DOI: 10.1590/1809-2950/17761325022018

Comparative analysis of respiratory muscle strength in healthy individuals in soil and in the pool

Análise comparativa da força dos músculos respiratórios em indivíduos saudáveis no solo e na piscina

Análisis comparativo de la fuerza de los músculos respiratorios en individuos saludables en el suelo y en la piscina

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ABSTRACT | Respiratory muscle strength is evaluated by manovacuometry, which provides two measures: inspiratory muscle strength and expiratory muscle strength. During immersion in a pool, pulmonary function changes in such a way as to interfere in length and in the activities of the respiratory muscles. The aim of this study is to analyze and compare the respiratory muscle strength, in healthy individuals, exercised in soil and in therapeutic swimming pool with the chest immersed in water. This was a cross-sectional, descriptive and observational study conducted between August and November 2016. Twenty-four scholars of the Physical therapy course of the Universidade Luterana do Brasil (Ulbra) from Canoas participated in the study and were evaluated by manovacuometry in the soil and in the pool. When compared with inspiratory pressures, we observed that after a minute with the chest immersed there was no statically significant difference in relation to the soil. However, after 20 minutes of immersion, a significant increase in the inspiratory pressure was found. For expiratory pressure, on the other hand, the difference between the conditions analyzed was not significant. A value of $p<0.05$ was considered statistically significant. We concluded that the permanence of 20 minutes with the chest immersed in warm water increased inspiratory muscle strength and did not modify the expiratory muscle strength.

Keywords | Hydrotherapy; Immersion; Respiratory System; Respiratory Function Tests.

RESUMO | A força dos músculos respiratórios é avaliada pela manovacuometria, que fornece duas medidas: força muscular inspiratória e força muscular expiratória. Durante imersão em uma piscina, a função pulmonar é alterada de modo a interferir no comprimento e nas atividades dos músculos respiratórios. O objetivo deste estudo é analisar e comparar a força muscular respiratória, em indivíduos saudáveis, exercida em solo e na piscina terapêutica com o tórax submerso na água. O estudo foi do tipo observacional descritivo transversal, realizado entre os meses de agosto e novembro de 2016. Participaram 24 acadêmicos do curso de Fisioterapia da Universidade Luterana do Brasil (Ulbra) de Canoas, avaliados pela manovacuometria no solo e na piscina. Quando compararam-se as pressões inspiratórias, observou-se que após um minuto com o tórax em imersão não houve diferença estaticamente significante em relação ao solo. Entretanto, ao final do período de 20 minutos em imersão, houve um aumento significativo da pressão inspiratória. Já para a pressão expiratória, a diferença entre as condições analisadas não foi expressiva. Um valor de $p<0,05$ foi considerado como estatisticamente significante. Concluímos que a permanência de 20 minutos com o tórax em imersão em água aquecida aumentou a força muscular inspiratória e não modificou a força muscular expiratória.

Descritores | Hidroterapia; Imersão; Sistema Respiratório; Testes de Função Respiratória.

RESUMEN | La fuerza de los músculos respiratorios es evaluada por la manovacuometría, que provee dos medidas: la fuerza muscular inspiratoria y la fuerza muscular espiratoria. Durante la inmersión en una piscina, la función pulmonar es alterada de modo a interferir en el complimiento y en las actividades de los músculos respiratorios.

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El objectivo de este estudio es analizar y comparar la fuerza muscular respiratoria, en individuos saludables, ejercida en el suelo y en la piscina terapéutica con el tórax sumergido en el agua. El estudio fue del tipo observacional descriptivo transversal, realizado entre los meses de agosto y noviembre de 2016. Participaron 24 académicos del curso de Fisioterapia de la Universidad Luterana de Brasil (Ulbra) de Canoas, evaluados por la manovacuometría en el suelo y en la piscina. Cuando se compararon las presiones inspiratorias, se observó que después de un minuto con el tórax en inmersión no hubo diferencia estadísticamente significante en relación al suelo. Mientras tanto, al final del período de 20 minutos en inmersión, hubo un incremento significativo de la presión inspiratoria. Ya para la presión espiratoria, la diferencia entre las condiciones analizadas no fue expresiva. Un valor de p<0,05 fue considerado como estadísticamente significante. Concluimos que la permanencia de 20 minutos con el tórax en inmersión en agua caliente incrementó la fuerza muscular inspiratoria y no modificó la fuerza muscular espiratoria.

Palabras clave | Hidroterapia; Inmersión; Sistema Respiratorio; Pruebas de Función Respiratoria.

INTRODUCTION

Whereas the pulmonary mechanics is based on its elastic properties, the measurement of respiratory muscle strength provides information that may be important for the characterization of the pathophysiology of lung abnormalities[1]. The quantification of respiratory muscle strength is one of the stages of the pulmonary function test[2].

