Development of the running test in shallow water for women engaged in water exercises: reliability and norms for evaluation of the distance covered

Michele Heinen Alves da Silva[1] and Geraldo de Albuquerque Maranhão Neto[2]

ABSTRACT

An increasing number of people have been looking for water exercises with the purpose of improving overall physical fitness. However, only a limited number of tests assess aerobic fitness, as well as evaluate the performance of practitioners of different age groups in water. The main goals of the present study is to introduce a running test for shallow water to evaluate women of different age groups according to the maximal distance covered during 12 minutes, and to investigate the test-retest reliability of this procedure. Our sample consisted of 135 women between 21 and 84 years of age, who were already adapted to the water. Seventeen women were randomly selected for the test-retest reliability study, and were retested within one week. We observed a high Intraclass Correlation Coefficient (ICC) for the test-retest reliability (ICC = 0.91), suggesting a high degree of consistence between measurements. We also observed an inverse and significant relationship between age and distance covered during the test (r = –0.69). The distance covered during the test was also significantly correlated with the heart rate at the end of the test (FC12). This association was not influenced by age, according to the multiple regression and partial correlation analyses conducted (r = 0.35). We ordered the results for the distance covered during the test for each age group in quintiles, which are proposed as norms for the evaluation of the performance. Although the test results were not compared with data obtained from a gold-standard measure of cardiorespiratory fitness (i.e. direct maximal oxygen uptake assessment), they are consistent with literature reports on the topic. This suggests that the proposed test has a good content validity. This manuscript provides evidence that the 12-min-run test in shallow water is reliable. It may also serve as a reference for future studies on criterion validity and concurrent validity. Future studies on the sensitivity of the test in detecting training adaptations are also granted.

Keywords: Aerobic exercise. Physical fitness. Fitness assessment.

INTRODUCTION

Water exercises have been expressively spreading in the last decades and the number of practitioners of this kind of exercise is still increasing. Such fact may be due to the lower incidence of ostearticular and muscle lesions in the water medium[1] and the easiness that people with this condition find in exercising in water. However, many healthy people are searching for water exercises, remarkably the water gymnastics, as a physical activity option and with the aim to improve overall physical fitness-health related[2].

Among the components of overall physical fitness, the cardiorespiratory fitness is one of the most important and its improvement is related to health[3-4]. Maximal or submaximal effort tests, mainly done in ergometers such as treadmills or bicycles, are necessary to assess it. However, the lack of specificity of these ergometers for the water gymnastics practitioners is a limiting factor, and may be inaccurate in the evaluation and consequently in the control of its evolution.

Since it is a cycle activity, as swimming and running, it is not simple to develop a test to specifically and reliably evaluate the cardiorespiratory fitness in water gymnastics. In order to minimize such problem, some researchers proposed running tests in water and verified the criterion related validity comparing the results to maximal effort tests and using the direct measure of the maximal oxygen consumption[5-8]. Some studies were able to generate equations to predict the $\dot{V}O_{2\ max}$ considering variables such as body fat, weight and height. Although these studies have been validated[7-8], none of them proposed gender or age group classification that could indicate the level of cardiorespiratory fitness. Probably, such fact is related to the reduced number of participants in these studies.

Moreover, the age group verified (up to 30 years of age) limits the results generalization, since the water gymnastics is one of the most wanted activity among the elderly[9]. The lack of studies specifically developed for individuals in this age group is a reason why not even proposals of results classification according to age are suggested.

Another noticed limitation in the mentioned studies lies on the lack of movements standardization. The water running could be done using many different combinations of arms and legs movements, which may facilitate or make the dislocation difficult.

Thereby, the aim of the present study was to propose a 12 minute-running test for shallow water with standardized movements, that may generate a classification of the distance covered, for women of different age groups and that is close to the characteristics of the considered activity. Furthermore, the test-retest reliability was verified in order to demonstrate the accuracy and stability of the found results.

METHODOLOGY

135 women between 20 and 84 years of age, healthy and adapted to the water medium participated in the present study. All of them were instructed not to practice physical activities in the 6 hours prior to the test. The study was limited to women who did not use medication that could alter the heart rate, which is the case of beta blockers. All participants signed the informed consent term, according to the 196/96 Resolution of the National Health Committee recommendations, after the institutional ethics committee approval.

1. Corpo & Água Sports Center – Petrópolis, RJ.
2. Programa de Pós-Graduação em Saúde Coletiva – Instituto de Medicina Social – UERJ. Laboratório de Atividade Física e Promoção da Saúde – LABSAU/UERJ. Universidade Católica de Petrópolis (UCP), Instituto de Desenvolvimento e Pesquisa em Atividades Físicas – IDEATIVA.

