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Anthropometric characteristics and physical activity level of Orienteers: a pilot study

Características antropométricas e nível de atividade física de Orientistas: um estudo piloto

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Abstract — The present study aimed to describe a study protocol for Orienteers' anthropometric characteristics and physical activity level. This is an individualized, observation and cross-sectional pilot study, that has encompassed three Orienteers (2 Portuguese men and 1 Spanish woman) with mean age 22.6 ± 3.78 years and 8.0 ± 2.64 consecutive years of Orientation practice. In total, 26 anthropometric variables were assessed: four basic measurements, nine skinfolds, nine girths and four breadths; Body Mass Index was calculated, as well as body composition and somatotype (according to the Heath-Carter method). The International Physical Activity Questionnaire – Short Form was used to obtain the score expressed as metabolic equivalent and the energy expenditure in kilocalories, both during the reference week. Mean somatotype recorded for Orienteering athletes could be defined as balanced mesomorph. Scores recorded for different physical activity/ inactivity expressed domains have shown high-energy expenditure. Sports Science Professionals can use the herein proposed protocol to improve Orienteers' training.

Key words: Anthropometry; Body composition; Somatotypes.

Resumo — *Objetivou-se descrever um protocolo de estudo das características antropométricas e do nível de atividade física de Orientistas. Trata-se de um estudo piloto, caracterizado como individualizado, observacional e transversal. Participaram do estudo três Orientistas (2 homens Portugueses e 1 mulher Espanhola) com 22,6 ± 3,78 anos de idade e 8,0 ± 2,64 anos de prática consecutiva de Orientação. Foram avaliadas 26 variáveis antropométricas: quatro medidas básicas, nove dobras cutâneas, nove circunferências e quatro diâmetros ósseos; Índice de Massa Corporal foi calculado, bem como a composição corporal e o somatotipo (de acordo com o método Heath-Carter). O Questionário Internacional de Atividade Física, versão curta e auto-administrado, foi utilizado para obter a pontuação expressa como equivalente metabólico e o dispêndio energético em quilocalorias, ambos durante a semana de referência. A média do somatotipo dos atletas de Orientação pode ser definida como mesomorfo balanceado. As pontuações dos diferentes domínios da atividade física/ inatividade expressas, demonstraram um elevado dispêndio energético. Profissionais das Ciências do Esporte podem usar o protocolo proposto para melhor controle do treinamento de Orientistas.*

Palavras-chave: *Antropometria; Composição corporal; Somatotipos.*

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INTRODUCTION

Sports modality 'Orienteering' was acknowledged by the International Olympic Committee (IOC) back in 1977; it "involves an individual or team sprint in which Orienteers or Orienteers' Teams must, as fast as possible, find a series of control points (prisms) on an unknown terrain", with the aid of only a detailed topographic map and a compass[1,2].

At international level, Orienteering is tutored by the International Orienteering Federation (IOF), which was launched on May 21, 1961, in Copenhagen, Denmark. Nowadays, its headquarters is settled in Karlstad, Sweden; moreover, it counts on 76-member countries[2].

IOF manages four Orienteering disciplines: 1) Foot orienteering (FootO): Sprint (Running time of the winner: 12-15 minutes), Middle Distance (32-38 minutes), Long Distance (Women: 80-90 minutes; Men: 100-120 minutes) and Relay (consists of two team competitions, men and women's relay). Each relay has 3 legs. All teams start at the same time, in mass start; courses are forked, which means that competitors running the same leg may have different controls; therefore, after all 3 legs, all teams have run the same course, in total. Approximate combined winning time for all three legs is 1 hour 45 min. The first team to finish wins; 2) Mountain Bike or MTB (MTB orienteering); 3) Ski orienteering (SkiO); and 4) Trail orienteering (TrailO) - which is destined to people with different disabilities, although they are often open to all[2].

Despite the broad outspread of Orienteering worldwide, more representative studies to contribute to the ideal performance of athletes in this sports modality remain scarce; except for two recent studies, one that has tried to set differences between Running athletes (RA) and Orienteers according to several motor coordination components, regardless of nationality[3], and another one whose aim was to assess differences in physical and cognitive performance, affective states, perceived exertion, and physiological responses across tests with cognitive, physical, or combined cognitive and physical load[4].

Data on human body's measurable features gotten according to standardization by the International Society for the Advancement of Kinanthropometry (ISAK)[5] to Orienteering athletes (OA) are even lesser frequent, and this is different from the most recent information available for RA[6], which is the sports modality most similar to Orienteering.

