SOCIEDAD CHILENA DE PEDIATRIA 1922

ANDES PEDIATRICA
REVISTA CHILENA DE PEDIATRÍA

SciELO Chile
www.scielo.cl

Andes pediatr. 2021;92(4):541-547
DOI: 10.32641/andespediatr.v92i4.1520

ORIGINAL ARTICLE

# Body adiposity and abdominal muscle resistance in young people with Down syndrome

## Adiposidad corporal y resistencia muscular abdominal en jóvenes con síndrome de Down

**Marcelo Pino[a], Fernando Muñoz[b,h], Matías Henríquez[c,h,i], Cristian Luarte Rocha[d,i], Rossana Gomez Campos[e], Marco Cossio Bolaños[f], Luís Felipe Castelli de Campos[g,i]**

[a]Escuela Nacional de Pedagogía en Educación Física, Facultad de Educación, Universidad Santo Tomás. Santiago, Chile
[b]Departamento de Kinesiología, Universidad Metropolitana de Ciencias de la Educación. Santiago, Chile
[c]Instituto Nacional de Rehabilitación Pedro Aguirre Cerda. Santiago, Chile
[d]Escuela de Educación Física, Facultad de Educación, Universidad San Sebastián. Concepción, Chile
[e]Departamento de Diversidad e Inclusividad Educativa, Universidad Católica de Maule. Talca, Chile
[f]Departamento de Ciencias de la Actividad Física, Universidad Católica del Maule. Talca, Chile
[g]Departamento de Ciencias de la Educación, Universidad del Bío-Bío, Chillán, Chile
[h]Sociedad Chilena de Actividad Física Adaptada-SOCHIAFA, Chile
[i]Grupo de Investigación en Deporte Adaptado y Paralímpico-GIDEPAUSS. Chile

Received: November 22, 2019; Approved: February 12, 2021

**What do we know about the subject matter of this study?**

Several studies have suggested that muscle strength and body adiposity levels may influence the quality of life, autonomy, and functional independence of young people with and without disabilities, especially those with Down syndrome.

**What does this study contribute to what is already known?**

Young people with Down syndrome, who present satisfactory levels of abdominal muscle endurance, presented decreased body mass index values and waist-to-height ratio, highlighting the usefulness of these variables for the evaluation of physical condition in this population.

## Abstract

**Objective:** to verify the relationship between abdominal muscle endurance and the level of body fat, measured through the waist-to-height ratio, in young people with Down syndrome (DS). **Patients and Method:** A comparative descriptive study was carried out in 115 young people with DS (n = 65 men and n = 50 women) aged between 10 and 18 years, from the Maule Region. Age, weight, height, and waist circumference were evaluated. Body mass index (BMI) and waist-to-height ratio (WHtR) were calculated. The abdominal muscle endurance test (AME) was evaluated in 60 seconds and clas-

**Keywords:**
Body Fat;
Muscle Strength;
Down Syndrome;
Physical Fitness

Correspondence:
Luis Felipe Castelli Correia de Campos
lcastelli@ubiobio.cl

How to cite this article: Andes pediatr. 2021;92(4):541-547. DOI: 10.32641/andespediatr.v92i4.1520

sified into two categories (low AME and acceptable AME). **Results:** Subjects of both sexes classified with adequate levels of AME showed lower WHtR and BMI values ($p < 0.05$), while those classified with low levels of AME showed higher values of WHtR and BMI ($p < 0.05$). The correlations between adiposity and AME were negative and ranged in both sexes from $r = 0.20$ to $0.25$, $p < 0.05$. **Conclusion**: The study showed that young people of both sexes with DS classified with adequate levels of AME, presented decreased values of WHtR.

## Introduction

Worldwide, Down syndrome (DS) is one of the most prevalent intellectual disability[1]. Due to improvements in medical treatment and access to health services, the life expectancy of children with this syndrome has increased[2]. It is widely known that people with DS are at high risk for cardiovascular disease, Alzheimer's disease, and childhood leukemia[3]. In addition, they are more likely to have a sedentary lifestyle, obstructive sleep apnea, dyslipidemia, hyperinsulinemia, gait difficulties, low levels of physical fitness, overweight, and obesity[3-8].

