The Effect of Aerobic Walking on Sleep Quality, Stress and Life Satisfaction: A Longitudinal Analysis a Randomized Control Trial

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Research article

Keywords: moderate, walking, aerobic exercise, mental health, physiotherapy

DOI: https://doi.org/10.21203/rs.3.rs-39694/v1

Abstract

Background

This study aimed to evaluate the longitudinal effects of a randomized control trial about a goal-setting aerobic walking intervention conducted among sedentary young adults.

Methods

A 4-week daily aerobic walking (a. continually walking for at least 10 minutes; b. walk at least 60 steps per minute.) intervention was conducted to examine its effectiveness on sleep quality, stress and life satisfaction. Fifty-four participants aged 19–36 years old were assigned into two groups randomly (i.e. intervention group, control group). Sleep quality, stress and life satisfaction were assessed at baseline, post intervention and four weeks after the intervention by a battery of questionnaires. Omron HJ-112 pedometer and daily diary were used to facilitate the intervention process.

Results

The comparison between intervention group and control group did not show significant difference in terms of sleep quality, stress and life satisfaction after intervention. Repeated measures ANOVA showed significant longitudinal effect with regard to stress ($p = 0.03$). Sleep quality was improved close to statistical significance ($p = 0.06$). Longitudinal analysis reported that the aerobic walking effect pertaining to life satisfaction rather than stress and sleep quality ($p = 0.05$).

Conclusions

Aerobic walking is an effective exercise for stress and sleep. Further studies are suggested to explore feasible intervention strategies that could bring long-term effectiveness to health.

Trial registration

ClinicalTrials.gov, NCT04427696. Registered 11June 2020- retrospectively registered, https://clinicaltrials.gov/ct2/show/NCT04427696?cntry=HU&city=Budapest&draw=2&rank=1

Background

Sedentary behavior among young adults has become a major concern and its rapidly emergence contributes to considerable health issue.[1] Conventionally, “sedentary behavior” is defined as primarily sitting behaviors (such as TV viewing and computer use, or travelling in a car) that requires low levels of energy expenditure to perform (< 1.6 METs of rest).[2] In the present era, the invasion of electronic entertainment products surprisingly increased the screen time, which becomes a key component of sedentary behavior. It was reported that young people spend 2–4 hours per day in screen-based behaviors and 5–10 hours per day sedentarily.[3] Even though young males were supposed to have higher

participation in physical activity than women, they also spent more time watching television/videos and using the computer.[4]

Health outcomes associated with sedentary behavior among young people should be taken into consideration. Evidence showed that there was a relationship between sedentary behavior and physical health coupled with mental health and cognitive development in young adults[3]. More specifically, previous study documented that sedentary behavior is associated with an increased risk of depression and physical inactivity has been identified as a factor for mental depression.[5–6] Mental health indicators include psychological distress, anxiety symptoms, stress and loneliness etc.,[7] furthermore, prolonged sedentary time and sleep deprivation are independently associated with the risk of stress symptoms.[8] Sleep deprivation may trigger a stress response in the healthy young population. In addition, sleep disturbance was reported to be a risk factor for depression.[9] Sleep quality and mental status are regarded as essential elements pertaining to life quality. Even though general life satisfaction is a socially constructed phenomenon among young adults, to ensure the life satisfaction from health-oriented perspectives should not be neglected.

Considering the positive effects of physical exercise on sedentary behavior related mental health implications, health promotion programs for young adults may benefit from incorporation of physical activity strategies to reduce stress, improve sleep quality and life satisfaction. Walking is a recreational activity without financial cost, and has the possibility to be implemented for public health to promote both physical and mental health. Walking was shown to increase natural killer cell activity and immune function, which supported that the physiological and psychological benefits of walking may due to stress reduction. Walking may contribute to better sleep quality because of the efficacy in stress reduction and physical exercise involved.[10] Nevertheless, Buckworth highlighted that gender-related relationships between sedentary and active behaviors should be considered and to promote exercise in young adult population.[4]

The National Institute for Health (NIH) and Clinical Excellence suggested that physical activity should be consist for three sessions of 45–60 minutes per week for a period of at least 10–14 weeks. However, less is known whether there is a long-lasting effect of physical benefits. An understanding of longitudinal effect of physiological intervention on health is vastly underrepresented. In essence, there exists a clear need for better understanding of this topic. The aims of this study were, firstly, to display the health outcomes of 4-week aerobic walking intervention regarding to sleep quality, stress and life satisfaction; secondly, to examine the longitudinal effectiveness of aerobic walking exercise on sleep quality, stress and life satisfaction among young adults.

