Body Composition and Somatotype of Athletes in the Chilean Sport Talent Development Program

Carlos Bahamondes-Avila[1], Jaime Cárcamo-Oyarzún[2], Esteban Aedo-Muñoz[3], Claudio Hernandez-Mosqueira[2], Cristian Martínez-Salazar[2], Marcelo Rosas-Mancilla[4], Pedro Delgado-Floody[2], Felipe Caamaño-Navarrete[5], Daniel Jerez-Mayorga[6]

[1]Escuela de Kinesiología, Facultad de Medicina y Ciencias de la Salud, Universidad Mayor, Temuco, Chile. [2]Department of Physical Education, Sport and Recreation, Universidad de La Frontera, Temuco, Chile. [3]Universidad de Santiago de Chile. [4]Instituto Nacional de Deportes. Centro de Entrenamiento Regional. Centro de Evaluación Funcional. Región de Aysén. Chile. [5]Pedagogía en Educación Física, Universidad Autónoma de Chile, Temuco, Chile. [6]Escuela de Kinesiología. Facultad de Ciencias de la Rehabilitación. Universidad Andrés Bello. Santiago. Chile.

doi: 10.18176/archmeddeporte.00126

Recibido: 15/04/2020
Aceptado: 23/11/2020

Summary

Introduction: Determining the body composition and somatotype in sport talents provides a useful reference to improve the trajectory toward high-level competition.
Objective: The aim of this study is to determine the body composition and somatotype by discipline of children and adolescents of both genders in the sport talent development program at the Regional Training Center.
Material and method: Seventy-two subjects participated (29 females, 15.9 ± 2.0 years; 43 males, 15.9 ± 2.3 years) from the disciplines of athletics, cycling, judo, karate, and table tennis. a) Baseline measurements: weight, height, and body mass index (BMI); b) Body masses by fractioning into five components (in %): muscle, fat, bone, residual and skin, using Kerr's method and c) Somatotype, according to the model proposed by Heath and Carter were performed.
Results: Females have a higher percentage of fat mass than males. Exactly the opposite occurs with muscle mass, where males present a higher percentage than females, with the exception of table tennis. Regarding residual mass, males present higher values in all the disciplines. The males were classified as endo-mesomorphs, except for those in athletics, who were classified as ecto-mesomorphs, while the females from athletics and table tennis were classified as central, those from cycling and judo as endomorph–mesomorphs, and those from karate as meso-endomorphs.
Conclusion: Through a two-dimensional contrast of the somatotype of CER athletes and that of adult athletes at the High Performance Center in Chile, it was determined that both groups are different, indicating that CER athletes do not yet meet the structural requirements necessary for a trajectory to high-level competition, suggesting that training modifications be considered to get closer to the ideal somatotype.

Key words:
Anthropometry. Somatotypes. Body composition. Athletes. Sports.

Composición corporal y somatotipo de los atletas del programa de desarrollo de talentos deportivos chilenos

Resumen

Introducción: Determinar la composición corporal y el somatotipo en los talentos deportivos es una referencia útil para mejorar la trayectoria hacia la competición de alto nivel.
Objetivo: El objetivo de este estudio es determinar la composición corporal y el somatotipo por disciplina de los niños y adolescentes de ambos géneros en el programa de desarrollo de talentos deportivos del Centro de Entrenamiento Regional.
Material y método: Participaron setenta y dos sujetos (29 mujeres, 15,9 ± 2,0 años; 43 hombres, 15,9 ± 2,3 años) de las disciplinas de atletismo, ciclismo, judo, karate y tenis de mesa. Se realizaron las siguientes evaluaciones a) peso, altura e índice de masa corporal (IMC); b) Masas corporales fraccionadas en cinco componentes (en %): músculo, grasa, hueso, residual y piel, utilizando el método de Kerr y c) somatotipo, según el modelo propuesto por Heath y Carter.
Resultados: Las mujeres tienen un mayor porcentaje de masa grasa que los hombres. Exactamente lo contrario ocurre con la masa muscular, donde los hombres presentan un porcentaje mayor que las mujeres, con la excepción del tenis de mesa. En cuanto a la masa residual, los hombres presentan valores más altos en todas las disciplinas. Los hombres se clasificaron como endo-mesomorfos, excepto los de atletismo, que se clasificaron como ecto-mesomorfos, mientras que las mujeres de atletismo y tenis de mesa se clasificaron como centrales, las de ciclismo y judo como endomorfas-mesomorfas, y las de karate como meso-endomorfas.
Conclusión: Mediante un contraste bidimensional del somatotipo de los atletas del CER y el de los atletas adultos del Centro de Alto Rendimiento de Chile, se determinó que ambos grupos son diferentes, lo que indica que los atletas del CER no cumplen aún con los requisitos estructurales necesarios para una trayectoria hacia la competencia de alto nivel, sugiriendo que se consideren modificaciones del entrenamiento para acercarse al somatotipo ideal.