However, to the best of our knowledge, none of these studies have assessed anthropometric profile and Physical Activity Level (PAL) in OA, which are often analyzed parameters for several populations.

Fulfilling this knowledge gap may provide reference values set for anthropometric characteristics linked to body composition and OA somatotype, as well as contribute to enhance the prescription of exercising/ training and diet programs, besides monitoring the acute and chronic effects from interventions, which are partially modelling factors for Orienteering's excellency[7]. Thus, the aim of the present study was to describe a protocol to study OA's anthropometric characteristics and PAL, though a pilot study conducted to find preliminary results capable of allowing sample size estimates for future studies.

METHOD

Participants

Three OA (two Portuguese men and one Spanish woman; mean ± standard deviation (SD) age: 22.6 ± 3.78 years; body mass: 67.5 ± 3.50 kg; height: 174.3 ± 6.29 cm; 8.0 ± 2.64 years of consecutive Orienteering practice in the FootO discipline), free from injuries and medical and/or pharmacological treatments, currently training from 2 to 8, or more, hours per week, at international competition level, have voluntarily participated in this pilot study. This study was submitted to and approved by the Faculty of Human Kinetics Research Ethics Committee/ University of Lisbon and the protocol (no. 13/2022) was written in accordance with the standards set by the Declaration of Helsinki[8].

Initially, sample size (n) was calculated according to the population (N) of 675 OA "from Lisbon and Tejo Valley Region", back in 2021, based on the Portuguese Orienteering Federation (FPO)[9] ("SERVICES" - "CLUBS" – FILTERS - "Name / acronym": blank - "License": FPO - "Country": Portugal - "Region": Lisbon and Tejo Valley - "Details": selected). Thus, confidence level of 95% was adopted to the sampling calculation, as well as associated critical value of 1.96 (Z-score), ± 5% error margin and population with heterogeneous features (p = 0.5)[10]. Inclusion criteria set for all subjects were being OA with valid license in FPO, being in the age group 20 to 40 years, without metabolic disease or any disease that could affect body fat, not having taken hormone treatment or corticoids in the three months prior to the anthropometric assessment, except for contraceptives. All volunteers were informed about study procedures and agreed to participate in it by signing the informed consent form, which was forwarded by email, by FPO. Data collection process applied to demographic and physical activity characteristics was based on online electronic scheme built on Google Forms© by the researchers. Data of all OA's were collected on a single day, at Portugal Absolute National Championship in 2022, in appropriate location, between 6.30 a.m. and 10.00 p.m.

Procedures

Anthropometric measurements

Anthropometric measurements were taken by following standardized techniques adopted by ISAK[5], under basal conditions, including anthropometric landmarks before measuring and measurements in duplicate, a third measurement on skinfolds that obtained difference between measurements larger than 5% for skinfolds or 1% for the basic measurements was performed. The final value for the data analysis was the mean if two measurements were taken or the median if three measurements were taken. It means that circumstances that affect skinfold measurements' thickness and compressibility, such as previous exercising, baths, sauna sessions or dehydration states, were avoided. Participants were measured barefoot, shirtless and with shorts on. All measurements were taken by the same appraiser, who was an ISAK level 3 Anthropometrist[11], and adopted hygienic-sanitary care against COVID-19[12]. Twenty-six anthropometric variables were measured for each subject, namely: four basic measurements (weight or body mass, height, sitting height, arms span), thickness of nine

skinfolds (pectoral - according to procedures described by Liguori et al.[13] -, triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and calf); nine girths (neck, relaxed arm, flexed and tensed arm, chest, waist, hips, thigh middle, calf and ankle), and four breadths (humerus, bi-styloid, femur and bimalleolar). Body mass was measured using a portable scale with a capacity of 250 kg and a sensitivity of 1000 g (model 760, SECA gmbh & co. kg, Hamburg, Germany) and height and sitting height were measured on a portable stadiometer with an accuracy of 0.1 cm, with the head in the Frankfort plane (model 213, SECA gmbh & co. kg, Hamburg, Germany). Arms span was measured with measure tape, at 0.1 cm accuracy. Girths measurements were taken by using flexible anthropometric steel tape, at 0.1 cm accuracy (ROSSCRAFT INNOVATIONS, Spokane, USA), breadths measurements were taken in ROSSCRAFT CAMPBELL 10, at small bone caliper (ROSSCRAFT INNOVATIONS, Spokane, USA), and 0.1 cm accuracy, and skinfold thickness was measured in ROSSCRAFT SLIM GUIDE skinfold caliper, calibrated at 0.5 mm accuracy (ROSSCRAFT INNOVATIONS, Spokane, USA). CESCORF segmometer (CESCORF, Porto Alegre, Brazil) was used to mark the anthropometric reference points (0.1 cm), with the aid of dermatograph pencil.

