Aerobic Walking Exercise and Lifestyle Habits Interact with Sleep Quality, Stress, and Life Satisfaction: Results from a Randomized Crossover Study

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Aerobic Walking Exercise and Lifestyle Habits Interact with Sleep Quality, Stress, and Life Satisfaction: Results from a Randomized Crossover Study

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ABSTRACT
Background: Physical exercise interacts with sleep quality, stress and life satisfaction.
Purpose: The current study examined the effectiveness of regular aerobic walking on sleep quality, stress and life satisfaction and to explore the associations between lifestyle habits and sleep quality, stress and life satisfaction.
Methods: A 12-week randomized cross-over study with fifty-four participants was conducted.
Results: Sleep quality (p = .002, r = -.46), stress (p = .007, r = -.38), and life satisfaction (p = .003, r = -.42) showed favorable changes in the intervention group and only life satisfaction increased in the control group (p = .003, r = -.43). Alcohol consumption showed positive correlation with sleep quality (p < .05). Males and females did not differ regarding sleep quality, stress and life satisfaction (p > .05).
Discussion: The improvement of sleep quality, stress and life satisfaction was significant in the intervention group, although changes in control group did not indicate big differences.
Translation to Health Education Practice: This study provides information and guidelines for Certified Health Education Specialist to design, implement and evaluate sleep education programs.

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Background

Epidemiological studies showed that exercise is helpful in promoting sleep.1 With the increase of sleep disorders, several research paradigms have been used to examine the effect of exercise on sleep.2,3 Exercise is widely believed to impact sleep quality due to the traditional hypotheses that sleep promotes energy conservation, thermoregulatory functions, or body restoration.4 Sleep physiology underlines the mechanism(s) between sleep and exercise.5 Exercise intensity may also play a role in the efficacy of exercise-associated sleep promotion. Furthermore, regular physical activity (PA) is reported to enhance sleep quality.6

Physical exercise has been found to generate intermediate effects between well-being and stress.7 As suggested, exercise can be beneficial to general well-being and is necessary to determine appropriate exercise volume and intensity.8 Evidence demonstrates that regular exercise can relieve stress because exercise protects against the negative emotional consequences of stress.8 Furthermore, specific types and dosages of exercise are reported to be associated with mood benefits, self-esteem, and stress activity.9 Given this evidence, there is promise related to using exercise as a stress-management tool.

Life satisfaction can be influenced by health, physical activity, socio-economic variables, and the amount of PA.10 Additionally, life satisfaction is considered as one indicator of well-being, and PA is considered a valuable tool to impact daily well-being.11 Physical activity programs should be implemented to enhance life satisfaction; however, the association between physical activity and life satisfaction appears to involve age and exercise level.12

The impact of aerobic exercise and sleep quality on chronic disease has been documented for osteoarthritis,13 pain symptoms,14,15 chronic kidney disease, etc.16 Other conditions such as obesity, arthritis, diabetes, lung diseases, stroke, and osteoporosis have been associated with sleep-related problems such as breathing pauses, snoring, daytime sleepiness, restless legs, or insufficient sleep (<6 h nightly).17 Evidence on the effects of exercise support that aerobic/functional capacity and muscle strength can be improved by exercise training among people with chronic diseases. Furthermore, psychological health and health behaviors would be a valuable part of a comprehensive chronic disease management strategy.18
Purpose

Sleep, stress and life satisfaction interact with physical exercise and chronic diseases, thus, it is feasible and practical to examine physical activity interventions for health promotion. Factors such as age, gender, lifestyle habits (e.g. alcohol and caffeine consumption, smoking, etc.) may also influence the efficacy of exercise. Therefore, the purpose of this study was to 1) examine the effectiveness of an aerobic daily walking program on sleep quality, stress and life satisfaction; 2) explore the potential social factors (e.g. drinking, smoking) that may be associated with sleep quality, stress and life satisfaction. Based on previous reports, we hypothesize that regular exercise will yield a positive relationship to sleep quality, stress and life satisfaction.

