

## Reference values for height, weight, and body mass index of children and adolescents aged 2 to 18. A systematic review with an emphasis on the Colombian population

Valores de referencia para estatura, peso e índice de masa corporal en niños, niñas y adolescentes de 2 a 18 años. Una revisión sistemática con énfasis en la población colombiana

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### Abstract

**Introduction:** Basic body measurements (height, weight, and body mass index) of children and adolescents are essential indicators in the field of health and sports talent identification and selection.

**Objectives:** To identify and synthesize original research studies on basic body measurements in children and adolescents aged 2 to 18 years published between 2003 and 2018.

**Materials and methods:** The search was carried out in PubMed, Epistemonikos, and Google Scholar between May 2017 and June 2018. The inclusion criteria established that the works to be analyzed should be original research articles published in English, Spanish or Portuguese and that they should discuss morphological profile, use basic body measurements or physical fitness measurements as reference criteria, include children and adolescents aged 2 to 18 years in their study population, and be published between 2003 and 2018 in open-access journals with an impact factor.

**Results:** The search yielded 18 articles that described the morphological profile of children and adolescents aged 2 to 18 years; all had a cross-sectional design. Five papers were conducted in Colombia and the remaining 13 in countries or regions of America, Europe, and Asia.

**Conclusion:** This systematic review allowed establishing reference values for height, weight, and BMI, and highlighted the variability of the basic body measurements associated with sex, age, and country of evaluation.

**Keywords:** Body Height; Anthropometry; Body Mass Index; Morphology (MeSH).

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### Resumen

**Introducción.** Las dimensiones corporales básicas (estatura, peso e índice de masa corporal) de niños, niñas y adolescentes son indicadores indispensables tanto en el ámbito de la salud, como en procesos de selección de talentos deportivos.

**Objetivos.** Identificar y sintetizar los estudios originales de investigación sobre dimensiones corporales básicas en niños, niñas y adolescentes de 2 a 18 años publicados entre 2003 y 2018.

**Materiales y métodos.** Se realizó una búsqueda de la literatura en PubMed, Epistemonikos y Google Académico entre mayo de 2017 y junio de 2018. Se buscaron artículos originales de investigación en inglés, español o portugués que abordaran el perfil morfológico, que hubieran utilizado como criterio de referencia las dimensiones corporales básicas o las de la condición física; que en su población de estudio incluyeran niños, niñas y adolescentes de 2 a 18 años, y que hubieran sido publicados entre 2003 y 2018 en revistas con factor de impacto y de libre acceso.

**Resultados.** Se encontraron 18 artículos que describían el perfil morfológico en niños, niñas y adolescentes de 2 a 18 años, todos de corte transversal. De estos, 5 se realizaron en Colombia y los 13 restantes en países o regiones de América, Europa y Asia.

**Conclusión.** La presente revisión sistemática permitió establecer un valor de referencia para las variables estatura, peso e IMC, y destacó la variabilidad del perfil morfológico básico asociada con el sexo, la edad y el país de evaluación.

**Palabras clave:** Estatura; Antropometría; Índice de masa corporal; Morfología (DeCS).

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## Introduction

The study of body measures as indicators of physical growth and development plays a key role in the health area for identifying the risk of developing some type of condition,<sup>1</sup> for example, in the field of sports talent selection.<sup>2</sup> Therefore, identifying morphological characteristics and references of the human population allows preventing diseases,<sup>3</sup> implementing health care with a focus on nutrition,<sup>4</sup> and guiding and selecting the practice of a sport modality<sup>5-8</sup> in children and adolescents. All this is possible because such characteristics allow establishing the potentialities of the morphological qualities of each individual.

In general, multiple significant changes have been achieved in sports over the last few decades, so, over time, a growing need for athletes to have good physical condition has been identified, as well as certain morphological-functional profiles for optimal performance.<sup>9</sup> Particularly, when working with children and adolescents, growth and individual functional maturation rates must be respected<sup>10</sup> to avoid affecting their development. An example of this is the premature stimulation of the metabolic system, which can cause irreversible damage to their development.<sup>11</sup>

In this sense, anthropometry is a tool that allows guiding people when selecting a sports discipline in which they can perform well.<sup>12</sup> For example, height, body weight, and body mass index (BMI) can help establish whether someone is talented in a particular sport.<sup>1,13,14</sup> Consequently, identifying the predominant body type, in the context of a sports discipline (i.e., establishing a parameter to facilitate a rigorous selection process)<sup>15</sup> would predict the future physical capacity of children and adolescents in that discipline.

Worldwide, countries such as the United States have produced anthropometric reference tables based on sex and age. They are mainly focused on health with the aim of characterizing the behavior of variables such as weight, height, and BMI and establishing their relationship with some diseases. Studies to create such tables have been carried out in the school population.<sup>16</sup>

The present article is the result of the first phase of a research project consisting of four parts: (i) systematic review of basic body measurements in children and adolescents aged 2 to 18 years; (ii) characterization of the morphological profile of this population in Huila, Colombia; (iii) determination of the growth and development rate of this population; and (iv) performing a bivariate analysis of the body dimensions of reference for this age range and the sport practiced. Therefore, the objectives of this review were to identify and synthesize the original research studies on basic body measurements in children and adolescents aged 2 to 18 years, published between 2003 and 2018.

## Materials and methods

### Search strategy

The literature search was conducted between May 2017 and June 2018 in PubMed, Epistemonikos, and Google Scholar. Articles published in English, Spanish and Portuguese were considered.

The first search was carried out on May 28, 2017, using the descriptors young+colombia, which allowed retrieving 835 000 records without restrictions in publication period. Then, the terms young+children+colombia were used, finding 212 000 records, and young+anthropometric+colombia, with 10 990 records.

For a more specific search, other descriptors were added, and Boolean operators were used as follows: young AND anthropometric AND physical activity OR physical ability AND Colombia; this equation yielded 8 240 studies. Then, the publication date limit (years) was specified, and the citations and patents option was unchecked, resulting in 980 studies. Similarly, both PubMed and Epistemonikos used the descriptors height+weight+BMI+children+young, obtaining 5 138 and 101 studies, respectively. The information regarding the search characteristics is described in Table 1.