Method

Study Design

The study described in this paper evaluated an aerobic walking intervention conducted among young adults. The walking was not a self-selected speed as many walking interventions did, but with two basic speed requirements: a. continually walking for at least 10 minutes; b. walk at least 60 steps per minute. Walking for one hour per day in the requested speed was obligatory, which was the so-called daily aerobic walking intervention. Participants were assigned into two groups randomly (i.e., intervention group and control group). The intervention period of the study was four weeks continued with four weeks follow-up, which in total, was eight weeks. A battery of online questionnaires measuring sleep quality, stress status and life satisfaction were sent to all of the participants at the baseline of the intervention (pre-intervention), after intervention (4 weeks later) (post-intervention), and at follow-up (8 weeks later). The intervention study was approved by university ethical committee (registration code: 2018/421).

Intervention

The participants in the intervention group performed daily aerobic walking (DAW) for 60 minutes (in reality, 50–60 minutes are acceptable), and the participants in the control group were in the waiting list and were asked to maintain sedentary lifestyle. Both of the two group members were asked to avoid any additional physical exercise programs during the intervention period. The DAW was tracked by pedometer and daily diary. Omron HJ-112 (Omron Corporation, Kyoto, Japan) pedometer was used to track the daily walking activity.

Participants in the intervention group were asked to complete a 60-minute DAW daily and record the data (e.g. total steps, aerobic steps, starting time, ending time, miles, calorie expenses) from the pedometer to the dairy sheet. The advantage of the using this pedometer is that it could differentiate normal walking and aerobic walking as requested in the experiment. Participants were orientated about how to use and set the pedometer before starting the intervention. Participants were encouraged to carry out the intervention for 4 weeks, but each participant could have 3 days off in case of bad weather, illness, emergency etc.

The online questionnaires were formulated by Qualtrics, and were sent electronically to the participants via anonymous link. All participants have signed the written consent form before joining the study. The daily routine of the participants was not interrupted except the 60-minute DAW. The participants in the intervention groups were requested to send the aerobic walking steps and walking time to a research assistant, which served as a way of controlling the walking performance of the participants and data collection as well.

Participants

Participants were recruited by advertisement through both electronical and printed posters. The electronical posters were posted on social media platform (e.g. Facebook, WeChat etc.). The printed posters were posted on the information bulletins in Eötvös Loránd University, Hungary. People who are interested in the study were welcomed to contact the first author by email or WhatsApp. Text or phone-call interviews were organized with each contacted volunteer to assess the eligibility of the contacted people. Despite the demographic information (e.g. age, health status, general life routine etc.), we screened the

volunteers with two questions (1. Do you participate in any kind of regular exercise programs (weight-lifting, walking, running, swimming etc.)? 2. Are you involved in any physical or sport teams?) in order to roughly assess their sedentary life status.

After screening, 54 participants met the inclusion criteria (both answers were “NO” for the above two screening questions), and 27 participants were assigned to intervention group and 27 to the control. The grouping was done by lottery method. All the participants in both groups were equipped with pedometers to record their daily steps, calories expenses, miles etc. The demographic characteristics of the participants are presented in Table 1. Participants who failed to complete the questionnaires did not mean they dropped off from the intervention. The quality of the intervention process was controlled by pedometer and diary sheet and one research assistant recorded the walking figures from each participant in the intervention group every day. The age range of the participants was 19 to 36 years old, and the mean body mass index (BMI) was 22.46 (SD = 3.10).

