The Effect of Duration and Frequency of Walking Exercise on Cognitive Functions: A Randomized Controlled Comparative Study

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1.1. Brief Background

Physical activity is well-documented to provide benefits beyond physical health, including improvements in cognitive functions such as memory, attention, processing speed, and executive functions. Aerobic exercise, in particular, has been shown to enhance cognitive performance by promoting neurogenesis, synaptic plasticity, cerebral blood flow, and reduced inflammation. Among all forms of aerobic activity, **walking** stands out due to its simplicity, low cost, and accessibility across various populations.

While the benefits of exercise on cognition are established, there is limited consensus on the **optimal duration and frequency** required to achieve these effects. Health authorities like the World Health Organization (WHO) endorse accumulating physical activity in bouts of at least 10 minutes throughout the day, but direct comparisons of **short-duration, high-frequency** versus **long-duration, continuous** walking on cognitive outcomes in young, healthy adults are sparse.

1.2. Rationale for the Study

Despite the evidence supporting exercise for cognitive enhancement, many individuals—especially students and working adults—struggle to engage in long-duration workouts due to time constraints or physical limitations. Shorter, more frequent bouts of walking may offer a **feasible alternative** for achieving cognitive benefits. However, there is limited clinical evidence directly comparing these two approaches in a **controlled, randomized trial** setting.

This study addresses a critical knowledge gap by evaluating whether **three short walking sessions (10 minutes each)** throughout the day are as effective as a **single continuous 30-minute session** in improving cognitive function in sedentary young women. The results will help inform more accessible, time-efficient exercise prescriptions aimed at preserving and improving cognitive health.

1.3. Objectives and Hypotheses

Primary Objective:

To compare the effects of two different walking protocols (short-duration vs. long-duration) on cognitive function, specifically **processing speed and executive function**, in sedentary young adult females over a 6-week intervention.

Secondary Objective:

To evaluate changes in attention, inhibition control, and overall cognitive flexibility through various subtests of the Stroop Test following each walking protocol.

Primary Hypothesis (H_1):

Both short-duration and long-duration walking exercise protocols will lead to significant improvements in cognitive performance after 6 weeks.

Secondary Hypothesis (H_2):

There will be **no significant difference** in cognitive improvement between the two groups, indicating that **short, frequent bouts** of walking are **as effective** as a longer, continuous session.

2. Study Design

This study was conducted as a **randomized controlled trial** using a **parallel assignment model** to compare the effects of two different walking protocols on cognitive function in sedentary young adult females. Participants were randomly assigned in a 1:1 ratio to either a **short-duration walking group** or a **long-duration walking group**. The intervention period lasted for **six weeks**, with both groups engaging in walking exercise **five days per week**.

The **short-duration group (experimental arm)** performed **three separate 10-minute walking sessions** daily, while the **long-duration group (active comparator arm)** completed **one continuous 30-minute walking session** per day. In both groups, walking was performed on a treadmill at **60% of each participant's maximum heart rate**, calculated using the formula (220 - age). Heart rate was monitored during sessions using treadmill sensors and cross-checked with a pulse oximeter to ensure consistency. Standardized warm-up and cool-down periods were applied to both protocols.

Randomization was conducted using the Research Randomizer tool (Version 4.0), and allocation concealment was maintained throughout the study. Although participants were aware of their assigned protocol (due to the nature of the intervention), the study employed **double masking**: the **investigator supervising the exercise sessions** and the **outcomes assessor conducting cognitive tests** were both blinded to group assignments to minimize bias.

This design aimed to investigate whether short, frequent bouts of aerobic exercise provide comparable cognitive benefits to longer, continuous sessions, potentially offering a more flexible and accessible option for individuals with time constraints.

3.

This study was conducted at the Faculty of Health Sciences, Gazi University, in the Department of Physiotherapy and Rehabilitation. Ethical approval was obtained from the Ethics Committee of Gazi University with the record number 2023- 1134 to conduct the study.

4. Participants

Participants in this study were **female individuals aged 18 to 25 years** who maintained a **sedentary lifestyle**, defined as taking fewer than 5000 steps per day. Additional inclusion criteria included being a **non-smoker**, having the **physical ability to walk on a treadmill**, maintaining a **work or school schedule compatible with the intervention schedule**, and providing **written informed consent**.

Exclusion criteria included having a **body mass index (BMI) of 30 kg/m² or higher**, a history of **neurological or severe cardiovascular conditions**, participation in another **regular exercise program** during the study period, any **physical limitation that would interfere with safe walking**, and **pregnancy**. These criteria were established to ensure the safety of participants and to maintain the homogeneity of the study population.

5. Interventions

Participants were randomly assigned to one of two intervention groups. The **experimental group** performed **three 10-minute walking sessions per day**, while the **active comparator group** completed **one continuous 30-minute walking session per day**. Both groups exercised **five days per week for six weeks**. The intensity of the exercise was standardized at **60% of the participant's maximum heart rate**, calculated using the formula *(220 - age)*. Heart rate was continuously monitored using treadmill-integrated sensors and confirmed with pulse oximeter readings. Standardized warm-up and cool-down periods were integrated into both protocols.

6. Outcomes

The **primary outcome** of the study was the **change in Digit Symbol Substitution Test (DSST) scores** from baseline to post-intervention (6 weeks), reflecting improvements in **processing speed and executive function**.

Secondary outcomes included changes in performance on three subtests of the **Stroop Test**, which evaluated various aspects of cognitive function.

7. Sample Size and Power

A power analysis was conducted using **G*Power 3.1** software. Based on an expected **effect size of 0.5**, a **power of 95%**, and a **significance level of 0.05**, the **minimum required sample size** was determined to be **34 participants**, with **17 in each group**. This calculation ensured that the study would be adequately powered to detect meaningful differences between groups.

8. Randomization

Randomization was performed using the online tool **Randomizer.org (Version 4.0)** to generate a computer-based random sequence, ensuring unbiased allocation of participants. A **1:1 allocation ratio** was used. Although participants were aware of their assigned walking schedules, **both the investigator supervising the training sessions** and the **assessor performing the cognitive tests** were **blinded to group assignment** to maintain objectivity in outcome evaluation.

9. Data Collection and Management

Cognitive function assessments were conducted at **baseline** and again **after the 6-week intervention**. All data were anonymized and stored securely in password-protected digital files accessible only to the research team. To ensure adherence, participants maintained **daily exercise logs**, and researchers conducted routine follow-ups throughout the intervention period. Any protocol deviations or dropouts were documented.

10. Statistical Analysis Plan (SAP)

Statistical analysis was performed using **SPSS version 24**. The **normality of distribution** for outcome variables was tested using the **Shapiro-Wilk test**. **Independent samples t-tests** were used to compare baseline values between groups, while **ANCOVA** was applied to adjust for any baseline differences when comparing post-intervention outcomes. **Paired t-tests** were used to evaluate within-group changes from baseline to post-intervention.

Effect sizes were calculated using **Cohen's d** to quantify the magnitude of observed changes. A **p-value of less than 0.05** was considered statistically significant. **Outliers** were identified through **z-score analysis** and **visual inspection of boxplots**. In cases of dropout or incomplete data, **listwise deletion** was applied, and only participants who completed both pre- and post-tests were included in the final analysis.