Validation of 12-minute walk test in cuban adults with coronary risk.

Validación de prueba de marcha de 12 minutos en adultos cubanos con riesgo coronario.

Validação do teste de caminhada de 12 minutos em adultos cubanos com risco coronariano.

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ABSTRACT: In Cuba, many of the deaths due to heart conditions occur due to ischemic diseases, of which almost half are due to myocardial infarction. For this reason, physical exercise programs are developed for the prevention of coronary risk factors. The objective of the study was to verify the validity and reliability of the 12-minute walk test to estimate oxygen consumption in adults with coronary risk participating in physical exercise programs at the community level. A non-experimental, correlational study was carried out using the parallel forms method. As a result, an evaluation methodology composed of a linear regression model was obtained to estimate oxygen consumption. It was concluded that the test met the criteria for validity, reliability and diagnostic capacity of oxygen consumption for this sample and can be used in health promotion centers at the community level.

Keywords: Walk test, estimation, oxygen consumption, coronary risk.

RESUMEN: En Cuba, muchas de las muertes por afecciones del corazón ocurren por enfermedades isquémicas, de ellas, casi la mitad son por infarto del miocardio. Por ello se desarrollan programas de ejercicios físicos para la prevención de los factores de riesgo coronario. El objetivo del estudio fue comprobar la validez y confiabilidad de la prueba de caminar 12 minutos para estimar el consumo de oxígeno en adultos con riesgo coronario participantes en programas de ejercicios físicos en el nivel comunitario. Se realizó un estudio no experimental, correlacional, mediante el método de formas paralelas. Se obtuvo como resultado una metodología de evaluación compuesta por un modelo de regresión lineal para estimar el consumo de oxígeno. Se concluyó que la prueba cumplió con los criterios validez, confiabilidad y capacidad de diagnóstico del consumo de oxígeno para esta muestra y, puede ser utilizada en centros de promoción de salud a nivel comunitario.

Palabras claves: Prueba de marcha, estimación, consumo de oxígeno, riesgo coronario.

RESUMO: Em Cuba, muitas das mortes por problemas cardíacos ocorrem por doenças isquêmicas, das quais quase a metade é por infarto do miocárdio. Por isso, são desenvolvidos programas de exercícios físicos para a prevenção de fatores de risco coronariano. O objetivo do estudo foi verificar a validade e confiabilidade do teste de caminhada de 12 minutos para estimar o consumo de oxigênio em adultos com risco coronariano participantes de programas de exercícios físicos em nível comunitário. Foi realizado um estudo correlacional não experimental utilizando o método de formas paralelas. Como resultado, obteve-se uma metodologia de avaliação composta por um modelo de regressão linear para estimar o consumo de oxigênio. Concluiu-se que o teste atendeu aos critérios de validade, confiabilidade e capacidade diagnóstica do consumo de oxigênio para esta amostra e pode ser utilizado em centros de promoção da saúde em nível comunitário.

Palavras-chave: Teste de caminhada, estimativa, consumo de oxigênio, risco coronariano.

INTRODUCTION

With regard to health, according to WHO's 667 abbreviated list, in the world, cardiovascular and cerebrovascular diseases rank first among the causes of death, with 36.8%.

In Cuba they also occupy the first place, with an incidence rate of 238.1 per 100 000 inhabitants. 61.3% of deaths from heart disease occur due to ischemic diseases, of which 44.2% are due to acute myocardial infarction (Ministerio de Salud Pública de Cuba, MINSAP, 2020, p. 12).

For this reason, programs are developed for the prevention of coronary risk factors through the practice of physical exercises (Pérez et al, 2017, p.15). These programs, if precautions are taken to modify their benefit-risk ratio, are safe for most individuals and constitute an instrument to prevent or reduce damage to health (Pérez et al, 2017, p.32; American College of Sports Medicine, ACSM, 2018, p 7).

In the process of evaluating the programs, laboratory tests are the first option to obtain direct results of the health status of the participants, however, due to the impossibility of acquiring the expensive resources they require, especially at the community level, Field tests with the application of physical exercises persist as an important diagnostic modality, if the factors that determine their reliability and validity are taken into account, among which are the use of tests developed in contexts and populations with different characteristics (climate, physical condition, diseases suffered, among others) (Hernández, Fernández & Baptista, 2014, pp. 247-248).

