ISSN (electrónico): 1699-5198 - ISSN (papel): 0212-1611 - CODEN NUHOEQ S.V.R. 318

ARÁN

Nutrición Hospitalaria

Trabajo Original

Pediatría

The influence of body composition on the six-minute walk test in Chilean preschool and school children

Influencia de la composición corporal en el test de la caminata de seis minutos en preescolares y escolares chilenos

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Abstract

Background: the six minutes' walk test (6MWT) measures submaximal physical activity. Objective: this study determines the association of children´s nutritional status and body composition with the results of the 6MWT.

Methods: a sample of 1419 Chilean children, 4 to 10 years of age, were assessed including anthropometry, body composition by validated equations, the 6MWT test, and in 50 % of the sample heart rate prior the test, at one minute into the test, and at one minute posttest with a Polar watch.

Results: the distance walked ranged from 473.1 ± 47.8 meters in preschool children to 584.2 ± 65.7 meters in school children. In heart rate there was a significant difference between obese and eutrophic children. The distance walked in the 6MWT was positively associated with fat-free mass ($p < 0.05$) and BMI ($R^2 = 0.49$). Body composition influences 6MWT quartile distribution, as well as nutritional status. Age and height explained 49 % of the variance ($R^2 = 0.42$ and 0.47, respectively) in the 6MWT, and there are significant differences in this variable by sex, body composition, and nutritional status.

Conclusions: body composition was associated with walking performance in children. Thus, it is important to evaluate height and body composition when assessing the six-minute walk test because of this important relationship.

Keywords:

Six minutes' walk. Body composition. Submaximal exercise.

Resumen

Introducción: el test de la marcha de seis minutos (TM6M) mide una actividad física submáxima. Este estudio evaluó el efecto del test de la marcha sobre la composición corporal y el estado nutricional en niños.

Métodos: en una muestra de 1419 niños chilenos de 4 a 10 años de edad se evaluaron la antropometría, la composición corporal por ecuaciones validadas, el TM6M y, en el 50 % de la muesta, la frecuencia cardíaca mediante un reloj Polar.

Resultados: la distancia caminada varió desde 473,1 ± 47,8 metros en los niños preescolares hasta 584,2 ± 65,7 metros en los escolares. En la frecuencia cardíaca hubo una diferencia significativa entre niños obesos y eutróficos. La distancia caminada se asoció positivamente con la masa libre de grasa ($R^2 = 0{,}37$) y el IMC ($R^2 = 0{,}49$). Por otra parte, la composición corporal varía en función de los cuartiles de composición corporal y el estado nutricional. La edad y la altura explicaron el 49 % de la varianza de la prueba ($R^2 = 0{,}42$ and 0,47, respectivamente). Existen diferencias significativas en la distancia recorrida en el TM6M en función del sexo, la composición corporal y el estado nutricional.

Conclusiones: composición corporal, talla e IMC se asociaron a la distancia recorrida en el TM6M. Por tanto, se sugiere medir estas variables cuando se evalúe el test de marcha de seis minutos.

Palabras clave:

Test de marcha de seis minutos. Composición corporal. Ejercicio submáximo.

Received: 05/11/2020 • Accepted: 08/05/2021

Conflicts of interest: the authors declare none. All authors agree and declare that the content of this paper has not been published elsewhere.

Funding: funding was received from the Chilean Ministry of Sports.

Acknowledgements: we acknowledge the collaboration of schools' headmasters, teachers and children in the borough of Macul, South East Region, in Santiago, Chile. We are thankful to the Ministry of Sports for funding this work.

Salazar G, Vásquez F, Concha F, Leyton B, Kain J. The influence of body composition on the six-minute walk test in Chilean preschool and school children. Nutr Hosp 2022;39(1):27-32

DOI: http://dx.doi.org/10.20960/nh.03424

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INTRODUCTION

The measurement of physical fitness is important as it gives information on the health status of a person. A low physical fitness, measured by any method, is linked to either a physical or a cardiovascular deficiency. The assessment of the six minutes' walk test (6MWT) is a simple measurement that allows detecting poor physical fitness, alongside monitoring heart rate during the test, which provides information on the aerobic submaximal capacity and functional capacity of the subject (1), and allows to predict peak oxygen uptake (2) and maximal fat oxidation rate in children and adolescent with overweight and obesity (3,4), in healthy children (4) and in children with a disease (5,6).

