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Original Article

DOES HABITUAL PHYSICAL ACTIVITY LEVEL INFLUENCE AEROBIC CAPACITY AND HEART RATE VARIABILITY IN POSTMENOPAUSAL WOMEN?

EXISTE INFLUÊNCIA DO NÍVEL DE ATIVIDADE FÍSICA HABITUAL NA CAPACIDADE AERÓBIA E VARIABILIDADE DA FREQUÊNCIA CARDÍACA EM MULHERES NA FASE DA PÓS MENOPAUSA?

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RESUMO
O objetivo da pesquisa foi verificar se o nível de atividade física habitual (NAFH) de mulheres em fase pós menopausa apresenta influência na capacidade aeróbia e atividade parassimpática em repouso. Participaram do estudo 30 mulheres na fase da pós menopausa (59,3 ± 5,3 anos; 1,58 ± 0,06 m; 64,5 ± 9,6 kg; 25,6 ± 3,1; %G = 27 ± 5%). Foram divididas em 2 grupos a partir da mediana do número de passos no pedômetro do NAFH (G1 = <NAFH, G2 = >NAFH). Realizou-se um teste incremental de caminhada progressiva (ISWT) e análise da variabilidade da frequência cardíaca (VFC) em repouso. Foram encontradas diferenças entre os grupos G1 e G2 para número de passos (p = 0,0001; tamanho de efeito (TE) = 2,55), distância percorrida no ISWT (p = 0,0002; TE = 2,24), índice da raíz quadrada entre os intervalos RR normais adjacentes RMSSD (p = 0,0001; TE = 1,56) e banda de alta frequência HF (p = 0,0001; TE = 1,31). Conclui-se que mulheres na fase da pós menopausa com maior NAFH possuem maior capacidade aeróbia e modulação parassimpática da VFC.
Palavras-chave: Capacidade Aeróbia. Atividade Física Habitual. Pós menopausa. Frequência Cardíaca.

ABSTRACT
The aim of this research was to verify whether habitual physical activity level (HPAL) influences aerobic capacity and parasympathetic activity at rest in postmenopausal women. Thirty postmenopausal women participated in the study (59.3 ± 5.3 years old; 1.58 ± 0.06 m; 64.5 ± 9.6 kg; 25.6 ± 3.1 body mass index; 27 ± 5%fat). The women were divided into two groups based on the median pedometer step count of HPAL (G1 = <HPAL, G2 = >HPAL) and submitted to the incremental shuttle walking test (ISWT) and analysis of heart rate variability (HRV) at rest. Substantial differences were found between G1 and G2 for step count (p = 0.0001); effect size (ES) = 2.55), ISWT distance (p = 0.0002; ES = 2.24), root mean square of successive difference (RMSSD) (p = 0.0001; ES = 1.56), and high-frequency band (p = 0.0001; ES = 1.31). In conclusion, postmenopausal women with higher HPAL have greater aerobic capacity and parasympathetic modulation of HRV.
Keywords: Aerobic Capacity. Habitual Physical Activity. Postmenopausal stage. Heart Rate Variability.

Introduction

The energy demand above resting levels produced by muscle contraction can be understood as physical activity and is closely related to behavioral aspects such as work-related activities, leisure and free time activities, household chores, personal care, and non-oriented sports activities[1]. However, daily energy expenditure is not only composed of physical activity but is complemented by energy expenditure at rest (basal metabolism), the thermic effect of foods, facultative thermogenesis, and voluntary metabolism. In addition, the energy expenditure estimated over a period of 24 hours, considering its components, corresponds to the values known as habitual physical activity level (HPAL)[2].

The HPAL can be measured by direct methods such as gas analysis (gold standard), accelerometers, pedometers and heart rate monitors, and by indirect methods such as interviews and questionnaires. The application of direct and indirect methods permits to determine whether individuals are susceptible to the health benefits that an active lifestyle can provide[3]. Within this context, a less active lifestyle leads to health problems and is certainly related to a decrease in a person's daily steps[4], as a greater daily step count is inversely proportional to obesity at population level[5]. Accelerometers and pedometers are generally used for measuring daily steps[6]; however, pedometers are used more frequently because of their low cost and easy applicability[7]. Thus, pedometer-monitored daily step count seems to be a good alternative to control and objectively evaluate HPAL[8].

