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ORIGINAL ARTICLE

Response to the six-minute walk test in children with cardiovascular risk

Respuesta a la prueba de caminata de seis minutos en niños con riesgo cardiovascular

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

Childhood obesity is a public health issue that required assessment tools to improve prevention and early detection of cardiovascular diseases in obese children. The six-minute walk test seeks to achieve this goal.

What does this study contribute to what is already known?

The literature validates the six-minute walk test as an instrument to determine aerobic performance in obese children and to define their cardiorespiratory impairment. The study questions this statement and proposes alternatives.

Abstract

Introduction: Cardiovascular risk (CVR) is defined as the possibility of a subject suffering from cardiovascular disease within a certain period. Although the pathology appears in adult life, the physiopathological changes start to develop at an early age. **Objective:** To establish the relationship between cardiorespiratory capacity (CRC)and CVR in children with metabolic syndrome. **Patients and Method:** We analyzed data corresponding to 42 children aged from 5 to 15 years who were seen at the Children's Cardiology Unit of the Carlos Van Buren Hospital between 2015 and 2017. Each participant was categorized according to the Alustiza's CVR score, which defines 3 levels of risk: low (0 to 6 points), medium (7 to 8 points) and high (9 or more points), which representing a greater probability of developing cardiovascular disease, and performed 6MWT. **Results:** The mean age of the children was 10.9 ± 2.7 years, body mass index (BMI) = 31.0 ± 4.6 kg/m^2 (z-score 3.2 ± 0.7), percentage of theoretical distance walked = 75.2 ± 8.9, and percentage of heart rate reserve (HRR) = 31.0 ± 9.4. There was no statistical association between 6MWT and CVR. **Conclusions:** There is no relationship between the cardiorespiratory capacity and the CVR. The use of the 6MWT is questioned as an instrument to assess CVR in the population under study.

Keywords:
Cardiovascular Risk;
Alustiza Score;
Six-Minute Walk Test;
Children;
Metabolic Syndrome

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Introduction

According to the latest National Health Survey, 11 million people in Chile (aged 15 and over) have some form of cardiovascular risk (CVR) such as hypertension (27.6%), obesity (34.4%), diabetes (12.3%), smoking (33.4%), or a sedentary lifestyle (87%)[1].

CVR is defined as the possibility of a subject suffering from cardiovascular disease within a certain period of time[2]. This will depend on the number of risk factors of the individual, which may or may not be modifiable. Modifiable factors include obesity, high blood pressure, long-term intake of atherogenic diet, and habits such as sedentary lifestyle smoking, and alcoholism, among others. Also, genetic factors are the mainstay of non-modifiable factors[3]. Currently, in the child population, there is evidence of these factors that will facilitate and establish the CVR[4,5], therefore, it is necessary to early identify the risk in this population. This will ensure that this individual, as an adult, has a lower probability of developing cardiovascular disease.

Worldwide, 360 million children and adolescents aged between 5 and 19 years are overweight or obese, as well as 41 million children under the age of 5[6]. In Chile, overweight and obesity present a 50.9% prevalence in children of 1st grade in de primary education[7]. When assessing cardiovascular performance and maximal aerobic capacity in children of 8th grade, 72% of them presented an insufficient level[8]. In addition, it is known that those children who are overweight or obese are the least physically fit students in the school population[9].

Cardiorespiratory tests aim to evaluate the body's capacity to absorb, transport, and use oxygen during exercise and physical activity. The most reliable indicator for measuring cardiorespiratory capacity (CRC) is the quantification of maximal oxygen consumption (Max.VO_2). There are two ways to measure this indicator, one is through direct gas analysis in the laboratory, and the other one is through indirect field tests that estimate Max.VO_2. Among the latter are cardiorespiratory exercise tests. The most used and recommended test is the 20 m shuttle test in children and adolescents and, if the population is at risk, the six-minute walk test (6MWT) since it is a simple, safe, reliable, and highly valid test[10-13].

The objective of this study was to determine if there is a relationship between cardiorespiratory capacity, estimated through 6MWT, and CVR in children with metabolic syndrome, in order to validate the test as a support tool in the prevention and identification of cardiovascular diseases in this age group.