The most popular clinical exercise tests in order of increasing complexity are 6MWT, stair climbing, shuttle-walk test, and cardiopulmonary exercise test (7). The 6MWT is a simple and easy measure that assesses the distance a person can walk on a flat, hard surface during six minutes. Its measurement may be accompanied with heart rate assessment. The measurement does not need a wide space, provided a 30-50 walk distance treadmill with no elevation is available where the test may be conducted. It is a clinical test by definition, but recently has been used in epidemiological studies and school surveys due to its simplicity and the important results it provides (7), and the fact it offers has good validity and reliability (2,9,10). It is also used to classify children or adults according to their capacity to conduct more tests that are enduring. There are references for the six minutes' walk test for children (3-10 years old), which provides a possibility to assess improvement in physical activities of daily living (5) in the long run (7,11).

A national survey has determined physical fitness using a 20-m course test, standing long jump, flexibility, and 6MWT, among other tests, in children attending 8th grade, whereas children with a low output in the 6MWT had worse results in the fitness battery (12).

The 6MWT has been used in the assessment of patients with a variety of cardiopulmonary diseases including pulmonary arterial hypertension. The result reflects the integrated exercise response of complex physiology involving the pulmonary and cardiovascular systems, systemic and pulmonary circulations, and neuromuscular function (13). The 6MWT has been used in children in several studies (14) by Li et al., who established the validity of the test in this age group (15).

The change in the distance walked in the 6-minute walk test can be used to evaluate the efficacy of an exercise-training program or to trace the history of change in exercise capacity over time (16). The 6MWT is most commonly used as a baseline and follow-up assessment after a specific intervention, or in monitoring disease progression. In particular, it is used in overweight patients (8). Additionally the inclusion of heart rate measurement adds functional capacity to the test (15).

Body composition is indicated as an important marker of health, as are validated equations in Chilean children for body fat and fat-free mass, which influence the results of the 6MWT, including background heart rate and response to this submaximal exercise post-test. Thus, body composition is an important factor determining the performance of the 6MWT (16).

Given the present sedentary habits of our population (12), as 78 % do not perform any physical exercise, this test is convenient as a first assessment to determine if a patient would be fit to do other tests more demanding in exercise capacity. In children, it has been used to provide an input as a product of a physical activity intervention at schools (14).

The test has proven to be valid and reliable in children and adolescents (15) and, in this paper, the association of the distance walked will be compared to nutritional status and body composition, as possibly important intervening factors.

MATERIALS AND METHODS

SUBJECTS

A total of 1419 subjects (aged 4 to 10 years, 694 boys) from eight different schools located in Macul, a middle-low class district of Santiago.

SAMPLE

The sample was obtained randomly from each level (preschool to 4th grade) in each school, in order to assess the 6MWT and body composition. The Ethical Committee of the Institute of Nutrition and Food Technology approved this study. Parents or legal guardians provided a written informed consent for all participants.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria included healthy children of four to 10 years of age. In turn, exclusion criteria included cardiorespiratory problems, physical inability to walk, cold or influenza in the previous days, or use of any medicines that might affect physical activity performance.

METHODS

Anthropometry

Weight (kg) and height (cm) were measured in the morning with minimal clothing (underwear only), with the children standing on a portable electronic scale (Seca 770, SECA®, Hamburg, Germany) with a capacity of 200 kg and an accuracy of 10 g. Height was measured with a portable stadiometer (Harpenden 603; Holtain Ltd, Crosswell, UK) with a scale of 1 to 200 cm and an accuracy of 0.5 cm.

Skinfold thicknesses (mm) (triceps and subscapular) were measured with a millimeter precision Lange Caliper (1 mm) according to the standard procedure (17). These skinfolds were used to determine total body fat in anthropometric models.

Body fat

Total body fat was assessed by validated equations in Chilean children, using anthropometric variables such as weight, skinfolds and ZBMI as performed in a similar population (18).

Body fat (kg) for three-to-five year olds (18) = 0,371 * weight - 0,114 * (triceps + subscapular skinfolds) - 0,238 * age + 0,378 * sex - 0,105 * calf circumference - 1,524

Where weight = kg, skinfolds = mm, age = years, calf circumference = cm, and sex = 1 for boys and 2 for girls. The equation was generated and validated using the measurement of total body water by deuterium dilution.

