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ORIGINAL RESEARCH

Functional exercise capacity evaluation in an aquatic environment

Avaliação da capacidade funcional de exercício no ambiente aquático

Evaluación de la capacidad funcional del ejercicio hecho en ambiente acuático

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ABSTRACT | The aim of this study was to investigate the correlation between distance achieved and compare the average speed while walking in the six-minute walk test (6MWT) performed on solid ground and in the three-minute walk test in water (3MWT-W) with healthy young individuals, as well as compare physiological (heart rate, oxygen saturation and blood pressure) and symptomatic variables between tests. It is a cross-sectional study, with a sample of 20 healthy young subjects. All patients underwent spirometry, answered a questionnaire on health and physical activity, in addition to performing the 6MWT and 3MWT-W. Statistical analysis used the Shapiro-Wilk test to evaluate normality of the data, the paired Student's t-test and Wilcoxon in the comparisons between the variables and the Pearson correlation coefficient to verify associations. Statistical significance of $p < 0.05$ was adopted. The mean age was 22 (±2) years, the mean BMI was 23 (±3) kg/m2 and all subjects had normal pulmonary function. The average distance achieved in the 6MWT was of 657 (±43) meters and in the 3MWT-W of 135 (±13) meters. A weak correlation between the 3MWT-W and 6MWT (r=0.35) was found. The speed during the tests showed a statistically significant difference (3MWT-W 0.75±0.07 *versus* 6MWT 1.85±9.1, p<0.0001). There was no difference in the initial and the final physiological variables between 3MWT-W and 6MWT. The 3MWT-W may be a good tool for evaluation and exercise prescription in the aquatic environment, but showed a weak correlation with the 6MWT and similar physiological strain, though further studies are suggested to confirm this finding.

Keywords | Exercise Tolerance; Hydrotherapy; Aquatic Environment; Walking.

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RESUMO | Os objetivos deste estudo foram verificar a correlação da distância percorrida e comparar a velocidade média durante a caminhada por meio do teste de caminhada de seis minutos (TC6min) realizado em solo com o teste de caminhada de três minutos aquático (TC3minA) em jovens saudáveis, bem como contrastar variáveis fisiológicas (frequência cardíaca, saturação periférica de oxigênio e pressão arterial) e sintomatológicas entre os testes. Estudo transversal com amostragem de vinte indivíduos jovens saudáveis. Todos foram submetidos à espirometria, responderam a um questionário sobre saúde e atividade física, além de realizarem o TC6min e o TC3minA. Na análise estatística foi utilizado teste de Shapiro-Wilk para avaliar normalidade dos dados, o teste t de Student pareado e Wilcoxon nas comparações entre as variáveis e o coeficiente de correlação de Pearson para verificar associações. A significância estatística de p<0,05 foi adotada. A média de idade foi de 22 (±2) anos, IMC de 23 (±3) Kg/m2 e todos os indivíduos apresentaram valores normais de função pulmonar. A distância média percorrida no TC6min foi de 657 (±43) e no TC3minA 135 (±13) metros. Foi encontrada fraca correlação entre o TC3minA e TC6min (r=0,35). A velocidade durante

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os testes apresentou diferença estatisticamente significante (TC3minA 0,75±0,07 *versus* TC6min 1,85±9,1, p<0,0001). Não houve diferença nas variáveis fisiológicas iniciais e finais entre o TC3minA e o TC6min. Aquele embora possa ser uma boa ferramenta a ser utilizada para avaliação e prescrição de exercício no ambiente aquático mostrou uma fraca correlação com o TC6min e semelhante esforço fisiológico, porém novos estudos são sugeridos para comprovar esse achado.

Descritores | Tolerância ao Exercício; Hidroterapia; Ambiente Aquático; Caminhada.