In the country, for the evaluation of the people who join the programs, tests validated in different countries and populations are frequently used, without considering that they must correspond to the characteristics of the participants who will be evaluated.

The studies, "Diagnosis about the current situation in Cuba for the estimation of oxygen consumption in adults with coronary risk ..."(Arias, 2017, p. 82), and "Theoretical feasibility of a test to estimate oxygen consumption in adults with coronary risk" (Arias, Zaldívar y Sentmanat, 2020), contributed elements to determine the validity and reliability of the 12-minute walk test. Therefore, the general objective was formulated: To empirically validate the effectiveness of the 12-minute walk test to estimate oxygen consumption in Cuban adults with coronary risk who actively participate in community programs of physical exercises.

MATERIALS AND METHODS

A non-experimental and correlational study was carried out, using the method of of reliability-parallel forms. The sample was intentionally selected, consisting of 624 subjects(indivuals) (347 women and 277 men), who performed physical exercises, between November 2015 and March 2016, in community health promotion centers for suffering from coronary risk factors. The inclusion criteria were the age range between 40 to 69 years, the systematic participation in the programs and the presence of coronary risk factors. Exclusion criteria were: physical limitations that affected walking, suffering severe diseases, and people who did not meet the age requirement.

In the first stage of the study, the evaluation of aerobic capacity and previously validated protocols were investigated. Surveys were applied to specialists to determine the status of the evaluation of aerobic capacity in Cuban people with coronary risk.

In the second stage, different modalities of pilot tests were applied to groups with similar characteristics to the sample, the results of which made it possible to standardize the conditions and requirements of the test. It was detected that, although it was required that the march be at the highest possible speed, the individuals did not comply with this requirement, so it was decided to establish a minimum speed limit of 0.8 m/s (50 m / min), criterion used by the American College of Sports Medicine (ACSM) in the oxygen consumption prediction equations (ACSM, 2018, p.173).

In the third stage, the practical application of the test to the selected sample made it possible to assess the indirect estimation equation for oxygen consumption obtained from a multiple linear regression model.

Components of test protocol.

- Name of the test.
- Objective.
- Methodological steps for application in practice.
- Standardization guidance.
- Means and instruments.
- Estimation method. Linear regression equations were obtained:

  Women: VO_2 = 30.58- (0.33 x Age) - (0.07 x Weight) - (0.11 x Fc) + (0.04 x Distance) - (7772.9 / Distance)
  Men: VO_2 = 30.58- (0.33 x Age) - (0.07 x Weight) - (0.11 x Fc) + (0.04 x Distance)

- Evaluators.
- Criteria for evaluating.

Table 1. Characterization of the sample, according to the coronary risk factors or diseases they suffer.

Diseases	Female	Male	Total	Percentage
High blood pressure	226	173	399	63,9 %
Diabetes Mellitus	64	38	102	16,3 %
Obesity	313	183	496	79,6 %
Obese-hypertensive	192	103	295	47,3 %
Bronchial asthma	38	18	56	8,9 %
Chronic obstructive lung diseases	12	44	56	8,9 %
Musculoskeletal diseases	31	22	53	8,5 %
High cholesterol (LDL)	48	41	89	14,3 %

Statistical analysis

To establish the previous evaluation scale, it was decided to use the median and the interquartile range, according to Fernández (2003, p.10), the 25th and 75th percentiles were used, the interquartile deviation was determined in each age range (Qd). The ranges were established from the addition or subtraction, from an interquartile deviation for the mean values, to three deviations for the extreme values.

For the descriptive processing of the data, the mean and standard deviation were used. To perform the inferential analysis, the following procedures and statistical tests were used:

To check the criteria of convergent validity, the method of reliability-parallel forms was used and the Wilcoxon test by ranges was applied, where the Rockport and 12-minute walk tests were compared. The comparison of both tests allowed us to assess the stability and internal consistency of the results (Hernández, Fernández & Baptista, 2014, p. 249; Monterola et al, 2018, pp. 686-687).