Pulmonary function tests are important tools to assess the integrity of the respiratory system[3]. They involve objective measures to diagnose various diseases[4]. Manovacuometry is a simple, non-invasive and easy-to-apply resource[5] used to assess respiratory pressures, which reflect the respiratory muscle strength[6]. Inspiratory muscle strength is evaluated through maximal inspiratory pressure (Mip) and expiratory muscle strength is measured through maximum expiratory pressure (Mep)[7]. The test is commonly used to determine respiratory muscle weakness and to quantify the severity of certain diseases[8].

During immersion, at the level of C7 vertebra, the mechanics and pulmonary function are altered in such a way as to interfere in the length and in the activities of the respiratory muscles[9]. Physiological reactions in immersion vary according to several factors, such as: water temperature, depth of the therapy pool and the patient's disease conditions. The water temperature would be ideal between 34°C and 37°C[10] and the greater the depth, the greater the hydrostatic pressure[11].

As the hydrostatic pressure increases, the vital capacity (VC), functional residual capacity (FRC) and expiratory reserve volume (ERV) decreases thanks to the diaphragm displacement in the cephalic direction and to the increase in the work of expiratory muscle[12, 13]. The respiratory system changes because of the blood displacement from peripheral regions to the central region of the chest, in addition to the hydrostatic pressure on the rib cage, thereby increasing the respiratory work[14, 15].

The aim of this study is to analyze and compare the respiratory muscle strength in healthy individuals, exercised in soil and in the pool, with the chest immersed in water.

METHODOLOGY

This was a cross-sectional, descriptive and observational study conducted between August and November 2016. The scholars of the Physical therapy course of the Universidade Luterana do Brasil from Canoas participated in the study, and they were individually evaluated by the manovacuometry in soil and in the pool.

The convenience sampling included students over the age of 18 years, of both sexes, who were undergraduate students of physical therapy that year, from all periods. We excluded students with body mass index (BMI) above 30.0 (obesity grade I) and with any pulmonary disease.

The project was approved by the Research Ethics Committee from Ulbra Canoas (RS), under the opinion No. 1,618,286, CAAE 57022616.6.0000.5349. The researcher randomly invited students, informally, to participate in the data collection. The participants were told about the objectives, the methodology and the application of the test. Then they were asked to sign the Free and Clarified Consent Term (FCCT) in accordance with resolution 466/12 of the National Health Council.

Data was collected from the evaluation form (student's name, date of birth, sex, height, weight, body mass index – BMI, physical activities, smoking and a history of previous diseases), and the scholars were assessed individually. The volunteers were subjected to the manovacuometry test, which analyzes the respiratory muscle strength. For evaluation on water, we used the therapy pool of the Clinical School from Ulbra Canoas. All individuals wore bathing suits (swimsuit/swim brief) at the time of the evaluation.

The measurement of both inspiratory and expiratory pressures was obtained through manovacuometry (Wika/MV120). Each volunteer was asked to put pressure on the nozzle, so the air would not escape. A nasal clip was used to prevent the escape of air through the nose.

The variables were measured in three moments. First in the soil, to quantify the Mip, the individual, sitting on a chair in a 90-degree angle with the feet on the floor, expired as completely as possible, placed the mouth on the nozzle and inhaled as hard as he/she could, from two to three seconds. The maneuver was made three times and the highest Mip was used. To quantify the Mep, the volunteer was instructed to sit on a chair in a 90-degree angle, with both feet on the floor, and to inhale as hard as he/she could before placing the mouth on the nozzle, and to expire as deep as possible, keeping it from two to three seconds. The highest measurement was used after three attempts.

The second time, the volunteers were instructed to enter the pool slowly, where they remained seated on the steps of the ladder, holding on to a bar in the wall with the feet on the steps below, so the water was on the same level of their shoulders. As no participant mentioned aquaphobia, a minute was enough for acclimatization and acquaintance with that environment. The water temperature was 34.5°C and the dimensions of the pool were 10.5 meters long, 3.5 meters wide and 1.10 meter deep. After the first minute, the maneuver to measure the Mip and Mep was repeated. Finally, after the volunteer was in the pool for 20 minutes, the measurements were made again. The interval between each measure was one minute, being performed by the same evaluator and with the same verbal command.

Data were analyzed by the GraphPad Prism program. All variables were tested by D'Agostino-Pearson omnibus normality test to assess if they followed the Gaussian distribution. The Repeated Measures ANOVA, followed by *post hoc* Newman-Keuls test for multiple comparisons, was used to compare the values of maximum inspiratory and expiratory pressures in soil after one minute immersed and after 20 minutes in the pool. For anthropometric variables, the student's t-test was used. A value of $p<0.05$ was considered statistically significant.