Methods

Study design

This study was conducted between March and May 2019. This was a cross-over study design. Crossover study design is generally restricted to the study of short-term outcomes in clinical diseases or pharmacological processes. In theory, intervention effects can be estimated with greater precision given the same number of participants. This study was approved by university ethical committee (registration code: 2018/421). This study was registered at ClinicalTrials.gov (Identifier: NCT04427696).

Participants

Research volunteers were recruited in Budapest, Hungary. Online and offline advertisements were used to recruit research volunteers. The only selection criteria was participants had to be between the ages of 18 and 60 years old. The contacted volunteers went through a textual or verbal interview. Out of 60 contacted volunteers, a total of 54 volunteers were eligible to participate in this study. The selected participants, aged between 19 and 36 years old (24.28 ± 4.55), were assigned into two groups randomly (intervention, n = 27; control, n = 27).

Participants who completed the whole intervention process were granted incentives. Participants who were students in Eötvös Loránd University could obtain 2 elective credits by completing the study. Participants who were not students in Eötvös Loránd University were provided with a free Yoga course voucher. All participants who completed the research requirements had the chance to win a mountain bike which was chosen by random.

Measurements

Daily walking activity was tracked by Omron HJ-112 pedometers which provide valid step assessment in different body mass index (BMI) groups. The pedometer records aerobic steps, total steps, calorie expenses, miles and time. The aerobic steps were counted when walking more than 60 steps per minute and for more than 10 minutes continuously. A break of less than 1 minute taken after a continuous walk for more than 10 minutes was regarded as part of a “continuous walk.” Our study required one-hour continuous aerobic walk as a PA intervention.

Sleep quality, stress status, and life satisfaction were assessed pre- and post-intervention (i.e. first and third session) (see Figure 1). Sleep quality was measured using the Pittsburgh Sleep Quality Index (PSQI) which contains seven sleep components (i.e. sleep duration, sleep disturbance, sleep latency, daytime dysfunction due to sleepiness, sleep efficiency, overall sleep quality, and sleep medication use) for the past month. The validity and reliability of PSQI among young people evidenced good convergent and divergent validity and moderate reliability (Cronbach’s alpha = .72).

Perceived stress was assessed by four questions from the Perceived Stress Scale (PSS-4): 1. In the last month, how often have you felt that you were unable to control the important things in your life? 2. In the last month, how often have you felt confident about your ability to handle your personal problems? 3. In the last month, how often have you felt that things were going your way? 4. In the last month, how often have you felt difficulties were piling up so high that you could not overcome them? The four questions were reported on a Likert scale with scores ranging from 0 to 4, where 0 indicated never and 4 indicated often. The PSS-4 administered to an English sample (n = 1568) was found to have acceptable psychometric properties and confirmed that PSS-4 is a reliable measure of global perceptions of stress.

Satisfaction With Life Scale (SWLS) is a 5-item scale that is designed to measure cognitive judgments about life satisfaction. The responses range from 1 to 7, and a summary score of the 5 items shows how satisfied the respondent is with his/her life. Higher scores represent better life satisfaction. The SWLS is recommended as a complement scale that focuses on psychopathology or emotional well-being. In addition, it has also shown good convergent validity and discriminant validity in relation to emotional well-being.

Social factors such as alcohol consumption, smoking habits, gender, bodyweight, and height were collected at the baseline of the intervention. Self-administrated questions were used to assess related variables.
Procedure

The intervention lasted for 12 weeks, which was split into three sessions (4 weeks for each session). Participants in the intervention group completed the intervention for 4 weeks followed by a 4-week washout period than a 4 week control period. Participants in the control group maintained their lifestyle without any changes in the first and second session, and in the third session, they performed the intervention for 4 weeks. Figure 1 shows the allocation process, it is necessary to note that the figures do not show the final enrolled number of participants, which can be calculated by dropouts, but show the procedures of the intervention process. The reporting model of the intervention process refers to the Consolidated Standards of Reporting Trials (CONSORT) statement and is partially adapted from Marchetti's paradigm of reporting cross-over interventions.30,31

One researcher was responsible for collecting the everyday walking data from the participants who were
undergoing active aerobic walking exercise. All the participants were asked to keep a diary to record the parameters of their walking activity from the pedometer. Participants were not restricted to indoor or outdoor walking activity.