The Shapiro-Wilk test was applied to verify the normal distribution of the data, supported by the frequency distribution graph of the residuals and the normal probability graph, which allowed evaluating the assumptions underlying the linear regression.

To evaluate the homogeneity of variance, the scatter plot of the residuals versus the prognostic value was used, while the linearity was checked through partial regression plots. (Shapiro & Wilk, 1965)

Concurrent validity was assessed from the administration of both tests to an extreme group of 92 university students and the application of the Mann-Whitney test, to compare the results between the groups (Sganga & Farinola, 2019, p. 3).

The Spearman rank correlation was performed to obtain the relationship between the measurements (Monterola et al, 2018, pp. 681-683).

Multiple linear regression by parts was applied, with the step-by-step selection method, to obtain the equations for estimating oxygen consumption (Molinero, 2002). The comparison of non-typified residues was carried out. To analyze the homogeneity of variances and means (homoscedasticity), the Levene test and Student's T test were used (Molinero, 2002).

To analyse the stability and internal consistency of the test, Cronbach's Alpha was applied (Reidl, 2013, pp. 110-111).

The statistical significance value was $p < 0.05$. To perform the statistical analyzes and tests, the IBM SPSS program, version 21.0 was used.

RESULTS

Table 2. Qualitative evaluation of oxygen consumption by gender and age ranges.

Values in women (ml/Kg/min)			Classification
40-49	**50-59**	**60-69**	
<28,2	< 25,4	<22,6	Low
28,2-31,7	25,4-28,9	22,6-25,3	Regular
31,8-39	29-32,5	25,4-30,7	Average
39,1-42,6	32,6-36,1	30,8-33,4	Good
>42,6	>36,1	>33,4	Outstanding
Values in men (ml/Kg/min)			Classification
40-49	**50-59**	**60-69**	
<34,7	<33,2	<30,3	Low
34,7-38,2	33,2-35,7	30,3-32,9	Regular
38,3-45,5	35,8-40,3	33-38,4	Average
45,6-49,1	40,4-43,5	38,5-41,1	Good
49,>1	>43,5	>41,1	Outstanding

Table 3. Analysis of the normality of the results. (Shapiro-Wilk test)

Measurements	Probability value (P)
Oxygen consumption (ml/min)	.056
Age (years)	.000
Weight (Kg)	.000
Heart rate in the Rockport test	.000
Heart rate in the 12-minute test	.000
Rockport test time (min)	.000
Distance in the test 12 minutes(12-min test) (m)	.000
Rockport test speed (m/s)	.000
Speed in the 12 minute test (m/s)	.000

Table 4. Means and standard deviations by sex and their Significance.

Measurements	Mean ± SD		Significance
Sex	Female	Male	
Oxygen consumption (ml/min)	29.1 ± 5.8	35.82 ± 5.7	.000
Age (years)	54.2 ± 8.5	54.08 ± 8.6	.902
Weight (kg)	84.0 ± 10.5	90.7 ± 15.2	.000
Heart rate in Rockport test (bpm)	145.9 ± 9.8	144.42 ± 9.7	.088
Heart rate in the 12-min test (bpm)	142.3 ± 9.2	141.28 ± 8.9	.215
Rockport test time (min)	16.5 ± 1.2	16.26 ± 1.2	.075
Distance in the (m)	1194.76 ± 91.8	1207.95 ± 99.0	.183
Rockport test speed (m/s)	1.637 ± 0.1	1.659 ± 0.1	.075
Speed in the 12-min test (m/s)	1.659 ± 0.1	1.678 ± 0.1	.183

Table 5. Comparison of the means of the tests and the significance of the differences.

Measurements	Mean ± SD		Significance between tests
Test	Rockport	12-minutes	
VO2 (ml/min)	29.4 ± 6.6	29.5 ± 6.1	.000
Heart rate (p/min)	145.4 ± 9.8	141.9 ± 9.1	.000
Speed (m/s)	1.6 ± 0.1	1.7 ± 0.1	.000

Table 6. Significant Spearman rank correlation.