Palabras clave:
Antropometría. Somatotipo. Composición corporal. Atletas. Deportes.

Correspondencia: Daniel Jerez-Mayorga
E-mail: daniel.jerez@unab.cl

Introduction

Using several anthropometric studies conducted on elite athletes, precise data have been obtained on the structural requirements needed in the different disciplines, as there are morphological characteristics that will be selective in the development of top-level sports[1,2]. Anthropometry not only enables the design of physical activity and training programs, but it is also useful as a predictive measure in identifying sport talents[3]. Thus, although all individuals have similar training conditions, both qualitatively and quantitatively, those athletes with more favorable morphological conditions for sports would perform better[4,5]. Even the anthropometric characteristics and state of maturation have been considered as predictors of success in young athletes[6]. Consequently, the information that can be obtained from these evaluations acquires great importance for the trajectory of sport talents toward high-level competition. Accordingly, the Chilean government program responsible for detecting, selecting, and developing sport talents, called the "National Sport Projection – Regional Training Centers (*Centro de Entrenamiento Regional* -CER- in Spanish) Program)" and dependent on the National Sports Institute of Chile, establishes as part of its technical guidelines certain training processes with technical instruments for detecting and developing talent, including periodic anthropometric assessments[7]. However, although there are multiple anthropometric studies on children and adolescents in schools[8], there is little information about the morphological characteristics of boys and girls who train regularly[9] and who are considered potential sport talents to enable the definition of a characteristic anthropometric profile by gender and sport. Therefore, the aim of this study is to determine the body composition and somatotype by discipline of children and adolescents of both genders in the sport talent development program at the Regional Training Center in (CER).

Materials and method

Sample

Seventy-two subjects participated in the study (29 females, 15.9 ± 2.0 years; 43 males, 15.9 ± 2.3 years) belonging to athletics, cycling, karate, table tennis, and judo who are part of the sport talent development program at the CER. They train a minimum of 10 hours per week and regularly participate in official competitions of the respective national federations. The study followed the guidelines of the Declaration of Helsinki with respect to the ethical principles of human research: each athlete participated voluntarily; signed an informed assent and consent form; had the permission of their parents, coaching staff, and respective physician.

Instrument and Procedures

The assessments were carried out by a level I anthropometrist certified by the International Society for the Advancement of Kinanthropometry (ISAK) and supervised by a level III instructor. Every six months during the measurement process, standardization of the measurements was checked with 20 subjects of similar physical characteristics, obtaining a technical error of measurement (%TEM) for the evaluating anthropometrist of 0.68% in the diameters, 0.43% in the perimeters, and 3.57% in the skin folds. The procedures were routinely performed during the annual sports season, establishing by protocol that these were outside the training schedule, with no sport practice for at least 24 hours, with a food intake of more than four hours prior, and with gastric and bladder emptying prior to the assessment. The ISAK assessment protocol was followed[10], measuring 25 variables, using a Seca® 769 electronic column scale with an accuracy to 100 grs., a Seca® 217 stadiometer with an accuracy to 1mm, a Harpenden skinfold caliper with an accuracy to 0.2 mm, two Campbell sliding calipers with long and short branches, and a Rosscraft anthropometric tape measure, all from Rosscraft, and a Gaucho Pro model with an accuracy to 1mm. With this, the following variables of interest were determined individually: a) Baseline measurements: weight, height, and body mass index (BMI); b) Body masses by fractioning into five components (in %): muscle, fat, bone, residual and skin, using Kerr's method[11] ; and c) Somatotype, according to the model proposed by Heath and Carter[12], Using the concepts of classification that correspond to the literal translation of the original work.

