RESPONSE TO RESISTANCE EXERCISE PERFORMED IN WATER VERSUS ON LAND

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The objective of the study was to verify if the cardiovascular and metabolic demands of well-designed water resistance training are at least comparable to their land-based equivalents. Five trained men were evaluated similarly with a horizontal shoulder adduction movement in water with a Hydro-Bells and on land with an elastic band (EB). Previously in order to equate resistance of movement, a rhythm rate in water and on land was established as well as distance in the holding distance of the EB. Subsequently physiologic response was evaluated with both devices by means of a set of twenty-five repetitions until reaching muscular fatigue. The results showed that there were no statistically significant differences between both material resources concerning heart rate at exertion and the response of lactates. We conclude that if the resistance training in water is performed according to the methodological indications followed in this study will produce a similar physiological response to that produced by land-based exercise.

Key Words: aquatic training, resistance exercises, heart rate, lactates.

INTRODUCTION
Strength is the neuromuscular ability to overcome or oppose external resistance by means of muscular tension. The above resistance may be created when training, for example, with weights, elastic bands, air devices or even with movements in water. Regardless of the material used, in order to gain improvements in physical performance, or in health, it will be necessary to create that muscular tension so that the muscle groups involved are stimulated. However, said muscular tension must reach a minimum threshold in order to create enough physiological stress with which to produce the desired adaptations. To this end, currently the majority of internationally renowned researchers recommend land-based resistance training with different materials and procedures. However, the use of the water environment is usually undermined as a material in itself for resistance training since there is a generalised belief that this water-based exercise cannot create an intensity of training similar to the one that is obtained by the exercises of strength in dry-land (2). For resistance training the role played by lactates and heart rate (HR) is a possible physiological indicator which could be linked to the exertion intensity. However no studies were found to have analysed this aspect using water exercises for resistance training, unlike the land-based setting where different studies are available (5, 6). So, this study aims secondarily to vouch for an objective methodology for quantifying intensity in water-based exercise by following previous proposals (2, 3), and primarily to verify if the cardiovascular and metabolic demands of well-designed water resistance training are at least comparable to their land-based equivalents.

METHODS
The sample consisted of five young, healthy males with an age of 25.75 ± 1.5 years old, a height of 1.79 ± 0.07 metres, a weight of 83.52 ± 10.95 Kg, a body fat of 17.12 ± 2.3%, an experience of training exercises of 2.5 ± 1.5 years, and a weekly training frequency of 3.6 ± 0.9 sessions, with the session lasting between 1.3 ± 0.2 hours and a perceived exercise intensity usually between moderate and high (7).

A) Equalling intensity for both exercises and evaluation tests of physiological response.
At all times the research was carried out on the premise that the technical characteristics and the resistance provided by both materials (water-based device vs. elastic band) were the same. The movement to be evaluated was a shoulder level abduction to 80º, with a 20º elbow bend and no support from any other body segment. The distance covered in each movement was such as to allow the subject to almost join hands in the horizontal shoulder adduction movement and reach a horizontal shoulder abduction of at least 20 degrees, taking as a reference point the frontal plane of the subject's body. Despite being familiar with the movement involved with both devices, the subjects received instruction prior to performing the exercise and supervision at all times in the correct execution of the movements. In order to guarantee the homogeneity between both exercises the speed of the movements was monitored as were the number of repetitions and the placing and correct use of the material. The aquatic exercise taken as the reference standard was a horizontal opening in water with Hydro-Tone Bells (3) (Aquatic Fitness Systems, Inc., Huntigron Beach, CA). The hydrodynamic position of the device was also monitored, as it could influence the overall intensity of the exercise (2, 3). So, the vertical position of the Hydro-Bell was established for the horizontal shoulder abduction phase (figure 1) and the horizontal position for the horizontal shoulder adduction phase. The subjects were immersed to shoulder level in water at a temperature of 28º centigrade. Speed of movement was established following a digitalized rhythmic sequence of the beats of a metronome. This rhythm was to delimit the alternative movements of horizontal shoulder abduction and adduction. Each subject selected a rhythmic sequence that allowed him to carry out twenty-five repetitions of the movement, reaching fatigue (maximum rate of perceived exertion; RPE of 9-10 with OMNI-RES of Robertson et al. (7)). In the event of the subject not completing the repetitions anticipated, or doing more, not following the rhythmic sequence or altering the performance technique the test was stopped, a five-minute rest was given and another rhythmic sequence of greater or lesser speed was selected depending on why the previous attempt had failed.