	VO_2	Age	Weight	HR Rockport	HR 12-min	Time in Rockport	Distance 12 min.
VO2 (ml/min)	1	-	-	-	-	-	-
Age (years)	-0.6	1	-	-	-	-	-
Weight (Kg)	-	-0.1	1	-	-	-	-
HR in Rockport (bpm)	-	-0.4		1	-	-	-
HR in 12-min (bpm)	-	-0.2		0.7	1	-	-
Time Rockport (min)	0.8	-0.4	-	0.1	-	1	-
Distance 12 min (m)	0.7	-0.4	-	0.2	0.1	-0.9	1

Table 7. Multiple linear regression coefficients.

Measurements	Coefficient	Significance
Constant	30.5796015774	.000
Age (years)	-0.3396514630	.000
Weight (kg)	-0.0744003342	.000
Heart rate (p/min)	-0.1096904549	.000
Distance in 12 min (m)	0.0378940212	.000
Distance correction factor, female	-7772.912914	.000

Table 8. Analysis of homogeneity of means and variances.

Comparison of non-typified residues			
		SD	Mean
Sex	Male	1.399	0.010
	Female	1.305	-0.007
General		1.242	0
Significance of Levene's test		.439	Equal variances
Significance of the T Student test		Equal means	.902

Table 9. Means and standard deviations of the extreme groups and their significance.

Test	Mean ± SD		Significance between samples
	Students	Adults	
Herat(heart) rate (p/min)	127 ± 15	141.9 ± 9.1	.000
Distance in 12-min test	1352 ± 91.1	1201 ±96	.000
Speed (m/s)	1.9 ± 0.1	1.7 ± 0.1	.000

DISCUSSION

Table 3 shows the results of the analysis of the non-typified residuals, which reflected a significance level of 0.056 for oxygen consumption as the highest value, which shows that the loss of normality of the data is not very significant for all the variables considered. These results support the use of the Mann-Whitney, Wilcoxon, Spearman and Levene's and Student's T tests.

Table 4 shows significant differences between the sexes for maximum oxygen consumption and body weight. The difference in heart rate, time in the Rockport test, and distance in the 12-minute walk test is insignificant.

The results of the comparison between tests, in table 5 it is reflected that in the 12-minute walk test the speed reached by those evaluated is higher and the heart rate is lower, with significant differences with respect to the results of the walking test. Rockport.

Table 6 shows a strong and positive correlation of 0.8 between the estimated oxygen consumption and the time spent in this test, a strong and positive correlation (0.7) between oxygen consumption and the distance achieved in the 12-minute walk test. It is also moderate and negative (-0.6) between oxygen consumption and the age of the subjects and a very strong and, negative correlation (-0.9) between the time of the Rockport test and the distance covered by the subjects in the 12-minute walk test. These results indicate that there is a causal relationship between the variables oxygen consumption, heart rate, distance of the 12-minute walk test and the time of the Rockport test.

Table 7 presents the coefficients of variation of the independent variables analyzed, which have high significance, which explains their introduction in the linear regression equations. After applying multiple linear regression, the fourth step introduced the variables: Distance, Age, Body weight and Heart rate, and the highest correlation coefficient was obtained (R=0.95), coefficient of determination (R2 = 99.1 %) and the lowest estimated standard error (SEE=1.7 ml/min). The regression model explains 98.3% the result of oxygen consumption.

In Table 8, both the variances and the means are equal. Therefore, it is assumed that the linear regression model obtained complies with the theoretical assumption of homoscedasticity.

When applying Cronbach's Alpha, a value of 0.9 was obtained, that is why the test has internal consistency and stability, as criteria of its reliability.

Table 9 shows the comparison using the Mann-Whitney U statistical test for independent samples, which revealed very significant differences between the extreme groups, with a statistical significance lower than 0.01 (1%), so the proposed test It meets the criteria for concurrent validity, which indicates the diagnostic capacity of the test.

The 12-minute walk test has a structure in accordance with previous protocols, with the advantage that it offers a methodology that consists of steps for better understanding and application; It arises from the statistical processing of the results of a sample of the Cuban population, which offers the possibility of estimating this indicator more reliably. The novelty is the requirement to establish a minimum speed of 50 m/min, to which only the ACSM refers.