Health-related physical fitness, regardless of the type of population (with or without intellectual disability), according to Heyward[9], includes body composition, aerobic capacity, muscle strength, and flexibility. Muscle strength is one of the components that has been most studied in children and adolescents without disabilities[10-12]. However, in young people with intellectual disabilities, and mainly with DS, studies have suggested that muscle strength greatly impacts quality of life[13-15], autonomy, and functional independence[13].

In this context, preserving muscle strength at a satisfactory level, regardless of the type (e.g., maximal isometric strength, muscular endurance, and explosive strength)[16] is necessary for the development of daily activities in young people with DS. Several studies in children without an intellectual disability have shown that muscle strength is inversely and independently associated with insulin resistance, metabolic risk, inflammatory proteins, and body adiposity during childhood and adolescence[10,11,16,17]. Likely, increased body adiposity in these individuals is negatively related to abdominal muscle endurance, which dynamic endurance tests can assess (e.g., performing sit-ups for one minute)[18].

The objective of this study was to verify the relationship between abdominal muscle endurance and body adiposity, measured by the waist-to-height ratio in young people with DS. This information can be used to develop intervention programs in young people with low levels of muscular endurance and at risk of developing overweight and obesity.

## Patients and Method

Descriptive and comparative cross-sectional study. We studied 115 young people with DS (n = 65 males and n = 50 females), aged between 10 and 18 years. All attend three special education schools in the commune of Talca, Chile. The sample was selected by quota sampling (non-probability sampling).

The IQ degree of the students was classified as mild and/or moderate according to the WAIS-IV scale for young people ≥ 17 years of age and the WISC-V scale was used for participants aged 16 years to 11 months[19,20]. We obtained this information from the administration of each school where the students attended. The guardians of the participants were informed about the study design and the variables to be collected. They all voluntarily signed the informed consent form. This study was conducted following the Helsinki declaration for human subjects and was approved by the ethics committee of the University of Santo Tomás (Code no. ID-116).

### Procedures

All assessments were conducted in three consecutive weeks in August 2019 during physical education classes at school.

The evaluations of the anthropometric variables weight, height, and waist circumference (WC) were performed with students wearing shorts, t-shirts, and barefooted. The standardized protocol proposed by the International Society for the Advancement of Kinathropometry[21] was used. Body mass (kg) was measured using a digital scale (Tanita, model SC 240-MA; accuracy 100 grams); height (cm) was measured using a portable stadiometer (Seca, model 213; accuracy 1mm); and WC was measured using a tape measure (Seca; accuracy 1mm). Body mass index [$BMI = Weight(kg)/Height\,(m^2)$] and waist-to-height ratio [$WHtR = W/H$] were calculated. Nutritional status was calculated using the Z-score for BMI (Z-BMI) according to the reference of the World Health Organization (WHO), considering values of Z-score < 1.00 as normal weight, Z-score 1.00 < to < 1.99 as overweight, and Z-score > 2.00 as obese.

The abdominal muscle endurance (AME) test was used for the assessment of muscle strength, which consisted of performing the highest number of repetitions for 60 seconds. For this, a 10-minute warm-up was performed with alternating joint mobility exercises and static and dynamic flexibility. As a protocol, participants were instructed to lie on their back with their knees bent and feet flat on the floor. The test was performed on a mat with a partner holding the feet. To record the time, a Casio® stopwatch (accuracy 1/100sec)[23] was used. The assessments were carried out by 3 evaluators, all with extensive experience in the process of measuring and evaluating health-related physical fitness.

The cut-off points for AME were considered according to the reference guide of Physical Fitness Testing[24] for students in California (United States). The cut-off points were determined by age and sex for AME as follow: In boys: ≤ 12 sit-ups at age 10 years, ≤ 15 at age 11 years, ≤ 18 at age 12 to 18 years; In girls, ≤ 12 sit-ups at age 10 years, ≤ 15 at age 11 years, ≤ 18 at age 12 years, ≤ 21 at age 13 years, and ≤ 24 sit-ups at age 14 to 18 years.