RESULTS

The characterization of the sample presented in Table 1 shows that there are homogeneous characteristics of female predominance and a mean age of 24 years. All the analyzed parameters passed the D'Agostino-Pearson omnibus normality test ($p>0.05$), except for height ($p=0.049$). When divided into groups according to sex, all variables showed normal distribution.

Table 1. Sample characterization

Variables*	Total sample (n=24)	Female (n=18)	Male (n=6)	P (t test)
Age (years)	24.08±5.2			
Height	1.68±0.07	1.649±0.04	1.77±0.08	0.0002
Weight	65.91±10.84	62.94±8.26	74.33±13.54	0.023
BMI	23.22±2.39	23.1±2.43	23.54±2.47	0.7127

*Data are described by mean ± standard deviation

Table 2 shows the values of inspiratory and expiratory pressures in soil and water after 1 and 20 minutes. The results are also shown in Figure 1.

By comparing inspiratory pressures (Figure 2), a significant difference was found after 20 minutes in the water. After one minute in the water no statically significant difference was found in relation to the soil. However, the period of 20 minutes in the water also significantly increased inspiratory muscle strength in relation to one minute.

In expiratory pressure, on the other hand, the difference between the conditions analyzed was not significant.

Table 2. Maximum inspiratory (Mip) and expiratory (Mep) pressure (mmHg) in soil and in water after 1 and 20 minutes

	Mip soil	Mep soil	Mip 1'	Mep 1'	Mip 20'*	Mep 20'
Mean	−107.8	94.57	−104.6	92.61	−113.5	91.96
Standard deviation	26.96	25.71	27.96	25.49	25.74	26.14

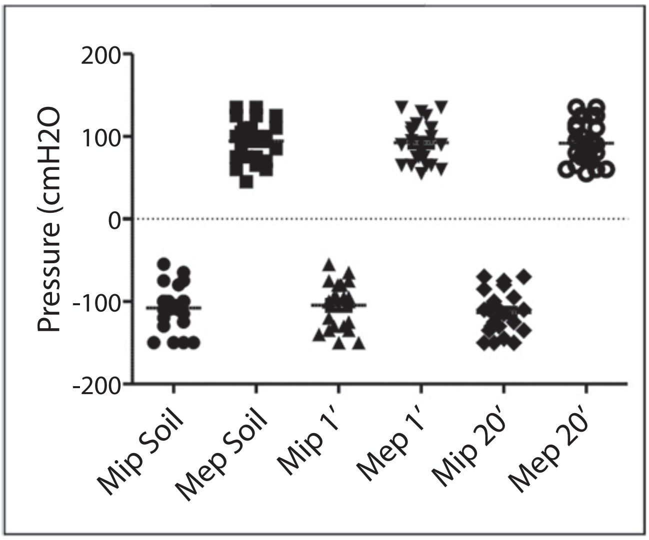

Figure 1. Individual values of all participants are represented on the graph, as well as means and standard errors of the mean. Mip (maximum inspiratory pressure); Mep (maximum expiratory pressure)

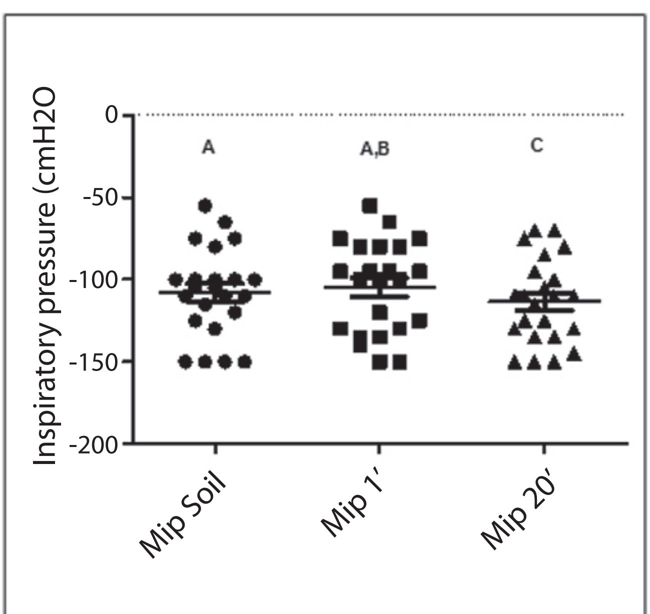

Figure 2. Inspiratory pressures for each condition evaluated are represented as mean and standard error of the mean. Different letters represent statistically significant differences after the Repeated Measures ANOVA followed by the *post hoc* Newman-Keuls Multiple Comparison test ($p<0.05$). Mip (maximum inspiratory pressure); Mep (maximum expiratory pressure)

