Percentile values of the standing broad jump in children and adolescents aged 6-18 years old

Ewan Thomas (1), Luca Petrigna (1), Garden Tabacchi (1), Eduardo Teixeira (2), Simona Pajaujiene (3), David J. Sturm (4), Fatma Nese Sahin (5), Manuel Gómez-López (6), Jelena Pausic (7), Antonio Paoli (8), Marianna Alesi (9), Antonino Bianco (1)

(1) Sport and Exercise Research Unit, Department of Psychology, Educational Science and Human Movement, University of Palermo, Palermo, Italy; (2) CIEQV, Escola Superior de Desporto de Rio Maior, IPSantarém, Portugal; (3) Department of Coaching Science, Lithuanian Sports University, Kaunas, Lithuania; (4) Associate Professorship of Educational Science in Sport and Health, Technical University of Munich, Uptown Munich Campus D, Georg-Brauchle-Ring 60/62, 80992 Munich, Germany; (5) Faculty of Sport Sciences. Coaching Education Department, Ankara University, Ankara, Turkey; (6) Department of Physical Activity and Sport. International Campus of Excellence "Mare Nostrum", Faculty of Sports Sciences, University of Murcia, San Javier, Spain; (7). Faculty of Kinesiology, University of Split, Croatia; (8) Department of Biomedical Sciences, University of Padova, Padua, Italy; (9) Department of Psychology, Educational Science and Human Movement, University of Palermo, Palermo, Italy

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Abstract

The standing broad jump (SBJ) is a valid, reliable and feasible field-based test, which can evaluate explosive strength of the lower limbs and physical fitness. This study aimed to provide normative data for the SBJ for male and female children and adolescents and describe differences in performance between age groups and genders. A total number of 2140 children and adolescents, sampled in seven European nations have been included for analysis. The SBJ was performed to derive percentile values for gender and each age group. In general, males have greater jumping performance compared to females. Data demonstrate a linear increase in the jumping distance for both males and females until adolescence. However, such increase is evident in males up to 16-17 years old, whereas in females a plateau value is met at 12-13 years old, with a subsequent decrease in the jumping performance. No differences were present in jumping performance between male and female children, however differences between male and female adolescents were evinced. The study has provided percentile values useful to monitor the physical fitness status of children and adolescents.

Key Words: standing broad jump, normative data, children, adolescents

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Muscular fitness is an important health-related aspect,[1] a fundamental component for complex athletic tasks but also during the execution of simple everyday life tasks.[2] The importance of taking care and monitor such system since a young age is highlighted by the fact that it is positively associated with bone health while it is inversely associated with central adiposity, cardiovascular diseases and metabolic risk factors,[3] and clustered metabolic risk.[4] Furthermore, muscular fitness may reduce the risk of insulin sensitivity, important aspects either in a healthy population or for those who are exposed to metabolic risk factors.[5,6]

Muscular fitness corresponds to the level of muscular strength of both the upper and the lower limbs and an evaluation strongly associated with tests for the upper (basketball throw and push-ups) and lower limbs (countermovement jump and squat jump) is the standing broad jump (SBJ).[7] This test is designed to measures lower limb muscular fitness and explosive muscular strength of children, adolescents and adults.[7,8] Moreover, this test provides the opportunity to monitor gains after training, to identify sports talent and for pre-recruitment testing in institutions where other measurement instruments are not applicable.[9] Finally, the SBJ is

considered the most valid and reliable field-based muscular fitness test in children and adolescents,[7,10,11] and is also applied to measure anaerobic power of the lower limbs.[9]

One of the best ways to monitor the muscular fitness status of children and adolescents is through specific gender and age normative data. Several studies have been performed from different geographical locations such as Australia,[12,13] Colombia,[14] Colombia-India, [15] China, [16] Hungary,[17] Greece,[18] Spain,[19] or as part of larger transnational studies,[20,21] however such results are limited to confined age ranges or national populations. A recent study has proposed percentile values for the main tests of the Alpha-fit test battery (handgrip strength, standing long jump, and 4x10m shuttle run test),[22] one of the most adopted batteries in Europe to assess physical fitness in children and adolescents.[23] Kolimechkov, et al,[22] to reach their goal, collected data from different studies,[20, 24] filling the gap between ages through linear interpolation. However, the authors stated that this was a temporary solution until such gap was filled by experimental research.[22] Considering the aforementioned reasons, this study aims to provide normative data regarding male and female children and adolescents aged 6 to 18 years old from seven different European countries.