**Table 1.** Search characteristics.

Search platform	Descriptors	Boolean operators *
Google Scholar PubMed Epistemonikos	Population group: "Young"- "children" "Anthropometric", "Sport" "Height", "Weight" "BMI", "Reference Tables" Country: "Colombia" and "International Community"	+, And, Or

\* Combination of descriptors and terms used.  
Source: Own elaboration.

### Inclusion and exclusion criteria

The inclusion criteria established that the works to be analyzed should be original research articles published in English, Spanish or Portuguese and that they should discuss morphological profile, use basic body measurements or physical fitness measurements as reference criteria, include children and adolescents aged 2 to 18 years in their study population, and be published between 2003 and 2018 in open-access journals with an impact factor.

On the other hand, monographs, dissertations, theses, books, systematic literature reviews or opinions of specialists, such as essays, were excluded. Studies in children and adolescents with special characteristics, syndromes or diseases were also excluded, as well as those that did not describe the age and sex of the population or had a different objective than the one of interest for this review.

### Identification of relevant studies

Studies that could potentially be analyzed were selected by reading their titles and abstracts. Once the relevant ones were selected, they were examined by reading the full text. The whole selection process was made based on the PRISMA recommendations<sup>17</sup> and is described in Figure 1.

## Data extraction and quality of studies

To extract data, an application was developed using the relevant information in a Microsoft Excel sheet; this was done by a single investigator.

The overall methodological quality of the studies was measured using the critical review forms for quantitative studies,<sup>18</sup> which consider 13 general topics. Based on such topics, 16 items were established (form of citation; purposes; rationale; study design; knowledge of the topic and problem; variables; ethical considerations; sampling bias; measurement bias; intervention bias; description of the sample; justification of the sample size; reliability and validity; results; drop-outs; and conclusions and limitations). Said items were assessed through two response options: meets or does not meet the criteria; the options were assigned a score, 1 or 2, respectively, and if the item was not applicable, NA was checked.

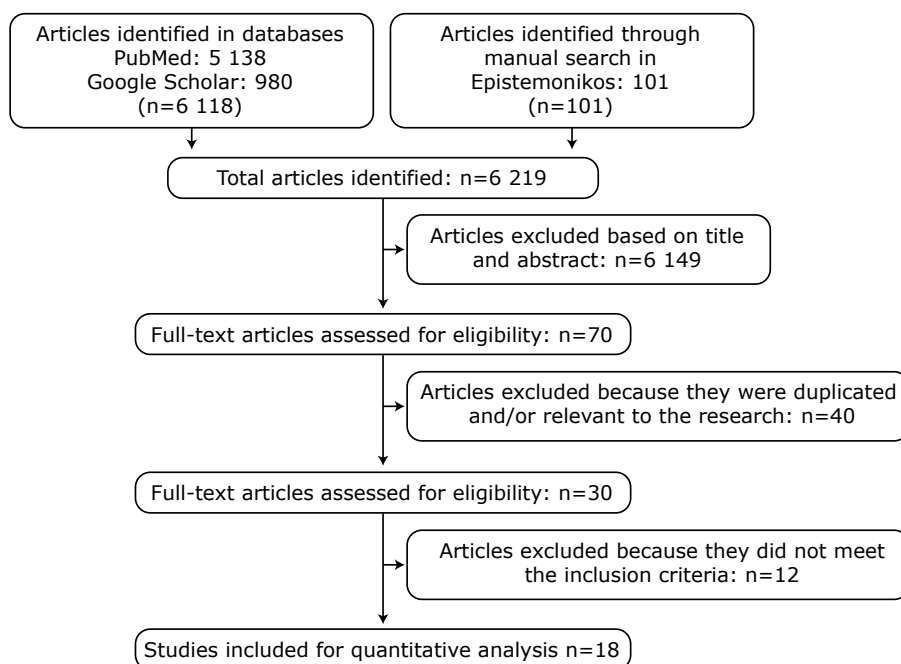
The results of this approximation were expressed as a percentage calculated for each study<sup>19</sup> and the final

quality index was the sum of the results in each article divided by the total number of items. These percentages were classified according to the methodological quality classification ranges: excellent (>75%), good (51-75%) and low ( $\leq$ 50%).

## Results

### Study selection process

The initial search yielded 6 219 results: 5 138 from PubMed, 980 from Google Scholar and 101 from Epistemonikos; the latter were obtained through a manual search. Once the studies were analyzed, 6 149 were excluded after reviewing their title and abstract. Subsequently, the remaining 70 articles were analyzed in depth, finding that 40 were not relevant to the research and/or were duplicated. Of the remaining 30 articles, 12 were excluded because they did not meet the inclusion criteria. Finally, 18 articles were included for qualitative analysis (Figure 1).



**Figure 1.** Flow chart for article selection.  
Source: Own elaboration.

## Design of the included studies

The 18 studies included were cross-sectional; in addition, 2 of them were complementary and their methodology had been described in previous studies.

### Participants

The studies totaled 690 919 participants, 14 720 in Colombian publications and 676 199 in international publications (Table 2). The countries with the lowest and highest number of participants were Germany (n=797) and Greece (n=473 837), respectively. No study showed significant sex differences regarding the number of participants.

The age range of participants in most of the included studies ranged from 2 to 18 years. Only international studies reported data for each year of age, whereas those carried out in Colombia did it by age group (up to 2 years per group); moreover, the age range of the Colombian population ranged from 5 to 18 years.

### Quality of studies

The methodological quality of the reviewed studies was good, with an average rate of 77%: 7 studies had rates of >75%, and 11 rates between 51% and 75% (Table 2).

## Purpose of the studies

It was observed that the studies were conducted to create anthropometric reference tables to measure the development and physical growth of children and adolescents, some focused on health (excess weight, adiposity, etc.) and others on physical condition and sports.