Patients and Method

Retrospective descriptive correlational non-probability study, using an anonymous database of 71 children of both sexes, between 5 and 15 years old, with a history of hypothyroidism, hypercholesterolemia, dyslipidemia, insulin resistance, obesity, and overweight. All of them were in the CVR program of the Children's Cardiology Polyclinic of the *Hospital Carlos Van Buren* (HCVB) in Valparaiso between 2015 and 2017. The exclusion criteria from the analysis were data on children with associated heart pathologies, use of cardiovascular drugs, musculoskeletal or gait disorders, uncontrolled bronchial asthma, and history of hospitalization or consultation at the emergency department in the last four weeks (Figure 1).

42 records were selected, analyzing age, sex, weight, height, and z-score BMI. Each participant was categorized according to the Alustiza CVR score (Table 1), which defines 3 levels of risk: low (0 to 6 points), medium (7 to 8 points), and high (9 or more points), which would mean a greater probability of developing cardiovascular disease[14].

The 6MWT was performed according to the American Thoracic Society (ATS) protocol to estimate cardiorespiratory capacity[11-13]. The objective of this test is to cover the greatest possible distance in six minutes, walking as fast as possible without running, in a 30-meter long corridor, which must be covered cyclically as many times as the subject can during the indicated time.

Before the test, each subject was evaluated in weight and height with a SECA stadiometer model 220, and their resting heart rate ($_{R}$HR), oxygen saturation (SaO2), and blood pressure (BP) with a Contec monitor model CMS5000. The subject was seated for 10 minutes at rest before the respective measurements. Subjective muscle-fatigue sensation in the low limbs (SFS - LL) and sensation of dyspnea were assessed according to the modified Borg scale (range 0 to 10)[15]. The measurements were repeated immediately after the test, at 5 and 10 minutes of rest, and the maximum heart rate reached after exercise was also recorded ($_{\text{Max Exercise}}$ HR). The theoretical maximum heart rate ($_{\text{Max Theoretical}}$ HR) and the reserve heart rate (RHR) percentage were recorded according to the following formulas:

$_{\text{Max Theoretical}}\text{HR} = 210 - (\text{age}*0.65)\ bpm$ and

$$\%\,RHR = \frac{\text{Max Exercise HR - resting HR}}{\text{Max Theoretical HR - resting HR}} \text{x } 100$$[11,16],

in order to monitor cardiac response and intensity levels of physical exercise.

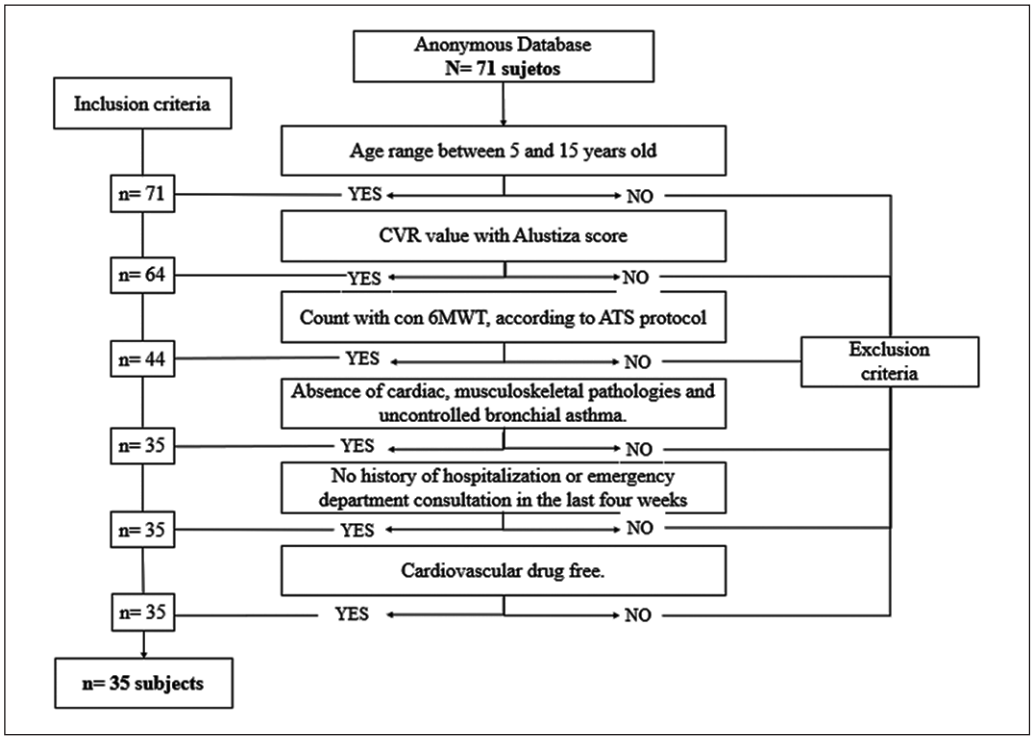

Figure 1. Sample selection.