The high rate of physical inactivity and growing prevalence of obesity among middle-aged women represent major threats to public health[9]. In this case, intervening in the HPAL of these women seems to be a good option in an attempt to reduce this problem, as 3 hours per week of regular physical activity of moderate intensity or more than 10,000 steps per day are able to ensure a better body composition in inactive middle-aged women[10].

Furthermore, a more active lifestyle is associated with improved aerobic capacity, suggesting that changes in HPAL could exert a strong influence on this parameter[11]. Aerobic capacity is defined as the process of uptake, fixation, transport and utilization of oxygen as an energy source, even in the muscle, generated by aerobic metabolism. It is generally used by the organism at rest and during low-intensity long-term physical activity, and may therefore play an important role in HPAL[12]. Aerobic capacity can be easily evaluated by indirect tests, such as the incremental shuttle walking test (ISWT) based on the ratio between the distance walked and maximum oxygen consumption (VO_{2max})[13]. Similarly, heart rate variability (HRV) is associated with VO_{2max}[14] and reflects the interaction between the sympathetic and parasympathetic neural pathways that determine the increase or decrease in heart rate, together with the autonomic nervous system (ANS)[15]. The measurement of HRV is a simple, noninvasive and sensitive method for assessing autonomic modulation of the sinus node[16]. In this respect, it is important to note that low aerobic capacity and low HRV indexes are closely linked to physiological problems associated with metabolic and cardiovascular diseases[17].

In view of these considerations, HRV and, particularly, aerobic capacity are extremely important for the health of postmenopausal women since greater parasympathetic activation is antagonistic to problems of metabolic syndrome[18]. Similarly, better aerobic capacity can reduce metabolic and cardiorespiratory diseases[19]. However, it remains uncertain whether HPAL influences the autonomic modulation of heart rate and aerobic capacity. Therefore, the aim of this study was to determine whether HPAL influences aerobic capacity and parasympathetic activity of the heart at rest in postmenopausal women. The initial hypothesis of the present study is that women with higher HPAL also have greater aerobic capacity and parasympathetic modulation of HRV at rest.

Methods

Participants

The study included 30 postmenopausal women from a physical activity counseling group of a Basic Health Unit (BHU). None of the volunteers had cardiovascular diseases or metabolic and neuromuscular disorders that would impair the participation in exercises. Smokers and volunteers with a body mass index (BMI) $\geq$ 30 kg/m^2 were excluded from the sample. All volunteers were asked about the use of any substance that could interfere with the results of the tests during the experiment, such as alcohol, energy drinks and drugs containing beta-blockers (in the case of HRV). None of the volunteers was undergoing hormone replacement therapy. All procedures were explained to the participants who signed the free informed consent form (Appendix 1). The study was approved by the Ethics Committee of the local institution (Approval No. 13-01/218).

Procedures

The study had a duration of 4 days. It should be noted that the volunteers were already familiar with the procedures of the ISWT, analysis of HRV, and use of the pedometer for

HPAL monitoring. These assessments are part of the physical activity counseling program of the BHU in which the sample participated (twice a week). These procedures are applied every 6 months during the program in which the volunteers were enrolled for more than a year. On day 1, HRV analysis was performed, followed by the ISWT. On days, 2, 3 and 4, the volunteers were submitted to pedometer step counting for the evaluation of HPAL.

To meet the objective proposed in the present study, the 30 volunteers were subsequently divided (G1 and G2, n=15) (Table 1) according to increasing order of median pedometer step count. The groups were formed at the end of the study considering the HPAL of the volunteers measured objectively with the pedometer: G1 (< median) and G2 (> median). The median step count of the present sample was 8,396 steps. Thus, the 15 volunteers of G1 exhibited the lowest step counts (< HPAL), while those of G2 had the highest counts (> HPAL).