**Statistics**

The Graphpad Prism® 8 software was used for statistical analysis. The normality of the data was evaluated using the Shapiro-Wilk test and the homogeneity of variances using Levene's test. The mean and standard deviation (SD) were calculated for all results. For comparisons between the means of both sexes, the Student's t-test for independent samples was used. AME was classified into two groups (low and acceptable) and compared by t-test for related samples. Comparisons between categories according to Z-BMI were compared by one-way analysis of variance (ANOVA) and Tukey's test of specificity. Relationships between variables were performed using Pearson's correlation coefficient. The prevalence of nutritional status was compared using the chi-square ($X^2$) test. A $p < 0.05$ was considered for the significance level.

## Results

Table 1 describes the anthropometric variables, adiposity indexes, and AME. There were no significant differences in age, WC, and BMI between both sexes. Boys presented higher weight, height, Z-BMI, and AME than girls ($p < 0.05$), however, girls presented higher WHtR than boys ($p < 0.05$). There were no significant differences between the prevalence of nutritional status (normal weight, overweight, obesity) between both sexes ($X^2 = 0.6000$, $p = 0.7408$).

Figure 1 shows the comparisons between WHtR and BMI by AME categories. In both sexes, significant differences were observed between the two AME categories ($p < 0.05$), both for WHtR and BMI. The WHtR in boys was considered low AME 0.54 ± 0.06 and acceptable AME 0.51 ± 0.03 and in girls was low AME 0.56 ± 0.04 and acceptable AME 0.53 ± 0.04. Regarding BMI, in boys was low AME 25.3 ± 4.6kg/m$^2$ and acceptable AME 21.3 ± 2.8kg/m$^2$, while in girls was low AME 25.4 ± 3.5kg/m$^2$ and acceptable AME 23.6 ± 5.2kg/m$^2$.

Figure 2 presented comparisons of AME by nutritional category according to Z-BMI (normal weight, overweight, and obese). There were no significant differences between the normal weight and overweight categories in both sexes ($p > 0.05$), however, these two categories, both in boys and girls, differed from those classified as obese ($p < 0.05$). In boys, the mean values of AME in the normal weight category was 15.7 ± 7.5 sit-ups, overweight 16 ± 6.4, and obesity 10.6 ± 4.2; and in girls, in the category normal weight, overweight, and obesity it was 14.2 ± 5.1 sit-ups, 14.5 ± 6.5, and 9.0 ± 5.1, respectively.

Figure 3 presented the relationships between the WHtR with the AME test in both sexes. In boys and girls, the correlations were negative and low but significant (boys: $r = -0.20$, $p < 0.05$, girls: $r = -0.25$, $p < 0.05$).

## Discussion

This study showed that there were significant differences in body adiposity measured by WHtR when they were classified according to AME and there was a negative relationship between WHtR and AME in both sexes.

Young people of both sexes classified with better AME presented lower values of WHtR compared with their peers with low AME. In addition, young people classified with obesity according to Z-BMI presented a lower performance in AME. These findings confirm that physical fitness and especially muscular endurance are relevant and associated with a decrease in the accumulation of abdominal adiposity in young people with DS.

These findings are consistent with other studies carried out in children and adolescents with intellectual disabilities, where they have reported that low levels of physical fitness are negatively related to general health[25-28]. Other studies have also indicated that decreased muscle strength has relevant implications in daily life and is essential to perform daily activities[29], so apparently, the combination of low levels of physical activity and a high level of sedentary lifestyle could have a greater impact[30] on muscle strength performance.