We used the values of Gatica et al.[11] to calculate the theoretical maximum distance to be covered in the 6MWT, and the formula of Jalili et al.[12] for the estimation of the Max. VO_2.

Statistical analysis

For the statistical analysis, we used the IBM SPSS Statistics software 24.0. The descriptive statistics were expressed as means with their respective standard deviation and median [minimum - maximum]. Since the nature of the Alustiza score variable, we performed the Spearman correlation test (rho), which is not normally distributed as it is a discrete variable.

Results

We obtained a sample of 18 male and 24 female subjects. Table 2 describes the characteristics of the subjects under study and Table 3 shows the results obtained in the 6MWT and Alustiza score. Regarding the categorization of their CVR, only 3 subjects are in the medium-risk category (7-8 pts.) and the remaining 39 in high risk (9 or more pts.).

All subjects completed the 6MWT without major problems in terms of cardiorespiratory performance and only 2 subjects recorded a stop during the test. The $_{\text{Max Exercise}}$ HR reached was 124.2 ± 11.1 bpm, for a total distance covered (CD) of 433.4 ± 58.6 m. Concerning

Tabla 1. Puntaje de RCV de Alustiza et al

Variable	Value	Score
Age	2 to 5 years	0 points
	6 to 12 years	2 points
	> 13 years	3 points
Sex	Female	0 points
	Male	2 points
Family Background	Absent	0 points
	(+) Biochemical	2 points
	(+) Clinical	4 points
Exercise	> 2 h/day and TV < 3 h/day	0 points
	< 2 h/day and TV > 3 h/day	1 point
Tobacco/Alcohol	No	0 points
	Yes	1 point
Obesity (BMI)	< 95 Percentile	0 points
	> 95 Percentile	1 point
Blood Pressure	< 95 Percentile	0 points
	> 95 Percentile	1 point
Cholesterol	TC: 150-199, LDL 100-109	0 point
	TC: 200-220, LDL 110-130	1 point
	TC: 221-230, LDL 131-160	2 points
	TC: 231-280, LDL 161-190	3 points
	TC > 281, LDL > 190	6 points

Score: Total points 19; low risk: 0-6; medium risk: 7-8; high risk: 9 or more. CVR: Cardiovascular risk. BMI: Body Mass Index. TC: Total cholesterol.

the RHR percentage, it was 31.0 ± 4.6 at the end of the test. The percentage of SaO2 was 97.2 ± 1.5, systolic blood pressure (SBP) was 125.2 ± 13.4 mmHg, and diastolic blood pressure (DBP) was 68.1 ± 10.4 mmHg. The estimated maximum $VO2_{max}$ was 15.8 ± 4.7 ml/kg/min. The median SFS - LL was 0 [0-5] and median dyspnea was 0 [0-2].

Analyzing the behavior of the variables under study (Table 4), there were correlation values between CD and: Age = 0.44; Height = 0.50; $_{Max\ Theoretical}$HR = 0.43; Theoretical distance covered (%) = 0.53; DBP = 0.43; and Max. SaO2 = 0.67.

Table 2. Characterization of study subjects

	Total (n = 42)	Male (n = 18)	Female (n = 24)
Age (years)	10.90 ± 2.72	10.61 ± 3.16	11.13 ± 2.38
Weight (kg)	70.49 ± 18.31	70.61 ± 20.18	70.40 ± 17.22
Height (m)	1.49 ± 0.12	1.50 ± 0.15	1.49 ± 0.09
BMI (kg/m²)	31.04 ± 4.58	30.58 ± 4.53	31.40 ± 4.68
BMI z-score	3.20 ± 0.66	3.43 ± 0.78	3.08 ± 0.51

BMI: Body Mass Index.