## Context

Regarding the Colombian studies, 5 focused on this issue, 3 of them were carried out in Bogotá, 1 in Me-

dellín, and 1 in Argelia; it should be noted that of the 3 studies carried out in Bogotá, 1 was selected to represent the 5 studies of the FUPRECOL project as they had the same sample. On the other hand, there were 13 international studies conducted in countries or regions of the Americas (USA, Peru, Argentina, and Brazil), Europe (Spain, Portugal, Germany, Poland, Italy, and Greece) and Asia (Korea, Hong Kong, Saudi Arabia, and Bahrain). The results are presented in Table 2.

**Table 2.** Main characteristics of the included studies.

City/Country	Year/period of study	Population	Age (years)	Variables	Program	Author (Reference)	QI	MQC
Bogotá, Colombia	2014-2015	8 034 schoolchildren (3 488 boys and 4 546 girls)	9 to 17.9	Height, Weight, BMI	LMS	Ramirez-Vélez <i>et al.</i> <sup>20</sup> 2017	E	75
Bogotá, Colombia	No data	306 children from 32 soccer schools	7 to 16	Height, Weight, BMI	SPSS	Correa <sup>21</sup> 2008	B	69
Bogotá, Colombia	2013	2 241 schoolchildren (1 082 boys and 1 159 girls)	6 to 17.9	Height, Weight, BMI	LMS	Diaz-Bonilla <i>et al.</i> <sup>22</sup> 2018	E	75
Medellín (Antioquia), Colombia	No data	2 611 schoolchildren (1 253 boys and 1 358 girls)	6 to 18	Height Weight	SPSS	Uscátegui-Peñuela <i>et al.</i> <sup>23</sup> 2003	M	51
Argelia (Cauca), Colombia	2009	1 528 schoolchildren (786 boys and 742 girls)	5 to 19	Height Weight	SPSS	Ortega-Bonilla & Chito-Trujillo <sup>24</sup> 2014	M	51
United States	2007-2010	20 015 people (3 343 boys and 3 091 girls)	2 to 19	Height, Weight, BMI	SUDAAN	Fray <i>et al.</i> <sup>16</sup> 2012	B	69
Brazil	2004-2005	41 654 schoolchildren (23 328 boys and 18 326 girls)	7 to 17	Height, Weight, BMI	SPSS	Silva <i>et al.</i> <sup>25</sup> 2010	B	75
Peru *	2009-2011	8 753 schoolchildren (4 130 boys and 4 623 girls)	4 to 17	Height, Weight, BMI	LMS	Bustamante <i>et al.</i> <sup>26</sup> 2015	B	75
Greece	2014	473 837 schoolchildren (241 657 boys and 232 180 girls)	4 to 18	Height, Weight, BMI	LMS	Tambalis <i>et al.</i> <sup>27</sup> 2015	E	88
Poland	2007-2009	13 015 schoolchildren (6 227 boys and 6 558 girls) <sup>†</sup>	6.5 to 18.5	Height, Weight, BMI	LMS	Kaluga <i>et al.</i> <sup>28</sup> 2010	E	88
Spain	2007-2009	6 463 participants (3 408 men and 3 055 women)	3 to 24	Height, Weight, BMI	SAS v.8.2	López-de Lara <i>et al.</i> <sup>29</sup> 2010	E	88
Italy	1994-2004	69 917 schoolchildren (35 227 boys and 34 690 girls)	2 to 20	Height, Weight, BMI	LMS	Cacciari <i>et al.</i> <sup>30</sup> 2006	B	75
Germany	No data	797 Turkish children and adolescents born in Germany (371 boys and 426 girls)	0 to 18	Height, Weight, BMI	LMS	Redlefsen <i>et al.</i> <sup>31</sup> 2007	B	75
Portugal	2008-2010-2012	3 094 schoolchildren (1 557 boys and 1 537 girls)	7 to 17	Height, Weight, BMI	LMS	Chavez <i>et al.</i> <sup>32</sup> 2015	B	75
Korea	2009-2011	1 919 schoolchildren (1 024 boys and 895 girls)	10 to 18	Height, Weight, BMI	LMS	Kim <i>et al.</i> <sup>33</sup> 2016	E	88
Bahrain	1999-2001	2 594 schoolchildren (1 268 boys and 1 326 girls)	6 to 18	Height, Weight, BMI	LMS	Gharid <i>et al.</i> <sup>34</sup> 2009	E	88
Hong Kong	2005-2006	14 842 schoolchildren (7 472 boys and 7 370 girls)	6 to 18	Height, Weight, BMI	SPSS	Sung <i>et al.</i> <sup>35</sup> 2008	E	94
Saudi Arabia	2016 ‡	19 299 schoolchildren (9 827 boys and 9 472 girls)	5 to 18	Height, Weight, BMI	LMS	El Mouzan <i>et al.</i> <sup>36</sup> 2016	E	88

QI: Quality Index; MQC: Methodological Quality Classification; LMS: Lmschartmaker pro software; SAS: Statistical Analysis Software; SPSS: Statistical Package for the Social Sciences; SUDAAN: Statistical Software for Analyzing Correlated data.

\* The study reports data from the Peruvian population compared to Argentinian and North American population references.

† In the original study, 230 individuals were excluded for having postural deficiency, genetic syndrome, cancer, or other chronic disease.

‡ The study was based on data collected from the 13 regions of the Kingdom of Saudi Arabia between 2004 and 2005.

Source: Own elaboration.

## Anthropometric profile

The 50 (P50) or median percentile was used as a reference to describe the behavior of height, weight, and BMI in the reviewed studies.

### Height

**Male sex:** In Colombia, this population showed a variety in height, especially at the age of 15. In addition, in Bogotá, differences of up to 7cm were observed at age 15.<sup>20,21</sup> On the other hand, when compared with the population of Medellín, the Bogotá population showed differences of -2cm at the age of 16.<sup>23</sup> Finally, the median height in the country was 168.3cm at 17 years.<sup>20-24</sup>

At the international level, by the age of 17, it was found that the highest P50 for height in America was in the USA (176.1cm),<sup>16</sup> followed by Brazil (174.2cm),<sup>25</sup> Argentina (171.7cm)<sup>26</sup> and Peru (163.2cm),<sup>26</sup> with the latter being the country with the lowest median. In Europe, the highest P50 was found in Greece (178.3cm),<sup>27</sup> followed by Poland (178.1cm),<sup>28</sup> Spain (175.5cm),<sup>29</sup> Italy (175.3cm),<sup>30</sup> Germany<sup>31</sup> (174.3cm) and Portugal (172cm).<sup>32</sup> Finally, in Asia, the country with the highest P50 was Korea (173.8cm),<sup>33</sup> followed by Bahrain (171cm),<sup>34</sup> Hong Kong (171.9cm),<sup>35</sup> and Saudi Arabia (167.4cm)<sup>36</sup> (Table 3).