Table 1. Characteristics of the groups of women analyzed in the present study*

Variable	**Age** (years)	**Height** (m)	**Body weight** (kg)	**BMI** (kg/m^2)	**% Fat**
G1 (n = 15)	59.1 ± 6.2	1.58 ± 0.04	64.8 ± 9.4	25.5 ± 3.0	27 ± 5.4
G2 (n = 15)	59.7 ± 5.3	1.57 ± 0.08	64.3 ± 9.8	25.8 ± 3.2	26 ± 5.1

Legend: *No significant differences were observed in the variables between G1 and G2
Source: The authors

Analysis of heart rate variability

The HRV data were collected in the morning between 7:30 and 8:30 h, approximately 30 minutes after the volunteers woke up. A BHU nutritionist standardized the breakfast, suggesting three meal options that would not influence the analyses on the 1st day (e.g., avoiding energy drinks, supplements, and high-fat foods). The volunteers then came to the BHU for the analysis. Upon arrival, the women were asked to empty their bladder. The heart rate monitors were positioned and the women were asked to lie down on a gurney. After this procedure, the volunteers remained in the supine position, lying comfortably and immobile with the eyes open and maintaining spontaneous breathing[20]. The R-R intervals were recorded over a period of 7 minutes, with the first 2 minutes being discarded for stabilization[21].

The R-R intervals were recorded with the Firstbeat® device (Firstbeat Technologies, Jyväskylä, Finland) and then exported to the Firstbeat Analysis Server® (version 5.3.0.4). For analysis of the HRV variables, the data were transferred to the Kubios HRV 3.0® software (Biomedical Signal Analysis Group, University of Kuopio, Finland).

All R-R intervals with a difference greater than 20% from the previous adjacent interval were automatically filtered, removing inappropriate and premature beats (low filter). Next, the Kubios software was used to generate the time-domain index, calculating the root mean square of successive differences between normal heartbeats (RMSSD), and the frequency-domain index (high-frequency [HF] band). The two indexes represent the parasympathetic activity of HRV[22]. The HF values used for analysis were calculated as normalized units (un). It should be noted that RMSSD possesses greater reliability when compared to other HRV indexes[23] and can be obtained during spontaneous breathing[22]. Because of the distorted HRV recordings, the RMSSD data were transformed using the natural logarithm (lnRMSSD)[24]. In addition, the use of ln values avoids outliers and simplifies the analysis[21].

Incremental shuttle walking test

The ISWT was performed along a 10-meter covered and airy corridor demarcated with cones. Walking cadence was increased by 0.17 m/s every minute, starting at 0.5 m/s, until exhaustion of the volunteers[25]. The speed was controlled by an audio signal emitted by the Beat Training & Test® software (CEFISE, Nova Odessa, Brazil). Since the protocol was not applied to subjects with chronic respiratory diseases, it was extended to 15 levels (1,500 m) to minimize ceiling effects. The distance walked (in meter) in the test was recorded for presentation of the results. This measure is an indicator of the subject's aerobic capacity[25].

Pedometer assessment of habitual physical activity level

The HPAL was evaluated using a BP 148 TECHLINE® pedometer, a small device that estimates the number of steps taken based on vertical oscillations of the body. The classification of Thompson[9] was used for the analysis of step counts in the subjects studied, with sedentary individuals taking up to 5,999 steps per day, those practicing mild physical activity taking 6,000 to 9,999 steps, and active subjects taking more than 10,000 steps per day.

The instructions for pedometer attachment and use described in the study of Lara[26] were followed, in which the device was firmly attached to the hip and only removed for sleeping, showering, swimming, changing clothes, or performing activities that could put the subject or device at risk. Each participant used the pedometer for 3 days during the week. Weekdays were chosen to reflect daily habits. A chart was given to each volunteer for daily recording of the time of attachment and removal of the device, as well as of total step count at the end of each day, data provided by the pedometer. This daily recording was necessary because of the low storage capacity of the equipment. The device was configured individually according to body weight and step length (determined with a tape measure between the subject's right and left heel).