There was no correlation between CD and CVR variables, with a Rho value of 0.004; p of 0.98.

Discussion

The study's results show that there is no relationship between CD by children in the 6MWT and CVR. However, the children in the sample covered less distance than the healthy Chilean pediatric population[11] and also have a high CVR. Although test performance may be influenced by other factors such as height, sex, health status among others[13], we question the usefulness of the 6MWT to assess CRC in the study population. The 6MWT has proven to be an excellent tool for measuring CRC in pediatric populations with chronic diseases[11], however, concerning obesity, there is little scientific evidence in our country.

The clinical use of walking tests to assess CRC in children without clinical manifestations is questioned due to that walking tests are submaximal exercise tests. During submaximal exercise, the body's ability to transport and use oxygen is perfectly covered for a relatively long time, so CRC is not fully explored. In contrast, a maximum progressive exercise test involves a considerable increase in oxygen demand, testing all those physiological functions that determine a rapid response of the oxygen transport system, allowing a more accurate evaluation of CRC[17].

Table 3. Mean and standard deviation of the six-minute walk test and cardiovascular score

	Total (n = 42)	Male (n = 18)	Female (n = 24)	p-value
CD (m)	433.4 ± 58.6	430.5 ± 47.1	435.5 ± 66.9	0.27
Theoretical Distance (m)	575.9 ± 22.9	565.89 ± 26.6	583.32 ± 16.6	*0.02
Theoretical Distance (%)	75.2 ± 9	76.0 ± 6.7	74.5 ± 10.4	0.52
$_{Max\ Exercise}$HR reached (bpm)	124.17 ± 11.11	122.67 ± 11.57	125.29 ± 10.86	0.75
$_{Max.\ Theoretical}$HR (bpm)	203.34 ± 3.18	203.08 ± 2.06	203.54 ± 3.85	0.62
80% $_{Max.\ exercise}$HR reached (bpm)	162.23 ± 1.45	162.43 ± 1.64	162.08 ± 1.30	0.45
RHR (%)	31.03 ± 9.42	29.88 ± 9.78	31.90 ± 9.25	0.68
SaO_2 (%)	97.24 ± 1.54	97.44 ± 1.25	97.08 ± 1.74	0.74
SBP (mmHg)	125.24 ± 13.38	126.11 ± 13.95	124.58 ± 13.20	0.36
DBP (mmHg)	68.14 ± 10.37	67.94 ± 9.08	68.29 ± 11.43	0.1
Max. VO_2 (mL/kg/min)	15.80 ± 4.71	15.73 ± 4.29	15.85 ± 5.09	0.07
		Median (Minimum-Maximum)		
Alustiza Score (score)		11 (7-14)		
Dyspnea (Borg)		0 (0-2)		
SFS - LL (Borg)		0 (0-5)		

p-value = referred to comparison between male and female values as significant differences, according to t-student test. CD: Total distance covered; HR: Hearth rate; SaO_2: Oxygen saturation; SPB: Systolic blood pressure; DBP: Diastolic blood pressure; Max VO_2: Maximum oxygen uptake; SFS – LL: subjective muscle-fatigue sensation in the low limbs. *It is considered a value p < 0,05.

The physical condition related to health is considered as associated with CRC, understanding it as a measurement of the ability to perform physical activity and/or exercise by integrating most of the functions involved in body movement[17]. The more demanding the test, the more accurate the evaluation of this variable in the health condition of children with CVR[10].

Based on this assumption, the behavior of CRC was studied with another walking test, the Incremental Shuttle Walk Test (ISWT), where children effectively obtain a better result than in the 6MWT, with an RHR percentage higher than 90%. To achieve this condition, the authors recommend in the pediatric population, adding three additional levels of speed to the original test and allowing the child to run, in search of maximum progressive effort[15,18,19]. Another possible explanation for the low correlation between 6MWT and the CVR measured using the Alustiza Scale score, points directly to the same instrument as screening children at metabolic risk.

Despite the authors stating the lack of statistical power in their results, our observations are mainly directed at the evaluation methodology and score assigned to the 'exercise' variable. Alustiza et al. research the level of the child's physical activity based on the hours/day she/he spends watching television, categorizing her/his condition as sedentary or not. This does not necessarily represent the child's physical condition, which is related to muscular strength and endurance, flexibility, speed, agility, and CRC, and are aspects studied by the 6MWT. Also, within the total score of the scale, the exercise variable only considers a maximum of one point[14]. We would like to mention the work of Toulouse et al. who, using indirect calorimetry, heart rate monitoring, and near-infrared spectroscopy during incremental exercise, are studying reliable field tests to evaluate the physical condition in obese children[20].