**Female sex:** The median height of women in Colombia was 158.8cm at the age of 17 years.<sup>20-24</sup>

At the international level, by the age of 17, it was found that the highest P50 for height in America was in the USA (164cm),<sup>16</sup> followed by Brazil (162.5cm),<sup>25</sup> Argentina (160.7cm)<sup>26</sup> and Peru (152.9cm).<sup>26</sup> In Europe, the highest P50 was found in Portugal (166cm),<sup>32</sup> followed by Greece (164.9cm),<sup>27</sup> Poland (164.7cm),<sup>28</sup> Spain (162.6cm)<sup>29</sup>, Italy (162.3cm),<sup>30</sup> and Germany (160cm).<sup>31</sup> Finally, in Asia, the country with the highest P50 was Korea (161.6cm),<sup>33</sup> followed by Hong Kong (158.9cm),<sup>35</sup> Bahrain (156.3cm),<sup>34</sup> and Saudi Arabia (155.5cm)<sup>36</sup> (Table 3).

### Weight

**Male sex:** In Colombia, this population showed a variety in weight, especially at the age of 15. In addition, in Bogotá, differences of up to 7kg were observed at age 15.<sup>20,21</sup> On the other hand, when compared with the population of Medellín,<sup>23</sup> the Bogotá population showed differences of -3kg at the age of 16. Finally, the median weight in the country was 59.9kg for the age of 17,<sup>20-24</sup> the lowest was found in Argelia (57.6kg at 17 years).<sup>24</sup>

At the international level, by the age of 17, it was found that the highest p50 for weight in America was

in the USA (71.0kg),<sup>16</sup> followed by Brazil (66.1kg),<sup>25</sup> Argentina (63.3kg)<sup>26</sup> and Peru (57.4kg).<sup>26</sup> In Europe, the highest P50 was found in Greece (73.2kg),<sup>27</sup> followed by Germany (69.44kg),<sup>31</sup> Spain<sup>29</sup> (68.9kg), Italy (67.3kg),<sup>30</sup> Poland<sup>28</sup> (67.2kg), and Portugal (6.23kg).<sup>32</sup> In Asia, the country with the highest P50 was Korea<sup>33</sup> (65.9kg), followed by Bahrain<sup>34</sup> (63.2kg), Hong Kong (61.5kg),<sup>35</sup> and Saudi Arabia<sup>36</sup> (58.5kg) (Table 4).

**Female sex:** The median weight of Colombian women was 55kg at the age of 17 years.<sup>20-24</sup>

At the international level, by the age of 17, it was found that the highest P50 for weight in America was in the USA (60.8kg),<sup>16</sup> followed by Brazil (57.1kg),<sup>25</sup> Argentina (53.1kg)<sup>26</sup> and Peru (52.5kg).<sup>26</sup> In Europe, the highest P50 was found in Portugal (61.5kg),<sup>32</sup> followed by Greece (59.7kg),<sup>27</sup> Germany (57.2kg),<sup>31</sup> Spain (56.1kg)<sup>29</sup>, Italy (55.8kg),<sup>30</sup> and Poland (55.8kg).<sup>28</sup> Finally, in Asia, the country with the highest P50 was Bahrain (56.7kg),<sup>34</sup> followed by Korea (56.7kg),<sup>33</sup> Saudi Arabia (53.2kg),<sup>36</sup> and Hong Kong (51.4kg)<sup>35</sup> (Table 4).

### BMI

**Male sex:** In Colombia, it was not possible to obtain the median national BMI because the studies conducted in Medellín<sup>23</sup> and Argelia<sup>24</sup> did not report these data. However, the median BMI in the population of Bogotá, at the age of 16, was 20kg/m<sup>2</sup> in untrained boys,<sup>20,22</sup> and 18kg/m<sup>2</sup> in trained boys.<sup>21</sup>

At the international level, by the age of 16, it was found that the highest P50 for BMI in America was found in the US A (22.7kg/m<sup>2</sup>),<sup>16</sup> followed by Peru (21.1kg/m<sup>2</sup>),<sup>26</sup> Brazil (20.9kg/m<sup>2</sup>)<sup>25</sup> and Argentina (20.2kg/m<sup>2</sup>).<sup>26</sup> In Europe, the highest P50 was found in Germany (22.49kg/m<sup>2</sup>),<sup>31</sup> followed by Greece (22.43kg/m<sup>2</sup>),<sup>27</sup> Portugal (21.77kg/m<sup>2</sup>),<sup>32</sup> Italy (21.7kg/m<sup>2</sup>),<sup>30</sup> Spain (21.0kg/m<sup>2</sup>)<sup>29</sup> and Poland (20.4kg/m<sup>2</sup>).<sup>28</sup> Finally, in Asia, the country with the highest P50 was Korea (21.6kg/m<sup>2</sup>),<sup>33</sup> followed by Bahrain (21.0kg/m<sup>2</sup>),<sup>34</sup> Hong Kong (20.7kg/m<sup>2</sup>)<sup>35</sup> and Saudi Arabia (20.3kg/m<sup>2</sup>)<sup>36</sup> (Table 5).