Table 1
The description of the participants

	Intervention group			Control group		
	n	Range	Mean ± SD	n	Range	Mean ± SD
Age	21	19–36	23.38 ± 4.58	25	19–35	24.08 ± 5.13
Gender	24	10 males	14 females	27	9 males	18 females
BMI	24	18.73–30.43	22.87 ± 2.63	26	17.38–31.80	22.88 ± 2.63
Study/Work	21	20 study	1 work	24	21 study	3 work
Note: BMI Body Mass Index						

Please insert Table 1 *about here.*

Measurements

We used Pittsburgh Sleep Quality Index (PSQI),[11] which is a self-report scale to assess sleep quality and sleep components for the past month. The scale contains 19 items, which are grouped to evaluate seven sleep components including (1) sleep duration, (2) sleep efficiency, (3) sleep latency, (4) daytime dysfunction due to sleepiness, (5) sleep disturbance, (6) sleep medication use, and (7) subjective sleep quality. The component score ranges from 0 to 3, a sum of seven sleep components’ score is the global sleep quality (ranges from 0–21). Higher score indicates poorer sleep quality. The borderline of good sleeper and bad sleeper is 5. A score over 5 indicates bad sleeper, while a score less than 5 (or equals 5) indicates good sleeper.

The Perceived Stress Scale (PSS) by Cohen[12] is recognized as the most widely used psychological instrument to measure perceptions of stress. It measures the degree to which situations one is appraised

as stressful. The items were designed to discover how unpredictable, uncontrollable and overloaded people find their life to be. There are two version of the PSS: the long-version with 10 items, and short version with 4 items. In the present study, we adopted the short version to assess the stress of the participants.

Satisfaction With Life Scale (SWLS) is a 5-item instrument to measure cognitive judgments of one's life satisfaction. Respondents point out how much they agree or disagree with the 5 statements about life by using a Likert scale that ranges from 1 (strongly disagree) to 7 (strongly agree). SWLS is designed to assess respondents' life as a whole, which does not assess domains such as health or finances. The total score climes from 5 to 35, which was grouped into seven categories ranging from extremely dissatisfied to extremely satisfied. Statistical Analysis

In line with the first aim of the study, we used independent t-test to show the intervention outcomes regarding to sleep quality, stress and life satisfaction. Linear regression was used to predict the covariant effect of age, gender and BMI, which can be potential confounders. The difference between post intervention and baseline for those main variables (i.e. PSQI, PSS, SWLS) were used as dependent variables. For the second aim of the study, repeated analysis of variance ANOVA manures was applied to disclose the longitudinal effectiveness of DAW exercise on sleep quality, stress and life satisfaction among young adults.

Considering the missing data and drop-off of participants, we selected only those who both completed the intervention and completed the questionnaire assessment for statistical analysis. The rigorous data sortation reduced the potential bias caused by the drop-outs (reasons for drop-off are presented in the limitation section below). The diary sheet records were utilized as filters. Eventually, we got 13 participants from the intervention who adhered to the intervention process and follow-up and 17 participants in the control group who were consistent with the study. Statistical analysis was performed by SPSS version 21.0, of which the statistical significance level was set at 0.05.

Results

Predictive Confounders

In order to examine the confounding effect of age, gender and BMI of the participants, linear regression was performed. The difference between post-intervention and baseline regarding to sleep quality, stress and life satisfaction was predicted by age, gender and BMI. Table 2 shows that there was no severe confounding effect in this research group in terms of age, gender and body mass index. In contrast, age, gender and BMI did not predict sleep quality, stress and life satisfaction at significance level ($p > 0.05$).

Table 2
Description of potential confounders for sleep quality, stress and life satisfaction

	DF-PSQI		DF-PSS		DF-SWLS	
	t	p	t	p	t	p
Age	-0.32	0.75	0.01	0.99	0.70	0.49
Gender	-0.50	0.62	-0.44	0.66	0.11	0.91
BMI	-0.13	0.90	0.45	0.66	0.75	0.46
Note: DF-PSQI = difference of sleep quality global score; DF-PSS = difference of perceived						
stress score; DF-SWLS = difference of life satisfaction score; BMI = body mass index						

