Different Exercise Behaviors Influence Heart Rate Variability, Autonomic Nerve System Function and Menopausal Symptoms in Post-Menopausal Women

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Abstract. [Purpose] Post-menopausal women are often affected with menopausal syndromes, and their sedentary lifestyle may increase their risk of cardiovascular diseases. The aim of this study was to assay the correlation between heart rate variability (HRV), the adjustment of the autonomic nervous system (ANS), and menopausal symptoms among different exercise behaviors of post-menopausal women. [Subjects and Methods] This was a cross-sectional study, and the relationships between exercise behavior, menopause rating scale (MRS), and HRV were analyzed. Subjects were assessed by a structured questionnaire and electrocardiography, and assigned to Group A, Group B, and Group C according to exercise behaviors (low, medium, and high, respectively). [Results] Three hundred and twenty-seven post-menopausal women were assessed. The correlation analysis revealed that exercise behaviors had negative correlations with MRS, and the low frequency component and the low frequency / high frequency ratio of heart rate power spectra. MRS of Group C was significantly lower than that of Groups A and B. There were no significant differences in HRV among the three groups. [Conclusions] The differences of exercise behavior affected post-menopausal symptoms and the adjustment of ANS of post-menopausal women.  

Key words: Menopause rating scale, Exercise behavior

INTRODUCTION

Post-menopausal women are affected with several syndromes, including hot flushes, paresthesia, insomnia, nervousness, palpitation, anxiety and depression. The reduction of progesterone and estrogen causes these syndromes which influence the daily life of aged women. Aged women who have not experienced menstruation for one year are defined as “post-menopause”, and the average age of menopause of middle-aged women is from 48 to 50 years old in Taiwan. Previous research has found that post-menopausal women have higher risk of cardiovascular disease, anxiety and depression. Hence, health management is important for post-menopausal women.

In Taiwan, aged women often have a sedentary lifestyle with poor exercise behaviors which may increase the risk of cardiovascular diseases in post-menopausal women. Post-menopausal women often have endothelial dysfunction of peripheral blood vessels which could affect their heart function during resistance exercises. However, research regarding the correlation between exercise behavior and heart function of post-menopausal women is still lacking.

Heart rate variability (HRV) is a highly reliable predictor of cardiovascular diseases and is an assessment tool of heart function. The adjustment of the autonomic nervous system (ANS) involves the balance of sympathetic and parasympathetic nerve activity and can represent changes in psychological status. Numerous studies have indicated that HRV and the adjustment of ANS can be used to assess the psychological status of humans, such as depression and anxiety. We hypothesized psychological status and heart function of post-menopausal women could be assessed via HRV and the adjustment of ANS. Therefore, the aim of this study was to investigate the correlations between HRV, the adjustment of ANS, and menopausal symptoms with different exercise behaviors of post-menopausal women.

SUBJECTS AND METHODS

This cross-sectional study was approved by the Institutional Review Board on Human Participants Research of a general hospital. The inclusion criteria were post-menopausal women who had experienced menopause for more than one year who did not have a history of heart disease. The subjects were recruited from the community and they provided their signed informed consent. The exclusion criteria were: currently receiving hormone replacement therapy, currently taking medicine, caffeine or alcoholic drinks, or a history of heart surgery or smoking. This study was conducted in an air-conditioned (25 °C) room with a quiet environment in a hospital.

Participants were assessed by a structured questionnaire and electrocardiography (ECG). There were three parts to
the structured questionnaire, basic information, exercise behavior evaluation, and menopause rating scale (MRS). The contents of the Chinese-version questionnaire were modified for expert validity, and the content validity index of the questionnaire was 0.87. All assessments were conducted by the same physician.

The information of participants, such as age, height, weight, body mass index (BMI), and the duration of the post-menopausal period were collected in basic information. The participants’ exercise frequency, intensity and duration were also collected to assess their exercise behavior. Exercise frequency was the number of days on which the participants performed exercises per week. Exercise intensity was the number of times that the participants felt rapid heart rate during exercises. It was recorded on a 3-point ordinal scale: 1 (no feeling); 2 (1–2 times per week); 3: more than 3 times per week). Exercise duration represented the time of each exercise session, and was scored on a 5-point ordinal scale: 1: less than 30 min; 2: 31–60 min; 3: 61–90 min; 4: 91–120 min; 5: more than 121 min). The formula of exercise behavior was as follows: Exercise behavior = exercise frequency × (exercise intensity + exercise duration)³.