RESUMEN | En este estudio se verificó la correlación de la distancia recorrida en jóvenes saludables y se comparó la velocidad media durante la caminata mediante el test de caminata de seis minutos (TC6min) realizado en suelo y del test de caminata de tres minutos acuático (TC3minA), así como se contrastó las variables fisiológicas (frecuencia cardiaca, saturación periférica de oxígeno y presión arterial) y de síntomas entre los test. Es un estudio transversal con muestra de veinte sujetos jóvenes saludables. Se les sometieron a la espirometría y se les aplicaron un cuestionario sobre salud y actividad física, además de que realizaron el TC6min y el TC3minA. En el análisis estadístico se utilizó la prueba Shapiro-Wilk para evaluar la normalidad de los datos, la prueba t Student emparejada y Wilcoxon para las comparaciones entre las variables y el coeficiente de correlación de Pearson para verificar las asociaciones. Se utilizó la significancia estadística de p<0,05. El promedio de edad fue el de 22 (±2) años, el IMC de 23 (±3) Kg/m^2 y todos los participantes presentaron valores normales para la función pulmonar. El promedio de distancia recorrida en el TC6min fue de 657 (±43) y en el TC3minA de 135 (±13) metros. Se encontró una débil correlación entre el TC3minA y el TC6min (r=0,35). La velocidad durante los test presentó diferencias estadísticamente significativas (TC3minA 0,75±0,07 *versus* TC6min 1,85±9,1, p<0,0001). No hubo diferencias en las variables fisiológicas iniciales y finales entre el TC3minA y el TC6min. Aunque el TC3minA pueda ser una buena herramienta a utilizarse para la evaluación y la prescripción del ejercicio en el ambiente acuático se mostró una débil correlación con el TC6min y semejante esfuerzo fisiológico, sin embargo se recomiendan nuevos estudios para comprobarlo.

Palabras clave | Tolerancia al Ejercicio; Hidroterapia; Ambiente Acuático; Caminata.

INTRODUCTION

Physical tests have been commonly used in clinical practice and in exercise prescription in rehabilitation programs[1]. The six-minute walk test (6MWT) measures the functional capacity of exercise, also present a good reproducibility and be a simple and easy to access test[2]. It can assess the global and integrated responses of the systems involved during exercise, including cardio-respiratory and musculoskeletal systems[3]. The evaluation of functional capacity of exercise can provide information on the physical capacity and, furthermore, guide the prescription and progression of exercise in physical training programs[4].

A physical training alternative that has been commonly used by different areas is the hydrotherapy[5,6]. In the aquatic environment, thrust results in the reduction of body weight and the drag force increases the resistance during walking[7,8]. So, bearing your own weight in this environment becomes easier when compared to a terrestrial environment, because there will be a minor impact on the musculoskeletal system and greater ease of movement control[7]. Physical training in water has provided physical benefits in different populations[9-13]. The literature suggests that physical activity or tests performed in water permit aerobic conditioning maintenance, because the hydrotherapy exercises enable the appropriate use of body mechanics and the practice of exercises directed to the problem[14].

However, few studies have investigated the differences between walking in the aquatic environment versus walking on solid ground. Alberto et al.[15] and Barela et al.[16] found differences between walking in healthy subjects in both environments. In relation to field-testing, no study appears to have assessed the functional capacity of exercise in the water. Considering the importance of proper evaluation of the functional exercise capacity in an aquatic environment, a specific field test to measure exercise capacity and to determine exercise prescription needs to be established. However, there are no findings in the literature regarding the use of a functional capacity test exercise in the aquatic environment, therefore the study proposed to use the three-minute walk test in an aquatic environment (3MWT-W).

Therefore, the aim of this study was to verify the correlation between distance achieved and compare the average speed while walking in the 6MWT on the ground with the 3MWT-W in healthy young people. In addition to comparing the physiological (heart rate [HR], oxygen saturation [SpO_2] and blood pressure [BP]) and symptomatic variables (sensation of dyspnea and fatigued legs) before and after the 6MWT on the ground *versus* the 3MWT-W.

METHODOLOGY

Sample

This is a cross-sectional study of analytical character, with a sample of 20 young people of both genders. The study was approved by the Bioethics Research Committee, all participants received information on the procedures to be performed in the study and they all signed a free consent form.

Inclusion criteria were: young adults aged between 18 and 30 years, with no musculoskeletal, neurological, heart or pulmonary problems that might prevent the performance in the tests. The study excluded individuals that: could not perform the tests proposed; or opted, at any time, to end their participation in the study.

Procedures

General evaluation

Initially, all participants answered a structured questionnaire, which collected demographic data such as gender, age and comorbidities. In addition, we collected anthropometric data such as weight, using a scale (Filizola® accurate to 0.1kg and capacity up to 180kg) and height, measured with the individual in orthostatic position by a stadiometer (Sonny), consisting of a scale graduated in centimeters and accuracy of 0.1cm. From these measurements, the Body Mass Index (BMI) was calculated, using the relationship between body mass and the square of height (weight/height^2), with body weight in kilograms (kg) and height in meters (m).

Pulmonary Fuction

To confirm the absence of pulmonary alterations, a pulmonary function test was performed using the Pony spirometer (Cosmed, Italy). The participants were instructed to perform the forced expiratory maneuver according to the international standardization[17]. The reference values for the Brazilian population[18] were used. The collected variables were forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1) and the FEV_1/FVC ratio.