Received in 3/8/05. Final version received in 26/10/05. Approved in 17/4/06.

Correspondence to: Michele Heinen Alves da Silva, Rua Duarte da Silveira, 415, Bingen – 25665-470 – Petrópolis, RJ. E-mail: micheleheinen@ig.com.br

Six instructors previously trained applied the test in a 12 m long, 4 m wide and around 116 and 132 cm deep pool, which left the volunteers with water at their xiphoid process level during the exercise. The water temperature varied from 30,5°C to 31,0°C. Weight and height (Welmy® scale with stadiometer) were measured, with all participants wearing bathing suits comfortable for the physical activity in water medium. No specific foot gear was used; all volunteers took the test bare feet. Afterwards, they were all informed about the movements' standardization. The running performances with the arms outside the pool or pushing the edges of the pool with hands or feet were not allowed. The participants could only touch the edge with one of the hands and return in the same depth. The heart rate was checked at the end of the 12 min (HR12) using Polar A1 frequency meters.

The running movements were standardized so that the knees would not surpass the hip line and the upper body would be slightly leaned over. The arms were submerse and were moved similarly to the breast style swimming stroke.

This standardization is due to fact that a previous pilot study had been conducted to verify which movements would favor the vertical dislocation, giving more balance and security to the volunteers. Another reason, was to give priority to movements that would use the highest possible number of muscular groups, once the main muscular groups are used in the majority of the classes, and for that reason, standard movements were tried for a more specific test.

The decision whether foot gear would be used was part of the pilot study as well. Since the participants showed adaptation problems to the slippers, it was decided to have them bare feet. It was preestablished that the test would be interrupted in case dislocation difficulty for any reason was characterized.

All volunteers would get in the pool and stay at the edge in the given depth (with water at the xiphoid process level). A warm-up lap was conducted with the movements that would be later used The intensity for this lap was established as Poor (2), according to the Borg Subjective Effort Scale (CR-10). After this lap, the 12 minutes of uninterrupted running were timed, in the highest possible speed.

The pool's edges were marked at every meter in order to verify if the distance was being correctly measured. Besides the distance marking, the movements were controlled to assert correction and verbal motivation was given so that the volunteers would run as fast as they could.

17 participants were randomly selected in order to verify the test-retest reliability of the covered distance. These participants took the test two times, with a week interval. The Intra-Class Correlation Coefficient was used for the calculation (ICC).

The Pearson Correlation was initially used to analyze the association between age and HR12 and between weight and height in the completed distance. The calculations of a stepwise forward multiple regression equation and partial correlation would be later done, if necessary, the latter to verify the association of a variable without interference of the former.

Moreover, the quintiles (division in five parts) of the distribution of the results by age group were calculated in order to establish a possible classification of the performance by age.

All analyses, besides the descriptive statistics, were conducted through the Stata Standard Edition 8.0 software, taking a significance level of $p < 0,05$.

RESULTS

Table 1 presents the descriptive statistics related to age, completed distance, weight, height and 12 HR.

In the test-retest reliability analysis, the ICC obtained was of 0,91, which demonstrates a good agreement between the completed distance in the two tests, suggesting that it is able to present quite stable results in a week period. The descriptive statistics related to the two tests can be found in table 2.

TABLE 1
Descriptive statistics of the collected variables

Variables	Average	Standard deviation	Minimum	Maximum
Age	49,5	15,1	21	84
Distance (meters)	321,0	71,4	149	477
Weight (kg)	65,9	13,2	44	106
Height (cm)	161,0	6,3	147	178
HR12 (bpm)	134,2	33,1	88	179

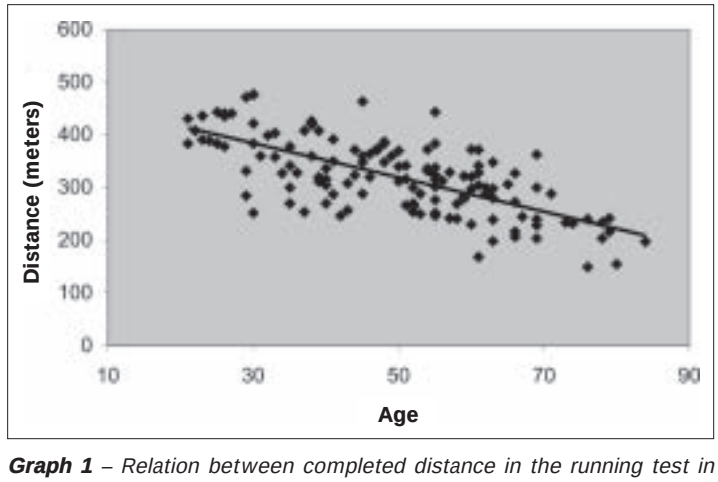
TABLE 2
Descriptive statistics of the two tests used in the reliability analysis

Completed distance (mts)	Average	Standard deviation
Test 1	352,8	76,1
Test 2	362,2	66,9

It is possible to verify the associations in the many collected variables, besides the statistical significance through the Pearson correlation matrix (table 3). The strongest relation seems to be between completed distance and age (–0,69), suggesting that the older the age group, the smaller the obtained distance within the 12 minutes of the test. In the dispersion figure (graph 1), such relation can be better seen.