MRS was used to evaluate the symptoms of post-menopausal women in three dimensions: somatosomatic subscales (including hot flushes, heart discomfort, sleep problems and joint and muscular discomfort), psychological subscales (including depressive mood, irritability, anxiety and physical and mental exhaustion), and urogenital subscales (including sexual problems, bladder problems and dryness of vagina)⁴. There were 11 self-reported questions which were scored on a 5-point ordinal scale ranging from 1 (no symptom) to 5 (symptoms are very severe).

Limb-leads ECG (CheckMyHeart, DailyCare Bio-Medical, Taiwan) was used for ECG measurement. We placed electrodes (Al/AgCl electrodes, Kendall, Germany) on the radial side of bilateral wrists to record ECG for 5 min, and then we analyzed the ECG signals with HRV software (HRV analysis software, Daily Care Bio-Medical, Taiwan). In time domain analysis, the record of ECG signals was used to calculate the difference between R-R intervals. The standard deviation of normal to normal intervals (SDNN) is HRV, and it is a predictor of cardiovascular diseases⁵. Frequency domain analysis was used to analyze ECG signals in three categories: the percentage of the high frequency component (HF), which ranges from 0.15 to 0.40 Hz, represents the activity of parasympathetic nervous; the percentage of the low frequency component (LF), which ranges from 0.04 to 0.15 Hz, represents the activity of sympathetic nervous system; and the LF/HF ratio represents the balance between the parasympathetic nervous and sympathetic nervous system⁶. All the ECG was assessed by the same physician, and the test-retest reliability was 0.91. The definitions were as follows: HF (%) = HF power/(HF power + LF power); LF (%) = LF power / (HF power + LF power); LF/HF ratio = LF/HF.

The participants’ data were analyzed using the statistical analysis software, SPSS 13. We used descriptive statistics to present the demographic characteristics of subjects’ basic information. The value of exercise behavior, based on the maximum score of 56, was presented as a percentage. According to the method of Fox et al.⁸, participants were separated into three groups: low (Group A, 0–33.3% exercise participation degree), medium (Group B, 33.3%–66.6% exercise participation degree), and high (Group C, 66.6%–100% exercise participation degree) exercise behavior. The values of MRS, SDNN, LF, HF, and the LF/HF ratio of the three groups were analyzed using one-way analysis of variance (ANOVA). A post hoc test was used to compare the differences among the groups. We also used Spearman’s correlation coefficient to examine the correlations among the variables. Data of continuous variables were presented as means ± standard deviations, and the α value was chosen as 0.05.

RESULTS

Three hundred and fifty post-menopausal women were recruited for this study. Twenty three participants were excluded as eighteen of them were receiving hormone replacement therapy or taking heart medication at the time, while the other five participants took caffeinated drinks before the assessments. Thus, three hundred and twenty seven participants (age = 59.56 ± 7.34 years, BMI = 24.64 ± 3.05 kg/m², and postmenopausal duration = 9.77 ± 6.41 years) completed the assessments. As shown in Table 1, depressive mood (72%), hot flushes (68%) and anxiety (64%) were the major symptoms of the participants.

Table 2 shows the exercise behavior score of the participants was 18.54 ± 12.13. The total MRS score was 8.04 ± 2.67, and the psychological subscale (3.49 ± 2.67) had the highest score of the three subscales. We found that HRV

Table 1. The basic information of the participants (n = 327)