**Female sex:** the median BMI in Colombian women was 22 kg/m<sup>2</sup> at the age of 16.

At the international level, at the age of 16, it was found that the highest P50 for BMI in America was in the USA (22.1kg/m<sup>2</sup>),<sup>16</sup> followed by Peru<sup>26</sup> (22.0kg/m<sup>2</sup>), Brazil (21.4kg/m<sup>2</sup>)<sup>25</sup> and Argentina<sup>26</sup> (21.6kg/m<sup>2</sup>). In Europe, the highest P50 was found in Germany (22.4kg/m<sup>2</sup>),<sup>31</sup> followed by Portugal (22.1kg/m<sup>2</sup>),<sup>32</sup> Greece (21.8kg/m<sup>2</sup>),<sup>27</sup> Italy (21.0kg/m<sup>2</sup>),<sup>30</sup> Spain (20.8kg/m<sup>2</sup>)<sup>29</sup> and Poland (20.2kg/m<sup>2</sup>).<sup>28</sup> Finally, in Asia, the country with the highest P50 was Bahrain<sup>34</sup> (23.1kg/m<sup>2</sup>), followed by Saudi Arabia (21.5kg/m<sup>2</sup>),<sup>36</sup> Korea<sup>33</sup> (21.4kg/m<sup>2</sup>) and Hong Kong (20.2kg/m<sup>2</sup>)<sup>35</sup> (Table 5).



**Table 3.** Median height (cm) by sex in the reviewed literature.

Age (years)	Colombia					Argentina <sup>26</sup>	Peru <sup>26</sup>	Brazil <sup>25</sup>	United States <sup>16</sup>	Spain <sup>29</sup>	Portugal <sup>32</sup>	Italy <sup>30</sup>	Greece <sup>27</sup>	Germany <sup>31</sup>	Poland <sup>28</sup>	Bahrain <sup>34</sup>	Saudi Arabia <sup>36</sup>	Hong Kong <sup>35</sup>	Korea <sup>33</sup>
	Bogotá			Cauca	Antioquia														
	<sup>20</sup>	<sup>21</sup>	<sup>22</sup>	Argelia <sup>24</sup>	Medellín <sup>23</sup>														
<b>Male sex</b>																			
2	-	-	-	-	-	-	-	-	92.0	-	-	88.8	-	88.32	-	-	-	-	-
3	-	-	-	-	-	-	-	-	98.8	98.1	-	97.0	-	96.93	-	-	-	-	-
4	-	-	-	-	-	101.9	104.7	-	106.0	100.6	-	104.1	110.3	104.78	-	-	-	-	-
5	-	-	-	116	-	107.9	109.6	-	113.1	107.8	-	110.7	116.3	111.46	-	-	107.9	-	-
6	-	114	-	-	119.4	114.2	113.5	-	119.5	114.2	-	116.8	122.3	118.17	-	118.0	113.6	120.4	-
7	117.5	120	-	-	-	120.2	119.1	127.7	124.8	121.2	125	122.8	128.1	123.91	124.9	121.5	119.1	125.7	-
8	125.8	126	-	129	128.3	125.9	123.5	131.6	131.4	127.1	129	128.4	133.8	129.18	130.6	126.0	124.4	130.7	-
9	129.1	131	133.5	-	-	131.1	128.8	137.4	136.7	133.2	133	133.8	139.4	134.56	136.3	130.5	129.4	135.6	-
10	134.7	136	137.3	-	137.7	135.8	133.0	141.3	142.5	139.0	138	139.0	145.2	139.70	141.5	134.5	133.9	141.2	142.3
11	138.8	143	141.9	143	-	140.3	138.5	146.1	149.3	142.9	144	144.3	151.2	144.22	146.7	139.5	133.6	147.3	149.0
12	145.8	149	147.1	-	150.5	145.4	145.1	152.1	153.4	148.4	150	150.2	157.4	149.57	152.6	146.3	144.0	154.1	156.3
13	153.0	157	153.5	-	-	151.5	150.1	158.9	164.5	154.8	157	157.2	163.3	155.79	160.3	151.3	149.6	161.2	162.2
14	156.0	164	158.9	157	161.2	158.4	156.8	165.6	169.5	159.9	162	164.4	168.6	163.04	166.8	162.0	155.8	166.3	169.4
15	160.7	167	163.3	-	-	164.6	160.8	169.7	173.7	167.0	167	170.4	172.9	168.69	172.8	164.0	161.4	169.8	171.7
16	166.9	168	166.7	-	170.1	169.1	163.1	173.4	175.4	172.7	170	173.7	176.1	172.33	175.5	169.0	165.1	170.9	173.8
17	-	170	168.1	167	-	171.7	163.2	174.2	176.1	175.5	172	175.3	178.3	174.28	178.1	171.0	167.4	171.9	173.8
18	-	-	-	-	-	-	-	-	176.8	177.6	-	176.0	180.2	175.14	178.5	171.0	168.8	171.7	173.2
<b>Female sex</b>																			
2	-	-	-	-	-	-	-	-	90.0	-	-	87.2	-	87.00	-	-	-	-	-
3	-	-	-	-	-	-	-	-	99.0	95.9	-	95.4	-	95.81	-	-	-	-	-
4	-	-	-	-	-	100.5	103.5	-	104.7	103.8	-	102.8	109.2	103.55	-	-	-	-	-
5	-	-	-	116	-	106.7	109.3	-	112.0	109.9	-	109.7	115.2	110.55	-	-	107.8	-	-
6	-	113.4	-	-	118.2	113.0	113.0	-	118.8	116.9	-	116.1	121.3	117.35	-	118.7	113.0	118.7	-
7	-	121.6	-	-	-	118.8	118.5	125.6	125.1	123.0	124	122.0	127.2	122.92	123.6	120.0	118.5	124.2	-
8	-	127.7	-	128	129.0	124.1	124.3	131.0	130.7	128.7	128	127.6	133.3	127.97	129.1	125.4	123.8	129.9	-
9	-	133.4	134.6	-	-	129.2	129.8	137.7	136.7	135.0	132	133.1	139.4	133.17	135.1	130.3	129.1	135.1	-
10	-	140.7	138.4	-	139.8	134.6	135.2	142.4	144.5	139.9	138	139.0	145.5	138.61	140.7	136.4	134.6	141.7	143.8
11	-	146.5	143.7	145	-	140.6	142.0	148.8	150.7	148.2	144	145.5	151.2	144.22	146.8	141.8	140.3	148.9	150.3
12	-	151.2	148.5	-	151.5	147.0	145.9	154.3	156.7	152.4	151	151.9	156.0	150.67	153.4	147.6	145.5	153.1	155.8
13	-	155.7	152.4	-	-	152.9	149.6	157.7	159.5	157.8	156	156.8	159.6	155.81	159.1	152.8	149.8	156.2	157.8
14	-	157.0	154.6	154	156.0	157.2	151.0	160.3	161.9	161.4	160	159.2	162.0	158.26	162.4	156.1	152.6	157.6	159.6
15	-	158.2	155.7	-	-	159.6	152.3	160.7	161.7	163.7	162	161.2	163.6	159.35	163.6	155.5	154.3	158.3	160.7
16	-	157.2	156.4	-	156.9	160.5	153.0	163.6	161.4	163.8	164	162.0	164.4	159.90	164.5	156.6	155.1	158.3	159.8
17	-	158.1	156.8	156	-	160.7	152.9	162.5	164.0	162.6	166	162.3	164.9	160.04	164.7	156.3	155.5	158.9	161.6
18	-	-	-	-	-	-	-	-	163.0	164.2	-	162.5	165.3	160.10	165.1	156.6	155.8	158.6	161.1