Materials and Methods

Participants

The sample recruited was composed of school-children aged between 6 and 18 years old. These were recruited as part of different projects, namely the ASSO project,[25] the ESA program,[26, 27] and Alfabetizzazione Motoria.[28] The data were recruited from primary and secondary schools and sports centres located in Italy, Lithuania, Germany, Spain, Portugal and Croatia, with the addition of data from Turkey. The locations were those of the partners of the above mentioned projects. A consent form has been signed by the parent or the legal guardian of each participant and such condition was required to participate in the study. Only children who were able to perform the required motor task were included for investigation. Children were excluded if presented medical issues that could influence the jumping performance; or physical and mental disabilities. A total number of 2140 participants, 1176 males and 964 females were finally included. Further details regarding age and anthropometric parameters are shown in Table 1.

The local Ethical Committee of the University approved the project and the study is in accordance with the Helsinki Declaration of 1975, as revised in 2013.

Standing broad jump

The standing broad jump test was performed on a hard surface. The participants stood in a standing position with the heels on the starting line and the feet parallel. The participants, after being instructed by the investigator had to jump as far as possible in a horizontal direction. No indication had been given on the movement of the legs or the arms, so, the participants could perform a self-decided depth countermovement of the legs and perform a free-arm amplitude swing. The participants had to land with both feet together and block the jump without further advancement. All tests were performed three times with a five-minute rest between each attempt. The distance was measured with a tape, in centimetres, from the starting line to the heel of the closest foot to the starting line and the best score of the three attempts was

Table 1. *Descriptive characteristics of the sample*

	Total			***Male***			***Female***		
Age	n	Height (cm)	Mass (kg)	n	Height (cm)	Mass (kg)	n	Height (cm)	Mass (kg)
6	105	124.2±9.7	528.9±7.3	51	126.8±11.1	31.4±8.6	54	122.1±8.6	26.7±4.9
7	109	130.5±13.3	31.9±9.9	54	132.0 ±14.3	34.3±11.3	55	129.4±12.7	29.9±8.1
8	189	133.9±6.1	32.1±7.9	105	133.7±5.7	34.5±9.3	84	134.8±6.4	30.1±4.7
9	167	142.8±11.6	39.9±11.2	87	140.1±8.6	36.5±8.9	80	138.9±6.4	41.4±13.1
10	223	139.9±7.9	35.5±9.3	122	139.7±8.1	35.1±8.6	101	140.4±7.7	36.2±10.3
11	145	142.6±7.0	36.2±6.1	72	144.1±6.4	37.5±61.2	73	141.9±7.3	31.9±20.7
12	140	145.1±7.7	40.8±7.7	82	148.3±8.4	48.8±10.2	58	141.9±6.9	32.8±5.1
13	109	162.4±6.1	54.9±8.3	56	164.7±5.4	56.6±8.7	53	156.8±3.3	51±6.2
14	200	163.5±7.7	57.0±10.2	112	166.2±8.1	59.7±11.4	88	159.5±4.8	52.9±6.5
15	174	167.0±8.3	64.1±15.4	93	170.8±7.8	68.6±16.8	81	161.0±5.0	56.9±9.2
16	256	168.4±8.1	61.7±12.2	149	172.1±7.4	65.7±12.9	107	162.2±5.7	55.1±7.2
17	199	168.8±7.9	66.1±13.3	128	173.0±5.7	70.5±12.4	71	161.5±5.7	57.9±10.7
18	124	168.5±11.2	66.9±14.7	65	176.1±7.7	73.6±14.1	59	160±7.5	59.6±7.5
Total	2140	156.9±18.2	53.8±18.4	1176	161.6±18.4	58.1±19.4	964	150.9±15.9	47.9±14.9

Data are presented as means ± standard deviation.