Statistical Analyses

All the variables were grouped by sport in addition to being divided by gender. For their descriptive analysis, the means and standard deviations were recorded by discipline and gender. The Kolmogorov-Smirnov test was applied to assess the level of normality of the data. The statistical program SPSS 17.0 was used to develop these tests.

Results

Table 1 presents the anthropometric characteristics of the baseline measurements in the athletes belonging to the sport talent development program at the CER, distributed by sport, according to gender. Regarding the variable BMI, only in judo do females present values slightly higher than males.

Table 2 show the results corresponding to the body composition fractionated into five components. With the exception of table tennis, females have a higher percentage of fat mass than males. Exactly the opposite occurs with muscle mass, where males present a higher percentage than females, with the exception of table tennis. Regarding residual mass, males present higher values in all the disciplines. In terms of bone mass, males present a percentage higher than females, whereas in skin mass none of the disciplines have significant differences between the two genders.

With reference to the calculation of the somatotype of the athletes in the CER, Table 3 shows the values distributed according to discipline for both genders. A review of the somatotype classification reveals that all males are in the endo-mesomorph category, with the exception of males in athletics, who are in the ecto-mesomorph category. The female athletes in athletics and table tennis are in the central category, those in cycling and judo in the endomorph–mesomorph category, and those in karate are classified as meso-endomorph.

Figures 1 and 2 contain somatocharts with the somatopoints of the athletes from each of the disciplines at the CER, distributed for females and males, respectively.

Table 1. Baseline anthropometric measurements of the athletes in the CER Program, according to their discipline.

Disciplines	Gender	n	Age		Weight		Height		BMI	
			M	±	M	±	M	±	M	±
Athletics	F	10	15.42	1.56	52.63	7.26	161.39	4.03	20.21	2.83
	M	5	15.8	1.54	63.42	7.29	172.68	10.87	21.36	2.54
Cycling	F	7	15.93	1.98	55.13	8.58	157.31	7.1	22.17	2.11
	M	8	16.41	1.49	66.28	5.27	170.35	6.15	22.93	2.52
Judo	F	8	17.56	1.63	64.71	7.33	158.19	5.39	25.8	1.87
	M	12	17.1	2.53	69.32	8.96	170.1	6.21	24.03	3.46
Karate	F	2	14.3	1.56	54.6	7.35	156.5	2.12	22.35	3.61
	M	6	13.93	1.57	54.28	11.47	154.78	11.08	22.52	3.18
Table Tennis	F	2	13	0.42	45.75	5.3	152.65	1.2	19.6	1.98
	M	12	15.23	2.29	58.38	12.76	163.72	10.56	21.52	2.79

BMI: Body Mass Index; M: Mean; ±: Standard deviation.

Table 2. Body masses expressed as percentages of the athletes in the CER Program, according to their discipline.

Disciplines	Gender	n	% fat mass		% muscle mass		% mass residual		% bone mass		% skin mass	
			M	±	M	±	M	±	M	±	M	±
Athletics	F	10	31.67	2.99	41.01	2.27	9.38	0.8	11.56	1.00	6.38	0.69
	M	5	24.29	3.57	45.43	3.49	11.41	0.84	12.69	0.85	6.19	0.55
Cycling	F	7	32.39	3.45	41.18	3.26	10.07	1.2	10.47	0.9	5.88	0.41
	M	8	26.57	4.43	44.62	3.08	10.79	1.14	12.31	1.8	5.72	0.44
Judo	F	8	33.1	2.29	41.24	1.8	10.22	1.00	10.11	0.71	5.32	0.32
	M	12	22.55	4.09	48.42	4.17	11.71	1.06	11.91	1.08	5.42	0.58
Karate	F	2	33.61	0.57	42.01	0.78	9.48	0.95	8.93	0.45	5.98	0.71
	M	6	25.52	5.18	44.75	3.48	11.31	2.07	12.58	1.21	5.85	0.62
Table Tennis	F	2	29.5	3.46	42.52	0.63	9.86	1.08	11.62	0.92	6.51	0.83
	M	12	29.15	4.21	42.81	3.57	10.28	1.19	11.97	1.36	5.79	0.69