O 'Gorman et al (2007) analyzed the validity of field tests to evaluate endurance capacity in athletes, where strong positive correlations are shown between the distance and time indicators with the maximum oxygen consumption and negative correlation between time and distance reached.

Díaz et al (2000, p. 50), found a linear correlation between the 1000-meter field test and directly measured VO2max, with R = 0.86 and SEE = 0.8.

González P. & Maureira, F. (2017, p. 46), determined a positive and high correlation between the results of the oxygen consumption of the Rockport protocol and the laboratory measurement.

Kline et al (1987, p.258), when validating the Rockport test, found a linear correlation between age and sex with oxygen consumption values and include these variables in the regression equations (García, Ramos & Aguirre, 2016, p. 257).

Dolgener et al (1994, pp. 155-157) when validating the Rockport Test found a linear correlation between the direct measurement of VO_2 and the field test, with an R = 0.69 and an SEE = 5, 5.

Dolgener et al (1994, pp. 155-157) when validating the Rockport Test in young people found a linear correlation between the direct measurement of VO2max and the field test, with an R = 0.69 and an SEE = 5, 5.

The Estimated Standard Error (1.7 ml/min) agrees with the results of the Rockport Walking Institute equation (0.5 l/min); with the equation of the Montreal University test (2.8 l/min) and the equation of the 6-minute walk test (2.6 l/min) (García, 2011, p. 33).

ETHICAL CONSIDERATIONS

The study followed the ethical principles for research in humans (World Medical Association, 2013), emphasizing the signing of informed consent. It is a minimal risk research, where there was no intervention in the biological, psychological or social variables of the sample.

CONCLUSIONS

The assumed procedure allows establishing a methodology for the 12-minute walk test, composed of equations for the estimation of oxygen consumption

and qualitative evaluation criteria, based on the results of a sample of the Cuban population.

The test meets the criteria of convergent and concurrent validity, supported by the comparison of its results with the Rockport test and between the extreme groups.

The test is reliable to evaluate aerobic capacity, by estimating oxygen consumption, due to the level of internal consistency it showed and the stability of its results.

BIBLIOGRAPHIC REFERENCES

Ministerio de Salud Pública de Cuba. Dirección de Registros Médicos y Estadísticas de Salud (2020). *Anuario estadístico de Salud 2019. Edición 48*. La Habana: MINSAP. https://files.sld.cu/bvscuba/files/2019/04/Anuario-Electr%C3%B3nico-Espa%C3

Pérez, M., León, J. L., Dueñas, A., Alfonzo, J., Navarro, D., De la Nova, R., Pozo, H., Pérez Moreno, R., Llapur, J. R., González, R., Betancourt, I., Valdés, Y., Armas, N., Zayas, E., Pintos, J., Revueltas, M., Rivas, E., Deschapelles, E., Landrove, O. & Morales, A. (2017). Guía cubana de diagnóstico, evaluación y tratamiento de la hipertensión arterial. *Revista Cubana de Medicina,* 56(4), 242-321. http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S0034-75232017000400.

American College of Sports Medicine (2018). *ACSM's guidelines for exercise testing and prescription*. Tenth edition. Philadelphia: Lippincott Williams & Wilkins.

Hernández, R., Fernández, C. & Baptista, P. (2014). *Metodología de la Investigación*. Sexta Edición. México: McGraw Hill.

Arias, L. (2017). *Estimación del consumo de oxígeno en adultos con riesgo coronario, practicantes sistemáticos de ejercicios físicos*. [Tesis de doctorado]. Universidad de Ciencias de la Cultura Física y el Deporte, Manuel Fajardo.

