

## EFFECTS OF A HYDROTHERAPY PROGRAM ON FLEXIBILITY AND MUSCULAR STRENGTH IN ELDERLY WOMEN

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### ABSTRACT

**Objective:** To evaluate the effect of a hydrotherapy program on flexibility and muscle strength among sedentary elderly women. **Method:** The participants were 31 healthy sedentary elderly women aged between 65 and 70 years (16 in the experimental group and 15 in the control group). Muscle strength tests were carried out using myometry on arm, leg and chest muscles. Flexibility before and after the program was assessed by means of a photographic record of performance in toe-touch tests and tests of anterior flexion of the trunk. The program consisted of 28 one-hour sessions over a consecutive 14-week period. The physical exercises were organized in seven levels of difficulty that were selected to obtain gains in flexibility and muscle strength. **Results:** There was a statistically significant decrease in anterior flexion of the trunk of -15.4%, which signified a mean decrease of 19.3 cm ( $\pm 22.4$ ) in the distance from the styloid process of the ulna to the lateral malleolus, and an improvement of 4.2% in the toe-touch test, which indicated a mean increase in finger-to-finger distance of 4.7 cm ( $\pm 4.5$ ). There were no statistically significant changes in strength in the abdominal, gluteal and iliopsoas muscles. The quadriceps femoris, hamstring, biceps brachii, pectoralis major, middle pectoralis and middle deltoid presented significant improvement. **Conclusion:** The proposed hydrotherapy program was efficient in improving flexibility and partially effective in improving muscle strength among the early elderly women who took part in the study. Our results are compatible with the findings from similar studies carried out on the ground.

*Key words:* hydrotherapy; aging; aquatic exercises; flexibility; muscle strength.

### INTRODUCTION

The aging process may be understood as a set of unfavorable structural and functional alterations of the organism, which progressively accumulate, specifically due to advancing age. These modifications interfere with the performance of motor skills, making difficult the individual's adaptation to the environment, initiating changes of both a social and psychological nature<sup>1</sup>.

The loss of muscular strength in the muscular-skeletal system starts from 25 to 30 years of age, and occurs due to various factors<sup>2,3</sup>; simultaneous decreases in the flexibility of all joints. The flexibility and muscular strength losses in elders affects balance, posture and functional performance; increases the risk of falling and respiratory problems; decreases the speed of walk, and makes difficult daily living activities.

Consequently, the maintenance or gain of flexibility and muscular strength is an important aim for the control of elderly people's health. Physical training programs may diminish the effects of the immobility cycle: of falls, pain, and fear<sup>4</sup>. It is agreed upon that musculature should be strengthened in

a harmonious manner from optimized joint mobility, and that, in order to prevent aging dysfunctions, the most appropriate solution is a program of low impact to moderate intensity exercises over a long period<sup>5</sup>.

Hydrotherapy is a physical therapy resource that utilizes the physical, physiological and kinesiological effects that occur from the body's immersion in a heated pool as an auxiliary resource for the rehabilitation or prevention of functional alterations. Physical properties and the heated water perform important roles for the improvement and maintenance of joint range of movement, muscular tension reduction, and relaxation<sup>6</sup>. Decreases of joint impact during physical activities induced by flotation causes reductions of pain sensitivity, decreases of compression on the painful articulations, greater freedom of movement and decreases of painful spasms. The effects of flotation aids the movement of rigid articulations in wider ranges with minimal increases in pain<sup>7</sup>. The strengthening exercises with submerged patients are based on the physical principals of hydrostatics, which allow the generation of constant multi-dimensional resistance to the movements. This resistance increases proportionally while

the strength is exerted, generating a minimal overload of the articulations<sup>8</sup>.

Based on what was demonstrated above, and on the importance of exploring this subject, this study had as objective to assess the effects of a hydrotherapy program developed for flexibility and muscular strength gains in previously sedentary, early elderly women.

## METHODOLOGY

### Participants

Sixteen women aged between 65 and 70 participated of the hydrotherapy program. Fifteen women, who were similarly selected, took part as a control group, and they participated in a hydrotherapy program after the data sampling. The groups were defined by a random draw.