It is important to assess muscle fitness in young people with DS, especially AME, as low muscle strength and endurance levels could limit functional inde-

**Table 1. Anthropometric characteristics and Abdominal Muscle Resistance (AMR) of young people with Down Syndrome.**

| Variables | Male (n = 65) | | Female (n = 50) | |
|---|---|---|---|---|
| | mean | SD | mean | SD |
| Age (years) | 14.0 | 2.6 | 14.5 | 2.5 |
| Weight (kg) | 53.8* | 12.7 | 49.9 | 12.8 |
| Height (cm) | 148.4* | 9.3 | 143.5 | 9.8 |
| BMI (kg/m²) | 24.2 | 4.6 | 24.0 | 4.9 |
| *z-BMI* | 1.29* | 1.0 | 1.07 | 1.26 |
| WC (cm) | 78.6 | 9.3 | 79.4 | 9.1 |
| WHI (u.a) | 0.53* | 0.06 | 0.56 | 0.08 |
| AMR (rep) | 14.9* | 7.0 | 12.6 | 6.5 |
| Low AMR | 11.9 | 4.3 | 10.1 | 3.7 |
| Acceptable AMR | 23.3 | 6.4 | 22.9 | 4.8 |
| Nutritional Status (z-IMC) | n | % | n | % |
| Normal | 26 | 40 | 20 | 40 |
| Overweight | 27 | 42 | 19 | 38 |
| Obesity | 12 | 18 | 11 | 22 |

note: SD: standard deviation, BMI: Body Mass Index, WC: Waist Circumference, WHI: waist-height index, AMR: Abdominal Muscular Resistance, *:Significant difference between the groups, X2 = 0.6000, p = 0.7408.

pendence in adulthood[31]. In addition, the assessment and monitoring of strength levels during the growth stage should be prioritized. Early detection of low muscle strength levels in DS populations may help to detect insufficiencies in the maintenance of stability, and consequently in postural balance[32].

Following the results obtained in this study, it is highlighted that there is a need for further analysis and understanding of the importance of muscle strength in DS populations, as future studies could help to identify and select muscle strength tests that best fit and adapt in children, youth, and adults. However, assessing muscle fitness accurately in children with obesity may be particularly challenging[29].

These results coincide with other studies in that we should aim to develop intervention programs that promote health by increasing physical activity in adolescents with DS, since this can improve general physical fitness levels in young people with obesity in school education[28,33], focusing on the development of muscle-strengthening exercises which are associated with the improvement of muscular fitness for the performance of repetitive and daily movements[34]. These exercises could play a relevant role in improving the muscular fitness levels of young people with DS. These activities could be applied by designing guidelines or recommendations from an early age, since they could have a long-term influence and be implemented in the family, in structured therapies, intervention programs, and physical education classes[35].