Statistical analysis

All data are expressed as the mean and standard deviation. Normality and homogeneity of variances were verified using the Shapiro-Wilk and Levene tests, respectively. The paired t-test for independent samples was used for comparison between G1 and G2. A level of significance of $p \leq 0.05$ was adopted for the inferential tests. In addition to the comparisons, the effect size (ES) was calculated as described by Cohen[27]. The reference values for non-athletes are: < 0.50 trivial; 0.50 – 1.25 small; 1.25 – 1.90 moderate, and > 2.00 large. Magnitude-based inference of the ES was also performed[28]. In addition the 90% confidence interval (90% CI) was used for presenting ES. The probability of smaller or larger differences in mean values between G1 and G2 were qualitatively assessed as follows: 1%, almost certainly not; 1-5%, very unlikely; 5-25%, unlikely; 25-75%, possible; 75-95%, likely; 95-99%, very likely; > 99%, almost certain. If the odds of having values higher or lower than the smallest substantial difference were > 5%, the true difference was considered unclear. The data were analyzed using a modified Excel spreadsheet[28].

Results

Table 2 shows the number of steps, ISWT distance, parasympathetic activity indexes (lnRMSSD and HF band) obtained for G1 and G2. Substantial differences were observed between G1 and G2 for step count ($p = 0.0001$; ES = 2.55 [large], 90% CI [0.96]; almost certain difference [100/0/0%]), ISWT distance ($p = 0.0002$; ES = 2.24 [large], 90% CI [0.84]; almost certain difference [100/0/0%]), lnRMSSD ($p = 0.0001$; ES = 1.56 [moderate], 90% CI [0.62]; almost certain difference [100/0/0%]), and HF band ($p = 0.0001$; ES = 1.31 [moderate]; 90% CI [0.76]; almost certain difference [100%]).

Table 2. Step count, distance walked in the ISWT and parasympathetic activity indexes in the women analyzed in the present study

	G1 (n = 15)	G2 (n = 15)	G1 x G2		
Variable	Mean ± SD	Mean ± SD	ES (90% CI)	P	MBI
Number of steps (n)	6.530 ± 1.705	11,363 ± 2.066	2.55 (0.96) *Large*	0.0001	100/00/00 *Almost certain*
ISWT (m)	619 ± 86	816 ± 89	2.24 (0.84) *Large*	0.0002	100/00/00 *Almost certain*
HF (un)	32.4 ± 17.1	54.8 ± 16.0	1.31 (0.76) *Moderate*	0.0001	100/00/00 *Almost certain*
lnRMSSD (ms)	3.21 ± 0.27	3.61 ± 0.24	1.56 (0.62) *Moderate*	0.0001	100/00/00 *Almost certain*

Legend: ln: natural logarithm; RMSSD: root mean square of differences between normal R-R intervals; ISWT: incremental shuttle walking test; HF: high-frequency band. Data are reported as the mean and standard deviation (SD). ES: effect size; MBI: magnitude-based inference. 90% CI: 90% confidence interval.
Source: The authors

Discussion

The present study aimed to verify whether the HPAL of postmenopausal women influences aerobic capacity and parasympathetic modulation of the ANS at rest. The main finding of this study was that women with a lower HPAL had lower aerobic capacity and parasympathetic modulation of the ANS, confirming the initial hypothesis of the study. To our knowledge, this is the first study demonstrating the influence of HPAL on autonomic modulation of heart rate and aerobic capacity in postmenopausal women.

It has been established that a low HPAL of a group or population is closely linked to an increase in BMI and to the development of metabolic and cardiovascular diseases[29]. For example, one study[4] involving 43,806 Canadian children and adolescents demonstrated a significant decrease in daily step count over a period of 9 years (from 2005 to 2014), representing a change to a less active and more obese population. In addition, it is known that daily step count tends to decrease with increasing age[8]. The same is observed for VO_2max, especially in females[30]. Thus, the consequences of aging associated with the reduction in HPAL pose major threats to women's health, notably postmenopausal women, including a higher blood pressure, increased oxidative stress, decreased bone and muscle mass, increased risk of cancer, hair loss, decreased libido, reduced calorie expenditure, increased anxiety and risk of depression, greater weight gain, and estrogen deficiency[31] altering the baroreflex control of heart rate[32].