Body Mass Index (BMI) was calculated as weight (kg) to height squared (m^2) quotient[14]. Body density (BD) was estimated by using specific equations for male[15] and female[16] athletes. BD was transformed into body fat (BF) percentage using equations specific for each sex[13]. Bone mass (BM) and muscle mass (MM) were determined in kg through the methods by Martin[17] and Lee et al.[18], respectively. Somatotype was determined through the Heath-Carter anthropometric method[19] and calculations were performed in Somatotype 1.2.5. software (Figure 1). The tool known as ISAK Metry[20] was adopted to issue individual anthropometric reports for each OA (Profile Restricted ISAK, by calculating the sum of skinfolds, corrected girths, body composition at 2 to 4 component fractionation, somatotype, proportionality indices and Z indices).

Body composition

$$\begin{aligned} &Body\ density(BD)\ for\ male = 1.078865 - 0.000419 \times (\Sigma\ 4\ skinfolds) + 0.000948 \\ &(girth\ neck) - 0.000266 \times (age:\ in\ decimal\ years) - 0.000564 \times (girth\ ankle) \end{aligned} \quad (1)$$

Where: Σ 4 skinfolds for male = (abdominal + thigh + calf + pectoral); Girths: cm; Skinfolds: mm.

$$\begin{aligned} &Body\ density(BD)\ for\ female = 1.14075 - 0.04959 \times (log_{10} \Sigma\ 4\ skinfolds) + 0.00044 \times (age:\ in\ decimal\ years) \\ &-0.000612 \times (girth\ waist) + 0.000284 \times (height) - 0.000505 \times (girth\ hips) + 0.000331 \times (girth\ chest) \end{aligned} \quad (2)$$

Where: Σ 4 skinfolds for female = (triceps + subscapular + supraspinal + calf); Height: cm; Girths: cm; Skinfolds: mm.

$$\%\ Body\ fat\ for\ male = \left[(4.95 / body\ density) - 4.50\right] \times 100 \quad (3)$$

$$\%\ Body\ fat\ for\ female = \left[(4.96 / body\ density) - 4.51\right] \times 100 \quad (4)$$

$$Bone\ mass(BM)(kg) = 0.00006 \times height \times (\Sigma\ 4\ breadths)^2 \quad (5)$$

Where: Σ 4 breadths = (humerus + bi-styloid + femur + bimaleolar); Height: cm; Breadths: cm.

$$Muscle\ mass\,(MM)(kg) = height \times \left(0.00744 \times CAG^2 + 0.00088 \times CTG^2 + 0.00441 \times CCG^2\right) + \left(2.4 \times gender\right) - 0.048(age\ in\ years) + race + 7.8 \quad (6)$$

Where: CAG (cm) = corrected arm girth (relaxed) = arm girth relaxed – (3.1416 x skinfold triceps/10); CTG (cm) = corrected thigh girth (middle) = thigh girth middle – (3.1416 x skinfold thigh/10); CCG (cm) = corrected calf girth = calf girth – (3.1416 x skinfold calf/10); Sex = 0 for female; and 1 for male; Race = -2 for Asians; 1.1 for African Americans; and 0 for Whites and Hispanics; Height: m; Girths: cm; Skinfolds: mm.

Somatotype

$$Endomorphy = -0.7182 + 0.1451 \times \left(\sum 3\ skinfolds \times 170.18 / height\right) - 0.00068 \times \left(\sum 3\ skinfolds \times 170.18 / height\right)^2 + 0.0000014 \times \left(\sum 3\ skinfolds \times 170.18 / height\right)^3 \quad (7)$$

Where: ∑ 3 skinfolds = (triceps + subscapular + supraspinal); Skinfolds: mm; Height: cm.

$$Mesomorphy = 0.858 \times \left(humerus\ breadth\right) + 0.601 \times \left(femur\ breadth\right) + 0.188 \times CAG + 0.161 \times CCG - 0.131 \times \left(height\right) + 4.5 \quad (8)$$