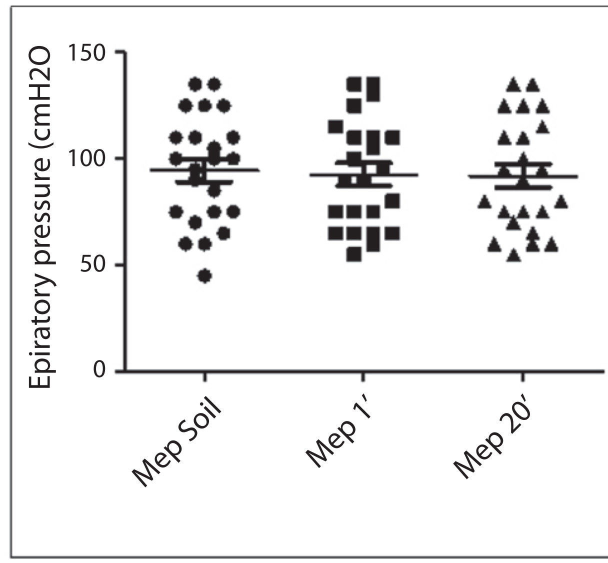

Figure 3. Expiratory pressures for each condition evaluated are represented as mean and standard error of the mean. The Repeated Measures ANOVA, followed by the *post hoc* Newman-Keuls Multiple Comparison test, was used ($p>0.05$)

DISCUSSION

We analyzed in soil and in the pool, through manovacuometry, 24 students, 18 women and 6 men. Also, no difference was found between the Mip soil and the Mip 1' of immersion, but statistically significant difference was found between the Mip soil and the Mip 20' in the therapy pool, as well as between the Mip 1' and the Mip 20'. However, data among the Mep showed no significant difference.

The pulmonary system is unaffected by immersion at a level above the shoulders. This occurs by the diversion of blood from the peripheral region to the central region of the body. The action of hydrostatic pressure changes the pulmonary mechanics[16, 17], which causes a resistance during inhalation and, consequently, increases the load on the inspiratory muscles[18].

Ide et al.[14] conducted an aquatic kinesiotherapy protocol that showed improvement in inspiratory muscle strength on older women, which suggested the benefit of immersion in the respiratory system. In our study, there was also an increase in the Mip; however, it was performed with static young people in the therapy pool. This result suggests that the inspiratory muscle strength increases even without any type of exercise. Expiratory muscles, on the other hand, did not show significant changes[14].

The study by Silva and Fagundes[10] has homogeneous characteristics of female dominance, such as this one, and shows that immersion up to the shoulder increases the load on the inspiratory muscles; however, the load will be lower with the immersion up to the xiphoid process, therefore, it does not offer great resistance in the inspiratory work[18].

Our study is consistent with the one by Sá et al.[1], who assessed 30 healthy women with an average age of 20 years[1]. This study was also carried out with a sample mostly composed of healthy women with an average age of 24 years and average height of 1.64 cm. It is noteworthy that in the study cited the values related to the respiratory function increased after immersion, however, these values were the minute volume and the tidal volume.

According to Norm and Hanson[19], the difference of depth in immersion changes the pulmonary function and increases the inspiratory work, which is in accordance with our study. However, they suggest that immersion in warm water does not change chest expandability[19]. On the other hand, due to immersion, the respiratory system needs to work more intensively, which increases the load and the respiratory muscle strength, improving breathing[20, 21]. It is not specified which respiratory muscle will be strengthened with the immersion and the depth of the effects observed[22].

Our study differs from the one by Sampaio et al.[23] for not having detected statistically significant difference between the Mep variables. Other authors, such as Becker and Cole[20], reported that the hydrostatic pressure causes an elastic recoil, which assists in the lung emptying thus decreasing the recruitment of expiratory muscles[20]. Therefore, under immersion conditions, the Mep decreases, which can be justified by the lower use of expiratory muscles[24]. Considering that expiration (residual functional capacity) is a passive process, differences in Mep are not expected if measured in the soil and in water[25].

CONCLUSION

We concluded that the immersion in warm water can increase inspiratory muscle strength and it does not influence expiratory muscle strength. However, studies with a greater number of individuals and a longer time of immersion are required to clarify the effects of immersion on the respiratory muscle strength. There is also the possibility of evaluating the VC of submerged individuals, which would bring more information about pulmonary mechanics in this condition. Therefore, we emphasize that the immersion in warm water influences inspiratory muscle strength and, thus, it is possible to create a differentiated respiratory muscle training protocol in the aquatic environment.

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