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ORIGINAL ARTICLE

Effectiveness of aquatic exercise on reduction B-type natriuretic peptide values in postmenopausal hypertensive women: a randomized clinical trial

Eduardo Aguilar Arca[1,2] · Rodrigo Leal de Paiva Carvalho[1,2] · Silvia Regina Barrile[1,2] · Camila Gimenes[1,2] · Bruno Martinelli[2] · Roberto Jorge da Silva Franco[3] · Luis Cuadrado Martin[3]

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Abstract
Purpose To compare the responses of aquatic exercise with dry land training and control inactive group on B-type natriuretic peptide and plasma renin activity levels in postmenopausal hypertensive women.
Methods Forty postmenopausal hypertensive women were randomly assigned to 3 groups: water group, dry land group and a non-intervention control group. The exercises programs consisted of consisted of 50-min sessions, three-times a week and was performed for 12 weeks. Samples of B-type natriuretic peptide and plasma renin activity levels were collected pre- and post-intervention. In the dry land exercise program, heart rate was maintained at around 50–60 % of the heart rate reserve, deducting 17 heart beats for aquatic exercise.
Results There was a statistically significant reduction in B-type natriuretic peptide in the water group (37 ± 11.1 ng/L) to (22 ± 9.4 ng/L), pre and post intervention, respectively. There was no difference in plasma renin activity levels between groups and moments.
Conclusion This study demonstrated the effectiveness of aquatic exercise in reducing B-type natriuretic peptide values in postmenopausal hypertensive women. Plasma renin activity levels values were not influenced by either of the interventions.

Keywords Hydrotherapy · Exercise · B-type natriuretic peptide · Hypertension

Abbreviations

ANP	Atrial natriuretic peptide
BNP	B-type natriuretic peptide
BP	Blood pressure
CG	Non-intervention control group
HR	Heart rate
LG	Dry land group
NT-proBNP	N-terminal of the prohormone brain natriuretic peptide
PRA	Plasma renin activity
RAAS	Renin–angiotensin–aldosterone system
WG	Water group

Introduction

The renin–angiotensin–aldosterone system (RAAS) is a central control mechanism of the salt and water homeostasis of the body and of blood pressure [1]. The physiological effects of the RAAS that result in the conservation of extracellular volume and stabilization of blood pressure are counterbalanced by the natriuretic peptides: atrial natriuretic peptide (ANP) and B-type natriuretic peptide (BNP) [1, 2].

Higher serum concentrations of BNP is a robust marker of pressure-induced cardiac damage, left atrial enlargement and left ventricular hypertrophy, in patients with hypertension [3].

✉ Rodrigo Leal de Paiva Carvalho
rodrigo.carvalho@usc.br

1 Post-graduate Program in Physiotherapy, Sagrado Coração University, USC, Rua Irmã Arminda, 10-50, Jardim Brasil, Bauru, SP CEP 17011-160, Brazil

2 Department of Physiotherapy, Sagrado Coração University, USC, Bauru, SP, Brazil

3 Department of Clinical Medicine, Paulista State University, UNESP, Botucatu, SP, Brazil

Studies comparing changes in the levels of BNP following dry land exercise training have demonstrated variable results [4–8]. Passino et al. [4] presented a 34 % reduction in BNP levels with a 9-month cycling program, which was performed 3 days a week for 30 min, compared to the group which maintained their usual life style, who presented a 7 % increase in BNP levels in heart failure patients. Accordingly Parrinello et al. [6], reported a 19 % reduction in BNP levels in heart failure patients trained with a 10-week walking program for 30 min a day, 5 days a week, compared to a 14 % rise in the control group.

Nevertheless, no studies have researched the effects of aquatic exercise on BNP levels in hypertensive individuals. Regarding PRA levels in hypertensive patients, there were no changes in dry land exercise training [9, 10]. It is known that the acute effect of water immersion may elevate natriuretic peptide values and decrease plasma concentration of rennin [11, 12]. The effect of aquatic exercise on blood pressure in hypertensive women showed a decrease in blood pressure as demonstrated previously in the study [13–15].

The hypothesis of the present study was that aquatic exercise could to affect the BNP and PRA levels in hypertensive women. Currently, there is no study available comparing the chronic effect of aquatic exercise on BNP and PRA. Thus, the objective of this study was to compare the responses of aquatic exercise with dry land training and control inactive group on B-type natriuretic peptide and plasma renin activity levels in postmenopausal hypertensive women.