Where: CAG (cm) = corrected arm girth = flexed and tensed arm girth – (triceps skinfold/10); CCG (cm) = corrected calf girth = calf girth – (skinfold calf/10); Breadths: cm; Height: cm; Girths: cm; Skinfolds: mm.

$$Ectomorphy = \left(HWR \times 0.732\right) - 28.58 \quad (9)$$

Where: (HWR) = height/$\sqrt[3]{}$weight.
Note: if HWR > 40.75, then Ectomorphy = HWR x 0.732 – 28.58; if HWR > 38.25, but < 40.75, then Ectomorphy = HWR x 0.463 – 17.63; and if HWR ≤ 38.25, then Ectomorphy = 0.1. A three-number somatotype rating was plotted in two-dimensional somatochart, by using X and Y coordinates. Coordinates were calculated as follows:

$$X = ectomorphy - endomorphy$$
$$Y = 2 \times mesomorphy - \left(endomorphy + ectomorphy\right). \quad (10)$$

Where: HWR: height-weight ratio; Height: cm; Weight: kg.

Physical activity

Physical activity was assessed based on the short version of the self-reported International Physical Activity Questionnaire – Short Form (IPAQ-SF)[21].

IPAQ-SF consists of eight open questions that allow estimating the time spent (per week) on different physical activity domains (walking and physical effort from moderate to vigorous intensity) and physical inactivity (sitting)[21].

IPAQ-SF validity and re-producibility have been tested in numerous countries, including Portugal[22].

IPAQ-SF data can also be used to estimate the score expressed as metabolic equivalent (MET)[21,23], in minutes per week (MET-min/week). This process makes it easier to compare continuous variables found with the aid of instruments such as accelerometers and physical fitness measures[24].

Total physical activity score was herein created based on the aforementioned criterion to report continuous physical activity data.

Total physical activity score was calculated by multiplying METs recorded for each activity type by the minutes spent (per week)[21]. The volume observed for each activity type was calculated by weighting its energy requirements: walking, 3.3 METs; moderate activity, 4.0 METs; vigorous activity, 8.0 METs. The sum of products found for each physical activity type gave origin to the total physical activity score (walking + moderate physical activity + vigorous physical activity = total physical activity score)[21]. Values lower than 10 minutes of physical activity (per day) were not included in the calculation; they were re-coded to "zero', since scientific evidence indicates that physical activity sessions shorter than 10 minutes do not lead to health benefits[21]. Cases whose total physical activity score exceeded 960 minutes (16 hours per day) were considered outliers; they were excluded from the analysis[21]. Categorical and continuous IPAQ-SF data processing and analysis have followed official guidelines[21].

Statistical analysis

Standard descriptive statistics, such as mean and standard deviation (SD), were used to present participants' characteristics for the variables. Microsoft Excel® 2013 software was used to build the database. Considering the small sample size it was not relevant to assess comparisons or associations between the variables in this study. Therefore, no additional inferential statistics have been applied.

RESULTS

Study sample data are shown in Table 1.

Table 1. Anthropometric, demographic and performance characteristics (mean ± SD) recorded for Orienteering athletes (n = 3).

Variable	Athlete 1	Athlete 2	Athlete 3	Mean ± SD
Demographic data				
Country	Portugal	Spain	Portugal	-
Sex	Male	Female	Male	-
Ethnicity	Caucasian	Caucasian	Caucasian	-
Age (years)	20	27	21	22.6 ± 3.78
OP (years)	10	5	9	8.0 ± 2.64
Anthropometry				
Basic measurements				
Body mass (kg)	71	67.5	64	67.5 ± 3.50
Height (cm)	181	168.5	173.5	174.3 ± 6.29
Sitting height (cm)	90	85.7	86.5	87.4 ± 2.28
Arms span (cm)	285	271	270.8	275.6 ± 8.14
Skinfolds (mm)				
Pectoral	4	8.5	5	5.8 ± 2.36
Triceps	7	14.5	12	11.1 ± 3.81
Subscapular	8	10	10	9.3 ± 1.15
Biceps	4	4	4	4.0 ± 0.00

Note: SD: standard deviation; OP: orienteering practice; kg: kilogram; cm: centimeter; mm: millimeter; BF: body fat; %: percentage value; BM: bone mass; MM: muscle mass; BMI: Body Mass Index; m^2: squared meter; HWR: height-weight ratio; IPAQ-SF: International Physical Activity Questionnaire - Short Form; MET: metabolic equivalent; min: minute; kcal: kilocalorie; MPA: moderate physical activity; VPA: vigorous physical activity; WPAL: weekly physical activity level.