Please insert Table 2 *about here.*

Intervention Effect of Aerobic Walking

The effect of aerobic walking intervention was examined. Between subject effect and within subject effect comparisons were analyzed by independent t-test and repeated measures ANOVA. In comply with the baseline evaluation, the statistical comparison between baseline and post intervention was made with the data from intervention group. Table 3 shows the results of independent t-test by calculating the difference of the PSQI, PSS and SWLS before and after intervention in both groups. At group level, it was hard to find out statistical significance of the three variables post intervention. Nevertheless, it is good to mention that stress level was improved close to statistical significance ($p = 0.06$). Furthermore, we used repeated measures to compare the baseline and post intervention difference in both intervention group and control group. Table 4 shows the results from repeated measures ANOVA that stress status ($p = 0.03$) was significantly improved in the intervention group rather than the control group. Sleep quality was improved but at the significance level of 0.06. On the contrary, there were no statistical differences at baseline and post intervention in terms of sleep quality, stress and life satisfaction between intervention group and control group ($p > 0.05$).

Table 3
The baseline and post-intervention comparison of intervention group by independent t-test

Variables	F	M ± SD	p	95% Confidence Interval	
				lower	upper
DF-PSQI	1.06	1.68 ± 2.25	0.33	-3.42	6.78
DF-PSS	4.73	0.32 ± 1.85	0.06	-3.86	4.51
DF-SWLS	0.03	0.68 ± 1.75	0.88	-3.29	4.64
Note: DF-PSQI = difference of sleep quality global score; DF-PSS = difference of perceived stress score; DF-SWLS = difference of life satisfaction score					

Table 4
The baseline and post-intervention comparison of intervention and control groups by repeated measures

Variables	Intervention group		Control group	
	F	p	F	p
PSQI	4.54	0.06	2.28	0.17
PSS	6.12	0.03	1.42	0.27
SWLS	0.23	0.65	0.00	0.98

Note: values refer to Greenhouse-Geisser; PSQI = sleep quality global score; PSS = perceived stress score; SWLS = life satisfaction score

Please insert Table 3 *&* Table 4 *about here.*

Longitudinal Effect of Aerobic Walking

Between-Subject effect and Within-Subject effect were examined by repeated measures ANOVA. No statistical results were found at follow up regarding to sleep quality and stress ($p > 0.05$). However, life satisfaction showed statistical significance ($p = 0.05$). Table 5 shows the statistical results.

Table 5
The Between-subjects effect and within-subjects effect comparison at follow up

Variables	Between-Subjects effect		Within-Subjects effect		95% Confidence Interval	
	F	p	F	p	lower	upper
PSQI	0.76	0.40	0.23	0.64	3.44	5.40
PSS	2.04	0.17	0.22	0.65	4.35	6.56
SWLS	2.06	0.17	4.47	0.05	23.12	28.67

Note: values refer to Greenhouse-Geisser; PSQI = sleep quality global score; PSS = perceived stress score; SWLS = life satisfaction score

Please insert Table 5 *about here.*

Discussion

This study indicates that daily aerobic walking has different degrees of influential effect on sleep quality, stress and life satisfaction among young adults. The finding indicated that physical exercise did not show beneficial effects on sleep quality was consistent with a recent study demonstrating that exercise performed 6 hours before bedtime did not promote increments in sleep need in sedentary, regularly sleeping young adults.[13] The results of this study can be used to modify physiotherapy intervention which may stimulate different effects on sleep quality, stress and life satisfaction among young adults.

Given that the significance level of aerobic walking effect on sleep quality is low, the longitudinal effect of aerobic walking can be ambiguous. The possible explanations are, on one hand, pedometer-based physical activity may reduce nighttime rest rather than improving sleep quality; on the other hand, energy expenses of brisk walking could be a factor to initiate sleep onset. The evidence that physical exercise has positive or negative effect on sleep disturbance is not concrete, which means there may be a bidirectional relationship between physical exercise and sleep.[14]

This study showed significant stress improvement effect of physical exercise in within-subject comparison. Even though the significance level is low in between-subject comparison, it is still reliable that physical exercise is functional in stress management. The finding is congruent with previous research outcomes that physical exercise has tended to precede psychological benefits indicating that aerobic exercise training has antidepressant and anxiolytic effects and protects against harmful consequences of stress.[15] Consistent with established literature, the mechanism between physiology and emotional reaction can be explained by laboratory discovery. Scientists explored the adult neurogenesis in two brain regions: the hippocampus and the olfactory bulb, which suggested that altered hippocampal neurogenesis is related to pathophysiology of mood disorders and mechanism of antidepressant treatments.[16] Accumulated knowledge of about the effects of physical exercise on brain function indicates that exercise training offers psychological therapeutic treatment, which can be recognized as key public health priorities.