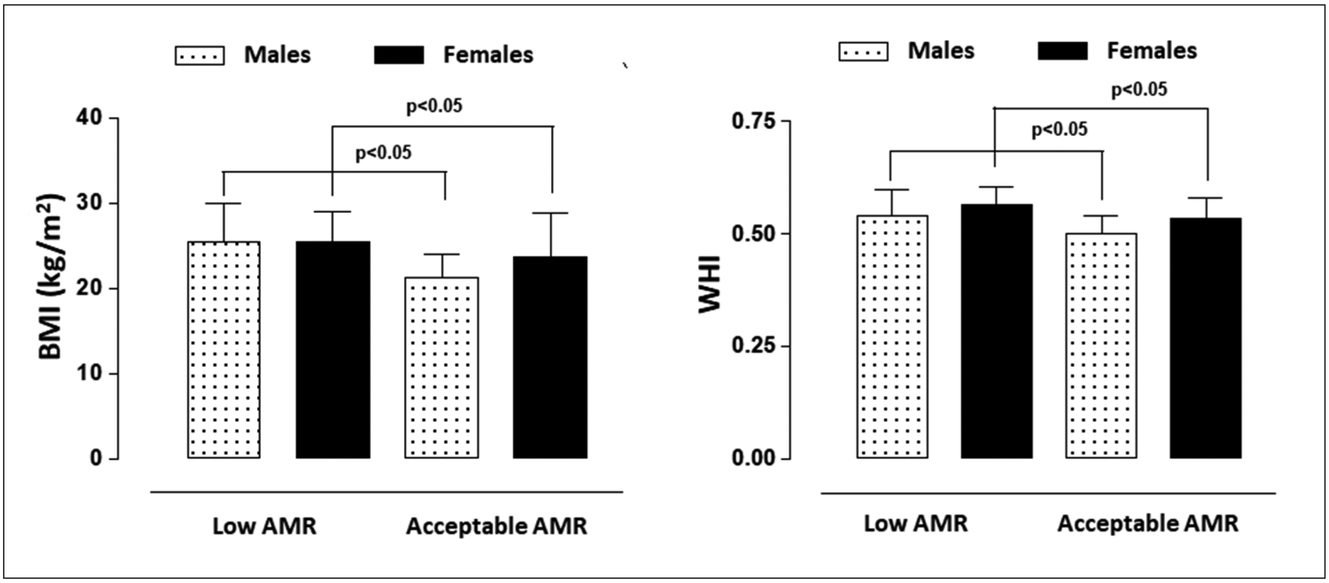


**Figure 1.** Comparison of the mean values of Body Mass Index (BMI) and the waist-height index (WHI) according to the categories of the Abdominal Muscle Resistance (AMR) in young people with Down syndrome. Note: BMI: Body Mass Index, WHI: waist-height index, AMR: Abdominal Muscular Resistance, p: Significant difference between the groups (low vs acceptable AMR).

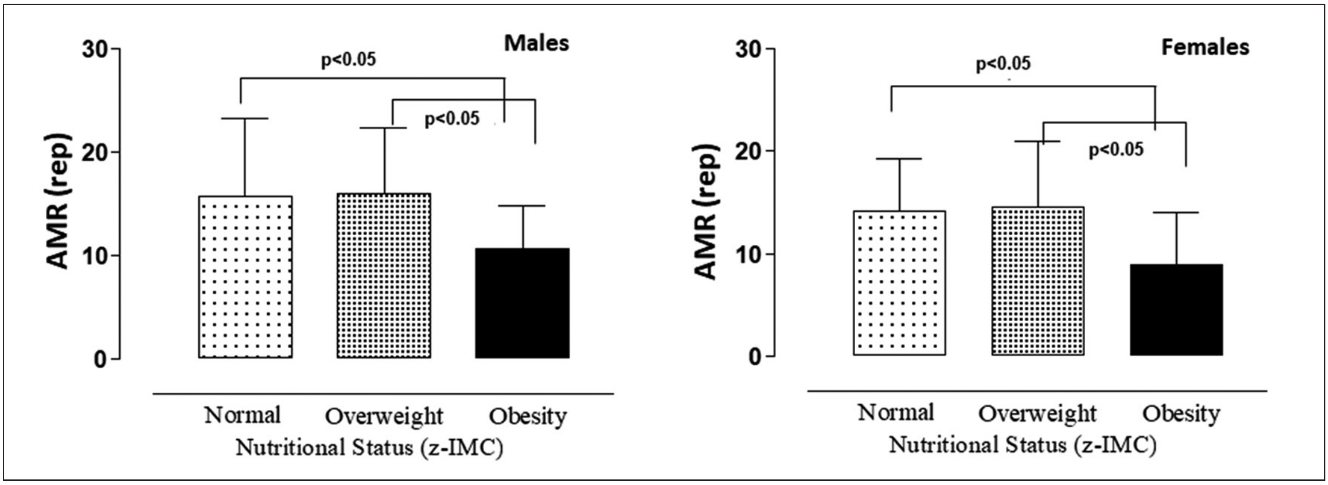


**Figure 2.** Comparison of the mean values of Abdominal Muscle Resistance (AMR) according to nutritional status (z-BMI) and sex in young people with Down syndrome. Note: AMR: Abdominal Muscular Resistance, p: Significant difference between the groups according to nutritional status for male and female.