Physical evaluation

To evaluate the level of physical activity, we used the International Physical Activity Questionnaire (IPAQ) in its reduced version[19]. The questions were related to the activities performed in the last week prior to the interview. Subjects were classified according to IPAQ standards. It classifies individuals as: Sedentary – individuals who do not engage in any physical activity for at least 10 continuous minutes during the week; Irregularly Active – individuals who practiced physical activities for at least 10 continuous minutes per week, but insufficiently to be classified as active; Active – individuals who meet the following recommendations: a) vigorous physical activity: ≥3 days/week and ≥20 minutes/session; b) moderate physical activity or walking ≥5 days/week and ≥30 minutes/session; c) any added activity: ≥5 days/week and ≥150 min/week; Very Active – subjects who meet the following recommendations: a) vigorous physical activity: ≥5 days/week and ≥30 min/session; b) vigorous physical activity: ≥3 days/week and ≥20 min/session + moderate and/or walking 5 days/week and ≥30 min/session.

Functional exercise capacity

6MWT and 3MWT-W were performed within a week of each other, with the 6MWT performed first, always in the afternoon. In both tests, HR, SpO_2 and PA were collected, in addition to dyspnea and fatigue of the lower limbs through a modified Borg scale[20]. All physiological and symptomatic variables previously mentioned were collected at the beginning and at the end of the tests. The distance achieved was verified, with this as the primary variable tested, and the average speed calculated during walking, using the distance achieved in the test divided by the duration of the same. Both tests would be interrupted immediately if, during the course of the same, the participant presented chest pain, dyspnea and/or intolerable fatigue, sweating, oximetry values lower than 88%, paleness, dizziness and/or cramps[2].

Six-minute Walk Test (6MWT)

Functional exercise capacity was evaluated using the conventional 6MWT (on solid ground), according to the European Respiratory Society (ERS)/American Thoracic Society (ATS) standardization[3]. Two tests were performed, the test with the greater distance achieved was picked for analysis. The reference values used were for the Brazilian population of Britto et al.[21].

Three-minute Walk Test in Water (3MWT-W)

Functional exercise capacity was evaluated by the 3MWT-W (Figure 1). This test was developed by the authors of this study and performed in the pool of the Physiotherapy Clinic of the University of North Paraná (Unopar), heated (33°C), flat, fitted with stairs, ramp and sidebars; with the following dimensions: height 1.13m, width 7.10m and length 12.7m. Capacity of 90,170 liters of water and water depth level of 1m, which should be about the height of the individuals' umbilicus.

The test was conducted at least two hours after meals. Participants were told to use their own, comfortable clothing to the aquatic environment. Prior to the test, they maintained 10 minutes of rest, during this period their PA, level of dyspnea and lower limb fatigue using a modified Borg scale[20], SpO2 and HR were evaluated. The maximum heart rate was calculated according to the of Karvonen formula (220 - age)[22].

Figure 1. Three-minute walk test in water (3MWT-W)

Two tests were performed near the edge of the pool and the one with greater distance achieved was used for analysis. Participants walked on a marked path of 10 meters, every meter per tape also marked. There was an interval of 30 minutes between each test and verbal encouragement of standardized phrases every 45 seconds were used during the exercise. Throughout the test, there was the presence of a physical therapist in the pool for any eventuality.

Statistical Analysis

The sample size calculation was based on the study by Iriberri et al.[23], who found a correlation coefficient between the 6MWT and the 3MWT on the ground of 0.98. Using the BioEstat® 5.0 software, with power of 80% and an alpha of 0.05, plus 20% of loss rate, six subjects would be required to detect a statistically significant correlation. The sample consisted of 20 participants, therefore larger than necessary to ensure the results.

For the statistical analysis, we used the GraphPad 6.0 software. The Shapiro-Wilk test was used to assess the distribution of data normality. Data with normal distribution were described as mean and standard deviation, otherwise as medians and their quartiles. For mean comparisons of the variables between the 6MWT and the 3MWT-W, we used the paired Student's t-test or Wilcoxon. To verify the correlation between the tests, we used the Pearson or Spearman correlation coefficient. Statistical significance was of 5% for all analysis.

RESULTS

The sample consisted of 20 healthy young individuals and all participants showed normal values in the pulmonary function test. As for physical activity, 65% of participants were considered physically active or very active and 35% were irregularly active or sedentary. These and other information about the sample characteristics studied can be found in Table 1.