Source: Own elaboration.

**Table 4.** Median weight (kg) by sex in the reviewed literature.

Age (years)	Colombia					Argentina <sup>26</sup>	Peru <sup>26</sup>	Brazil <sup>25</sup>	United States <sup>16</sup>	Spain <sup>29</sup>	Portugal <sup>32</sup>	Italy <sup>30</sup>	Greece <sup>27</sup>	Germany <sup>31</sup>	Poland <sup>28</sup>	Bahrain <sup>34</sup>	Saudi Arabia <sup>36</sup>	Hong Kong <sup>35</sup>	Korea <sup>3</sup>
	Bogotá			Cauca	Antioquia														
	20	21	22	Argelia <sup>24</sup>	Medellín <sup>23</sup>														
<b>Male sex</b>																			
2	-	-	-	-	-	-	-	-	13.9	-	-	12.8	-	12.90	-	-	-	-	-
3	-	-	-	-	-	-	-	-	15.9	14.9	-	15.2	-	15.71	-	-	-	-	-
4	-	-	-	-	-	16.7	18.2	-	17.7	15.5	-	17.4	19.0	18.45	-	-	-	-	-
5	-	-	-	21.0	-	18.7	20.2	-	20.2	17.6	-	19.6	21.8	21.08	-	-	16.5	-	-
6	-	21.3	-	-	23.3	20.7	21.7	-	23.1	19.7	-	22.0	24.7	24.18	-	20.2	18.6	23.9	-
7	20.9	24.4	-	-	-	23.1	24.2	27.5	24.9	23.1	26.68	24.7	27.8	26.76	24.3	21.5	20.6	26.4	-
8	25.6	27.9	-	28.2	27.2	25.7	26.7	30.0	29.8	25.8	28.61	27.4	31.3	29.51	27.4	23.7	23.2	29.3	-
9	27.7	30.8	32.1	-	-	28.6	29.9	33.4	33.0	29.7	31.42	31.3	35.1	32.63	30.7	27.0	26.0	32.7	-
10	31.7	34.1	34.5	-	32.9	31.7	32.7	34.3	38.0	34.5	34.83	35.1	39.4	36.24	34.3	29.7	29.0	37.5	38.8
11	33.9	39.1	37.2	37.4	-	35.0	37.4	38.9	42.4	36.7	39.01	39.4	44.1	39.88	38.0	33.6	32.4	41.8	45.0
12	36.8	42.9	41.3	-	42.2	39.1	42.0	42.5	49.2	41.8	43.95	44.2	49.1	44.38	42.2	40.6	36.4	46.6	49.4
13	41.5	46.9	46.0	-	-	44.3	44.5	47.8	56.6	47.5	49.24	49.7	54.5	49.91	48.0	42.0	40.8	51.1	54.7
14	43.6	53.6	50.0	43.9	50.3	50.5	50.1	53.6	60.4	49.7	54.38	55.8	59.7	56.66	53.8	51.7	45.7	54.9	61.6
15	50.3	56.2	54.4	-	-	56.5	53.8	57.7	66.0	55.6	59.08	61.3	64.7	62.54	60.1	53.2	50.7	59.1	61.6
16	53.0	60.1	57.7	-	59.9	60.8	56.5	63.1	70.7	62.7	62.94	65.2	69.2	66.78	63.1	61.7	55.1	60.6	65.5
17	-	61.3	60.8	57.6	-	63.3	57.4	66.1	71.0	68.9	66.23	67.3	73.2	69.44	67.2	63.2	58.5	61.5	65.9
18	-	-	-	-	-	-	-	-	78.3	71.2	-	68.7	77.0	70.77	70.0	64.9	61.2	62.3	65.2
<b>Female sex</b>																			
2	-	-	-	-	-	-	-	-	13.2	-	-	12.3	-	12.5	-	-	-	-	-
3	-	-	-	-	-	-	-	-	15.4	13.5	-	14.5	-	15.19	-	-	-	-	-
4	-	-	-	-	-	16.3	17.5	-	17.1	16.1	-	16.8	18.7	17.71	-	-	-	-	-
5	-	-	-	21.0	-	18.1	19.9	-	19.7	18.2	-	19.2	21.3	20.35	-	-	16.4	-	-
6	-	21.1	-	-	22.5	20.1	21.3	-	22.5	20.7	-	21.9	24.2	23.39	-	21.1	18.4	21.8	-
7	-	24.2	-	-	-	22.5	24.0	27.0	25.2	23.9	26.62	24.8	27.3	26.16	24.0	21.6	20.6	24.9	-
8	-	27.9	-	27.4	27.8	25.2	26.7	30.1	29.2	27.1	28.79	28.0	30.8	28.99	26.1	24.8	23.1	27.8	-
9	-	30.4	32.1	-	-	28.2	30.4	32.0	31.9	30.8	31.42	31.4	34.8	32.38	29.4	28.1	25.9	30.8	-
10	-	34.1	35.0	-	34.2	31.5	33.2	35.4	39.0	34.3	34.76	35.2	39.2	36.44	33.3	33.9	29.3	35.3	37.1
11	-	39.6	38.3	39.3	-	35.6	39.1	40.0	43.3	40.6	39.03	40.0	43.6	41.55	37.7	38.3	33.5	40.1	42.5
12	-	41.3	42.8	-	43.9	40.5	41.8	45.0	51.4	43.8	44.08	45.4	47.8	47.60	42.6	43.7	38.3	44.1	47.6
13	-	47.5	47.4	-	-	45.2	45.7	48.2	52.3	47.8	49.32	50.7	51.5	51.92	47.8	50.9	43.2	47.8	50.6
14	-	53.2	51.0	48.2	49.9	48.9	48.2	51.2	59.0	53.4	53.65	53.7	54.6	54.79	51.7	54.3	47.2	49.0	53.0
15	-	52.8	52.7	-	-	51.3	50.1	53.1	59.5	54.4	56.83	55.1	56.9	56.22	53.3	54.3	50.0	50.5	53.4
16	-	52.9	53.9	-	52.8	52.5	51.6	57.7	58.7	55.8	59.28	55.6	58.6	57.17	54.7	56.7	52.0	50.7	54.7
17	-	55.3	55.1	54.6	-	53.1	52.5	57.1	60.8	56.1	61.46	55.8	59.7	57.15	55.8	57.6	53.2	51.4	56.7
18	-	-	-	-	-	-	-	-	58.6	56.6	-	55.9	-	56.62	56.1	57.2	53.6	51.3	53.9

