockey	Eventing	p Value	Effect Size
Arm	30.4 ± 3.6 *[27.8-32.9]*	32.1 ± 1.6 *[31.4-32.9]*	32.0 ± 1.8 *[31.2-32.8]*	32.6 ± 2.5 *[30.8-34.4]*	32.0 ± 2.4 *[30.2-33.9]*	.218	.08
Waist	78.1 ± 6.6 *[73.4-82.9]*	82.4 ± 4.3 *[80.5-84.4]*	78.4 ± 3.6 *[76.8-79.9]*	82.9 ± 6.4 *[78.4-87.5]*	83.7 ± 7.6 *[77.9-89.6]*	.012	.17
Hip	93.5 ± 7.4 *[88.2-98.7]*	100.0 ± 4.9[ab] *[97.8-102.2]*	95.7 ± 3.1 *[94.4-97.1]*	98.4 ± 4.0 *[95.5-101.2]*	97.1 ± 3.6 *[94.3-99.9]*	.003	.21
Thigh	52.1 ± 5.7 *[48.1-56.2]*	56.5 ± 2.9[b] *[55.2-57.9]*	54.5 ± 2.5 *[53.4-55.6]*	57.4 ± 3.2[b] *[55.1-59.7]*	54.6 ± 2.9 *[52.4-56.9]*	.003	.21
Calf	36.0 ± 2.4 *[34.3-37.7]*	37.9 ± 2.4 *[36.9-39.0]*	37.6 ± 1.6 *[36.9-38.3]*	37.6 ± 1.8 *[36.3-38.8]*	36.7 ± 1.6 *[35.5-37.9]*	.098	.11
Arm Muscle Circumference	28.7 ± 3.5 *[26.2-31.2]*	29.9 ± 1.7 *[29.1-30.7]*	30.4 ± 1.9 *[29.6-31.2]*	30.4 ± 2.3 *[28.8-32.1]*	29.8 ± 2.1 *[28.2-31.4]*	.346	.06
Thigh Muscle Circumference	49.1 ± 5.2 *[45.4-52.8]*	52.5 ± 2.8 *[51.2-53.7]*	50.9 ± 2.5 *[49.8-52.0]*	54.2 ± 3.0[b] *[52.0-56.3]*	50.3 ± 2.9 *[48.0-52.5]*	.004	.20
Calf Muscle Circumference	34.3 ± 2.1 *[32.8-35.8]*	35.4 ± 2.3 *[34.3-36.4]*	35.6 ± 1.8 *[34.8-36.4]*	35.5 ± 1.6 *[34.3-36.7]*	34.7 ± 1.3 *[33.7-35.7]*	.382	.06

Data presented as Mean ± SD [95% CI]. [a]p ≤ .05 significantly different to swimming; [b]p ≤ .05 significantly different to boxing.

DISCUSSION

To our knowledge, this is the first study to report anthropometric characteristics during pre-season training of elite male athletes competing on National squads from boxing, cricket, swimming, hockey and eventing. The variation in anthropometric profiles between the different athletes and different sports is highlighted which may aid future monitoring and interpretation of body composition in athletes.

Normative values for Σ8SKF were reported for the various sports in this study with huge variability present. Reference ranges for swimming, boxing and cricket during pre-season training were 58 to 72 mm, 52 to 75 mm and 76 mm to 96 mm respectively. Greater within sport variation in Σ8SKF were seen for hockey at 63 mm to 101 mm and eventing at 66 mm to 114 mm. Despite Σ8SKF being recommended for use by ISAK (Marfell-Jones, 2001), as all eight skinfolds together are suggested to provide a strong correlation with the body's subcutaneous fat, limited comparative data for Σ8SKF is available. Meyer et al. (2013) suggested Σ7SKF are also regularly used by practitioners. Normative values for Σ7SKF for swimming presented in this study (Mean 52.6 mm; 95% CI [47.2-58.3]) were in line with the Σ7SKF reported by Santos et al. (2014) in which 95% CI had similarities (Mean 56.6 mm; 95% CI [50.4-62.8]). Normative values reported for cricket (Σ7SKF 70.6 ± 16.6 mm) were in line with other national level cricket players from Wales and the United Kingdom (Σ7SKF 69.7 ± 17.4 mm) (Johnstone and Ford, 2010). No comparative data appeared available for other sports highlighting the need for more standardised descriptive reporting of normative data.

Boxing had the lowest mean Σ8SKF compared to all other sports, highlighting how desirable it is for a boxer to have low fat mass with high fat free mass to achieve a high power to weight ratio (Sundgot-Borgen and Garthe, 2011). While the Σ8SKF is a useful overall indicator of subcutaneous fat, individual skinfold site thickness provide essential information on the distribution of fat with great variability seen between the sports and within the athletes. Swimming and boxing displayed similar Σ8SKF yet distribution of fat around the body varied which was evident by different skinfold site profiles. Swimming presented with greater skinfold thickness measures at the thigh compared to boxing having greater measures for the abdominal skinfold. The variation in fat may be reflective of the sport and training demands, for example the associated relationship between trunk stability and swim performance (Willardson, 2007). "Sports morphological optimisation" suggests the definitive athletes' body composition is dependent on the sport performed [28] which is evident in the current study given the apparent variability between the sports. It is worth noting that while eventing performed greater training hours weekly compared to all sports, this all was inclusive of time on the horse with varying intensities. Despite the longer training periods in this sport, the type of training demands seen in other sports may have a greater impact on body composition. Looking at individual skinfold sites in addition to Σ8SKF may be useful for practitioners when interpreting and providing guidelines to athletes.