M: Mean; ±: Standard deviation.

Table 3. Somatotype of the athletes in the CER Program, according to their discipline.

Disciplines	Gender	n	Endo		Meso		Ecto		X	Y	Categoría
			M	±	M	±	M	±			
Athletics	F	10	3.25	1.49	3.16	0.75	3.12	1.27	-0.16	-0.08	Central
	M	5	2.02	0.67	4.04	1.28	3.18	1.68	1.14	2.92	Ecto-Mesomorph
Cycling	F	7	4.34	0.91	4.04	0.84	1.81	0.84	-2.54	1.93	Endo-Mesomorph
	M	8	3.09	1.61	4.75	0.64	2.31	1.34	-0.75	4.09	Endo-Mesomorph
Judo	F	8	5.5	0.75	5.25	0.64	0.65	0.46	-4.86	4.35	Endo-Mesomorph
	M	12	2.58	1.2	5.5	1.27	1.96	1.77	-0.61	6.46	Endo-Mesomorph
Karate	F	2	4.5	1.27	3.7	1.27	1.8	1.56	-2.65	1.2	Meso-Endomorph
	M	6	3.28	1.76	5.52	0.76	1.72	1.06	-1.55	6.02	Endo-Mesomorph
Table Tennis	F	2	3	1.27	3.6	0.42	2.7	0.99	-0.3	1.45	Central
	M	12	3.28	1.21	4.92	0.7	2.54	0.96	-0.74	3.98	Endo-Mesomorph

Ecto: Ectomorphy; Meso: Mesomorph; Endo: Endomorphy.

Table 4. Somatotype values of athletes in the CER Program contrasted with the somatotype values of athletes in the CAR.

Disciplines	Gender	Study	n	Endo	Meso	Ecto	X	Y	Category	SDD of SM
Ciclyng	F	CER	7	4.34 ± 0.9	4.04 ± 0.8	1.81 ± 0.8	-2.54	1.93	Endo-Mesomorph	2.95
		CAR	7	3.8 ± 1.8	1.7 ± 4.7	1.9 ± 1.5	-1.3	-0.09	Endomorph Balanced	
	M	CER	8	3.09 ± 1.6	4.75 ± 0.6	2.31 ± 1.3	-0.75	4.09	Endo-Mesomorph	2.11
		CAR	6	3.0 ± 1.3	5.7 ± 1.3	2.0 ± 1.2	-0.7	6.2	Endo-Mesomorph	
Judo	F	CER	8	5.50 ± 0.8	5.25 ± 0.6	0.65 ± 0.5	-4.86	4.35	Endo-Mesomorph	5.55
		CAR	3	3.6 ± 1.3	6.5 ± 0.5	0.7 ± 0.3	-2.8	8.6	Endo-Mesomorph	
	M	CER	12	2.58 ± 1.2	5.50 ± 1.3	1.96 ± 1.8	-0.61	6.46	Endo-Mesomorph	5.23
		CAR	4	2.6 ± 0.3	3.2 ± 7.3	1.5 ± 0.9	-2.2	10.9	Endo-Mesomorph	
Karate	F	CER	2	4.50 ± 1.3	3.70 ± 1.3	1.80 ± 1.6	-2.65	1.2	Meso-Endomorph	4.95
		CAR	2	3.1 ± 0.2	5.2 ± 0.07	1.4 ± 0.3	-1.6	5.8	Endo-Mesomorph	
	M	CER	6	3.28 ± 1.8	5.52 ± 0.8	1.72 ± 1.1	-1.55	6.02	Endo-Mesomorph	3.75
		CAR	3	3.0 ±1.0	5.8 ± 0.6	1.5 ± 0.4	-3	8.8	Endo-Mesomorph	
Table Tennis	F	CER	2	3.00 ± 1.3	3.60 ± 0.4	2.70 ± 1.0	-0.3	1.45	Central	4.04
		CAR	5	4.6 ± 0.7	4.4 ± 0.7	1.9 ± 0.8	-2.6	2.1	Endo- Mesomorph	
	M	CER	12	3.28 ± 1.2	4.92 ± 0.7	2.54 ± 1.0	-0.74	3.98	Endo-Mesomorph	4.48
		CAR	6	4.4 ± 1.6	4.0 ± 6.6	1.2 ± 1.7	0.5	7.9	Endo-Mesomorph	