Data and statistical analysis

We compared the intervention group and control group in terms of sleep quality, stress status, and life satisfaction to examine whether aerobic walking intervention influences these variables using Wilcoxon Signed Rank Tests. In addition, after calculating the differences of sleep quality, stress and life satisfaction between pre- and post-intervention, Mann and Whitney U test was used to compare the magnitude of changes (delta scores) between intervention and control group. We examined the correlations of age, BMI, coffee, alcohol, smoking with the changes of sleep quality, stress status, and life satisfaction. Gender comparison regarding changes of main variables was performed by Mann-Whitney Test. Statistical analyses were performed with SPSS version 24, IBM. In all the analyses, the level of significance was set at $p < .05$.

Results

Results were analyzed with non-parametric tests for two reasons: (a) the assumption of normality was violated in the data and (b) the sample size was relatively low as based on the design sample size calculation with G* Power software. To test the hypothesis that the walking intervention had an effect on the dependent measures, Wilcoxon Signed Rank tests were used separately for the control and intervention group. The results are summarized in Table 1. As seen in Table 1, all measures showed increases that were statistically significant in the intervention group, but only life satisfaction increased in the control group.

Subsequently, we calculated the change (delta) scores by subtracting the second measurement (after one month/after intervention) from the baseline, or the initial measures obtained at the start of the study. These changes, or delta scores reflect the magnitude of changes that were reported in the three dependent measures. These were compared between the intervention and the control group. There were no statistically significant differences in any of the three measures between the two groups. The results are summarized in Table 2.

We also examined the correlations between the change scores. We found a statistically significant ($p < .05$) correlation between delta SPQI and change in perceived stress. Alcohol consumption showed a positive correlation ($p < .05$) with PSQI (see Table 3).

Finally, to assess whether the observed statistically significant differences could be due to gender effect, we performed Mann-Whitney U tests to compare the magnitude of changes within the one-month interval between men and women. These results revealed that there were statistically no significant differences between the sexes in terms of sleep quality, stress and life satisfaction (Table 4).

Discussion

This crossover study investigated the effects of aerobic walking in young adults who were not engaged in regular physical exercise habits. Three key variables (i.e. sleep quality, stress and life satisfaction) were tested before and after an aerobic walking intervention period. The improvements of sleep quality, stress and life satisfaction were significant in the intervention group, whereas the changes in control group indicated no differences. In addition, correlated life habits (e.g. BMI, coffee intake, and alcohol consumption) showed significant influence on the behavioral intervention. At present, regular aerobic walking is reported to contribute to health promotion.

Table 1. Results of the Wilcoxon signed rank tests testing the changes over one month in the intervention – (walking) and control group (no walking).

<table>
<thead>
<tr>
<th>Group</th>
<th>Measure</th>
<th>Time</th>
<th>N</th>
<th>M (SD)</th>
<th>Z</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>PSQI</td>
<td>Pre-</td>
<td>22</td>
<td>5.27 (3.01)</td>
<td>−3.08</td>
<td>.002</td>
<td>−.46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>22</td>
<td>3.59 (2.3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SWLS</td>
<td>Pre-</td>
<td>22</td>
<td>25.4 (5.6)</td>
<td>−2.93</td>
<td>.003</td>
<td>−.42</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>27</td>
<td>28.3 (5.76)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PSS</td>
<td>Pre-</td>
<td>22</td>
<td>6.77 (2.78)</td>
<td>−2.68</td>
<td>.007</td>
<td>−.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>27</td>
<td>5.52 (2.42)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>PSQI</td>
<td>Pre-</td>
<td>24</td>
<td>5.12 (2.98)</td>
<td>−1.47</td>
<td>.141</td>
<td>(NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>25</td>
<td>4.56 (2.38)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>LS</td>
<td>Pre-</td>
<td>22</td>
<td>23.9 (6.36)</td>
<td>−2.94</td>
<td>.003</td>
<td>−.43</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>24</td>
<td>27.0 (5.33)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PSS</td>
<td>Pre-</td>
<td>24</td>
<td>6.0 (2.70)</td>
<td>−6.52</td>
<td>.051</td>
<td>(NS)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Post-</td>
<td>24</td>
<td>6.17 (2.35)</td>
<td></td>
<td></td>
<td>−.94</td>
</tr>
</tbody>
</table>