TABLE 3
Correlation matrix in the collected variables

	Distance	Age	HR12	Height
Age	–0,69 (p < 0,001)			
HR12	0,58 (p < 0,001)	–0,53 (p < 0,001)		
Height	0,45 (p < 0,001)	–0,26 (p = 0,001)	0,26 (p = 0,002)	
Weight	0,06 (p = 0,48)	0,15 (p = 0,07)	–0,06 (p = 0,46)	0,36 (p < 0,001)



Graph 1 *– Relation between completed distance in the running test in water and age*

In table 3, a higher HR in the end of the test in the women who completed a longer distance tends to appear. Taller women also tend to complete longer distances. As a principle, such evidence would be somehow harmful to the test, once one of the main

concerns related to methodology was to decrease the influence of height for a better performance during the 12 minutes.

In table 3, the associations between HR12 and age; height and age; and HR12 and height can be observed. Older women reached a smaller HR at the end of the test, which is according to the literature[10], and older women (in the present sample) were shorter. These two factors would interfere in the association with the completed distance in the test, once it is unclear if the height influence in the final result would not be caused by the fact that the tallest women were also the youngest.

A stepwise forward multiple regression, considering age, HR12 and height, was applied with the purpose to verify which variables better explain the reached distance in test, generating the equation:

Completed Distance in meters = 360,8 – 2,52(age) + 0,63(HR12)

This equation presented a R^2 = 0,54 and a Standard Error of Estimate of = ± 48,7 meters. Analyzing the contribution of each of these variables to the explanation of the completed distance in the test, age contributes with 48% and the HR12 with the remaining 6%.

Although it was not a strong prediction, the equation was able to verify that only the age and HR12 variables remained, showing that age group was the main determining factor in the running test in water and with no height influence.

The association between distance and HR12 though, may suffer age influence, once with aging a reduction of the maximal HR is observed. An analysis of partial correlation was conducted in order to verify whether the association between HR12 and distance remains without age influence.

The partial correlation consists of the removal of the age effect in the dependent variable (distance) and in the other independent (HR12) through the residues analysis[11]. In other words, a correlation between the residues of an age and distance regression and the residues of an age and HR12 regression is done. After this analysis, the partial correlation coefficient found was of 0,35 for a significance level of $p < 0,001$.

The association between HR12 and distance decreased comparing to the result of the Pearson correlation (table 3), but such association existed even without age influence.

A classification of the performance is proposed according to age group, from the quintiles division, as well as the sample number obtained in each age group (chart 1), having as reference the distribution of the test results. It is interesting to observe the very different values found for the many age groups in the same classifications.

CHART 1
Result classification (in meters) in the running test in water according to age

Age group	Poor	Average	Quite good	Good	Very good
20-29 years (n = 15)	≤ 285	> 285-384	> 384-408	> 408-441	> 441
30-39 years (n = 24)	≤ 252	> 252-321	> 321-369	> 369-417	> 417
40-49 years (n = 24)	≤ 246	> 246-287	> 287-336	> 336-371	> 371
50-59 years (n = 34)	≤ 241	> 241-268	> 268-312	> 312-336	> 336
≥ 60 years (n = 38)	≤ 168	> 168-232	> 232-297	> 297-327	> 327

DISCUSSION

The results of the present study suggest that the running test in water proposed presents an age influence in the completed distance. Another relevant factor was the correlation found between the HR12 and the completed distance, which reoccurred even after the age variable removal from the analysis. Such finding suggests that a bigger effort was possibly reflected in a longer distance reached, despite the age influence.

Although height did not present significant correlation with distance, other authors found opposite results. Kaminsky[7] verified in his study better performance in the running test in water in taller subjects. However, the methodological control of the depth was not strict, which allowed the test being done with water between the navel and the xiphoi process. Thus, the individuals with water at the xiphoid process (shorter) probably were in disadvantage in relation to the ones who ran with water at the waist line (taller).