Methods

Ethical considerations

This study was performed according to the National Health Council resolution 196/96 and was approved by the local Research Ethics Committee (protocol: 041/05) and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards. Written informed consent was obtained from all volunteers.

Subjects

Study participants were postmenopausal hypertensive women who were on the waiting list of the Physical Therapy Clinic of the Sagrado Coração University, located in Bauru, São Paulo, Brazil.

Study design

An interventional controlled randomized trial was performed. Seventy-eight hypertensive female volunteers were enrolled to participate in the study. Of the 78 participants, 18 were excluded due to positive coronary insufficiency in the treadmill test. The 60 remaining participants were randomly assigned into three groups: water group (WG: $n = 20$), dry land group (LG: $n = 20$) and control group (CG: $n = 20$).

During the study, there was a loss of 20 participants from the 3 groups. There were 20 losses during the period of intervention and review, and analyzed data from 40 volunteers. The methodological sequence of selection and randomization of the study participants can be seen in Fig. 1.

Outcome measures

Table 1 shows the baseline characteristics of the study participants. The sample consisted of postmenopausal hypertensive women with overweight and obesity. Individual height and body weight were measured with the subjects wearing bathing suits. Body mass index and waist to hip ratio were calculated as previously described by Lohman et al. [16]. Blood pressure (BP) and heart rate (HR) were measured according to VI DBH [17].

Blood sample were collected for BNP and PRA measurements in the morning, pre and post intervention period, initially with the patients in a fasting state and then 2 h later with the patients in the standing position. Regular antihypertensive drug treatment and habitual diet were maintained by all patients groups. This procedure was performed in the Clinical Analysis Laboratory at Sagrado Coração University.

Blood sample for BNP analysis was stored in pre chilled tubes containing ethylene diamine tetra-acetic and the plasma was immediately separated after collection in a refrigerated centrifuge at 4 °C. BNP plasma concentrations were determined using an automated equipment methodology for microparticle enzyme testing, developed by AxSym analyzer ABBOTT® (Minnesota, USA) and the results were expressed in ng/L.

PRA measurements were performed by angiotensin I generation in vitro using a commercially available radioimmunoassay kit Renin® Mayan (Codolet, France), with results expressed in ng/mL/h. PRA and BNP were evaluated before and after exercise treatment.

Materials

The aquatic exercises were performed with the aid of a swim support ring from the manufacturer Nautika® (Guarulhos, Brazil) in a heated pool with a water temperature of between 33 and 33.5 °C. The dry land exercises were performed at an ambient temperature on a stationary exercise cycle ergometer Caloi® (São Paulo, Brazil).