The present intervention study did not find direct relationships between aerobic walking and life satisfaction. It was surprising to encounter that life satisfaction did not show significance right after intervention but showed significant improvement at follow up. Whereas, it is not assumed to be caused by the intervention effect. There are several reasons: the relationship between physical exercise and life satisfaction can be mediated by factors such as physical self-perceptions and age;[17] in addition, the association between life satisfaction and health-promoting behavior (e.g. physical exercise) may partially related.[18] Education, employment, financial status etc. can be predictors to life satisfaction,[19] thus, a multitude of aspects must be taken into account when assessing life satisfaction.

Despite that the drop off rate is relatively high in this study; physical exercise has significant implications for public implementation in sleep and stress management. It is reasonable to understand that it is not easy to conduct physical exercise intervention among sedentary population. It is suggested to facilitating greater exercise adherence and health benefits not only among sedentary population but also in society. Researchers are suggested to investigate physical exercise motivations for young adults.

Limitations exist in this study. This study was designed to enable ordinary citizens to carry out feasible physical exercise (e.g. walking) in daily life. In doing so, participants were allowed to carry out walking exercise according to their feasibility including exercise time and exercise location. Participants were free to choose walking in the gym or in the natural forest. But it was reported that a green environment has beneficial effects on human health. A systematic review of epidemiological studies elicited that living in greener environments is associated with better mental health.[20] Therefore, the difference in walking

environment could be a potential limitation in presenting the consistency of the intervention study. The drop-off rate should be restated as a limitation for the present study, there are several reasons: firstly, we were strict with data collection, incomplete data was not acceptable for analysis, hence, a number of incomplete data was trimmed off in statistical analysis which included those who participated half-way of the intervention process. Secondly, In March, the weather in Hungary was rainy and cold, some participants could not bear with the weather condition.

Conclusions

In conclusion, this study provides specified suggestions and evidences that goal-setting daily aerobic walking could be a potential beneficial activity to achieve sleep quality and psychological health benefits in young adults. Aerobic walking is suggested to be considered as an alternative non-pharmacotherapy in non-clinical settings. Moreover, it is strongly recommended to increase the adherence of intervention strategies and explore the longitudinal effect of physical interventions in further study. Last but not least, further studies are recommended to implement aerobic walking exercise in a larger sample size, which could potentially unfold the effect of physical exercise on sleep quality and life satisfaction.

Abbreviations

NIH
National Institute for Health
DAW
Daily Aerobic Walking
PSQI
Pittsburgh Sleep Quality Index
PSS
Perceived Stress Scale
SWLS
Satisfaction With Life Scale
BMI
Body Mass Index
SD
Standard Deviation
ANOVA
Analysis of Variance

Declarations

• Ethics approval and consent to participate:

• Written consent forms were signed by each participant. The intervention study was approved by Eötvös Loránd University ethical committee (registration code: 2018/421).

• Consent for publication:

• In the written consent form, all participants agreed for publication of this intervention study, and no personal data is included.

• Availability of data and materials:

• The data of the manuscript is part of a randomized cross-over intervention study. The full study has been registered at publicly available repository (ClinicalTrials.gov, Identifier: NCT04427696). The dataset is not ready to be shared publicly, but can be requested by the editorial office if needed.

• Competing interests:

• The author declares that they have no competing interests.

• Funding:

Not applicable.

• Authors' contributions:

The author conceptualized the proposal, and administrated the intervention process. The author completed the written up of this manuscript.

• Acknowledgements:

• Great thanks to my two colleges. In the intervention process, a research assistant, Darma Juwono, helped to collect daily aerobic steps from active participants. Dr. Szilvia Boros helped to test the validity of the pedometers.

• Authors' information: The author is a Ph.D. student in Institute of Health Promotion & Sport Sciences, Eötvös Loránd University (ELTE), HUNGARY. This manuscript is part of her Ph.D. project.

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Supplementary Files

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