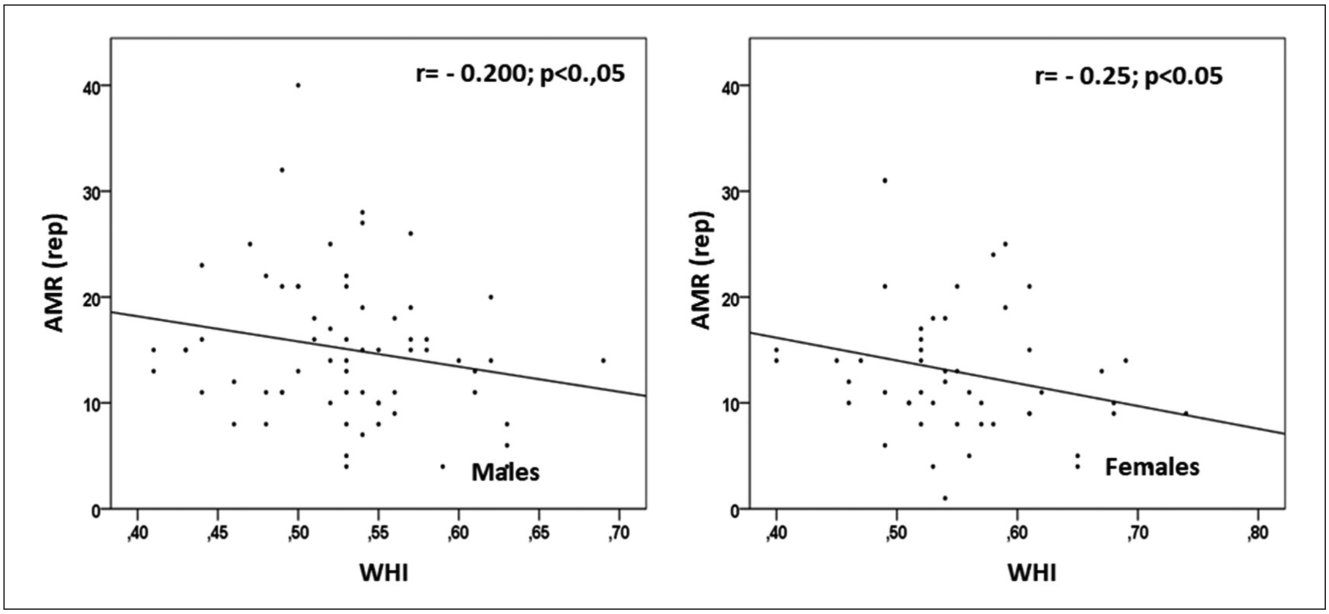


**Figure 3.** Relationship between waist-height index (WHI) and abdominal muscle resistance (AMR) in young people with Down syndrome.

The study presents some weaknesses that should be recognized. Physical activity levels and type of diet could not be evaluated, given that the research used a cross-sectional study design, in which causal relationships cannot be established, so the results should be cautiously analyzed. Without limiting the foregoing, the study provides a baseline for future comparisons and, at the same time, is one of the first investigations carried out in the Maule region, which provides relevant information that can be used for developing local public policies.

As a practical application of the study, identifying differences in body adiposity and strength level between individuals with DS of different ages and sexes contributes to a more efficient and less subjective intervention both in nutritional aspects and in the recommendation of physical activity, since they present specific characteristics that require a more individualized intervention.

## Conclusion

This study demonstrated that young men and women with DS classified with moderate and high levels of abdominal muscle endurance presented lower body adiposity (WHtR) values. These findings suggest that physical activity programs developed for youth with DS should consider physical exercise for muscular endurance and strength, as the study presented evidence of lower levels of body adiposity in youth with DS with adequate AME levels in both sexes, as well as the need for further research that can confirm these results.

## Ethical Responsibilities

**Human Beings and animals protection:** Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

**Data confidentiality:** The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

**Rights to privacy and informed consent:** The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

## Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

## Financial Disclosure

Authors state that no economic support has been associated with the present study.