Body fat (%) for sichildren aged 6 to 10 years was measured with the following equation (unpublished):

$$(1.826 \times \text{ZBMI}) + (0.783 \times \text{triceps skinfold}) + (0.3073 \times \text{biceps skinfold}) + 15.558$$

Six minutes' walk test

The children were advised to dress comfortably with appropriate footwear. A light breakfast was recommended as the test was conducted in the morning. Children did not engage in strenuous exercise for two hours prior to testing. The test was conducted in a 30-meter flat distance located in the school playground, with no obstacles.

In addition, a Polar watch was installed on the chest of 50 % of the sample, which were selected at random from the whole sample, and remained on the chest before the test, during the test, and one minute post-test.

Before the measurement of resting heart frequency, the children remained still during 10 minutes. The Polar equipment collected heart frequencies at resting time, one minute post initiation of the test, then at minute 6, and then at one minute post-test (7,11). The test was performed individually to prevent competition. The researcher made sure that the child determined the pace, and that heart rate was measured at the specified times. Some words (e.g., "Keep going", "You are doing well", "Continue" and "Time remaining") were given to the children during the duration of the test as encouragement to maintain the walk pace to the end. A trained examiner supervised all tests.

Children were advised to walk as fast they could, in a comfortable manner. In addition, children were told that they could stop and rest during the test if they felt tired. The children were not allowed to "practice" walks before the test. If the walk test needed to be repeated for clinical purposes, the child had to repeat it the next day. The longest distance was recorded and the Polar data were downloaded in a computer.

STATISTICAL ANALYSES

Mean values and standard deviations were calculated for continuous variables and frequency distributions for categorical ones. Student's t-test was used to assess differences in continuous variables for two groups and ANOVA in comparisons for three groups.

In the distribution by quartiles, the ordered data set was divided into four equal parts. Q1, Q2, and Q3 determine the values corresponding to 25 %, 50 %, and 75 % of the data.

A p-value of < 0.05 was considered statistically significant. The analyses were performed using STATA, version 12.0 (StataCorp 2011 Stata Statistical Software. Release 12, College Station, TX. StataCorp LP. USA).

RESULTS

Table I shows the age, weight and height of the sample children by school and BMI. Overweight (22.2 %) and obese (19.8 %) children amounted to near 40 % of the sample, and over 57 % had a normal nutritional status. Obesity was 16.5 % in preschool children and 20.7 % in school children. In table II, body composition factors are shown and differences were found by school level (preschool *versus* school children).

Table I. Anthropometric data from the sample (data were normally distributed)

	Age (y)	Weight (kg)	Height (cm)	BMI (kg/m²)
All (n = 1419)	7.6 ± 1.7	28.5 ± 8.5	124.4 ± 11.2	18.1 ± 2.9
Preschool (n = 199)	5.2 ± 0.5*	20.6 ± 3.6*	109.91 ± 5.3*	16.9 ± 2.1*
School (n = 1220)	8.2 ± 1.3*	30.5 ± 8.3*	127.9 ± 9.9*	18.3 ± 3.1*

*BMI: body mass index. *p < 0.001.*

Table II. Body composition in preschool and school children

	Triceps (mm)	Body fat (kg)	Fat-free mass (kg)	FMI (kg/m²)	FFMI (kg/m²)
All	13.4 ± 5.7	7.4 ± 3.8	21.1 ± 5.1	4.6 ± 1.8	13.4 ± 1.6
Preschool	9.9 ± 2.1*	5.1 ± 1.8*	15.5 ± 2.0*	4.2 ± 1.3*	12.6 ± 0.9†
School	12.8 ± 5.0*	8.0 ± 4.0*	22.5 ± 4.7*	4.8 ± 1.9*	13.3 ± 1.5†

*FMI: fat mass index; FFMI: fat-free mass index. *p < 0.001; †p < 0.01.*

In table III data on the six minutes' walk test are given, including the measurement of heart rate in half of the sample. It is clear that in this study, school girls had a poor condition due to a low heart rate recovery when compared even to preschool children.

The sample for the six minutes' walk test was 1419 and for the measurement of heart rate was 676 children (of these, 123 in preschool children). It is observed that girls have the least change in heart rate recovery indicating a worse cardiorespiratory fitness when compared to boys, even lower than in preschool children.

In table IV the data on the six minutes' walk test are shown by nutritional status, including heart rate both pretest and at minute one during the test.