Arias, L., Zaldívar, B. & Sentmanat, A. (2020). Factibilidad teórica de una prueba para la estimación del consumo de oxígeno en adultos con riesgo coronario, practicantes sistemáticos de ejercicios físicos. *Rev Olimpia*., 18, 413-428. https://revistas.udg.co.cu/index.php/olimpia/article/view/1515

Singh, D., Agusti, A., Anzueto, A., Barnes, P.J., Bourbeau, J., Celli, B. R., Criner, G. J., Frith, P., Halpin, D. M. G., Han, M., López Varela, M. V., Martínez, F., Montes de Oca, M., Papi, A., Pavord, I. D., Roche, N., Sin, D. D., Stockley, R., Vestbo, J. & Vogelmeier C. (2019). Global Strategy for the Diagnosis, Management, and Prevention of Chronic Obstructive Lung Disease: the GOLD science committee report 2019. *Eur Respir J,* 53(5). https://doi.org/10.1183/13993003.00164-2019

Monterola, C., Grande, L., Otzen, T., García, N., Salazar P & Quiroz G. (2018). Confiabilidad, precisión o reproducibilidad de las mediciones. Métodos de valoración, utilidad y aplicaciones en la práctica clínica. *Rev. Chilena Infecto*, 35(6), 680-688. https://scielo.conicyt.cl/scielo.php?script=sci_arttext&pid=S0716-10182018000

Sganga, M. & Farinola G. M. (2019). Validación de dos Pruebas de Predicción de la Potencia Muscular en el Ejercicio de Press de Banca. *Kronos,* 18(2). https://g-se.com/validacion-de-dos-pruebas-de-prediccion-de-la-potencia-mus

World Medical Association (WMA). (2013). *WMA Declaration of Helsinki- Ethical principles for medical research involving human subjects*. Fortaleza: 64th WMA General Assembly. https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principle

Fernández, J. A. (2003) *Indicadores de la composición corporal y peso adecuado para la evaluación nutricional el adulto cubano de 20 a 59 años*. Cuba: Instituto Nacional de Deporte, Educación Física y Recreación (INDER).

Shapiro, S. & Wilk & M. (1965). *Analysis of variance test for normality* http://www.math.utah.edu/~morris/Courses/ShapiroWilk.pdf

Molinero, L.M. (2002). *Construcción de modelos de regresión multivariantes. Asociación de la Sociedad Española de Hipertensión Arterial.* Construcción de modelos de regresión multivariantes | SEH-LELHA

Reild, L. M. (2013) Confiabilidad en la medición. *Inv Ed Med,*2(6), 107-111. http://riem.facmed.unam.mx/index.php/riem/article/view/440/1189

Díaz, F. J., Montaño, J. G., Melchor, M. T., Guerrero, J. H. & Tovar, J.A. (2000) Validación y Confiabilidad de la Prueba Aeróbica de 1000 metros. *Rev Invest Clin,* 1(52), 44-51. https://imbiomed.com.mx/1/1/articulos.php?method=showDetail&id_articulo=2

González, P. & Maureira, F. (2017). Validez del test de Rockport para evaluar el VO2 máx. En mujeres adultas mayores de Santiago de Chile. *Revista Acción con Sentido*, 3, 41-47. https://www.researchgate.net/publication/321803793_Validez_del_test_de_Rock

Kline, G. M., Porcari, J. P., Hintermeister, R., Freedson, P. S., Ward, A., Mccarron, R. F., Ross, J. & Rippe, J. M. (1987) Estimation of VO2max from a one-mile track walk, gender, age, and body weight. *Med. Sci. Sports Exerc*, 19(3), 253-259. https://europepmc.org/article/med/3600239

Dolgener, F., Hensley, L., Marsh, J., & Fjelstul, J. K. (1994). Validation of the Rockport Fitness Walking Test in College Males and Females. *Research Quarterly for Exercise and Sport*, 65(2), 152-158. https://pubmed.ncbi.nlm.nih.gov/8047707/

García, A. M., Ramos Bermúdez S., Aguirre O. D. (2016). Calidad científica de las pruebas de campo para el cálculo del VO2max. Revisión sistemática. *Rev Cienc Salud*, 14(2), 247-60. https://doi.org/10.12804/revsalud14.02.2016.09

García, A. M. (2011). *Capacidad predictiva de pruebas de campo para el consumo máximo de* oxígeno como medida de la resistencia cardiorrespiratoria en adultos no entrenados: revisión sistemática. [Tesis de magister, Universidad Autónoma De Manizales]. Repositorio de la Universidad Autónoma De Manizales. http://repositorio.autonoma.edu.co/xmlui/bitstream/handle/11182/646/Capacida