In order to be included in the study, participants had to be right-handed, have a medical report stating that they were in sufficient physical condition to participate in a physical exercise program of low to moderate intensity immersed in warm water. They also stated that they did not have any pathology that limited the practice of hydrotherapy and did not take any pharmacological treatments. The researcher confirmed by telephone, these proceedings. The participants also declared not to have practiced any specific physical activity or regular walking (for at least 30 minutes, twice a week) for five years, characterizing their sedentary status for at least five years<sup>9</sup>.

Exclusion criteria included the absence of training in the same week, and the lack of interest in the physical activities during classes. All participants agreed with and signed the post-informed terms of consent for the study, approved by the Ethics Committee of the Clinical Hospital Management and Medicine School of the University of São Paulo (Protocol n° 602/05).

### Facilities

The Physical therapy and Behavior Laboratory of the Physical therapy Course from the School of Medicine of the University of São Paulo, and Pool Center swimming and gymnastics school was used.

### Materials

The training was performed in a therapeutic pool with dimensions of 4 x 2 meters and 1.3 m deep, with an average temperature of 32.5° C. In order to assess flexibility, a Casio 3.0 mega-pixels digital photographic camera was used, together with Auto Cad 2000 software. A Lafayette myometer was used to measure muscular strength.

### Procedures

The subjects' evaluation occurred at two distinct moments, before and after interventions which were performed in the morning by the same properly trained investigator.

### Flexibility Assessment

The investigated tests were toe-touch and anterior flexion of the trunk in the seated position, a modification of the anterior trunk inclination from the position of bipedastation (toe-touch test). This position is necessary for an elderly population, since bipedastation induces exaggerated posterior pelvic dislocation and fear of falling<sup>10</sup>. The test of anterior flexion of the trunk is specific for assessing the posterior muscular chain, while the toe-touch test assesses shoulder mobility, scapular waist and upper limbs, and may be influenced by the degree of curvature of the vertebral spine.

After explaining and training the participants, the tests were performed and photographed in order to decrease the length of the examination, and to yield a more accurate evaluation, allowing a check-up of postural alterations incompatible with the subject's evolution and indications of sampling error. This also allowed the assessment of the sampled data by independent investigators. The verification was made with the 64 collected measurements for the control group and yielded a variance coefficient of 0.96, indicating the ability of the investigator in data collection<sup>11</sup>.

The production of trustworthy and reproducible measures for the anterior flexion of the trunk from the seated posture test was described in a study using radiography, performed by Perret<sup>12</sup>. The reproducibility of the distance data, considered as anatomical reference point of the ulnar styloid process. Rigid support, by means of photography, was performed in a study with elders, which showed high correlations between the measurements taken with the subject and the ones taken using photography<sup>13</sup>. The measurements sampled through photography of the finger to toe distance on the toe-touch photographic assessment was validated by Riehl<sup>14</sup>.

The routine of performing the anterior trunk flexion test started with the positioning of the subject, and placing marks on the anatomical points (ulnar styloid process and lateral malleolus). Afterwards, using the previously trained verbal command, the subject began the stretching in anterior flexion of the trunk. Photographs were taken during the third trial, and finally, the wrist-ankle distance was measured with aid of the CAD-2000 software. Each participant was photographed from the right lateral view. After obtaining the photographs, data analysis was performed.

To do so, two parallel straight lines vertical to the ground were traced – one passing through the ulnar styloid process and the other by the lateral malleolus – afterwards, a line was traced parallel to these two lines, and its measurement was established. This was considered next to a meter reference measure which was placed on the surface of a wooden table where the patient was positioned for the test<sup>9</sup>. The photographs were taken following the norms established by Watson and Macdonncha<sup>15</sup>, with the aim of avoiding image distortion. For the photographic recording, the participants were positioned in the test position on a 40 cm wide x 160 cm long wood table for the flexibility assessment. For

standing assessment, the subjects stood on a base with feet positioning, as proposed by Kendall et al.<sup>16</sup>, for the toe-touch test, and the photographic camera was placed on a tripod parallel to the ground at a height of 1.0 m from the ground and 2.40 m from the participant<sup>17</sup>.