There is a significant difference between obese and eutrophic children in heart rate, whether initial, one minute into the test, or one minute post-test. Thus, the assessment of heart rate adds functionality to the six minutes' walk test, where distance walked may not change on average, according to nutritional status. Obese children walk less than children with normal nutritional status, although not significantly.

In table V the quartiles of the six minutes' walk test are presented, as well as BMI, height, body fat (%) and fat-free mass. Each quartile represents 354.7 children from the global sample.

The factors changing most by quartile of six-minute walk test are height and fat-free mass ($p < 0.05$), the latter depending inversely on height. This fact shows the dependence of the 6MWT on body composition and height.

The main associations of the six minutes' walk test distance are with age ($R^2 = 0.49$) and with height ($R^2 = 0.42$, $p < 0.01$). On the other hand, BMI is associated with the six minutes' walk distance, whose $R^2 = 0.49$. The fat-free mass association to distance walked reaches $R^2 = 0.37$.

Table III. Six minutes' walk test information in preschool and school children

	Distance (m)	Pretest HR	Minute 1 HR	Minute 6 HR
All (n = 1419)	562.2 ± 77.7	92.0 ± 13.3	132.7 ± 18.4	114.1 ± 15.6
Boys (n = 717)	570 ± 80.01*	91.5 ± 13.3	130.9 ± 19.1	113.1 ± 15.3*
Girls (n = 702)	554.6 ± 71.4*	92.7 ± 12.6	135 ± 17.4	115.6 ± 15.1*
Preschool	473.1 ± 47.8	98.8 ± 11.3	129.2 ± 15.2*	113 ± 12.7
School	584.2 ± 65.7	90.3 ± 13.3	133.41 ± 17.6*	114.5.5 ± 16.5

*HR: heart rate. *p < 0.001.*

Table IV. Data from the six minutes' walk test by nutritional status in children

	Distance (m)	Pre- test HR	Minute 1 HR	Minute 1 post-test HR
Normal (n = 804)	566 ± 80.4	91.1 ± 13.0*	130.86 ± 18.3*	113 ± 15.4†
Overweight (n = 325)	556.3 ± 71.3	91.6 ± 12.1	133.2 ± 18.0	114.8 ± 14.8
Obese (n = 291)	558.2 ± 71.4	94.7 ± 13.6*	136.4 ± 18.8*	116.5 ± 13.5†

*HR: heart rate. *p < 0.001; †p < 0.01.*

Table V. Quartiles of 6MWT, BMI, height, and body composition

	Quartiles 6MWT	BMI (kg/m²)	Height (m)	Body fat (%)	Fat-free mass (kg)
Q1	462.7 ± 41.5*	17.2 ± 2.3*	1.14 ± 0.1*	24.9 ± 4.3†	16.9 ± 3.3‡
Q2	540.7 ± 16.3*	18.0 ± 3.0*	1.23 ± 0.1*	25.2 ± 5.5	20.3 ± 4.4‡
Q3	564.5 ± 35.1*	18.3 ± 3.1*	1.3 ± 0.1*	25.5 ± 5.7†	21.5 ± 4.8
Q4	655.6 ± 37.2*	18.4 ± 2.9*	1.33 ± 0.1*	24.5 ± 5.6†	24.5 ± 4.1‡

*6MWT: six minutes' walk test. *p < 0.001; †p < 0.05; ‡p < 0.01.*

DISCUSSION

Anthropometric information on body composition and the 6MWT differ between preschool and schoolchildren as expected ($p < 0.001$). This sample has three categories of nutritional status, thus the test provides results on the distance walked according to nutritional status. There is no difference in the distance walked, with the exception of obese children, who walked less meters (558.2 ± 71.4) *versus* normal-weight children (566 ± 80.4), showing a lower physical capacity and consequently less physical activity compared to other categories. There is also a difference in heart rate recovery between girls and boys, as well as between preschool and school children ($p < 0.01$). In the quartile distribution of the 6MWT is clear a relationship with fat-free mass, which varies significantly according to the distance walked.

This test has proven validity and reliability (15), is a good reflection of daily activities, and is well tolerated and easy to administer compared to other demanding exercise functional tests. The present standard to assess aerobic exercise is the increment of oxygen consumption, which can be assessed by heart rate measurement (16).

Most daily physical activities today, especially in children in school settings, are of submaximal capacity (walk, standing, sitting) (19), thus a submaximal functional test as the 6MWT is a good reflection of daily activities. On the other hand, the six-minute walk test is a submaximal exercise test that has been utilized to quantify functional exercise capacity as it measures the distance walked within a period of six minutes.