Table 2. *Percentile values for male children and adolescents for the standing broad jump*

Age/Percentile	10	20	30	40	50	60	70	80	90
6	101	113	116	119	124	125	128	131	138
7	103.6	116	119.9	122.2	125	127	132.2	135.8	153.2
8	100	109.6	119.8	130	133	137.4	145	150	159.2
9	104.6	116.2	120	127	133	138.6	147.2	159.8	179.4
10	111.1	124.2	129.3	135	142	148	152.7	160	172.9
11	117.4	137.2	143	148	152.5	155.6	164	168	177.7
12	137.4	150	158	161	163.5	169.6	178	182.6	192.8
13	135	149	153.5	160	167.5	175	179.5	183	188
14	130.3	141	153.3	160.4	166	178	183	192.4	205
15	132.2	145	153	164.8	170	176.4	181.8	192	197.8
16	135	149.2	164.4	172.2	180	190	200	210.4	223.2
17	150	165	175	184.8	195	200	210	216.2	228
18	146.2	154.8	160	172.6	178	190.2	196	200.2	219.8

All data are expressed in cm.

retained for investigation. The Standard Operating Procedures (SOP) can be found elsewhere.[11]

Statistical Analysis

Analysis were performed using SPSS (version 25 for Windows; IBM, Chicago, IL, USA). Means and Standard deviations were calculated for each age group from 6 to 18 years old and stratified by gender. Subsequently, values from the 10th to the 90th percentiles were derived, calculated for each 10th percentile. Data have been tested for normality using the Kolmogorov-Smirnov test. Being that all data presented a normal distribution, comparisons between age groups within each gender and between genders have been performed through parametric evaluation. ANOVA was performed to evaluate differences between age groups within each gender. Welch T-tests for independent samples have been performed between the same age groups across genders. α value was set at 0.05. The percentile values were finally represented through a smoothed percentile chart, which was obtained through a sixth order polynomial representation for each age group and percentile value using GraphPad PRISM (Version 8.0.1).

Results

Tables 2 and 3 report the percentile values of each age group of the sample for males and females, respectively. For each percentile category there is a linear increase of the jumping distance up to the age of 16-17 years. No statistical difference has been evinced between contiguous age groups, despite the significant difference ($p<0.001$) highlighted by the ANOVA on the whole sample. The same trend is shown for the male participants, who show a linear increase in the jumping performance up to 16-17 years old for all percentile values (Table 2 and Figure 1). No statistical difference has been shown between contiguous age groups, despite the significant difference ($p<0.001$) highlighted by the ANOVA on the whole sample. Female participants increase the jumping performance up to the age of 12-13 years with a subsequent decrease from 14 years old onwards (Table 3 and figure 2). No statistical difference has been found between contiguous age groups, despite the significant difference ($p<0.001$) highlighted by the ANOVA on the whole sample.

Table 3. *Percentile values for female children and adolescents for the standing broad jump*

Age/Percentile	10	20	30	40	50	60	70	80	90
6	95.1	104.6	108.9	113	115.5	117.8	122	127.4	133.4
7	94.4	105.6	112.6	120	122	123.4	128	134	148.6
8	88	101.2	108	114.6	122	129.8	135.4	147.4	161.8
9	100	112.6	117.7	120	122.5	129.4	135	143.6	154.5
10	109	116	123	130	138	149	154	162	175
11	106.2	122.4	139.6	143.8	152	155	160	165	174.8
12	122.2	131.4	139.1	146.8	150.5	155	160	163.2	174.9
13	121.4	129	130.6	135	142	149.2	154.4	160	178
14	111.4	116.4	125.2	130	137.5	145	150.9	160.6	167.3
15	112	121	127	134	139	145	150	160	176
16	101.6	115	120	127.2	131	140	148.4	156	164.8
17	95	108	112	120	126	134	140	152	169
18	100	110	114.4	120	123	130.6	137	151	157

All data are expressed in cm.

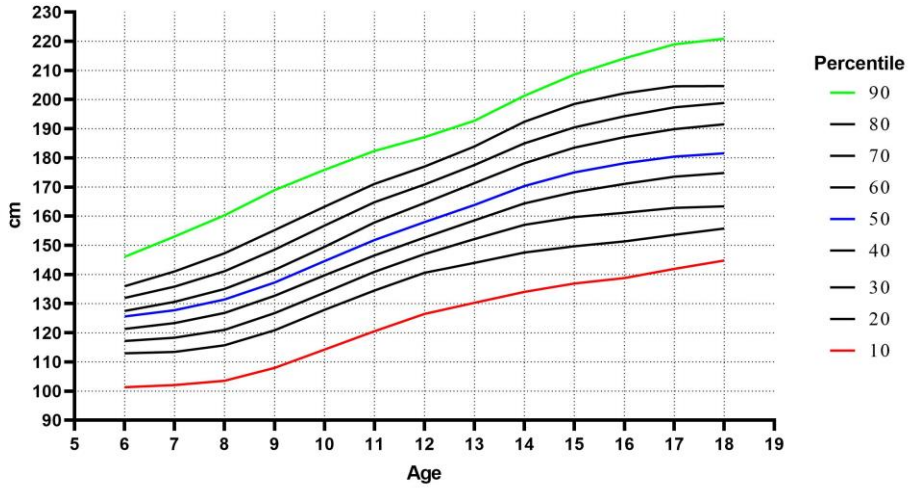

Fig 1. *The male participants show an almost linear increase in the jumping performance up to 16-17 years old for all percentile values*