### *Muscular Strength Evaluation*

In the present study, isometric strength was investigated. Muscular tests were performed according to the procedures described by Kendall et al.<sup>16</sup>. Manual resistance was assessed by the myometer – dynamometer which measures the isometric strength peak of a muscle or muscular group against the resistance offered by the examiner which has been adequately validated<sup>18,19</sup>. This technique is recommended for elderly people because it is a rapid test, does not require repetitions, and provides numerical data for developmental studies<sup>10</sup>. This protocol was for the assessment of strength with a device named the *make test*<sup>20</sup>. The tests were performed before and after the end of the exercise program, with three measures taken for each selected bilateral muscular group, with analysis performed on the best of the three measurements<sup>20,21</sup>.

Four muscles of the lower limbs were assessed: the medial gluteus, hamstrings, femoral quadriceps and iliopsoas; three muscles of the upper limbs: biceps brachii, middle and infra-spinal deltoid, major and middle pectoralis; and, in the trunk, the straight abdominal muscle was investigated. The choice of these muscles considered their utilization in functional activities. To assess trustworthiness of the collected data, the researcher and an independent examiner collected bilateral measures of muscular strength of the various muscular groups with 10 women who were available to take part of this activity. Considering the 160 measurements collected, the variance coefficient was 0.96, indicating the researchers ability to collect data<sup>11</sup>.

### *Hydrotherapy Program: Elaboration and Application*

The program aimed at developing muscular flexibility and strength improvements, although the programmed exercises also affected motor skills, balance, respiratory and circulatory functions, by the simple fact that the exercises were performed in water immersion up to the neck.

A hydrotherapy program of 32 sessions applied over 16 consecutive weeks was specifically elaborated for this study. The first four sessions (pre-training) were used for adaptation to the aquatic environment, and 28 sessions were used for muscular flexibility development and strength development with up to seven levels of increasing difficulty. The sessions took place in pairs and lasted for an hour, with 15 minutes for the measurement of vital signs, and 45 minutes for six warm-up activities, 11 flexibility activities, eight strengthening and four relaxation activities. Since the speed of the exercises varied according to the degree of difficulty and the addition of resistance with floaters, determination

of the number of repetitions was difficult, and it was decided to perform the exercises by periods of time, and not by the number of repetitions. During the training period, the women from the control group took part in the classes about general health care for equivalent periods of time.

### **Data Analysis**

In the present study, muscular flexibility and strength were assessed between the pre- and post-tests, comparing each participant with herself. The muscular flexibility and strength variable variations between the pre- and post-tests was compared to the zero value by means of the parametric test of comparison of an average with unknown  $\sigma$  (paired t-student's test) with a significance level of 5%. The percentage of strength variations was evaluated, considering on the basis of the pre-test strength measures. Strength variation is equal to the strength on the post-test minus the strength on the pre-test multiplied by 100 and divided by the strength on the pre-test<sup>22</sup>.

Clinical significance of the muscular strength responses of the participants was also analyzed. Clinical improvements were considered increases greater or equal to 20% of the muscular strength measured at the pre-test<sup>23</sup>. Evaluation of clinical improvements for the flexibility tests was not necessary because all participants showed increases of the wrist-ankle distance on the anterior flexion of the trunk test and on the finger-toe distance at that were greater than four centimeters, which are minimal values stipulated for signs of clinical improvement<sup>23</sup>.

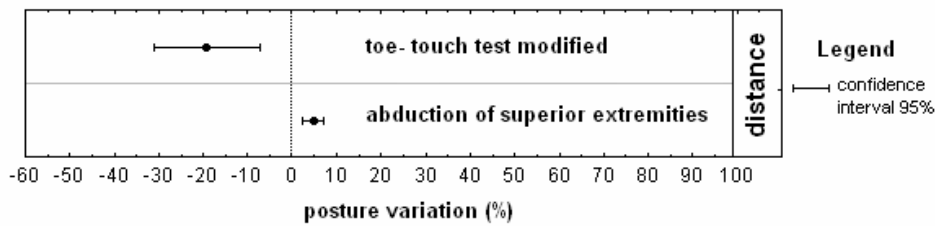
## **RESULTS**

### **Participants Features**

Sixteen women concluded the proposed exercise program; two elder women quit on their own will, two had to quit because of health problems and two women were disconnected from the program due to their absences. The women who participated in the study had a corporal mass index (CMI) considered overweight ( $28.6 \pm 4.8$ ), without the presence of obesity, when considering sex and age, which was a typical feature of this population<sup>24</sup>. All 15 women from the control group concluded the study, (CMI  $28.8 \pm 3.5$ ).