<table>
<thead>
<tr>
<th>Items</th>
<th>Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y / o)</td>
<td>59.56 ± 7.34</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>155.26 ± 5.19</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>59.47 ± 8.47</td>
</tr>
<tr>
<td>BMI (kg / m²)</td>
<td>24.64 ± 3.05</td>
</tr>
<tr>
<td>Postmenopausal duration (year)</td>
<td>9.77 ± 6.41</td>
</tr>
<tr>
<td>MRS</td>
<td></td>
</tr>
<tr>
<td>Hot flushes</td>
<td>222 (68%)</td>
</tr>
<tr>
<td>Heart discomfort</td>
<td>153 (47%)</td>
</tr>
<tr>
<td>Sleep problems</td>
<td>183 (56%)</td>
</tr>
<tr>
<td>Joint and muscular discomfort</td>
<td>159 (49%)</td>
</tr>
<tr>
<td>Depressive mood</td>
<td>234 (72%)</td>
</tr>
<tr>
<td>Irritability</td>
<td>171 (52%)</td>
</tr>
<tr>
<td>Anxiety</td>
<td>210 (64%)</td>
</tr>
<tr>
<td>Physical and mental exhaustion</td>
<td>198 (61%)</td>
</tr>
<tr>
<td>Sexual problems</td>
<td>78 (24%)</td>
</tr>
<tr>
<td>Bladder problems</td>
<td>138 (42%)</td>
</tr>
<tr>
<td>Dryness of vagina</td>
<td>126 (39%)</td>
</tr>
</tbody>
</table>

All data are presented as mean ± SD, except for items of the menopause rating scale, which are presented as n (%). BMI, body mass index; MRS, menopause rating scale.
was 34.85 ms ± 23.94, and that LF (53.15 ± 18.15) was higher than HF (46.85 ± 18.15) in the frequency domain analysis of ECG signals (Table 2).

In Table 3, the correlation analysis of exercise behavior with other variables shows that there was a negative correlation between exercise behavior and MRS, LF and the LF/HF ratio (p < 0.01), and there was a positive correlation between exercise behavior and HF (p < 0.01). Furthermore, there was a positive correlation between MRS score and HRV (p < 0.05), LF (p < 0.01) and the LF/HF ratio (p < 0.01) and a negative correlation between the MRS score and HF (p < 0.01).

In accordance with the degree of exercise behavior, participants were divided into three ordinal groups. Table 4 presents the differences of the assessments among the three exercise behavior groups. We found that the age of Group C (63.25 ± 5.78) was the oldest among the three groups (p < 0.01). Besides, the MRS score of Group C (3.80 ± 3.98) was significantly lower than that of the other two groups (p < 0.01). On the three subscales of MRS, Group C scores
were also significantly lower than those of Groups A and B (p < 0.05).

In the ECG assessments, there were no significant differences in HRV among the three groups (p > 0.05). However, HF of Group C (65.38 ± 16.48) was significantly higher than those of the other two groups (p < 0.01), and LF of Group C (34.61 ± 16.48) was the lowest of the three groups (p < 0.01). Furthermore, the LF/HF ratio of Group A (1.99 ± 1.26) was significantly higher than those of Group B (1.36 ± 1.33, p < 0.05) and Group C (0.67 ± 0.63, p < 0.01).

**DISCUSSION**

This study recruited 327 post menopausal women aged 48 to 76 years old. We found that BMI of all participants was higher than 24 kg/m², which is in the category of overweight. Some studies have indicated that endocrinological changes during menopause affect the basal metabolic rate of aged women creating a tendency of obesity1, 12), which would increase the risk of cardiovascular diseases. Sternfeld et al. pointed that engaging in high resistance exercises may help the post-menopausal women to reduce their BMI13); however, we found no difference (p > 0.05) in BMI among the different exercise behavior groups in this study. BMI is a measure of obesity; however, participants with different exercise behaviors still belonged to the same BMI category. The reason for this might be that exercise behavior was self-reported, and the participants’ frequency, intensity, and duration of exercises may have been insufficient to change their metabolism of fat.

Some research has indicated that as the metabolism of post-menopausal women changes, the increase of low density lipids and triglyceride in blood leads to a higher incidence of cardiovascular disease6, 14). HRV was investigated using time domain analysis of the SDNN. HRV is a predictor of cardiovascular disease15, 16), and an indicator of ventricular systolic dysfunction17). The results of our study show that the SDNN of post-menopausal women was 34.85 ± 23.94 ms, which was similar to the results of a previous study18). There was no significant difference of SDNN among the participants (p > 0.05), meaning that different exercise behaviors did not influence HRV of postmenopausal women. So, the postmenopausal women tended to have a high SDNN and a high risk of cardiovascular disease. Kimura et al. found that there was a difference in body fat percentages of post-menopausal women with different HRV19). Their study showed that the women with lower HRV has statistically higher BMI than those with higher HRV (p < 0.05). However, as all our participants belonged to the same BMI category, this may have resulted in there being no significant difference in HRV (p > 0.05).