Source: Own elaboration.

**Table 5.** Median Body Mass Index (BMI) by sex in the reviewed literature.

Age (years)	Colombia			Argentina <sup>26</sup>	Peru <sup>26</sup>	Brazil <sup>25</sup>	United States <sup>16</sup>	Spain <sup>29</sup>	Portugal <sup>32</sup>	Italy <sup>30</sup>	Greece <sup>27</sup>	Germany <sup>31</sup>	Poland <sup>28</sup>	Bahrain <sup>34</sup>	Saudi Arabia <sup>36</sup>	Hong Kong <sup>35</sup>	Korea <sup>33</sup>
	Bogotá																
	20	21	22														
<b>Male sex</b>																	
2	-	-	-	-	-	-	16.6	-	-	16.5	-	16.54	-	-	-	-	-
3	-	-	-	-	-	-	16.2	15.4	-	15.9	-	16.72	-	-	-	-	-
4	-	-	-	16.0	16.6	-	16.0	15.2	-	15.8	15.74	16.8	-	-	-	-	-
5	-	-	-	16.0	16.7	-	15.7	15.1	-	15.8	16.05	16.96	-	-	14.4	-	-
6	-	16.4	-	16.0	16.8	-	16.1	15.1	-	16.0	16.40	17.32	-	14.3	14.5	16.2	-
7	15.1	16.6	-	16.1	17.0	16.8	15.8	15.6	16.85	16.3	16.86	17.43	15.6	14.6	14.7	16.6	-
8	16.0	17.3	-	16.3	17.4	17.2	16.7	15.9	17.13	16.8	17.43	17.68	16.0	15.2	15.0	17.0	-
9	16.5	17.7	17.8	16.9	17.9	17.6	17.3	16.6	17.53	17.3	18.06	18.02	16.5	15.8	15.6	17.6	-
10	17.3	18.2	18.1	17.6	18.3	17.1	18.4	17.7	18.03	18.0	18.71	18.57	17.1	16.5	16.2	18.7	19.0
11	17.5	18.8	18.3	18.3	19.4	17.9	19.1	17.9	18.60	18.7	19.34	19.17	17.4	16.6	16.9	19.1	20.1
12	17.2	19.2	18.9	18.8	19.7	18.1	19.9	18.9	19.23	19.5	19.95	19.84	18.0	18.7	17.6	19.4	20.1
13	18.3	18.6	19.4	19.1	19.6	18.8	20.4	19.7	19.91	20.2	20.57	20.57	18.6	18.9	18.3	19.6	20.7
14	17.8	19.7	19.7	19.4	20.2	19.4	21.0	19.4	20.58	20.9	21.21	21.32	19.0	19.5	18.9	19.8	21.4
15	19.3	20.1	20.3	19.8	20.7	19.9	21.5	19.9	21.23	21.3	21.83	21.98	19.9	19.7	19.6	20.4	20.7
16	18.9	20.1	20.8	20.2	21.1	20.9	22.7	21.0	21.77	21.7	22.43	22.49	20.4	21.0	20.3	20.7	21.6
17	-	20.6	21.5	-	-	21.7	23.3	22.3	22.25	21.9	23.02	22.86	21.1	21.6	20.9	20.8	21.7
18	-	-	-	-	-	-	25.1	22.6	-	22.0	23.59	23.07	21.7	21.8	21.4	21.1	21.8
<b>Female sex</b>																	
2	-	-	-	-	-	-	16.4	-	-	16.1	-	16.52	-	-	-	-	-
3	-	-	-	-	-	-	15.8	14.6	-	15.7	-	16.54	-	-	-	-	-
4	-	-	-	16.1	16.3	-	15.7	14.9	-	15.6	15.59	16.52	-	-	-	-	-
5	-	-	-	16.0	16.6	-	15.8	15.0	-	15.8	15.91	16.66	-	-	14.3	-	-
6	-	16.3	-	15.9	16.6	-	15.8	15.1	-	16.1	16.29	16.99	-	14.8	14.4	15.4	-
7	-	16.3	-	16.0	17.0	17.0	15.9	15.7	17.22	16.4	16.77	17.32	15.5	14.9	14.7	16.0	-
8	-	17.1	-	16.3	17.2	17.4	17.1	16.3	17.55	16.9	17.33	17.71	15.6	15.5	15.1	16.3	-
9	-	17.0	17.6	16.8	17.9	17.0	17.3	16.8	17.96	17.4	17.94	18.26	16.1	16.4	15.6	16.8	-
10	-	18.1	18.1	17.5	18.0	17.4	18.9	17.4	18.33	18.1	18.58	18.97	16.8	17.9	16.0	17.4	17.8
11	-	18.3	18.4	18.1	19.2	18.0	19.0	18.3	18.75	18.9	19.22	19.98	17.3	18.8	17.1	19.0	18.7
12	-	19.3	19.3	18.8	19.5	18.9	20.6	18.7	19.38	19.8	19.86	20.97	17.9	19.9	18.1	18.7	19.5
13	-	20.0	20.3	19.4	20.4	19.4	20.9	19.1	20.22	20.4	20.47	21.39	18.7	21.6	19.2	19.6	20.2
14	-	21.5	21.3	20.2	21.1	20.0	22.4	20.5	20.97	20.8	21.02	21.88	19.4	22.2	20.1	19.7	20.8
15	-	21.1	21.7	20.9	21.5	20.6	22.1	20.3	21.57	21.0	21.47	22.17	20.1	22.4	20.8	20.1	20.6
16	-	21.4	22.0	21.6	22.0	21.4	22.1	20.8	22.07	21.0	21.83	22.37	20.2	23.1	21.5	20.2	21.4
17	-	22.1	22.4	-	-	21.6	22.5	21.2	22.47	21.1	22.14	22.28	20.5	23.3	21.9	20.3	21.7
18	-	-	-	-	-	-	21.8	21.0	-	21.1	22.42	22.09	20.6	23.3	22.0	20.4	20.7