### **Flexibility**

The improvements in the measures observed in the experimental group was 15.4% ( $\pm 22.41$  cm), which meant an average decrease of 19.3 cm of the distance between the wrist and the ankle between the pre- and post-tests. Participants' performance on the toe-touch test revealed statistically significant improvements, with an increase of 4.2% ( $\pm 4.47$ ), which meant an average increase of the finger-toe distance of 4.7 cm (Figure 1). The control group did not demonstrate significant flexibility changes on both investigated tests.



**Figure 1.** Percentile variations of the measures obtained in the toe-touch test and abduction of the superior extremities.

**Table 1.** Variation of the muscular force, for groups, between the pre- and post-tests for the right and left sides.

Muscles	Force - MID (%)	dp	p	SC (%)	Force - MIE (%)	dp	p	SC (%)
Ileuses	15.5	29.6	0.063	46.7	11.6	30.8	0.154	25
Quadriceps	44.8	39.3	0.001	66.7	42.2	43.8	0.002	68.8
Isquiotibial	18	15.9	0.001	40.0	24.7	26.4	0.002	56.3
Medium gluteus	0.4	17	0.935	13.3	2.1	21.6	0.697	25
Brachial and brachial biceps	46.5	48.6	0.002	66.7	68	74	0.002	81.3
Pectorals major	19.1	23.2	0.005	50	19.7	29.1	0.016	50
Medium deltoids	28	47.8	0.033	56.3	26.3	23.9	0.001	56.3
Abdominal	18.9	51.9	0.166	37.5	-	-	-	-

**Considering:** RIM: Right Inferior Member; dp: standard deviation; p: Comparison of the averages (5%); CS: Clinic Significance and LIM; MIE: Left Inferior Member.

### Muscular strength

The results of the experimental group's test of muscular strength are shown in Table 1. The control group did not demonstrate significant changes of muscular strength for any of the investigated muscles.

### DISCUSSION

The applied hydrotherapy program was efficient for the elder women's flexibility, with decreases of the wrist-ankle distance when performing the anterior flexion of the trunk test and for the finger-toe distance when completing the toe-touch test. This finding is relevant, since it confirms the expectations generated by the facilitation of high range exercises in the medium of water, and supports the suggestions in didactical books based on clinical experiences.

A previous study assessed the flexibility using the same methodology in response to a program of physical exercises performed on the ground, including stretching, muscular strength, respiratory, balance and motor skills exercises, or a general exercise program. The study was conducted with 15 early elderly women in the experimental group and 15 participants in the control group, who trained for four months, twice a week. The study showed improvements in the

experimental group's flexibility, decreasing the average wrist-ankle distance to half of the values found on the pre-test, that is, an average decrease of  $21.9 \pm 4.3$  m. The control group did not show significant alterations<sup>9</sup>. Our results are very similar to the ones found in this ground-performed study, indicating that both programs, hydrotherapy and ground-based, produced similar results, with the advantage of the former that it was low-impact.

These results are compatible with the data of Rauchbach<sup>25</sup>, who studied the effects of a general exercise program (stretching, respiratory, muscular strength training, joint mobilization, balance training, and relaxation, together with walking), applied for three months, three times a week, in sessions of one hour, of 42 subjects with an average age of 64 years. The author found a relationship between performing the proposed physical activities and improvement of the range of motion of the articulations of the upper and lower limbs. The flexibility of the lumbar spine, measured during the anterior flexion of the trunk, showed an average increase of 5 cm in 88.1% of the participants after training, showing that the association of the training proposed by the author increases flexibility. Our results have also shown that the hydrotherapy program increased the scapular waist and upper limb mobility (toe-touch test), which also occurred



in the study by Rauchbach, as assessed by goniometry of the upper limb.