In the time domain analysis of ECG, HF represents the parasympathetic nervous activity. The higher the HF is, the greater the parasympathetic nervous activities (blood pressure reduction, heart rate deceleration and relaxation of body). On the other hand, LF represents the sympathetic nervous activity. The higher the LF is, the greater the sympathetic nervous activities (blood pressure increase, heart rate acceleration and nervous tension). ANS balance is presented by the LF/HF ratio20). Moodithaya et al. found that compared to before menopause, HF of post-menopausal women decreased, whereas their LF/HF ratio significantly increased (p < 0.05)20). These results are similar to those of our study. Our study also showed that LF of post-menopausal women was higher than HF, meaning their sympathetic nervous activity was greater than their parasympathetic nervous activity. In addition, LF and the LF/HF ratio of Group C was lower than those of Groups A and B, HF of Group C was higher than those of Groups A and B. These results show that exercise behavior raises parasympathetic nervous activity and lowers sympathetic nervous activity. In addition, exercise also stabilized the ANS. A review study reported that exercises can decrease anxiety and depression, and explored the psychological mechanisms, including cognitive behavioral, social learning, and transfer hypothesis21). The authors claimed that the change in patients’ thinking and attention brought about by exercise, reduced their psychological symptoms. Physiological mechanisms, such as biogenic amines and endorphin production, show that exercises can cause endocrinal change reducing anxiety and depression21). The result of Markowitz’s study supports the opponent-process theory and it shows exercise can stimulate sympathetic nerve activity22). That causes counteraction with the increase of parasympathetic activity after exercise, tending to balance ANS and producing a relaxing effect. This may be the reason why changes in HF, LF and the HF/LF ratio were observed in our study.

Patients under a high degree of pressure would have low HF and high LF meaning their sympathetic nervous activity would be raised23). Hence, we thought that psychological status would affect their ANS activity. In our study, the MRS of the participants showed that their psychological subscale was more seriously influenced by exercise. Depressive mood (72%), irritability (52%), anxiety (64%), and physical and mental exhaustion (61%) were the major psychological symptoms. Kim et al. thought the imbalance of estrogen during menopause would lead to psychological problems in post-menopausal women24). Our present study found significant positive correlations between MRS and LF and the LF/HF ratio (p < 0.01), while MRS was negatively associated with HF (p < 0.01). This indicates that aggravation of post-menopausal symptoms increases sympathetic nervous activity and decreases parasympathetic nervous activity, and that ANS would tend to become more unstable. As a result, we believe that time domain analysis of ECG may illustrate the adjustment of ANS, and represent the psychological symptoms of post-menopausal women.

Post-menopausal women are often affected by obesity, exercise deficiency and estrogen insufficiency, which may cause metabolic and degenerative diseases25). Exercises can not only promote their health, but also can help to prevent psychological symptoms such as anxiety and depression25). Furthermore, post-menopausal women can effectively avoid osteoporosis by exercise26). Other research has indicated that exercise behavior alters the ANS activity of post-menopausal women27). We also found that the participants with high exercise behavior had better balance of ANS. Their parasympathetic nervous activity was higher than...
their sympathetic nervous activity meaning sympathetic nerve was not easily excited. In addition, we compared the MRS scores of the three exercise groups. Post-menopausal symptoms (somatovegetative, psychological and urogenital subscales) of Group C were less severe than those of the other two groups. Therefore, post-menopausal women with high exercise behavior had less overt psychological symptoms such as anxiety, depression and irritability.

In summary, this study found that differences in exercise behavior affected post-menopausal symptoms and the adjustment of ANS. The post-menopausal symptoms of women may be ameliorated by change in their exercise behaviors. Exercise behavior was used to demonstrate exercise habits, but it cannot render the intervention effects of exercise or physical activity on psychological symptoms. We agree with Canário et al., that physical activity can improve menopausal symptoms in middle-aged women. However, our study was limited to exercise behaviour and did not explore the impact of the type, intensity and frequency of exercise and physical activity. Future research is still needed in this area.

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