CAR: High Performance Center; CER: Regional Training Center; Ecto: Ectomorphy; Meso: Mesomorph; Endo: Endomorphy.

Figure 1. Somatotype of the female athletes in the CER Program, according to their discipline.

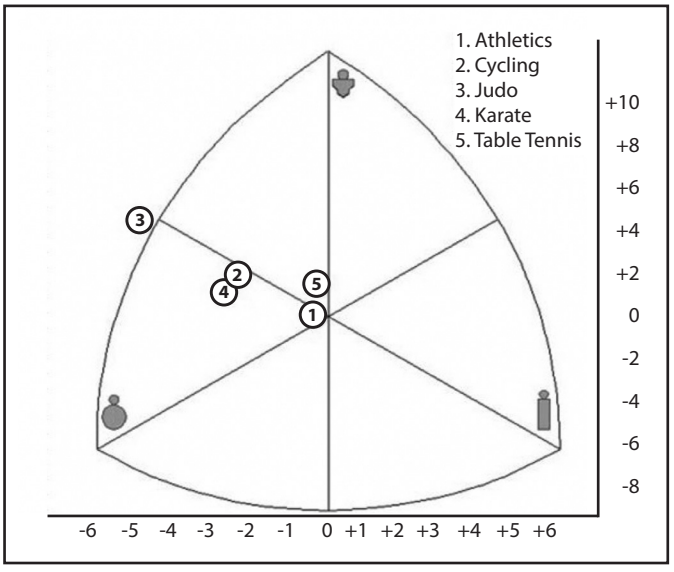
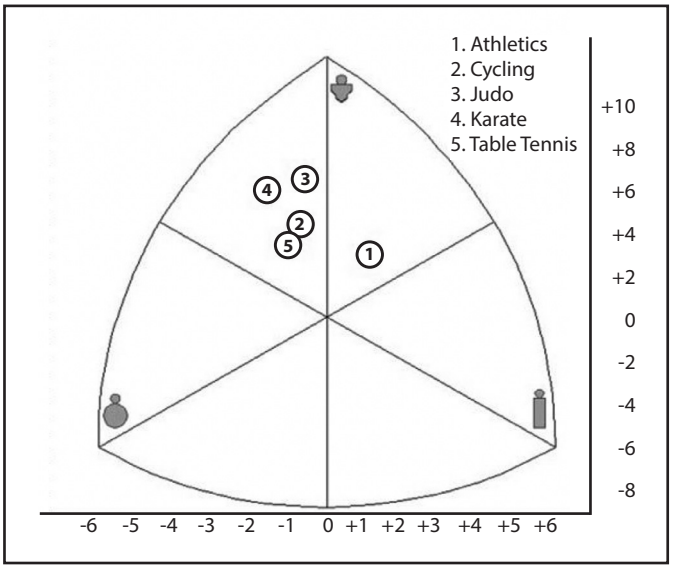


Figure 2. Somatotype of the male athletes in the CER Program, according to their discipline.