Dependent measures are: PSQI = Pittsburgh Sleep Quality Index; LS = Life Satisfaction; PSS = Perceived Stress. The effect size (r) is indicated in the last (far right) column. NS = Not Significant; SWLS = Satisfaction With Life Scale.
Table 2. Mann and Whitney U test comparing the magnitude of changes (delta scores) in three dependent measures between the intervention and control group.

<table>
<thead>
<tr>
<th>Group</th>
<th>N</th>
<th>Mean Rank</th>
<th>Z</th>
<th>p</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta PSQI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>22</td>
<td>25.32</td>
<td>–1.47</td>
<td>.141 (NS)</td>
<td>0.005</td>
</tr>
<tr>
<td>Intervention</td>
<td>22</td>
<td>19.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta satisfaction with life scale</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>21</td>
<td>22.98</td>
<td>–5.00</td>
<td>.617 (NS)</td>
<td>0.006</td>
</tr>
<tr>
<td>Intervention</td>
<td>22</td>
<td>21.07</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta perceived stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>21</td>
<td>25.74</td>
<td>–1.931</td>
<td>0.054</td>
<td>0.08</td>
</tr>
<tr>
<td>Intervention</td>
<td>22</td>
<td>18.43</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\( \eta^2 \) = effect size.

Table 3. Means, standard deviations, and Spearman correlation matrix of measured variables (N = 54).

<table>
<thead>
<tr>
<th>Variables</th>
<th>Mean</th>
<th>SD</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Age</td>
<td>24.28</td>
<td>4.55</td>
<td>–1.142</td>
<td>.107</td>
<td>–.053</td>
<td>–.176</td>
<td>–.153</td>
<td>–.003</td>
<td>–.172</td>
</tr>
<tr>
<td>2 BMI</td>
<td>22.39</td>
<td>3.06</td>
<td>1.00</td>
<td>–.103</td>
<td>.190</td>
<td>.281*</td>
<td>.150</td>
<td>–.063</td>
<td>–.102</td>
</tr>
<tr>
<td>3 Coffee</td>
<td>1.53</td>
<td>0.87</td>
<td>1.00</td>
<td>.303*</td>
<td>.150</td>
<td>–.063</td>
<td>–.102</td>
<td>–.039</td>
<td></td>
</tr>
<tr>
<td>4 Alcohol</td>
<td>2.03</td>
<td>0.99</td>
<td>1.00</td>
<td>.062</td>
<td>.319*</td>
<td>–.257</td>
<td>.158</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Smoking</td>
<td>1.57</td>
<td>1.16</td>
<td>1.00</td>
<td>.007</td>
<td>–.059</td>
<td>.092</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 Delta PSQI</td>
<td>–1.31</td>
<td>2.49</td>
<td>1.00</td>
<td>.021</td>
<td>.330*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Delta LS</td>
<td>3.30</td>
<td>4.37</td>
<td>1.00</td>
<td>.145</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Delta PS</td>
<td>–1.00</td>
<td>2.34</td>
<td>1.00</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Correlation is significant at the 0.05 level (2-tailed). PSQI = Pittsburgh Sleep Quality Index; LS = Life Satisfaction; PS = Perceived Stress; SWLS: Satisfaction With Life Scale.

Table 4. Comparison of sleep quality, life, and physical activity.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Gender</th>
<th>N</th>
<th>Mean rank</th>
<th>Z</th>
<th>p</th>
<th>( \eta^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delta PSQI</td>
<td>Male</td>
<td>7</td>
<td>15.43</td>
<td>–1.956</td>
<td>.051</td>
<td>0.182</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>15</td>
<td>9.67</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta satisfaction with life scale</td>
<td>Male</td>
<td>7</td>
<td>12.07</td>
<td>–5.62</td>
<td>.57</td>
<td>0.016</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14</td>
<td>10.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Delta perceived stress</td>
<td>Male</td>
<td>7</td>
<td>10.79</td>
<td>–1.14</td>
<td>.099</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>Female</td>
<td>14</td>
<td>11.11</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grouping variable: gender; \( \eta^2 \) = effect size.

and life improvement. The results of this study suggest that when physical exercise is expected to improve life functions and daily activity, the regularity and continuity of exercise should be emphasized.