## References

1. Maulik PK, Mascarenhas MN, Mathers CD, et al. Prevalence of intellectual disability: A meta-analysis of population-based studies. Res Dev Disabil. 2011;32(2):419-36. doi: 10.1016/j.ridd.2010.12.018.
2. Pitetti K, Baynard T, Agiovlasitis S. Children and adolescents with Down syndrome, physical fitness and physical activity. J Sport Health Sci. 2013;2(1):47-57. doi: https://doi.org/10.1016/j.jshs.2012.10.004.
3. Nixon DW. Down syndrome, obesity, alzheimer's disease, and cancer: A brief review and hypothesis. Brain Sci. 2018;8(4):1-14. doi: 10.3390/brainsci8040053.
4. Bertapelli F, Pitetti K, Agiovlasitis S, et al. Overweight and obesity in children and adolescents with Down syndrome-prevalence, determinants, consequences, and interventions: A literature review. Res Dev Disabil. 2016;57:181-92. doi: 10.1016/j.ridd.2016.06.018.
5. Guerra M, Llorens N, Fernhall B. Chronotropic incompetence in persons with down syndrome. Arch Phys Med Rehabil. 2003;84:1604-08. doi: 10.1053/s0003-9993(03)00342-3.
6. Alvear F, Gomez-Campos R, Urra-Albornoz C, et al. Predictores de los Indicadores de adiposidad corporal por edad cronológica y biológica en niños y adolescentes que residen en el sur de Chile. Rev Esp Nutr Hum Diet. 2017;21(4):360-8. doi: http://dx.doi.org/10.14306/renhyd.21.4.401
7. Pastore E, Marino B, Calzolari A, et al. Clinical and cardiorespiratory assessment in children with Down syndrome without congenital heart disease. Arch Pediatr Adolesc Med. 2000;154(4):408-10. doi: 10.1001/archpedi.154.4.408.
8. Wee SOT, Pitetti KH, Baynard T, et al. Impact of obesity and Down syndrome on maximal heart rate and work capacity in youth and adults with intellectual disabilities. Med Sci Sports Exerc. 2013;45(5):32-32. doi: http://hdl.handle.net/10057/10736
9. Heyward VH. Advanced Fitness Assessment & Exercise Prescription, 5th ed. Champaign, Illinois: Human Kinetics, 2006, p. 278.
10. Ortega FB, Ruiz JR, Castillo MJ, et al. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes. 2008;32:1-11. doi: https://doi.org/10.1038/sj.ijo.0803774.
11. Cohen DD, Gomez-Arbelaez D, Camacho PA, et al. Low muscle strength is associated with metabolic risk factors in Colombian children: the ACFIES study. PLoSOne. 2014;9(4):e93150. doi: 10.1371/journal.pone.0093150.
12. Plowman, SA. Muscular strength, endurance, and flexibility assessments. In S. A. Plowman & M. D. Meredith (Eds.), Fitnessgram/Activitygram reference guide (4th ed., pp. 8-1–8-55). Dallas, TX: Cooper Institute. 2010.
13. Gonzalez-Agüero A, Vicente-Rodrıguez G, Moreno A, et al. Health-related physical fitness in children and adolescents with Down syndrome and response to training. Scand J Med Sci Sports. 2010;20:716-24. doi: 10.1111/j.1600-0838.2010.01120.x.
14. Croce RV, Pitetti KH, Horvat M. Peak torque, average power, and hamstrings/quadriceps ratios in nondisabled adults and adults with mental retardation. Arch Phys Med Rehabil. 1996;77:369-72. doi: 10.1016/s0003-9993(96)90086-6.
15. Legerlotz K. The effects of resistance training on health of children and adolescents with disabilities. Am J Lifestyle Med. 2018;14(4):382-96. doi: https://doi.org/10.1177/1559827618759640.
16. Fernández-Santos J, Gonzalez-Montesinos JL, Ruiz J, et al. Kinematic analysis of the standing long jump in children 6- to 12-years-old. Meas Phys Educ Exerc Sci. 2018;22(1): 70-8. Doi: 10.1080/1091367X.2017.1383913.
17. Sepúlveda X, Méndez Cornejo J, Duarte Farfán C, et al. Relationship between body adiposity and horizontal jump in schoolchildren and adolescents. Rev Chil Pediatr. 2018; 89(6):701-8. doi: 10.4067/S0370-41062018005001003.
18. Van Praagh E. Testing anaerobic performance. In: Bar OR, editor. The child and adolescent athlete. Oxford: Blackwell Scientific Publications, IOC Medical Commission; 1996.64) Faigenbaum AD, Milliken LA, Westcott WL. Maximal strength testing in healthy children. J Strength Cond Res. 2003;17:162-6.
19. Wechsler D. WAIS-IV. Escala de