According to Thompson[9], inactivity of women aged 44 to 66 years can be overcome by taking 10,000 steps per day. The results of the present study, specifically those obtained for G2 (11,363 steps per day), support these recommendations. Interestingly, G2 also exhibited a greater ISWT distance (816 m), parasympathetic modulation of the ANS (lnRMSSD = 3.61 ms), and HF band (54.8 un) when compared to G1 (ISWT = 619 m, l RMSSD = 3.21 ms, HF = 32.4 un). In this case, the combination of positive values for HPAL, ISWT, lnRMSSD and HF provides a scenario for the maintenance or development of health. For example, an increase of lnRMSSD has been shown to be related to increased parasympathetic modulation of the ANS and high physical fitness[11,33]. On the other hand, lower lnRMSSD values have been associated with sleep disorders, chronic fatigue, depression, chronic pain, and an increased risk of cardiovascular disease and mortality[19,34]. In conjunction with greater aerobic capacity (e.g., > ISWT), there is a long-term cardioprotective effect[35]. In addition, the increase in vagal activity and VO_2max can reduce the risk of ventricular fibrillation and ischemia during exercise, which is certainly a key mechanism for reducing sudden death associated with physical activity[36]. In this case, women of G2 were more likely to have long-term benefits than those of G1.

An important point to consider is that, in addition to the fact that systematized physical training improves aerobic capacity and increases vagal activity at rest, this population (postmenopausal women) may also benefit from an increase in HPAL. The role of HPAL increase and systematized physical exercise in health improvement is widely discussed in the literature[6]. An important argument is that the window of opportunities for increasing HPAL is greater than the possibility of regular physical exercise during the week[37]. For example, minimal international recommendations[38] of weekly exercise volume to become an active individual are ≥150 minutes of exercises of moderate intensity or ≥ 75 minutes of vigorous intensity. However, these individuals can also increase their daily energy expenditure through different types of activities of daily living, enhancing HPAL[39].

Interestingly, in obese individuals, evidence indicates that recommendations of increasing HPAL compared to systematized strength and endurance training can have similar results in terms of reducing body weight and modifying body composition[40]. Benito et al.[40] studied 96 obese subjects (48 men and 48 women; age range: 18-50 years) submitted to a 22-week supervised program combined with the same hypocaloric diet who were randomly divided into four groups: strength training (S), endurance training (E), combined strength and endurance training (SE), and recommendation of increasing HPAL and weekly exercise volume (C). Whereas group C performed regular physical activity daily and increased HPAL, groups S, E and SE exercised only 3 days/week and had a compensatory reduction in daily physical activity. The lack of efficiency of the training programs was attributed to this compensatory reduction since the objective of combating obesity should be to reduce sedentary behavior and to increase daily activities (e.g., walking or cycling instead of using a car, climbing stairs instead of using the elevator). The increase in HPAL prevents sedentary behavior[40], a situation that is little explored by professionals who work with systematic exercises. In addition, increasing HPAL enhances the individual's adherence to a weight loss program[6].

It is exactly with regard to this point that the present results make a practical contribution to recommendations of increasing HPAL by demonstrating for the population studied that individuals with a higher HPAL will have greater aerobic capacity and parasympathetic modulation of the ANS. At the beginning of any systematized physical training program, postmenopausal women should also be instructed to increase their HPAL as this may imply greater health gains. However, chronic studies are necessary to test the combination of these different approaches in terms of morphological, cardiopulmonary and neuromuscular adaptations. It should be noted that these findings cannot be extrapolated to other populations. Studies involving other samples may help elucidate the recent finding.

Conclusions

The results permit us to conclude that aerobic capacity and autonomic parasympathetic modulation at rest are increased in postmenopausal women with a higher HPAL. This finding confirms the initial hypothesis of the present study. As a practical implication, healthcare professionals should recommend increasing HPAL in systematic exercise prescription programs as this could improve the health condition of participants, particularly aerobic capacity and parasympathetic activity of the heart.

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