Discussion

The present study provides the values of body composition and somatotype by sport discipline and gender in children and adolescents in the sport talent development program at the CER. When analyzing the baseline anthropometric measurements according to gender, with the exception of the athletes in karate, males have higher values in weight and height than females, which is consistent with similar studies involving Chilean children and adolescents[13,14]. In addition, with the exception of female Judo and male Karate who are between +1 and +2 standard deviations, all groups are in the range considered normal (median to +1 standard deviation)[15], which is to be expected considering that athletes are a very active population. However, this situation is not of great relevance given that the BMI does not discriminate several variables that influence the nutritional state[16], as occurs in this case, since it concerns athletes. Moreover, considering that it is a sport that is divided into weight categories, it is common that in the combat disciplines the athletes have a slightly higher weight than that of their

category[17,18]. The contrast of the body composition results obtained in this study with other investigations studying child and adolescent athletes of similar ages is complex, as different methodologies are used to measure this variable, fractioning into four or five components. Nevertheless and in the face of little existing evidence, they serve as a reference to create an image of the similarities or differences between equivalent populations. In that context, in the case of judo, the male athletes in the CER (assessed with the five-component methodology) present higher percentages of muscle mass (48.4%) and fat mass (22.6%) than Spanish adolescent judokas (assessed with the four-component methodology), with 45.6% muscle mass and 14.8% fat mass[19]. The female judokas in the CER present a very high percentage of fat (33.1%) compared to data found in the Spanish sample of selected female judocas[20], who present a percentage of fat mass of 19.9%, whereas in the percentage of muscle mass there is no evidence of a substantial difference between the two groups (judokas in the CER 41.2%, Spanish judokas 42.5%). In the case of the results obtained for body composition of table tennis athletes, there is a difference with the other sports in the CER, since only in this discipline do females present a higher percentage of muscle mass than males, and males present a higher percentage of fat mass than females. These results could be explained by the reduced size of the female sample, a situation similar to that found in the study by Pradas de la Fuente *et al.*[4] with selected Spanish table tennis players, where it was also found that the muscle component of females in the junior category was significantly greater than the percentage in males, noting that this could be due to the small sample size. Referring to the body composition in junior athletes in karate, males in the CER present a percentage of fat mass of 25.5%, a much higher value than junior Spanish karatekas (assessed with the four-component methodology), who present 12.2% of fat mass[21]. On the other hand, the percentage of muscle mass in the male karatekas in the CER is slightly less (44.8%) than junior Spanish karatecks, who present a muscle mass of 45.2%.

With respect to the variable somatotype, the results found that the athletes in the CER are different when contrasted with other studies on somatotype in athletes of the same disciplines and categories, there being similarities and differences. On the one hand, in the study of Godoy-Cumillaf *et al.*[14], the athletes belonging to the schools of karate present a somatotypical classification of endo-mesomorph in the men of both groups, whereas in the women it is categorized as mesomorph-endomorph, unlike the CER that was meso-endomorph. Likewise, in the discipline of athletics, in both studies, male athletes present a somatotype categorized as ecto-mesomorphic and central in women. On the other hand, in judo and table tennis results differed as to the somatotype found in other studies. In the former, the athletes in the CER are categorized as endo-mesomorph, which differs from the somatotype of the Spanish judokas in a similar category, since the most common categorization is balanced ectomorph[19]. In the case of females, the judokas in the CER were classified as endomorph–mesomorph, which differs from the results of female judokas from Spain of the same age, categorized as endo-mesomorph[20]. Regarding table tennis, the somatotype of males in the CER, classified as endomorph-mesomorph, also does not coincide with the table tennis players from Spain, who are classified as balanced mesomorph[22]. In the case of female table tennis players, the athletes in the CER are categorized as having a central somatotype, whereas the Spanish table tennis players are classified as meso-endomorph[22].