inteligencia de Wechsler para adultos-IV. Manual técnico y de interpretación. Madrid: NCS Pearson, 2012.
20. Wechsler D. WISC-V. Escala de inteligencia de Wechsler para niños-V. Madrid: Pearson, 2015.
21. International Society for the Advancement of Kinanthropometry (ISAK). International Standards for Anthropometric Assessment. Nueva Zelanda. 2001.
22. Growth reference data for 5-19 years. WHO reference 2007. Extraído January 8th 2016. Disponible en: http://www.who.int/growthref/en/.
23. Soares V, Sessa M. Medidas de força muscular. En: Matsudo VKR. Testes de ciência do esporte. 2da Ed. São Caetano do Sul: CELAFISCS. 1983:57-68.
24. California Physical Fitness Test (PFT): Reference Guide. California Department of Education, USA, 2020. https://pftdata.org/files/Reference_Guide.pdf
25. Ruiz JR, Castro-Piñero J, Artego EG, Ortega FB, Sjöström M, Suni J et al. Predictive validity of health-related fitness in youth: a systematic review. Br J Sports Med. 2009;43:909-23. doi: 10.1136/bjsm.2008.056499.
26. Izquierdo-Gomez R, Martinez-Gomez D, Tejero-Gonzalez CM, et al. Are poor physical fitness and obesity two features of the adolescent with Down syndrome? Nutr Hosp. 2013;28:1348-51. doi: 10.3305/nh.2013.28.4.6566.
27. Hartman E, Smith J, Westendorp M, et al. Development of physical fitness in children with intellectual disabilities. J Intellect Disabil Res. 2015;59(5):439-49. doi: 10.1111/jir.12142.
28. Wouters M, Evenhuis HM, Hilgenkamp T. Physical fitness of children and adolescents with moderate to severe intellectual disabilities. Disabil Rehabil. 2019;42(18):1-11. doi: 10.1080/09638288.2019.1573932.
29. Thivel D, Ring-Dimitriou S, Weghuber D, et al. Muscle strength and fitness in pediatric obesity: a systematic review from the European childhood obesity group. Obes Facts. 2016;9:52-63. doi: 10.1159/000443687.
30. Medonca CV, Pereira FD, Fernhall BO. Reduced exercise capacity in persons with Down syndrome: cause, effect and management. Ther Clin Risk Manag. 2010;8:601-10. doi: 10.2147/TCRM.S10235
31. Oppewal A, Hilgenkamp TIM, van Wijck R, et al. Physical fitness is predictive for a decline in daily functioning in older adults with intellectual disabilities: results of the HAID study. Res Dev Disabil. 2014;35:2299-315. doi: 10.1016/j.ridd.2014.05.027.
32. Shumway-Cook A, Woollacott MH. Dynamics of postural control in the child with Down syndrome. Phys Ther. 2011;65:1315-22. doi: 10.1093/ptj/65.9.1315.
33. Garcia-Vicencio S, Coudeyre E, Kluka V, et al. The bigger, ¿the stronger? Insights from muscle architecture and nervous characteristics in obese adolescent girls. Int J Obes. 2015;40:1-7. doi: https://doi.org/10.1038/ijo.2015.158
34. Elsawy, G. Effect of Functional Strength Training on Certain Physical Variables and Kick of Twimeo Chagi among Young Taekwondo Players. World J Sport Sci. 2010;3:683-6.
35. Barr, M, Shields, N. Identifying the barriers and facilitators to participation in physical activity for children with down syndrome. J Intellect Disabil Res. 2011;55(2):1020-33. doi: 10.1111/j.1365-2788.2011.01425.x.