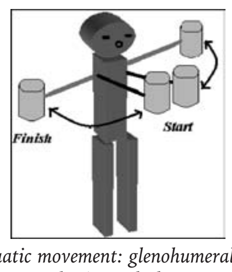

Figure 1. Aquatic movement: glenohumeral abduction on a horizontal plane.

It was essential to the study for the rhythmic sequence to be selected correctly, since the speed of the land-based exercise would be delimited by the same sequence. If not, the values obtained in the measurements would be incomparable, since subsequently in the final tests if the two exercises are conducted at different speeds could produce different metabolic responses. Therefore, once the rhythm was established in the water movement, the subjects were asked to follow the same sequence for the land exercise with the only change being the distance between thumbs when holding the elastic band in order to adjust the desired resistance, assuming that the closer together the thumbs were placed, the more resistance the subject would encounter. The elastic band was a Thera-Band model of light intensity and measuring 1 metre in length when slack. As in the water exercise, the test would be stopped in the event of not completing the desired repeats, going over the number of repetitions, altering technique or being unable to follow the rhythmic sequence, in which case a five-minute rest was given and the subject selected a different position in which to hold the elastic band depending on why the previous attempt had failed. In this way, resistance was adjusted individually, maintaining the rhythmic sequence as in the water exercise. The average width when holding the elastic band was 18.75 ± 6 cm. The subjects always were allowed to recover for 30 minutes after, respectively, determining the rhythm sequence in the water, the distance between thumbs when holding the elastic band in dry-land, and after each final tests (in water and in dry-land). Therefore, after carrying out equal intensity for both exercises the subjects conducted the final tests in which heart rate during exercise (HRE) and lactates concentration were recorded.
To monitor heart rate pulse was taken using a device of the POLAR brand, model S810i. Given that during exercise in water with this depth of water a fall in HRE of between 10 and 17 beats per minute is recorded compared with an exercise of the same intensity performed on land (1, 4), on recording HR immediately post-exercise a value of 14 beats per minute was added in order to equate it with the rate obtained during the land exercise. Subsequently, recovery HRE was recorded normally 3 and 5 minutes post-exercise when the subjects were passively seated at the poolside.
The usual protocol was followed for measuring lactates concentration. A lactate measurer from the commercial brand ARKRAY, Inc., model Lactate Pro LT-1710 was employed. The room temperature and humidity were 29° C and 53% respectively. Duration of each exercise was approximately one minute, ensuring an optimum production and accumulation of lactates for subsequent assessment. Before initiating any of the tests the basal concentration of the subjects was obtained, as was lactates concentration 3 and 5 minutes post-exercise.

B) Data analysis.
Using the programme Statistical Package for Social Sciences (SPSS), the descriptive statistics were obtained and finally Student´s t test was conducted for related data.

RESULTS AND DISCUSSION
The results are showed in table 1. For resistance training, the role played by lactates is a possible physiological indicator which could be linked to the exertion intensity, since the anaerobic metabolism is the main means of energy provision for this type of training. However in specific literature no studies were found to have analysed this aspect using water exercises for resistance training, unlike the land-based setting where many studies are available.