The pre-post comparison indicated that regular aerobic walking exercise showed beneficial outcomes in improving sleep quality, stress and life satisfaction. However, no difference was addressed through the comparison between intervention and control group. There were several possible reasons: On one hand, one-hour aerobic walking is helpful in improving sleep, stress and life satisfaction among healthy adults. Whereas it is necessary to mention that sleep quality was not an inclusion criterion for recruiting volunteers in this study. Therefore, participants could experience minor sleep complaints in connection with alcohol consumption. Daily alcoholic beverage consumption may be a moderator between anxiety status and sleep quality. However, people who sleep poorly should avoid misusing alcohol. Thus, there are both good sleepers and bad sleepers, which may interrupt the intervention outcomes. Nevertheless, the selection of participants did not break the compliance with research aims since this study did not work with people who suffer from sleep disorders but focus on the general population. On the other hand, as mentioned above, influential factors (e.g. lifestyle, behaviors) cannot be neglected when evaluating people’s perspectives about health and life. Lifestyle behavior interventions may influence daily life with short-term effect.

Walking has been broadly believed to yield positive public health outcomes. Moderate physical exercise is more prevalent in the general population compared with vigorous physical exercise. However, for adults, the intensity of walking, moderate or vigorous intensity physical interventions should be feasible and manageable. For example, walking 30 minutes as the target duration of activity. Another study suggested that a target of 10,000 steps per day is good to maintain health. From walking duration and step counts, it is hard to estimate the intensity of walking. Thus, there is a need to define walking requirements to facilitate public health education and communication. In the present study, a clear guideline for walking activity was initiated, and the most important, quantifications of the exercise volume, was clarified.

Walking at a standardized pace appears to be suitable for estimating physical function and deterioration due to chronic disease. There is no consensus regarding the optimal walking requirements such as distance, instructed pace and start mode. One study reported that clinical assessments of walking velocity were not conducted uniformly and common methodologic factors might influence the clinical interpretation of walking performances. Even though walking interventions have been examined against physical function, measures of general health, body composition, and chronic diseases, the results of current study...
provided a valid walking strategy including walking distance and walking pace for adults to promote health.

Limitations exist in this study. We used pedometers to track the daily data of participants. There was potential that pedometers acted as an external motivation to exercise. The study encountered a relatively high dropout rate, which may relate to the efficacy of the intervention. In interventions, it is highly recommended to note the rate and reasons for dropouts. In this study, these reasons include: 1) maintaining regular physical exercise as a daily habit is not easily achievable; 2) weather conditions need to be considered when conducting long-term outdoor interventions; and 3) motivation to exercise should be addressed during the intervention period.

**Translation to Health Education Practice**

Interventions to promote health status have been widely examined. Quantified aerobic walking is an important and easy way to maintain good health due to its feasibility and effectiveness. Pedometers are recommended for tracking walking activities from this perspective. Wearable devices are recommended but may not result in positive motivation among young adults. Health educators and policy makers should emphasize the importance of maintaining regular physical exercise to prevent chronic diseases.

The findings in the present study related to several Areas of Responsibility and Competencies for Health Education Specialist (HESPA II 2020) including “Determine the knowledge, attitudes, beliefs, skills, and behaviors that impact the health and health literacy of the priority population(s),” “Prioritize health education and promotion needs” and “Deliver health education and promotion interventions.”

Even though physical exercise is recognized as a way to prevent or delay the onset of chronic disease and clinical symptoms, the motivation to exercise varies between individuals. Interventions should work on the motivational strategies to increase initiation and adherence to physical activity. Future studies are suggested to examine the psycho-physiological mechanisms between walking exercise and health indicators.

**Acknowledgments**

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**Disclosure statement**

No potential conflict of interest was reported by the authors.

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