Age and height in a paper on Swiss children (11) explained 49 % of the variance, similar to our work ($R^2 = 0.42$, $p < 0.01$). The distance covered in six minutes of walking by Chilean children is less than that walked by Swiss children of the same age (11), and similar to that of girls in Sousse-Tunisia (20). In English children it is significantly different possibly due to a difference in height or physical fitness (11,21). When comparing Chilean children to data from the Netherlands (22) regarding distance walked in the 6MWT, the latter group walk more on average (78.1 m ± 45.9 m).

The main variables associated with the distanced walked in the 6MWT are age, height, fat-free mass and, less so, body mass index. Although these associations exist, the prediction equations in different studies for the distance walked (7), even in pooled data or reviews (23,24), may not coincide with those of children in this work, due to differences in level of physical activity and height. Thus, a specific reference may not be adequate for a different population. For instance, reported values for the proposed equation by Li et al. (15) (6MWD = (4.63 * height [cm]) - (3.53 * weight [kg]) + (10.42 * age) + 56.32) gives a mean difference of 49 meters as compared to our data, with two standard deviations reaching nearly 100 meters. Similarly, a recent review has proposed and equation for people under 18 years of age (22), which is based on age, weight and height, and which gives a mean difference of 40 ± 63 meters, which is almost a difference of 7-19 % with respect to the values measured in Chile. In this work the values obtained from the 6MWT do not coincide with those of international papers (25), and the distance walked is smaller than the one reported by Li et al. (15), with nearly a 100-meter difference. Thus it is clear that children in Chile have a different physical capacity or framework when compared to the children reported by Li et al. (15) or other papers (2,26). On the other hand, the 6MWT distance is similar to that reported by Lammers et al., who measured English children aged four to 11 years (21).

This test measures a submaximal capacity but provides a result of the functionality of children and is easy to administer almost in any school or setting, providing a screening tool previous to the undertaking of maximal tests, mainly in smaller children. The poor physical activity in Chile (31 % of children and 53 % of adolescents spend more than two hours in sedentary activity) and in other countries makes it difficult to submit children to more powerful tests, thus the 6MWT provides a good tool as screening analysis of cardiorespiratory tests in children (26-28).

The main differences found by nutritional status reside in the distance walked, pretest heart rate, and recovery heart rate, especially in obese children, who may have more difficulty to walk fast but reach a higher heart rate (29). In table II it is clear that height and fat-free mass vary most when compared to six minutes' walk test quartiles, and that body fat has no clear influence.

Age, height, and fat free mass are associated significantly with the distance walked during the test (4,30). The influence of body composition and height on the results of the test indicates that both factors are important for walking performance and aerobic capacity, and that both characteristics are important factors in test performance.

Moreover, height and fat-free mass differ significantly in the quartile distribution of the 6MWT. This association has been found in the paper where they conclude that total and segmental fat-free mass are associated with a better walking capacity than BMI in severe obesity.

In other papers they conclude that both fat and lean mass are associated with walking performance (31,32). This paper has some advantages: the big sample size (1419 children), the age span (four to 10 years of age), and standardized researchers did the measurements. The limitations refer to the use of a validated anthropometrical equation for obtaining body composition, instead of direct measurement.

In conclusion, the six minutes' walk test is an important tool as screening option or first measurement before more demanding physical exercise tests. It is a valid, replicable, simple to use test in a school setting, and would help allocate and follow up children. Additionally, it would serve as an impulse to improve the level of physical activity or to evaluate in a practical way the walking capacity of children (32). In contrast, this test relies on frame constitution, age, and sex, which in turn may relate to muscle content and body composition (33). Body composition in this work was associated with the walking performance of the children. Thus, it is important to evaluate height and body composition when assessing the six minutes' walk test due to their important relationship (33).

Given these results, the 6MWT needs to be considered an important clinical test, able and valid to assess the functional capacity of children, or a screening method prior to more enduring physical fitness tests, especially in small, overweight children. Body composition has been found to influence the results of the distance walked, suggesting it must be considered in the assessment of submaximal physical capacity in children.

A strength of our study is the sample size of children with different ages and nutritional status, and that anthropometric determinations were collected by highly trained nutritionists. One of the limitations was the selection of students. Only a group of students from one sector of Santiago participated in this study. Another limitation was the non-measurement of variables such as blood pressure or oxygen consumption.

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