*Table 1. Mean and standard deviation for heart rate values with regards to percentage of heart rate reserve and percentage concentration of lactates with regard to basal values. ** p< 0,01 Statistically significant difference.*

	Water		Land			
Minute post-exercise	*Heart rate*	*Lactic acid*	*Heart rate*	*Lactic acid*	*p (Heart rate)*	*p (Lactic acid)*
0	82,25 ± 9,71		68,75 ± 19,80		0,098	
3	47,75 ± 18,77	2,34 ± 1,66	33,25 ± 16,5	1,14 ± 1,43	0,079	0,125
5	37,00 ± 14,85	4,3 ± 3,24	25,75 ± 14,45	1,55 ± 0,78	0,002**	0,82

Lagally et al. (6) measured lactate concentrations before, immediately after and several minutes post-exercise. It was observed that levels of lactate increased as the intensity of exercise increased, confirming the direct link between both parameters, and confirming that for high intensities levels of lactate remained high for several minutes as is the case in this study. Moreover, Hollander et al. (5) observed the relationship existing between exertion intensity obtained by means of local muscular endurance exercises and heart rate. So, these studies confirm that heart rates as well as levels of lactates are values which allow exertion from local muscular endurance exercises to be quantified. Following on from the evidence presented and the results obtained in this study, we might point out that HRE on completing exercise in water shows, in a statistically non-significant way, a certain increase as regards the HR reserve. The data also suggest that HR in recovery was slower after exercise performed in water. The results also suggest, in a statistically non-significant way that with the aquatic exercise there was a higher percentage concentration of lactates with regard to basal values. From the data obtained we might also underline that the concentration of lactates after exercise taken in water continued to rise for up to 5 minutes whereas the concentration of lactates stabilised after exercise performed with the elastic band from minute three onwards. All these data could show that metabolic intensity of effort in water could become higher than on dry-land for the same resistance opposed to the movement.
Based on previous works (1, 4), and provided that the subjects have the appropriate motor ability in water and employ materials such as Hydro-Tone Bells, this trend towards a higher final lactate concentration and a slower recovery of HRE could be due (i) to lower perfusion pressure in the lower extremities as a result of an abnormal distribution of blood flow caused by hydrostatic pressure, (ii) to the synergy of other muscle groups that are not involved, or are involved to a lesser extent, on land, such as for example some stabilising trunk muscles (3), and (iii) to a longer duration of global muscle activity whilst performing the exercise.

CONCLUSION
(i) No statistically significant differences exist in the cardiovascular and metabolic response between a local muscular endurance exercise performed in water with a device that increased frontal and drag resistance and its counterpart performed on land with elastic band. (ii) The quantification of resistance to the aquatic movement through the identification

of a rhythmic sequence for a material and a certain exercise allows the “load” or resistance to be compared with land exercises performed with elastic bands.

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SHORT-TERM WATER EXERCISE EFFECTS ON THE PHYSICAL FITNESS OF ELDERLY SUBJECTS FROM COLD SNOWY REGION

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The purpose of the present study was to investigate the effects of short term water exercise on the physical fitness of elderly subjects from cold snowy region. Balance, reaction time and strength are important elements to prevent slips and falls on the frozen streets during winter season. Eleven subjects of the water exercise group (W-group, mean age: 59.4±9.2yrs) participated in a water exercise class for 6 weeks (twice a week for 90 min session). Eight subjects also served as a controlled group (mean age: 62.1±8.5yrs). As a result, systolic blood pressure, sitting trunk flexion and reaction time was significantly improved in W-group despite of the short term water exercise protocol. It was suggested that short term water exercise was beneficial to improve systolic blood pressure, flexibility and reaction time of elderly subjects from cold snowy region.

Key Words: water exercise, elderly, physical fitness, cold snowy region.

INTRODUCTION
In cold snowy region, it is very important that elderly people acquire physical fitness before winter season preventing slips and falls on the frozen streets. Slips and falls among elderly people are target for public health preventive efforts because they are relatively common, and have a high cost to the community (6). Moreover, prevention against slips and falls, and preservation of a certain level of fitness are essential factors for productive aging (4).
Water exercise is one of the most popular exercises for elderly because of the characteristics of water. Buoyancy of the water is less physically demanding than exercise on land, and water resistance can be adjusted by changing the speed or direction of the movements. Therefore, it is an effective training strategy for improving physical fitness in the elderly or of those who are physically unfit (5). Also, it is an useful exercise for citizens living in cold snowy region, because allows to sustain exercise during the winter season in indoor swimming pools. Balance, reaction time and strength are important elements to prevent slips and falls (1, 6) on the frozen streets during winter season. However, few studies have reported the effects of water exercise on the physical fitness of elderly subjects from cold snowy region.
The purpose of the present study was to investigate the effects of short-term water exercise on the physical fitness of elderly subjects from cold snowy region.