Source: Own elaboration.



## Discussion

According to the findings, the highest median height was found in European countries,<sup>37</sup> reaching differences of up to 15cm in males and 13.1cm in females in countries with short-stature figures such as Colombia and Peru. The difference in height among the 3 continents was between 10cm and 15cm in males and 6.5cm and 14cm in females.

Similarly, in males, height increases of up to 10cm were observed between the ages of 15 and 17-18; in females, this difference was up to 4cm. A decrease in median height was also observed at the end of the 18th year of age, especially in Asian regions such as Korea<sup>33</sup> and Hong Kong<sup>35</sup> (0.5cm and 0.3cm for both sexes, respectively), and in the USA<sup>16</sup> (1cm in female sex). Weight differences were up to 12kg in men and up to 3kg in women. BMI varied up to 2kg/m<sup>2</sup> in males and up to 1.3kg/m<sup>2</sup> in females. These variations depended on age<sup>16,27,32</sup> and were greater in males.<sup>27,29</sup>

On the continental level, it was established that males had the highest median height and weight in Europe (Greece)<sup>27</sup>, and BMI in Europe (Greece)<sup>27</sup> and America (USA).<sup>16</sup> On the other hand, females had the highest median height and weight in Europe, and the highest median BMI in Asia (Bahrein)<sup>34</sup>. Moreover, in men, the lowest medians for height, weight, and BMI were observed in countries of the Americas (Peru), excluding the USA.<sup>26</sup> In the case of women, the lowest median height and weight were found in the American continent (Peru)<sup>26</sup>, and in Asia (Hong Kong and Saudi Arabia)<sup>35,36</sup>, while the lowest median BMI was found in Europe (Spain and Poland)<sup>29,28</sup> and Asia (Hong Kong).<sup>35</sup>

At the country level, for the male sex, Greece<sup>27</sup> had the highest median height, while the USA<sup>16</sup> had the highest median BMI and weight. Also, for females, Portugal<sup>32</sup> reported the highest P50 in height and weight, while Bahrain<sup>34</sup> had the highest P50 in BMI. In contrast, in Peru,<sup>26</sup> the lowest median height and weight were found in both sexes, while the lowest P50 for BMI were in Argentina<sup>26</sup> for men and Hong Kong<sup>35</sup> for women.

Based on this information, the scope of this type of morphological studies in the development of health and anthropometric issues is evident, especially in the field of sports, as differences in the variables analyzed (height, weight, and BMI) at certain ages are described, which allow identifying and creating the profile of basic body measurements at an historical moment. For example, in Asia, an increase of 1.7cm was observed in men aged 17 when comparing a study conducted in 1993 in Japanese youth,<sup>38</sup> where the average height was 170cm, with one performed in young Koreans in 2005,<sup>35</sup> where the same average was 171.7cm. Furthermore, an increase of 0.7cm was observed in the average height of women of this age between the two studies (mean height: 157.9cm). Concerning weight, the comparison of these same studies<sup>35,38</sup> showed an increase of 800gr in males and a decrease of 500gr in females over a period of 15 years.<sup>35,38</sup> Therefore, it is possible to see the relevance of contextualizing the morphological references of children and adolescents in different historical periods.

In addition, in the studies included in this review, internal or contextualized measurements are higher than the reference weight values, height and BMI established by the Centers for Diseases Control and Prevention<sup>39</sup>

and the World Health Organization<sup>40</sup> for most ages.<sup>25,34</sup> Thus, the need to establish reference values for each country is evident;<sup>41,42</sup> this will also demonstrate that weight and height measurements tend to increase over time in this type of population.<sup>43</sup>

Even though these data, especially in children and adolescents, are influenced by the speed of development and the environmental, social, and economic conditions of each individual, they can be useful in projecting individuals into a sports career.<sup>44</sup> In this way, by knowing their context, the coach or sports professional can direct the training processes toward some sport modality. Consequently, assessment and follow-up throughout the different stages of growth and development determine the advantages and disadvantages that an individual may have in different regional contexts, which vary according to environmental,<sup>45</sup> ethnic, sex, and socio-economic factors.<sup>46,47</sup>

## Conclusions

In the Colombian case, academic studies published in journals with an impact factor related to anthropometry in children and adolescents are scarce and address two components: health, in relation to nutritional status in overweight and obesity, and physical fitness associated with cardiovascular risk. It is also interesting that, according to the findings, none of the studies included in the present review were carried out by government health agencies in each country, but by independent researchers or institutions.

This systematic review made it possible to establish a reference value for height, weight, and BMI, and highlight the variability of the basic morphological profile associated with sex, age, and country of evaluation. With this in mind, it is appropriate to move on to the next phase of the research program of which this review is part: Characterization of the morphological profile of children and adolescents in Huila, Colombia.

## Conflicts of interest

None stated by the authors.

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