When comparing age groups across genders, no significant difference in jumping performance is present between males and females from 6 to 12 years old. From 13 to 18 years of age, significant differences are shown for similar age groups between genders with greater performance measures in the male population ($p<0.01$). The percentile measures highlight differences regarding the jumping performance between male and female participants.

Discussion

The study has provided normative data for European children and adolescents aged between 6 and 18 years for the SBJ. The results of the present study are partially comparable with the values of the study of Kolimechkov and Alexandrova.[22] A distinction between male and female participants seems evident. As for the Colombian,[14] Colombian-Indian,[15] Chinese,[16] and Spanish,[19] normative data, girls showed an increase in SBJ performance up to the age of 12, with a subsequent decline from 13 years onwards. Male participants do not show such decline in performance, presenting conversely a linear increase of the horizontal jump performance, data comparable with the study by Kolimechkov and Alexandrova,[22] and other studies.[14-16,19]

It is known that from 6 years of age until 12 to 13 there is a gradual linear increase in muscular explosive strength,[29] therefore such increase in SBJ performance for both male and female was expected. During this early stage of life, sports practice is less competitive and

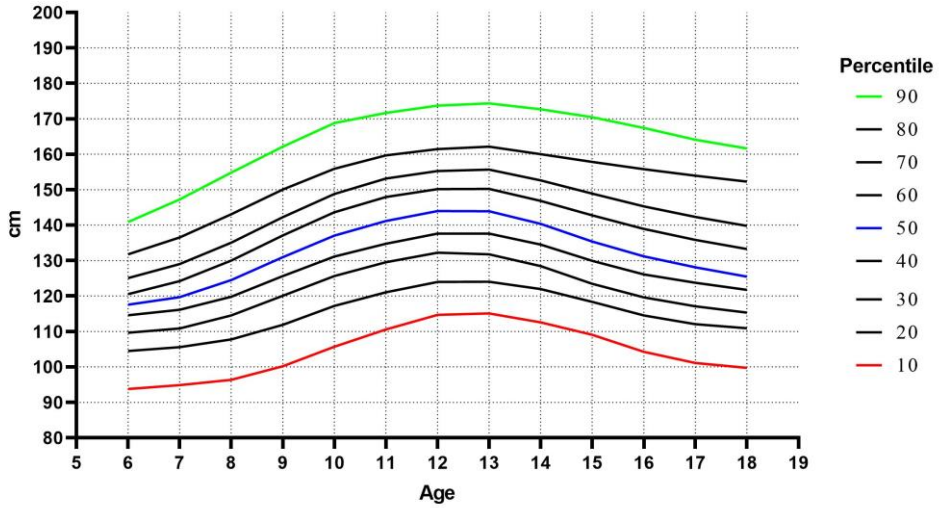

Fig 2. *Female participants increase the jumping performance up to the age of 12-13 years with a subsequent decrease from 14 years old onwards*

consequently it is more enjoyable than in secondary school.[30] During adolescence, other factors influence the SBJ performance and consequently the physical fitness related to physical and psychological characteristics. From a physical point of view, boys present an association between biological maturity and strength.[29] During puberty, boys present a faster increase of steroid hormones, growth hormone and bone mineral content.[16]. Considering that adolescents are influenced by their peers in terms of physical activity and diet,[31] it is likely that boys tend to practice a sport with the purpose of performance and competition while girls mainly practice physical activity for aesthetic purposes. In addition, different studies have tried to understand the reasons that push adolescents to be physically active.[32-35] Males tend to be positively influenced by friends and peers and have higher self-motivation and enjoyment in practicing physical activities during adolescence. Females, instead, suffer more from the transition from primary to secondary school, which leads to a change of their environment and this could be a cause of the reduction of the physical activity practiced,[36] a factor that is probably influenced by the social environment in which they live.[30,37] Furthermore, internal and external factors can influence girls' decision to practice physical activities as the sensation of not correctly performing the required sport skills,[37] the faulty perceptions of their abilities and self-consciousness,[38] the limited sporting activities that women can practice due to the limited number of programs and services available in schools which are specific for girls.[39] In the work of Slater and Tiggemann,[30] girls expressed different reasons for not attending sporting activities, as losing interest, feeling not competent for the required activity or not having enough time. Other factors reported by the authors concerning girls' withdrawal from sporting activities were the feeling that some activities were typically masculine or had the fear to become too muscular. All these factors alone or combined may result in a higher activity engagement in boys compared to girls, which may explain the decline in physical performance from 13 years old onwards in female participants. This is an interesting point since muscle weakness,[2] but not the decay rate of aging, [41] of the female compared to the male lasts for the lifetime.