Table 1. Continued...

Variable	Athlete 1	Athlete 2	Athlete 3	Mean ± SD
Iliac crest	12	21.5	10	14.5 ± 6.14
Supraspinal	6	7	7	6.6 ± 0.57
Abdominal	10	12	13	11.6 ± 1.52
Thigh	6	25	15	15.3 ± 9.50
Calf	6	9	8	7.6 ± 1.52
Sum of 6 skinfolds	43	77	65	61.6 ± 17.24
Sum of 8 skinfolds	59	102.5	79	80.1 ± 21.77
Girths (cm)				
Neck	35.5	32.4	37.9	35.2 ± 2.75
Relaxed arm	29	26.9	27.8	27.9 ± 1.05
Flexed and tensed arm	31	28	29.9	29.6 ± 1.51
Corrected arm	26.8	22.5	24.2	24.5 ± 2.17
Chest	103.5	91	95.5	96.6 ± 6.33
Waist	74	72.6	73.5	73.3 ± 0.70
Hips	94	98.2	90	94.0 ± 4.10
Thigh middle	52	54	48.2	51.4 ± 2.94
Corrected thigh middle	50.2	46.1	43.5	46.6 ± 3.37
Calf	35	37.6	34.6	35.7 ± 1.62
Corrected calf	33.1	34.7	32	33.2 ± 1.35
Ankle	23.6	23.2	23.7	23.5 ± 0.26
Breadths (cm)				
Humerus	6.6	5.9	6.3	6.2 ± 0.35
Bi-styloid	5.5	4.8	5.5	5.2 ± 0.40
Femur	9.9	8.8	9.4	9.3 ± 0.55
Bimalleolar	6.9	6.8	7	6.9 ± 0.10
Body composition				
BF (%)	7	18.3	8.9	11.4 ± 6.05
BM (kg)	9	6.9	8.2	8.0 ± 1.05
MM (kg)	31.6	24.9	27.4	27.9 ± 3.38
BMI (kg/m2)	21.6	23.7	21.2	22.1 ± 1.34
Somatotype				
Endomorphy	1.9	3.3	2.9	2.7 ± 0.72
Mesomorphy	3.6	3.7	3.7	3.6 ± 0.05
Ectomorphy	3.4	1.7	3.2	2.7 ± 0.92
HWR	43.7	41.3	43.3	42.7 ± 1.28
IPAQ-SF				
Walking				
MET-min/week	149	1.386	1.386	973.6 ± 714.18
kcal/week	184.5	1.637.2	1.552.3	1.124.6 ± 815.31
MPA				
MET-min/week	1.680	240	360	760.0 ± 798.99
kcal/week	2.087.4	283.5	403.2	924.7 ± 1.008.70
VPA				
MET-min/week	960	2.880	0	1.280.0 ± 1.466.42
kcal/week	1.192.8	3402	0	1.531.6 ± 1.726.11
Walking+MPA+VPA				
MET-min/week	2.789	4.506	1.746	3.013.6 ± 1.393.64
kcal/week	3.464.7	5.322.7	1.955.5	3.580.9 ± 1.686.60
WPAL	high	high	moderate	-

Note: SD: standard deviation; OP: orienteering practice; kg: kilogram; cm: centimeter; mm: millimeter; BF: body fat; %: percentage value; BM: bone mass; MM: muscle mass; BMI: Body Mass Index; m^2: squared meter; HWR: height-weight ratio; IPAQ-SF: International Physical Activity Questionnaire - Short Form; MET: metabolic equivalent; min: minute; kcal: kilocalorie; MPA: moderate physical activity; VPA: vigorous physical activity; WPAL: weekly physical activity level.

Mean BF, BM, MM and somatotype for the assessed OA were 11.4 ± 6.05%, 8.0 ± 1.05 kg, 27.9 ± 3.38 kg and 2.7 (± 0.72)-3.6 (± 0.05)-2.7 (± 0.92) - they could be defined as balanced mesomorph -, respectively. Two presented somatotype mesomorph-ectomorph and one central. Figure 1 presents a somatochart for OA overall.