In addition to comparing the somatotypes of the athletes in the CER with other studies that analyze similar variables, specifically discipline and age, and despite these athletes still being in a stage of structural development, it seems important to establish a contrast with elite adult athletes, whose reference appears as the somatotype value "to look for" by the current talents who are expected to be the future elite athletes in Chile, since an athlete performs better when their physical configuration is similar to the model for their sport[12]. Table 4 shows the somatotype values of the disciplines in the CER and the somatotype values of the nationally selected athletes at the High Performance Center (Centro de Alto Rendimiento (CAR) in Spanish), although without considering the athletics athletes because the data in the study by Rodriguez *et al.*[23] differentiate the athletes according to groups of track and field disciplines. A contrast of the values of the athletes at the CER and the CAR shows that the male cyclists, judokas, and karatekas in the CER are consistent in biotypological classification with the somatotype of the adult athletes at the CAR in their respective disciplines. However, a bidimensional comparison of the group of athletes in the CER with the athletes at the CAR as a reference, using the somatotype dispersion distance (SDD) of the somatotype mean (SM)[24] between the two groups, shows significant distances (SDD ≥ 2.0), with these being considered as different groups.

Conclusions

Considering that in each region of Chile there is a Regional Training Center dedicated to the development of children and adolescents with sport talent, this study is relevant as it provides data on a subject for which there is little information, making it a useful tool for teachers and trainers in this program. Thus, the recommendations made by De Rose and Guimaraes[25] can be followed, modifying the training in the direction suitable for adopting the somatotype according to age, the components (meso and endomorphic) and the discipline, to decide correctly whether to train strength to increase mesomorphy or to control caloric intake and increase the volume of training to reduce endomorphy.

Considering that the children and adolescents in the sport talent development program are still at an important stage of development, the physical structure of these athletes will be modified according to their evolution during their pubertal development and maintaining or increasing the volume and intensity of training according to the sport advances and the biological support they possess[26]. Additionally, the characteristics studied demonstrate several differences between genders for the same practice of a sport. Consequently, this study gives referential values to be taken into account by other populations of up-and-coming athletes and without a doubt, more research on this topic may contribute to recognizing better anthropometric aptitudes linked to sport development and thus provide a more detailed background for the planning and optimization of training potential elite athletes.

Acknowledgments

Thanks to the Chilean National Sports Institute (IND) and to the trainers and professionals of the CER Program in the Region of Aysén,

Chile, who collaborated in this study, as well as all the athletes who participated in the assessments.

Conflict of interest

The authors do not declare a conflict of interest.