Fig. 1 *Design* of randomization and follow-up of participants

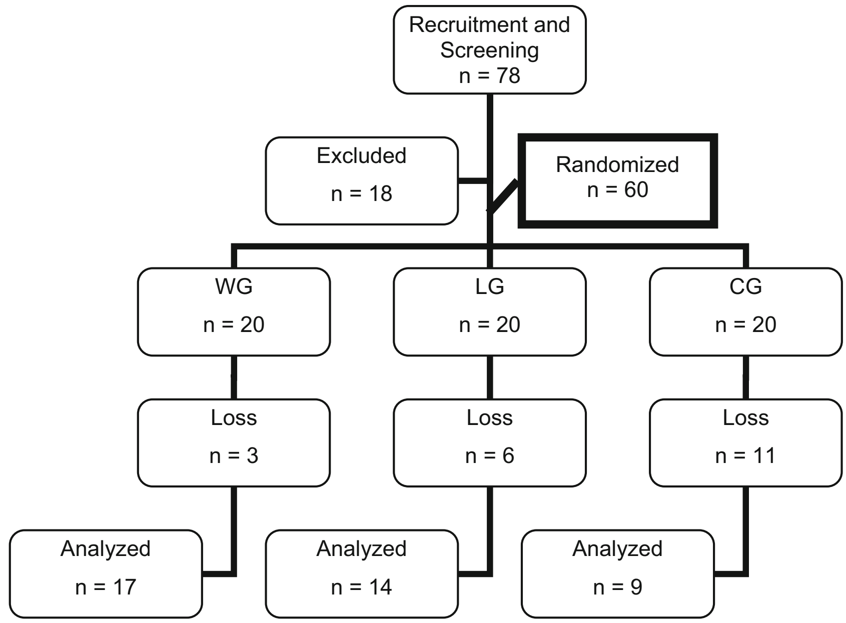

Table 1 Baseline characteristics of the study population

Characteristics	WG (n = 17)	LG (n = 14)	CG (n = 9)
Age (years)	65 ± 7.8	62 ± 7.3	64 ± 4.9
Body weight (kg)	69.6 ± 12.7	68.9 ± 12.4	76.2 ± 9.1
Height (cm)	1.57 ± 0.05	1.55 ± 0.06	1.55 ± 0.05
BMI (Kg/cm^2)	28.1 ± 4.9	28.4 ± 4.2	31.6 ± 3.55
AC (cm)	106.3 ± 7.9	105.6 ± 8.1	105.5 ± 10.7
SBP (mm Hg)	131 ± 17.7	134 ± 19.5	130 ± 19.22
DBP (mm Hg)	78 ± 10.6	77 ± 8.3	81 ± 14.8
HR (beats/min)	79 ± 16	75 ± 13	74 ± 14.3
HDL (mg/dL)	48.9 ± 11.6	44.5 ± 7.2	55.4 ± 11.9
LDL (mg/dL)	124.1 ± 35.8	120.5 ± 44.4	147.7 ± 33.9
VLDL (mg/dL)	33.8 ± 57.2	33.5 ± 15.5	26.8 ± 10.7
Cholesterol (mg/dL)	194 ± 41.3	199 ± 46.4	230 ± 40.1
Triglicerides (mg/dL)	133.8 ± 57.2	164.4 ± 77.4	134 ± 53.9
Urea (mg/dL)	38.4 ± 8.3	34.9 ± 8.8	50.8 ± 12.9
Creatinine (mg/dL)	0.7 ± 0.2	0.8 ± 0.3	0.8 ± 0.1
Urinary sodium (mEq/24 h)	150.2 ± 58	170.7 ± 78.4	161.2 ± 56

Values are mean ± SD. $p > 0.05$ for all comparisons

WG water group, *LG* land group, *CG* control group, *BMI* body mass index, *AC* abdominal circumference, *SBP* systolic blood pressure, *DBP* diastolic blood pressure, *HR* heart rate, *HDL* high-density lipoprotein, *LDL* low-density lipoprotein, *VLDL* very low-density lipoprotein

Intervention

The 12-week exercise program consisted of 50-min sessions, three-times a week. Both programs were divided into four different phases, including the same activities, intensity, frequency and duration.

Phase I: heating—the WG participants walked in water, with the water level at the xiphoid process, and the LG walked for 10 min outside the pool. Phase II: lower limb stretching—both groups performed lower limbs muscle stretching (10 min). Phase III: lower limb isotonic movements based on the deep water running technique [18]. The dry land exercise was performed on stationary bikes Caloi® (São Paulo, Brazil). Heart rate was verified every 5 min by pulse palpation of the radial artery. In the dry land exercise program, heart rate was maintained at around 50–60 % of the heart rate reserve [19], deducting 17 heart beats for aquatic exercise [20]. This phase lasted for 20 min for both programs. Phase IV: relaxation—in the WG, the participants remained afloat, relaxing for 10 min, in the LG, the patients remained lying on mats, softly breathing (10 min).

The aquatic exercises were performed in a heated pool with the water temperature maintained at between 33 and 33.5 °C and the exercises on dry land were performed at ambient temperatures of between 25 and 27 °C.

Statistical analysis

We used G*Power 3.1 software (Düsseldorf, Germany) to determine that a sample size of thirteen subjects was the minimum needed to provide a statistical power of 85 % with an alpha of 5 % for the analysis.

The Shapiro–Wilk test was used to confirm the data normality. The data were expressed as mean ± standard deviation. The ANOVA statistical test was used to compare the differences between groups and moments pre and post intervention. The significance level was considered when p was lower than 5 %.

Results

Figure 2 presents BNP values before and after treatment. There was a significant reduction in BNP in the WG (from 37 ± 11.1 to 22 ± 9.4 ng/L) when compared the pre and post-intervention.

Figure 3 shows PRA values before and after treatment. No changes were found between the moments and the groups.

Discussion

According to the present study, the WG presented a significant reduction in BNP levels compared the pre and post-intervention. In part, these results could be explained by warm water immersion having a diuretic like antihypertensive drug effect, which may reduce the overload volume and enhance water and salt excretion.