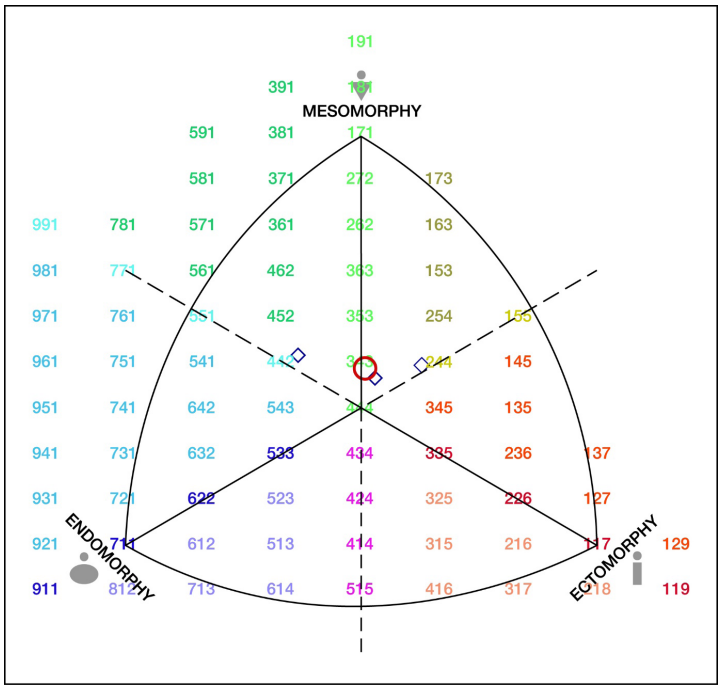

Figure 1. Somatotype profile distribution of Orienteering athletes (n = 3). Squares are individual somatotypes and the red circle is the mean profile.

Mean total physical activity (Walking+MPA+VPA) values recorded for the assessed participants were 3.013.6 ± 1.393.64 MET-min/week and 3.580.9 ± 1.686.60 kcal/week.

DISCUSSION

The aims of the present study were to describe a protocol to investigate Orienteers' anthropometric characteristics and PAL, and to find preliminary results for future studies. To be best of our knowledge, the current study was the first investigation based on participants' sex.

The main conclusion regards similarity in the anthropometric profile of recently investigated OA and RA[6,25]. It is known that Orieenteers' performance is mainly set by the aerobic component, which is intertwined by moments of anaerobic[26] and physiological demands also imposed to RA. However, speculation advocates that Orienteers have developed a better economy of sprints due to the constant need of adjustments in running techniques for different terrain types3, since this modality is a cross-country type event.

Scores of different physical activity/ inactivity domains expressed as MET-min/week have shown high-energy expenditure, but it was not possible finding a similar study for Orienteers' human performance for comparison purposes. However, it is likely speculating that OA's excellent physical skills can lead them to positive outcomes in Orienteering competitions.

It is worth highlighting that Orienteering differs from other sports modalities due to the influence of Orienteers' cognitive parameters and expertise; however, certain success predictors in the modality[27] can also be determining factors for Orienteering performance[26]. Accordingly, further studies must assess these variables to fulfil the gaps in the literature about the association among several demanding aspects in Orienteering investigated in the current study, or not.

The main contribution from the present study lies on the high quality of the assessed participants, who were OA with national and international experience in championships. Study limitations include its cross-sectional design, which prevents conclusions guided by association, as well as the small number of OA's. Results from a similar protocol can provide a reference frame, but they should not be used as fixed model to achieve better performances. Thus, the present results can be used, in the future, as standard references; however, they should be interpreted with caution, based on individual features and needs.

We suggest attending annual events, such as the "Portugal "O" Meeting" and the "Murcia Costa Cálida International Trophy", for data collection purposes, so that one could monitor the seasonal evolution of anthropometry and OA's human performance. Furthermore, we understand that our protocol can be used in collaborator networks worldwide.

CONCLUSION

The herein described protocol can provide reference values for anthropometric characteristics, body composition and somatotype scores for different OA's physical activity/ inactivity (MET-min/week) domains. Therefore, normative data can help coaches with OA's training.

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COMPLIANCE WITH ETHICAL STANDARDS

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Ethical approval

Ethical approval was obtained from the University of Lisbon/ Faculty of Human Kinetics Research Ethics Committee and the protocol (no. 13/2022) was written in accordance with the standards set by the Declaration of Helsinki.

Conflict of interest statement

The authors have no conflict of interests to declare.

Author Contributions

Conception and design of the experiment: VSS, FV; Realization of the experiments: VSS, FV; Data analysis: VSS, IS; Article Writing: VSS, FV, IS, EDR, HEI. All authors read and approved the final version of the manuscript.

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