In the present study, no significant correlation between body weight and completed distance was found. However, McComb *et al.*[8] suggest that the body fat percentage may be a good indicator of the results in running test in water. Further studies considering variables related to body structure and not only body weight are suggested to reinforce these findings.

Although the results were not compared to the ones obtained through the gold-standard tests (with the oxygen maximum consumption measure), or even to other existing aerobic tests, hence being the main limitations to the present study, we believe that it can contribute as starting point for future research for the 12 m running test in water.

A fact that reinforces the such idea is some aerobic tests found in the literature that use the completed distance in a predetermined time[12-15] as indicator of cardiorespiratory fitness. A straight association between completed distance and the $\dot{V}O_{2\ max.}$ is observed in these tests.

Moreover, the inverse associations found between age and completed distance in track tests of 12 minutes[16], which make the categorization according to age group possible, make this variable considered to explain the test results that had been conducted in samples of different ages.

We believe that these findings suggest that the obtained results in the present study agree with the information found in the scientific literature characterizing, according to the definitions by Morrow *et al.*[17], content validation. Although the criterion related validity has not been verified yet, it can be used as initial study for new research.

CONCLUSION

The present study showed that the running test in shallow water seems to generate a classification of the completed distance for women of different age groups, demonstrating reliable results.

This test seems to be the only one devised in a representative sample of water gymnastics practitioners and of different age groups so far.

It is suggested that the age group classification here presented should be used by other water exercise centers, or even that the present study should be reproduced by these centers in order to propose new classifications, especially for men.

New studies will be able to support the present findings, mainly verifying:

- The criterion related validity when comparing the results to the ones obtained by the gold-standard test or even the concurrent validity, when comparing these results to other obtained by known aerobic tests;
- Differences between the pre and post-training phases.

ACKOWLEDGEMENTS

We thank Professors Marcos Doederlein Polito and Vitor Agnew Lira for the contribution to the text; Doctor Antonio Ponce de Leon for the suggestions in the statistics field and Corpo e Água Sports Center for making the study conduction possible.

All the authors declared there is not any potential conflict of interests regarding this article.

REFERENCES

1. Baum G. Aquaeróbica: manual de treinamento. Ed. Manole, 2000.
2. Case L. Condicionamento físico na água. Ed. Manole, 1998.
3. Nieman DC. Exercício e saúde. Ed. Manole, 1999.
4. Pollock ML, Wilmore JH. Exercícios na saúde e na doença. Ed. Medsi, 1993.
5. Black M, Abadie BR, Schuler PB, Boling R, Dickey J, Nabors J. Estimation of treadmill maximal oxygen consumption from a 12-minute shallow water run in highly conditioned college male and female subjects. Med Sci Sports Exerc 1997; 29:S49.
6. Dowzer CN, Reilly T, Cable NT, Nevill A. Maximal physiological responses to deep and shallow water running. Ergonomics 1999;42:275-81.
7. Kaminsky LA, Wehrli KW, Mahon AD, Robbins GC, Powers DL, Mitchell HW. Evaluation of a shallow water running test for the estimation of peak aerobic power. Med Sci Sports Exerc 1993;25:1287-92.
8. McComb JR, Daesung R, Williams J. The prediction of maximal oxygen consumption from a submaximal water running test. Med Sci Sports Exerc 2004; 36:S90.
9. Matsudo SM, Matsudo VK. Hidroginástica: prática corporal voltada à promoção de saúde do idoso. Rev Bras Ciênc Mov 1992;6:19-30.
10. Sheffield LT, Maloof JA, Sawyer JA, Roitman D. Maximal heart rate and treadmill performance of healthy women in relation to age. Circulation 1978;57:79-84.
11. Altman D. Practical statistics for medical research. London: Chapman and Hall, 1995.
12. Balke B. A simple field test for the assessment of physical fitness. Rep Civ Aeromed Res Inst US 1963;53:1-8.
13. Cooper KH. A means of assessing maximal oxygen uptake. JAMA 1968;203: 201-4.
14. Bernstein ML, Despars JA, Singh NP, Avalos K, Stansbury DW, Light RW. Reanalysis of the 12-minute walk in patients with chronic obstructive pulmonary disease. Chest 1994;105:163-7.
15. Cahalin L, Pappagianopoulos P, Prevost S, Wain J, Ginns L. The relationship of the 6-min walk test to maximal oxygen consumption in transplant candidates with end-stage lung disease. Chest 1995;108:452-9.
16. Heyward VH. Advance fitness assessment & exercise prescription. 3rd ed. Champaign, Illinois: Human Kinetics, 1998.
17. Morrow JR, Jackson AW, Disch JG, Mood DP. Measurement and evaluation in human performance. Champaign, Illinois: Human Kinetics, 1995.