López et al.[21] made the first effort to characterize the cardiorespiratory response of obese children through the 6MWT, concluding that obese children do indeed cover less distance than a normal-weight child and that CRC was limited compared with the test that required physical effort of up to 77% of RHR. Our study obtained 31% in this variable, very similar to that of Gatica et al.[11], where they applied the 6MWT on 192 healthy children. In this light, and against the same criterion (% RHR), obese children in our research present the same behavior as healthy children, but not the children in the Lopez study. One explanation for this might be that their study performs a 6MWT where the evaluator accompanies the child during the walk, which is not part of the internationally accepted protocol which states that the patient should go alone[13].

If we review the international literature, the 6MWT is recommended for use in obese children and it shows a performance of around 85% compared with healthy normal-weight children. However, if we observe the heart rate behavior, subjective sensation of fatigue, and oxygen consumption of the children in these studies, once again we find that the test is far from moderate physical exercise, as it was in our study[22,23].

When analyzing the physiological variables against 6MWT, the question arises why do children perform poorly on this test? This could be associated with other factors, for example, a lack of motivation and/or concentration of the child regarding the performance of the test. Vilchez et al.[24] investigated the motivational climate in physical education classes, where they concluded that school children who present a greater pattern of physical-sports activity perceive a greater motivational climate, that is, there would be a directly proportional relationship between motivation and physical performance. From a practical point of view, achieving goals within child psychology would largely determine behavior when facing a test[25]. Therefore, it could be said that the 6MWT, by maintaining a constant speed of walking for six minutes, is a monotonous test for the child that lacks competitive objectives as

Table 4. Correlation between CD y cardiorespiratory parameters

	Correlation	p-value
Age (years)	0.44	*0.005
Weight (kg)	0.36	*0.019
Height (m)	0.50	*0.001
BMI (kg/m²)	0.13	0.418
BMI z-score	0.40	*0.009
Theoretical Distance (%)	0.53	*< 0.001
$_{\text{Max. exercise}}$HR reached (bpm)	0.11	0.504
$_{\text{Max. Theoretical}}$HR (bpm)	0.43	*0.004
80% $_{\text{Max. exercise}}$HR reached (bpm)	0.40	*0.008
RHR (%)	0.35	*0.022
Sa O2 (%)	0.21	0.434
SBP (mmHg)	0.35	*0.022
DBP (mmHg)	0.43	*0.004
Max. VO2 (mL/kg/min)	0.67	*< 0.001
Alustiza Score (score)	(rho) 0.004	0.982
Dyspnea (Borg)	(rho) 0.15	0.313
SFS - LL (Borg)	(rho) 0.21	0.182

p-value = referred to the meaning value of the test. BMI: Body mass index; HR: Hearth rate; SaO_2: Oxygen saturation; SPB: Systolic blood pressure; DBP: Diastolic blood pressure; Max VO_2: Maximum oxygen uptake; SFS-LL: subjective muscle-fatigue sensation in the low limbs. *It is considered a value p < 0,05.

would be in a game, which will directly affect final performance.

One of the weaknesses of our study is the low number of children who managed to complete the CVR study and perform the 6MWT. Therefore, the results obtained must be interpreted within the sample under study, and it is not possible to extrapolate them to the general population. However, we consider that the contribution of our article is to revisit the issue of CVR in obese children and how their cardiorespiratory functional impairment is being assessed.

Finally, based on the above, it is difficult to appreciate the consequences of CVR factors at an early age, since most cardiovascular events occur in adulthood. Thus, it is important to find a reliable tool to support early detection and prevention of cardiovascular disease in obese children.

Conclusion

There was no correlation between the estimated cardiorespiratory capacity through the 6MWT and the Alustiza CVR score. The behavior of physiological variables in children before and after the test shows a low physical effort required to complete the test.

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 state that the information has been obtained anonymously from previous data, therefore, Research Ethics Committee, in its discretion, has exempted from obtaining an informed consent, which is recorded in the respective form.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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