METHODS
Eleven subjects (W-group: 59.4±9.2yrs) participated in a water exercise class for 6 weeks (twice a week for 90 min session) and eight subjects served as control (C-group: 62.1±8.5yrs). The characteristics of the subjects are shown in table 1. All subjects read and signed an informed consent prior to participation. The present study was approval by the Human subjects Committee of Asai Gakuen University. The W-group exercised in an indoor swimming pool (25*6 line, depth: 1.0-1.1m: waist to xiphoid level of the subjects, water temperature 30 Cº) with the water exercise program shown in figure 1.

Table 1. Characteristics of the subjects.

Groups	Height (cm)	Body weight (kg)	BMI (kg/m2)
W-group (n=11)	152.3 ± 7.2	57.3 ± 7.6	24.7 ± 3.2
C-group (n=8)	157 ± 5.0	61.2 ± 8.8	24.9 ± 4.1

(Mean±SD)

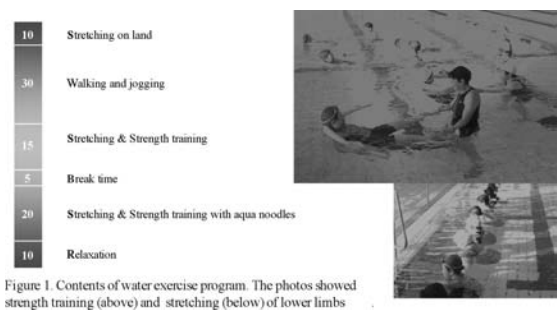

Figure 1. Contents of water exercise program. The photos showed strength training (above) and stretching (below) of lower limbs

Blood pressure (BP) was measured twice by the Terumo digital blood pressure meter P2000, and averaged data were used for analysis. Sitting trunk flexion (STF), right and left handgrip strength (GS) was also measured twice and maximal data were used. Whole body reaction time (RT) measured 5 times and from second to forth data were averaged for analysis. The sway paths of the center of gravity (locus length: LNG, environmental area: ENV area, Romberg quotients: RQ) for 30-seconds with eyes opened and closed were assessed with ANIMA gravicorder G620. In both groups, all variables were measured immediately before and after the experimental period.

RESULTS

Changes in physical fitness variables of W-group and C-group are presented in table 2, and changes in RT and RQ are shown in figures 2 and 3.

Table 2. Changes in physical fitness variables of W-group and C-group.

Variables	W-group							C-group						
	pre			post				pre			post			
Body weight (Kg)	55.8	±	7.2	56.1	±	7.0		61.2	±	8.8	61.7	±	8.8	**
BMI (Kg/m²)	23.8	±	2.6	23.8	±	2.5		24.9	±	4.1	25.2	±	4.2	**
Systolic BP (mmHg)	143.7	±	24.8	129.9	±	19.4	*	131.6	±	22.6	136.4	±	19.7	
Diastolic BP (mmHg)	80.3	±	11.9	74.4	±	10.7		82.3	±	8.7	79.5	±	7.8	
HR (bpm)	82.1	±	12.2	80.0	±	8.8		72.3	±	7.2	74.8	±	10.2	
Sitting trunk flexion (cm)	33.4	±	10.4	45.4	±	7.0	***	37.8	±	9.3	34.1	±	12.5	**
Grip strength: right (kg)	24.9	±	3.7	25.5	±	3.3		28.3	±	7.4	27.6	±	7.7	
Grip strength: left (kg)	25.8	±	4.5	23.7	±	4.1		27.9	±	7.2	26.9	±	7.6	
Locus length (EO)	3.1	±	2.3	3.1	±	1.5		2.4	±	0.7	2.3	±	0.7	
Locus length (EC)	4.1	±	1.7	3.2	±	1.7		2.6	±	0.5	2.9	±	0.7	
Environmental area (EO)	42.1	±	10.7	40.8	±	8.7		46.7	±	12.3	42.1	±	14.6	
Environmental area (EC)	60.2	±	15.9	55.8	±	15.8		52.8	±	12.5	52.0	±	12.8	
Romberg quotients	1.9	±	0.9	1.2	±	0.8		1.2	±	0.5	1.1	±	0.2	
Whole body reaction time (sec)	0.487	±	0.076	0.448	±	0.056	*	0.476	±	0.075	0.475	±	0.078	