The major strength of this study is that the data arise from seven European countries, which enables the analysis of transnational data, including children and adolescents over a large age group from different countries. Furthermore, these data could be used to detect children and adolescents that could be in a "warming zone" (e.g. under 10th percentile) when related to health prevention or select athlete in a "interesting zone" (e.g. over 90th percentile) in a school or public contest. Clearly, the data doesn't reflect the European population due to its relatively small sample according to age and country. To preserve a larger and more representative sample a stratification of data was not performed, although more specific and detailed information could have described cultural differences of the sample. Furthermore, other methodological issue is related to the study design, indeed, normative data should be created from a longitudinal study when it is evaluated a parameter related to growing, and this is a cross-sectional study. One last limitation is that, even if the same standard operating procedure has been adopted and an online training has been performed before the study, the data were collected by different teachers, sport science specialists, physical educators.

In conclusion, the study provides SBJ normative data for children and adolescents. It has been noted that SBJ presents a linear increase in the jumping performance in both male and female until adolescence. In adolescents, males continued a linear increase of the SBJ performance up to the age of 17 years old while female presented a plateau after 13 years old, after which a decrease was present. This study establish a reference point for further investigations in this research area.

List of acronyms

SBJ - standing broad jump
SOP - Standard Operating Procedures

Authors contributions

ET, LP, and AB developed the study concept and design as the data analysis and interpretation. ET, GT, ETex, SP, DS, NS, MGL, JP, MA, AB collected the data for the present manuscript. ET, LP, GT, AP, MA and AB wrote the first draft while ETex, SP, DS, NS, MGL, JP critically reviewed and added their contribution to the second version of the manuscript. All authors approved the final version of the manuscript and agree to be accountable for all aspects of the work.

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Conflict of Interest

The authors declare they have no conflict of interest.

Ethical Publication Statement

We confirm that we have read the Journal's position on issues involved in ethical publication and affirm that this report is consistent with those guidelines.

Corresponding Author

Luca Petrigna, PhD student, Sport and Exercise Sciences Research Unit, University of Palermo, Via Giovanni Pascoli 6 - 90144, Palermo, Italy.
ORCID iD: 0000-0002-8106-537X
E-mail: luca.petrigna@unipa.it

E-mail and ORCID iD of co-authors

Ewan Thomas: : ewan.thomas@unipa.it
ORCID iD: 0000-0001-5991-8316

Garden Tabacchi: tabacchi.garden@libero.it
ORCID iD: 0000-0002-7619-5153

Eduardo Teixeira:
eduardoteixeira@esdrm.ipsantarem.pt
ORCID iD: 0000-0002-4326-4175

Simona Pajaujiene: Simona.Pajaujiene@lsu.lt
ORCID iD: 0000-0001-5306-4188

David J. Sturm: david.sturm@tum.de
ORCID iD: 0000-0003-0372-041X

Fatma Nese Sahin: nesesahin@ankara.edu.tr
ORCID iD: 0000-0002-8777-5807

Manuel Gómez-López: mgomezlop@um.es
ORCID iD: 0000-0002-4595-3994

Jelena Pausic: jelenap@kifst.hr
ORCID iD: 0000-0001-7360-7282

Antonio Paoli: antonio.paoli@unipd.it
ORCID iD: 0000-0003-0474-4229

Marianna Alesi: marianna.alesi@unipa.it
ORCID iD: 0000-0002-7372-3205

Antonino Bianco: antonino.bianco@unipa.it
ORCID iD: 0000-0001-8334-6581

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