Table 1. Sample General Characteristics

Variables	Values
Gender (M/F)	10/10
Age (years)	22 (±2)
Weight (Kg)	66 (±11)
Height (meters)	1.67 (±0.06)
BMI (Kg/m2) PE (VA/A/IA/S)	23 (±3) 3/10/5/2
FVC (% exp)	87 (±9)
FEV1 (% exp)	88 (±9)
FEV1/FVC (%)	85 (±6)
6MWT (meters)	657 (±43)
3MWT-W (meters)	135 (±13)

M: Male; F: Female; Kg: kilograms; BMI: Body Mass Index; PE: Physical Evaluation; VA: very active; A: active; IA: irregularly active; S: sedentary; FVC = Forced Vital Capacity; FEV_1 = Forced expiratory volume at the first second; VEF_1/CVF = Ratio between forced expiratory volume at the first second and forced vital capacity; 6MWT: distance achieved in a six-minute walk test; 3MWT-W: distance achieved in a three-minute walk test in water

The correlation between exercise tests (3MWT-W and 6MWT) in healthy young individuals is shown in Figure 2. There was also a moderate correlation between the distance covered in 3MWT-W and the weight and BMI (r=0.49; r=0.47 respectively, both p≤0.03 for both).

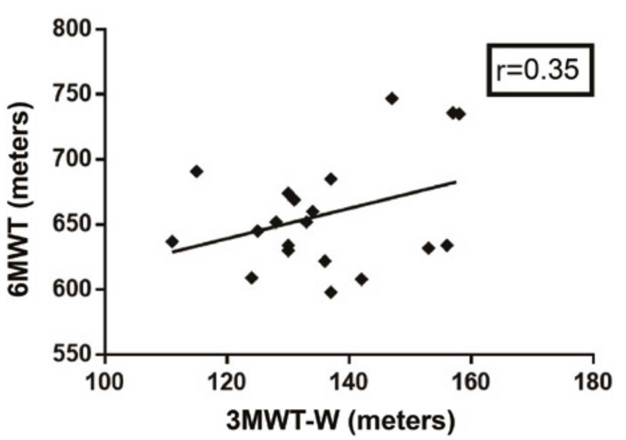

Figure 2. Correlation between the distance achieved in the six-minute walk test (6MWT) with the distance in the three-minute walk test in water (3MWT-W)

When comparing the speed during testing, we can observe a significant difference (TC3minA 0.75±0.07 *versus* 6MWT 1.85±9.1, p<0.0001) (Figure 3). When considering the water depth, 65% of participants had the water level at umbilicus, 10% had a level just above the umbilicus and 25% slightly below, therefore all below the xiphoid process.

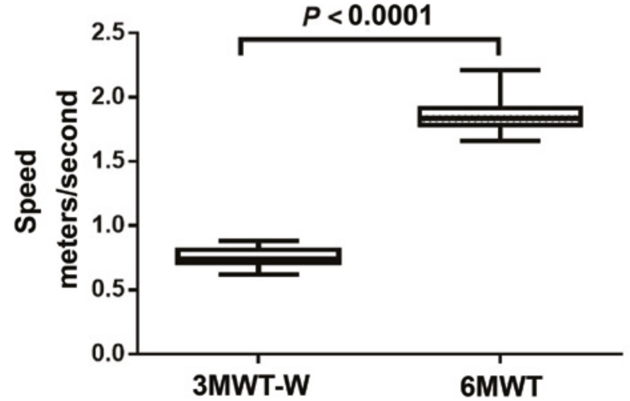

Figure 3. Speed comparison between the three-minute walk test in water (3MWT-W) and the six-minute walk test (6MWT)

Regarding the initial and final physiological and symptomatic (HR, SpO_2, PA, Borg dyspnea and Borg lower members) variables in the tests (3MWT-W and 6MWT), no significant differences were presented, except for initial diastolic blood pressure (DBP) (Table 2).