Bibliography

1. Lentini NA, Gris GM, Cardey ML, Aquilino G, Dolce, PA. Estudio somatotípico en deportistas de alto rendimiento de Argentina. *Arch Med Deporte.* 2004;21:497-509.
2. Silva R, Morouço P. Avaliação das características antropométricas e capacidades físicas ao longo de uma época desportiva em futebol: comparação entre sub-15, sub-17 esub-19. *Motricidade.* 2017;13:38–49.
3. Vitale M. Bio-anthropometric evaluation in sport and talent ID. Ital J Anat Embryol. 2010;115:195.
4. De la Fuente FP, Páez LC, Pardo EM, Pagán RH. Perfil antropométrico, somatotipo y composición corporal de jóvenes jugadores de tenis de mesa. *RICYDE*. 2007;3:11–23.
5. Cabral BG, Cabral SA, Medeiros RM, Alcatara T, Dantas PMS. Relationship of maturation with anthropometric and physical valences in sports initiation boys and girls. *Motricidade*. 2013;9:12–22.
6. Le Gall F, Carling C, Williams M, Reilly T. Anthropometric and fitness characteristics of international, professional and amateur male graduate soccer players from an elite youth academy. *J Sci Med Sport.* 2010;13:90–5..
7. Instituto Nacional de Deportes. Orientaciones Técnico-Administrativas Centros de Entrenamiento Regional. Santiago de Chile: Departamento de Alto Rendimiento del Instituto Nacional de Deportes de Chile; 2017.
8. Fernandez S, Alvero JR. La producción científica en cineantropometría: datos de referencia de composición corporal y somatotipo. *Arch Med Deporte*. 2006;23:17–28.
9. Haas AN, Plaza MR. Estudio comparativo del somatotipo de niñas-bailarinas cordobesas y porto-alegregrenses. *Arch Med Deporte*. 2016;33:18–23
10. Marfell-Jones MJ, Stewart AD, De Ridder JH. *International standards for anthropometric assessment*. Wellington. Editorial ISAK ;2011. p . 100.
11. Ross WD, Kerr DA. Fraccionamiento de la masa corporal: un nuevo método para utilizar en nutrición clínica y medicina deportiva. *Apunt Sport Med.* 28:175–88.
12. Heath BH, Carter JEL. A modified somatotype method. *Am J Phys Anthropol.* 1967;27:57–74
13. Garrido CR, Vásquez RM, Vitoria RV, Salazar CM, Alarcón VC. Descripción del estado nutricional en una muestra de estudiantes de colegios municipalizados de la ciudad de vilcún, ix región-chile. *Rev Ciencias la Act Física.* 2012;13:7–14.
14. Godoy-Cumillaf AER, Valdés-Badilla PA, Salvador Soler N, Carmona-López MI, Fernández JJ. Características antropométricas de adolescentes pertenecientes a distintas escuelas deportivas formativas. *Int J Morphol.* 2015;33:1065–70.
15. MINSAL. Patrones de crecimiento para la evaluación nutricional de niños y adolescentes, desde el nacimiento hasta los 19 años de edad. Santiago: Ministerio de Salud de Chile; 2018.
16. Curilem C, Almagià FA, Rodríguez F, Yuing T, Berral F, Martínez C, *et al.* Evaluación de la composición corporal en niños y adolescentes: directrices y recomendaciones. *Nutr Hosp.* 2016;33:734–8.
17. Franchini E, Takito MY, Kiss M, Strerkowicz S. Physical fitness and anthropometrical differences between elite and non-elite judo players. *Biol Sport.* 2005;22:315.
18. Úbeda N, Palacios G, Montalvo Z, García B, García Á, Iglesias E. Hábitos alimenticios y composición corporal de deportistas españoles de élite pertenecientes a disciplinas de combate. *Nutr Hosp.* 2010;25:414–21.
19. Torres FJ, Lara-Padilla E, Sosa-Tallei G, Berral FJ. Análisis de composición corporal y somatotipo de judokas infantiles y cadetes en el campeonato de España 2012. *Int J Morphol.* 2014;32:194–201.
20. Carratalá E, Benavent J, Carqués L. Valoración de los componentes cineantropométricos de los judokas infantiles y cadetes del equipo nacional español. III Congreso de la Asociación Española de Ciencias del Deporte, Universitat de Valencia. (material electronico) 2004 (consultado 07/07/2018). Disponible en: http://www.eweb.unex.es/eweb/cienciadeporte/congreso/04%20val/pdf/c51.pdf.
21. Grijota J, Muñoz D, Crespo C, Robles MC, Maynar M. Análisis comparativo de la composición corporal y de la condición física en deportistas en edad escolar practicantes de balonmano, natación y kárate. *Rev Kronos.* 2012;11:14-21.
22. Carrasco L, Pradas F, Martínez A. Somatotype and body composition of young top-level table tennis players. *Int J Table Tennis Sci.* 2010;6:175–7.
23. Rodríguez X, Castillo O, Tejo J, Rozowski J. Somatotipo de los deportistas de alto rendimiento de Santiago, Chile. *Rev Chil Nutr.* 2014;41:29–39.
24. Hebbelinck M, Borms J. Biometrische Studie vam een Reeks Lichaamskenmerken en Lichamelijke van Belgische Dinderen uit het Lager Onderwijs, Cent voor Bevolkings en Gezinsstudien (CBGS).Brussels.1975.
25. De Rose EH, Guimaraes AC. A model for optimization o somatotype in young athetes. In: Ostyn, M. & Bremen, G. & Simons, J. *Kinanthropometry II*. Baltimore, University Park, 1980.
26. Gonçalves LG, Aquino RL, Puggina EF. Caracterização do perfil de jovens jogadores de futebol: uma análise das habilidades técnicas e variáveis antropométricas. *Motricidade.* 2016;12:27–37.