BMI: Body Mass Index, BP: Blood pressure, HR: Heart rate. *p<0.05, **p<0.01, ***p<0.001 (Mean±SD)

EO: with eyes opened, EC: with eyes closed, Romberg quotients: ENV area EC / ENV area EO.

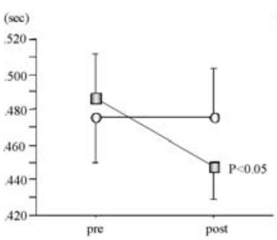

Figure 2 . Changes in w hole body reaction time

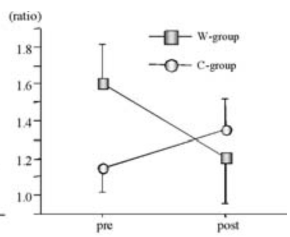

Figure 3 .Changes in Romberg quotients

After the experimental protocol, Systolic BP (p<0.05), STF (p<0.001) and RT (p<0.05) were significantly changed in W-group. On the other hand, body weight and BMI significantly increased (p<0.01) and STF significantly decreased in C-group. No significant changes were found in GS, LNG, ENV area and RQ (ENV area EC / ENV area EO) in both groups. However, RQ tended to decrease in W-group.

DISCUSSION

Inactivity during winter season because of the heavy snow is one of the serious problems for citizens in cold snowy region (4). Also, icy and snowy surfaces near melting temperature are more slippery increasing slips and falls occasions in elderly. Risk factors that have been associated with falls include decline in physical fitness, medication use, impairments to the sensory-nervous system, disorders of musculoskeletal system, and specific chronic diseases (6). To prevent slip and falls and keep healthy life in cold snowy region, it is important to sustain exercise to maintain a certain level of physical fitness before and during winter season.

Previous studies reported that balance, RT and strength are important elements to prevent slip and falls (1, 6), and exercise-based programs including agility training, balance and strength training were recommended to prevent falls (2, 6). As a result of the water exercise program, not only systolic BP (p<0.05) and STF (p<0.001) but also RT (p<0.05) was significantly improved in W- group. In C-group, body weight and BMI increased significantly (p<0.01) and STF was significantly decreased, which might result from inactivity. Previous study (5) reported that 8-week participation of water exercise program improves BP, STF and subjective pain in chronic low back pain patients in elderly. The present results showed that even shorter exercise periods have effects to improve systolic BP and STF in elderly.

However, no significant changes were found in strength, balance variables such as GS, LNG, ENV area and RQ in W-group. GS, LNG, ENV area are common variables to assess static balance, however, these variables showed individual differences and no significant changes were found in the present study. Simmons and Hansen (1996) reported that 6-week water exercise participation is an effective means of decreasing a subject's risk of falling as shown by an increase in subjects' functional reach (FR). Moreover, the authors suggested that water exerciser's postural control needs continually varied with the constantly changing pool environment while a person was moving in the water (3). These changing balance requirements would cause the subjects to acquire or enhance their postural control mechanisms in order to prevent a fall (3). By taking account of the pool environment and the results, it is likely that dynamic balance has much more possibility to show changes than static balance changes in practice of short-term water exercise. Although, not statistically significant, RQ tended to decrease in W-group. The decrease of RQ suggest that less contribution from the sense of sight and improvements of somatic senses to keep the standing posture. At postural control, the contribution of sense of sight will increase and some of the somatic senses will decrease with aging. The present results suggest that water exercises might improve somatic senses to keep balance and prevent slips and falls.

CONCLUSION

In conclusion, short term water exercise was beneficial to improve systolic blood pressure, flexibility and reaction time of elderly subjects from cold snowy region. However, strength and balance showed no significant improvements.

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