Table 2. Physiological variable comparison between the three-minute walk test in water (3MWT-W) and the six-minute walk test (6MWT)

Variables	3MWT-W	6MWT	p
Arterial Pressure (mmHg)			
Systolic Initial	110 [100-110]	110 [100-120]	0.14
Systolic Final	135 [122-140]	130 [120-140]	0.91
Diastolic Initial	80 [80-80]	70 [70-80]	0.004
Diastolic Final	80 [70-80]	80 [72-80]	0.22
Borg (points)			
Borg Dyspnea Initial	0 [0-0]	0 [0-0]	0.50
Borg Dyspnea Final	2 [1-3]	2 [0-3]	0.69
Borg Fatigue MMII Initial	0 [0-0]	0 [0-0]	0.37
Borg Fatigue MMII Final	3 [2-4]	3 [2-4]	0.88
Heart Rate			
Initial (bpm)	85 [78-91]	90 [78-95]	0.23
% HRimax	43 [41-46]	45 [40-47]	0.29
Final (bpm)	148 [120-161]	132 [107-144]	0.05
% HRfmax	74 [62-79]	67 [54-72]	0.08

% HRimax = Percentage of the maximum initial heart rate; % HRfmax = percentage of the maximum final heart rate; MMII: inferior members

DISCUSSION

In this study, 3MWT-W correlated weakly with 6MWT in healthy young individuals. When investigating the speed achieved in both tests performed, 3MWT-W showed a slower speed. Lastly, we found that the subjects had similar physiological variables in 3MWT-W when compared to the 6MWT.

Several authors have investigated the physical activity in the young population. Matsudo et al.[24], in their study of physical activity in adolescents and children from two different regions of socioeconomic development, observed that the studied population showed low levels of physical activity. When comparing findings, the study by Matsudo et al.[24] observed worst physical activity values, i.e. below values found in this study (65% active and very active). The level of physical activity found in this study was also higher than that found in the study by Mechelen et al.[25]. Despite the data, the fact that individuals in this study have higher levels of physical activity compared to the other two studies cited above, can be explained by the population belonging to a university physiotherapy course, where they might receive greater incentives to perform physical activity.

Iriberri et al.[23], in their study, comparing the three and six-minute walk test in a solid environment, observed a high correlation (r=0.98) in distance achieved during both tests. In this study, the subjects showed a weak correlation between the 3MWT-W and the 6MWT. Despite such result, there are several differences between the aquatic and terrestrial environments, which leads to the conclusion that the 3MWT-W can be a good tool to be used for evaluation of functional capacity in water exercise. Moreover, it a moderate 3MWT-W correlation can be observed with the weight and BMI of the subjects. Although not performed in an aquatic environment, the study by Price et al.[26], to assess the physical activity directly and indirectly in young adults, showed that BMI correlated with the level of physical activity of the individuals. Another study, which aimed to evaluate the level of physical activity and body composition, observed that an active lifestyle has a significant correlation with the body composition parameters[27]. It is worthy to note that physical activity is not the same as exercise capacity, but this finding leads to the conclusion that the level of exercise capacity relates to the BMI.

The findings of this study regarding speed exerted during the tests show that the water speed was one half to one third of the speed achieved on the ground, and that the water depth at the umbilicus level was observed in 65% individuals. These data was similar to the findings of Barela et al.[28], who observed that when the water depth was at the waist, approximately one-half to one-third of the walking or racing speed was required for the same level of energy expenditure of activities performed in the soil. To obtain the same physiological intensity of effort between these media, the solo exercise speed needs to be double the speed of the exercise performed in water[29]. This fact can be explained by the differences in physical properties between the terrestrial and water environments, with the physical properties of the water not only easier but also more resistant to certain immersion movements[30]. Resistance is imposed in the aquatic environment by the drag force, a physical property of the water, which related to speed, generating different force magnitudes for the limbs that perform the movements in this enviroment[31].

It is noteworthy that the physiological variables showed no statistical differences between the 3MWT-W and the 6MWT, so both tests showed similar physiological strain. Although the initial DBP showed a significant difference, this was not clinically significant, since it was within the range considered normal for this age group[32]. Fujishima et al.[33] showed in their study that the HR did not show significant differences between the maximum test efforts performed in the aquatic and terrestrial environment, coming in line with the findings of this study.

Despite every effort, this study shows some limitations. Regarding the sample, although above the size calculation, the small number of participants limits the analysis, making it impossible to perform a more in-depth comparison. Another topic that should be addressed, is the small size of the pool in used in testing (3MWT-W), which may have influenced the study results. Thus, this study opens the door for future research to deepen knowledge on functional capacity testing of exercise in an aquatic environment in healthy young people and in other populations to be studied.

CONCLUSION

When correlating the 3MWT-W and the 6MWT, we observed a weak correlation between the distances covered. While walking in an aquatic environment presented a lower speed compared to the walking on solid ground, similar physiological strain in the two environments were observed. Therefore, the 3MWT-W seems to be a good tool for evaluation and exercise prescription in the aquatic environment.

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