Regarding muscular strength, this study found that of the four muscular groups of the evaluated lower limbs, the quadriceps and the hamstrings demonstrated significant improvements, and the gluteus and iliopsoas muscles did not show statistically significant improvements. The three muscular groups investigated of the upper limbs showed statistically significant increases. A discrepancy between the right and left limbs was found on the brachii biceps, with a greater increase of muscular strength in the left limb. This difference may be even more significant in muscles that perform different tasks, depending on the side of the limb being, as shown by the strength of the finger flexion muscles of the right and left hands<sup>26</sup>. It is important to point out that all patients were right-handed and, in this way, the intervention produced a tendency to equal the strength between limbs, reducing discrepancies and showing that muscles less used in daily routines, react better to training.

Bohannon<sup>27</sup> measured muscular strength, by means of myometry in 13 muscle groups, and concluded that the right hemi-body was stronger than the left one by an average of 23.2% for flexor muscles of the elbow and 40.2% for the wrist extensors. Our data have shown that, for the studied muscles, only the brachii biceps muscle group showed similar differences before intervention. The straight abdominal muscle did not demonstrate statistically significant differences in muscular strength. Studies with the application of low to moderate intensity exercises for the development of muscular strength of this muscle were not found.

Although this study has been developed over a period of 16 weeks, it is worthy to point out that it was of low to moderate intensity and did not use maximal strength that could be produced by the participants, as has been reported by Mills<sup>28</sup>. This author studied the effects of eight weeks of moderate intensity exercises, with stretching and muscular strength training, with 20 elders aged on average of 75 years. They found an increase of the range of joint movement of the lower limbs, without any gains of muscular strength and considered that the training time was reduced, thus impeding improvements. In the present study, improvements in some of the investigated muscles were found, and it is believed that, with the continuation of training, the strength gains would become more evident, since the results presented in the clinical improvement analysis indicate (Table 1).

Data from this study are similar to those found by Hunter et al.<sup>29</sup>, who submitted 14 volunteers, aged between 60 and 77 years old, to 16 weeks of muscular training on the ground, twice a week. Among other measures, they studied the response of two muscles (elbow flexors, and knee extensors) with an isometric strength test using Universal Shear Beam Load Cell®, and found an average increase of 31% of these muscles strength. The author's did not consider the isolated strength of each muscle. The percentage of

increases found by the authors was also obtained in our study by the quadriceps and brachii biceps muscles.

Judge et al.<sup>30</sup> assessed the effects of 12 weeks of postural, balance, and strength training of the knee extensors, hip adductors, foot dorsal flexors, hip extensors and knee flexors with muscular exercise training with 16 participants. The control group, with 15 participants, performed general stretching exercises, seated on a chair. Average age of the participants was 82.1 years old. The authors found that the experimental group demonstrated increases in strength and walking velocity. The strength of the assessed muscles (measured by myometry) increased on average by 32%. The upper limb muscles showed strength increases of 7.2% of the flexor muscles of the elbow, but no alterations in the strength of the abductor muscles of the shoulder (average of 3.6%). This study is compatible with our findings, thus strengthening the idea that hydrotherapy programs, as well as general ground exercises, promote increases in strength and flexibility.

The gluteus muscles, although important for posture and walking, were studied very little in strengthening situations. Although no statistically significant differences were found, there were clinical improvements in 13% (n= 2) and 25% (n= 4) of the participants on the right lower limb and left lower limb, respectively. It is believed that a longer period of training is necessary to improve the strength or to perform exercises with more participants.

In reality, there is almost no evidence on hydrotherapy programs for the elderly described in the literature. This attempt is a beginning to reach an ideal program, that produces significant enhancement for all the trainable dimensions that are easy to execute, acceptable, and provide maintenance. The addition of other flexibility tests is suggested, as well as the evaluation of a greater muscle groups that provide information about the hands, feet, trunk and facial musculature, as well as for balance, with different elder populations.

## CONCLUSIONS

The proposed program has showed itself efficient in generating improvements in muscular flexibility and strength of previously sedentary early elder women, and confirms the clinical findings reported in most didactic books about hydrotherapy. The muscular flexibility and strength increases found are similar to the those found in ground-based studies.

Although the training time was limited and the research was developed with a small group of sedentary early elderly women without clinical complications, this work contributes to the development of more detailed programs of physical exercise directed towards the elderly population, with more exercise routines. The demonstration of the effects of various programs may facilitate more adequate exercise prescriptions, for the needs of the elderly.

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