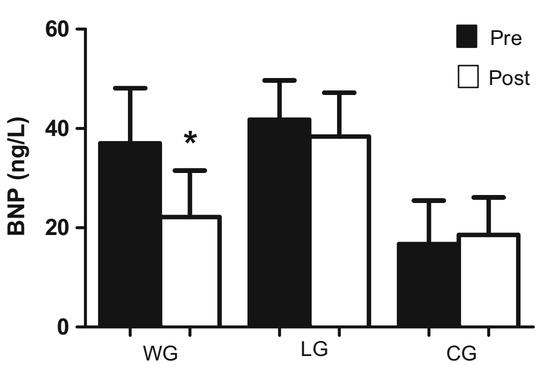

Fig. 2 Values of BNP in different groups pre and post treatment. $*p < 0.05$ in WG post vs pre

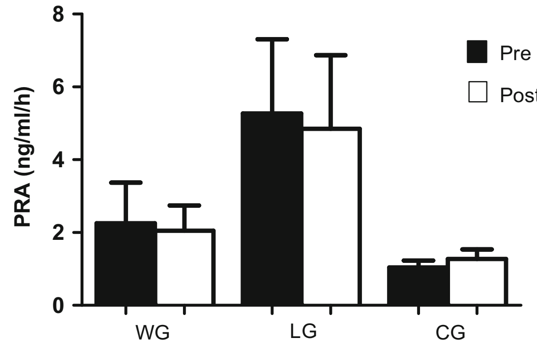

Fig. 3 Values of PRA in different groups pre and post treatment

This is in accordance with the experiment of Melo et al. [21] who studied antihypertensive treatment using two types of drugs (losartan/hydrochlorothiazide) with different mechanisms yielded powerful antihypertensive efficacy with safety and decreased plasma levels of BNP.

In relation acute physiological responses, it is known that immersion change the hydrostatic gradient promoting thoracic hypervolemia [22], a fact that causes an increase in plasma concentrations of atrial natriuretic peptide (ANP) [23].

The ANP and BNP are produced in the atria and ventricles of the heart and secreted by distension of these heart chambers and the elevated blood pressure [24]. Their acute effects are increased regulation of glomerular filtration and renal sodium and water excretion as well as suppression of secretion of renin and aldosterone [25].

However, there were differences in the responses of BNP levels, when individuals were subjected to acute immersion. In the study by Navasiolava et al. [26] eight healthy young volunteers were evaluated before, during and after 7 days of immersion. The levels of NT-proBNP increased significantly during recovery (10 ± 3 ng/L before dry immersion vs 26 ± 5 ng/L on the fourth recovery day).

It was not found in the literature any study that examined the chronic effects of aquatic exercise using the deep water running technique in BNP levels in hypertensive postmenopausal women. However, it is believed that the reduction in plasma BNP levels in the WG was due to association of the physiological effects of immersion and chronic exercise. These factors contributed to a decrease in peripheral vascular resistance, sympathetic activity, blood pressure, increased urine output and suppression of renin–angiotensin–aldosterone system (RAAS) [15, 27, 28].

The PRA data in Fig. 3 remained at the same level between groups in pre and post moments showing that PRA values were not influenced by the interventions. Despite showing great numerical difference, there was no statistically significant difference, probably due to the large standard deviation.

The limitations of the study were firstly in the training protocol, the control of aerobic exercise intensity was evaluated through manual pulse checking, which is an intermittent method. Secondly, due to the difficulty of finding male volunteers, only postmenopausal females participated in the study. On the other hand, it is important to note that there are more hypertensive women than men in the age range studied.

Despite the difference between the temperatures of the two environments in which programs have been conducted, it is quite complicated to equalize temperatures for carrying out exercises on dry land and water. However, previous studies of the authors [13, 15] showed that exercise performed with low and moderate-intensity at warm temperatures are recommended to decreased blood pressure in hypertensive women.

Finally, all patients were users of anti-hypertensive drugs, which were not withdrawn for ethical reasons. However, none of the patients changed the medication or its dose during the research protocol, mitigating this issue.

The clinical relevance of these observations is that the reduction in BNP levels in hypertensive postmenopausal women may indicate a decrease in cardiac work, which could contribute to the control of hypertension and cardiovascular diseases. In addition, the immersion decreases the joint overload, making possible to perform exercises in older people with chronic degenerative joint diseases [29, 30].

Conclusion

The present study showed the effectiveness of aquatic exercise in reducing BNP values in postmenopausal hypertensive women. PRA values were not influenced by either of the interventions.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval This study was performed according to the National Health Council resolution 196/96 and was approved by the local Research Ethics Committee (protocol: 041/05) and have been performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed consent Written informed consent was obtained from all volunteers.

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