It is well acknowledged that body composition is influenced by age, sex, genetics and ethnicity (Thomas et al., 2016) which is extremely important for practitioners and coaches to keep in mind. Swimming were significantly younger (20.7 ± 2.4 years) than eventing (35.7 ± 8.0 years) and also presented with significantly reduced Σ8SKF despite no differences in body mass reported. Variability was also seen within sports themselves. Eventing also displayed the most variations within a sporting group for age and Σ8SKF. While age may be a predictor of individual body composition, it is also important to consider training status and where within the season and athletic career one is. Variability was seen within hockey too however sample size did now allow the exploration of position specific differences which may also be apparent.

Expecting athletes to achieve body composition goals of set values for specific sports may place them at increased risk of developing relative energy deficiency syndrome (RED-S) which will ultimately lead to increased risk of infection, illness, fatigue and nutrient deficiencies amongst more serious physiological and psychological consequences ultimately reducing sports performance and severely compromising athlete health (Ackerman et al., 2019; Mountjoy, Sundgot-Borgen, Burke, Ackerman, Blauwet, Constantini et al., 2018). The associated pressure of achieving set body composition goals within high performance environment settings could even place athletes at increased risk of developing disordered eating patterns and eating disorders (Logue, Madigan, Delahunt, Heinen, Mc Donnell, and Corish, 2018). For this reason, it is important that a single and rigid "optimal" body composition should not be recommended for any group of athletes given the variability between individuals and the errors inherent in body fat assessment (Sundgot-Borgen, 2013). Normative data should always be provided in terms of ranges, ideally individualised and periodized for all athletes, which will allow individual attributes to be taken into account (Thomas et al., 2016).

The use of muscle circumferences have been highlighted as a useful anthropometric tool for estimating skeletal muscle mass (Santos et al., 2014) and another simple indicator to provide athletes with from easily accessible anthropometric measures. Swimming in this study were of the same age to those reported on in a study by Santos et al. (2014). While arm muscle circumference was comparable between the swimming, thigh (2.7cm greater) and calf (1.2cm greater) muscle circumferences in the present study were reported as greater. Swimming in the present study had a greater body mass but reduced Σ7SKF, suggesting that they had a greater whole body muscle mass compared to the other swimmers assessed. With the exception of thigh muscle circumference being different between hockey and boxing, no other apparent differences were present between the sports assessed for arm, thigh or calf muscle circumferences. The suggested similarities are interesting given comparable body mass between sports but variations in skinfold thickness. This highlights the recognised contribution of muscle mass to sports performance (Thomas et al., 2016). Further studies are required providing reference ranges for muscle circumferences in different sports.

With the varied and restricted training schedules of athletes at an elite level, assessment in a standardised manner (Kerr, Slater and Byrne, 2017) was not possible. As some method of standardisation, all athletes were assessed before midday and before consuming lunch however this is not without its limitations. Measures of skinfold thickness have been reported to remain reliable after activities or after ingesting a meal and also unaffected by changes in hydrations status (Kerr et al., 2017). Equivalent information is not available for the assessment of circumferences; therefore, it remains unknown if the lack of standardised preparation in this study impacted on the results. Reliability of body mass is acutely influenced by hydration status, gastrointestinal tract contents and muscle glycogen (Kerr et al., 2017), so variability in body mass in this study may have occurred. The athlete pool available for testing was small when recruiting elite athletes however numbers recruited within the sports groups were in line with that identified as required in the power calculation performed. Despite these limitations, results from this study provide sport-specific anthropometric profiles in elite male athletes from boxing, cricket, swimming, hockey and eventing during pre-season training. Moving forward, it would be useful to not only have sport-specific normative ranges but also weight category and position-specific too that could be used as guidelines.

Quantification of body composition is well established as a useful tool for monitoring the performance and health in all athletes (Thomas et al., 2016; Ackerman et al., 2019). Given that so many variables may influence individual body composition, it is important for it to be interpreted with the context of the athlete in mind. In addition to genetics, athlete age, training status, stage in competitive career, sporting demands, time of season and competition should all be considered when interpreting athlete data. This is highlighted in the current study not just with apparent sporting differences, but also by the varied Σ8SKF and individual skinfold site thickness seen within the athletes too. For this reason, it is important that athletes within sports are not expected to reach a specific “one size fits all target” and that ranges for body composition are provided, ideally individualised and periodized for all athletes. Data provided in this study of elite male athletes in the sports of boxing, cricket, swimming, hockey and equestrian eventing during the pre-season period of training may be of use to practitioners, coaches and scientists working with athletes. Normative ranges for elite athletes are provided to aid interpretation of individual athletes, however further normative data assessed and reported in a standardised manner is required.

CONCLUSION

While body composition is not the only contributor to athletic performance, it is identified as an essential component for health and performance (Thomas et al., 2016). Body composition data for athletes from specific sports, collected using standardised anthropometric assessment procedures and with raw values reported are limited in the literature. Often difficulties exist interpreting and using the currently available normative values for body composition and anthropometric measures given the variability in standardisation of methods and reporting of results. The anthropometric profiles for elite athletes from various sports during pre-season training will be a useful resource for sports professionals when monitoring and interpreting body composition data. Large variation exists in anthropometric profiles between the different athletes and different sports, highlighting the necessity to have sport-specific normative ranges available to allow optimal monitoring of individual athletes particularly varying across sports as well as age, training status and position.

AUTHOR CONTRIBUTIONS

SarahJane Cullen (study design, data collection writing), James Fleming (study design, writing), Danielle M Logue (data collection, writing), Joe O’Connor (data collection, writing), Brendan Connor (data collection, writing), John Cleary (data collection, writing), John A Watson (data collection, writing), Sharon M Madigan (study design, data collection, writing).

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The authors have nothing to declare regarding any potential conflicts of interest which may be perceived as prejudicing the impartiality of the research reported.

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