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Comparison between Pilates exercise and combination with transcendental meditation towards short-term memory among adult females

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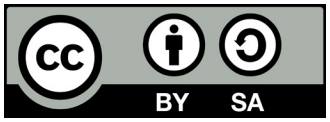

ABSTRACT

Background: Pilates is a kind of exercise that incorporates both physical and mental components in its practice. Transcendental meditation comprises a collection of approaches that center on attention and awareness cultivation. Upon reaching adulthood, a person must possess a significant level of cognitive ability to guarantee optimal production. Pilates and transcendental meditation have emerged as potential options for enhancing cognitive processes, especially short-term memory.

Objective: This study aims to investigate the impact of Pilates exercise, both alone and in conjunction with transcendental meditation, on short-term memory.

Methods: The present study used an experimental design including three parallel groups and performed a pre-test and post-test design. The participants in this study consisted of 45 adult females ranging in age from 25 to 55 years. They were selected using the purposive sampling method and were divided into three groups based on the interventions received. The first group received a combination of Pilates exercise and transcendental meditation (n=15), the second group received Pilates exercise alone (n=15), and the third group served as the control group (n=15). Both intervention groups participated in 16 sessions, which were performed three times per week over six weeks. The Scenery Picture Memory Test (SPMT) was used to assess short-term memory. The data analyses were done using the paired t-test and One-way ANOVA.

Results: Significant improvements ($p<0.05$) in SPMT scores were found across all groups after their respective therapies. There were stark differences in the results of the SPMT between the group engaged in Pilates exercise and the group practicing transcendental meditation ($p=0.001$), as well as between the Pilates exercise group and the control group ($p<0.001$). Besides, a significant result was found between the Pilates exercise group and the control group ($p=0.01$).

Conclusion: The Pilates exercise, whether performed alone or in conjunction with transcendental meditation, has been shown to enhance short-term memory. Notably, engaging in Pilates exercise with transcendental meditation has a more pronounced and efficacious outcome.

Latar Belakang: *Pilates merupakan salah satu jenis olahraga yang menggabungkan komponen fisik dan mental dalam praktiknya. Meditasi transendental terdiri dari kumpulan pendekatan yang berpusat pada pengembangan dan pemeliharaan perhatian dan kesadaran. Setelah mencapai usia dewasa, seseorang perlu memiliki kemampuan kognitif yang cukup untuk menjamin produksi yang optimal. Pilates dan meditasi transendental telah muncul sebagai pilihan potensial untuk meningkatkan proses kognitif, terutama yang*

berkaitan dengan memori jangka pendek.
Tujuan: *Tujuan dari penelitian ini adalah untuk mengetahui dampak latihan Pilates, baik sendiri maupun bersamaan dengan meditasi transendental, terhadap memori jangka pendek.*
Metode: *Penelitian ini menggunakan desain eksperimen yang mencakup tiga kelompok paralel dan menggunakan desain pre-test dan post-test. Partisipan dalam penelitian ini terdiri dari 45 wanita dewasa dengan rentang usia 25 hingga 55 tahun. Mereka dipilih menggunakan metode purposive sampling dan dibagi menjadi tiga kelompok berdasarkan intervensi yang mereka terima. Kelompok pertama menerima kombinasi latihan Pilates dan meditasi transendental (n=15), kelompok kedua menerima latihan Pilates saja (n=15), dan kelompok ketiga berperan sebagai kelompok kontrol (n=15). Kedua kelompok intervensi dialokasikan untuk berpartisipasi dalam total 16 sesi, yang dilakukan tiga kali seminggu selama enam minggu. Pemeriksaan Scenery Picture Memory Test (SPMT) digunakan untuk menilai memori jangka pendek. Analisis data dievaluasi menggunakan uji t berpasangan dan One-way ANOVA.*
Hasil: *Terdapat peningkatan skor SPMT yang signifikan (p< 0.05) pada semua kelompok yang mendapatkan perlakuan. Terdapat perbedaan bermakna hasil SPMT antara kelompok yang diberikan latihan Pilates dengan kelompok yang melakukan meditasi transedental (p=0.001), serta antara kelompok latihan Pilates dengan kelompok kontrol (p<0.001). Selain itu, terdapat perbedaan signifikan antara kelompok latihan Pilates dan kelompok kontrol (p=0.01).*
Kesimpulan: *Latihan senam Pilates, baik dilakukan sendiri atau bersamaan dengan meditasi transendental, telah terbukti meningkatkan daya ingat jangka pendek. Khususnya, melakukan latihan Pilates dengan meditasi transendental memiliki hasil yang lebih nyata dan manjur.*

INTRODUCTION

Pilates is a series of physical exercises that combines physical, mental, and psychological balance.[1] The Pilates exercise emphasized positional and motion control.[2] This exercise is simple, efficient, and cost-effective. Therefore, can be performed by anyone without special skill requirements. The main goal of Pilates exercise is to achieve the efficiency and functionality of a movement so there would be an elevation of the body's workload. The exercise that develops from pilates seeks to facilitate motor movements by leaving the body in a state that minimizes unnecessary muscle movements.[3]

Pilates technique exercises utilize stretching and strengthening methods to provide strength and flexibility.[4] The techniques are also beneficial in forming bodily memories of suitable movements with training. They help regain posture by promoting flexibility, muscular strength, and resistance of the legs, abdomen, hip, and back, hence achieving positive improvements in physical coordination and concentration.[5]

Meditation is defined as an arranged set of techniques to gain focus to maintain attention and awareness, with the primary goal of achieving better comfortability, serenity, and concentration.[6] Transcendental meditation came from the word "transcend", which means to go beyond. In this context, it means beyond the state of thought, thus it is called "transcendental" meditation. During transcendental meditation, a person sits comfortably for approximately twenty minutes and repeats a mantra or sound that is taught in a calm condition to enable the mind to transcend into a calmer state.[7] A mantra can be described as a sound or a simple sentence, usually in Sanskrit, that facilitates the "implanting" attention process.[8]

Several studies have revealed that even short and intermittent meditation can support cognitive function.[9,10] In the early stages of meditation showed a significant increase in selective and executive attention, which aims to cultivate focused attention. Meditation is known to have a higher effect on increasing cognitive function if done regularly and consistently.

Memory is defined as one's ability in a dynamic mechanism to collect and store past information for future recall. Short-term memory temporarily stores a memory, also known as primary memory. The characteristics of short-term memory encompass the necessity of consciousness or engagement in a conscious cognitive process. Its duration typically spans 20-30 seconds unless the information is rehearsed repetitively to facilitate retention. Furthermore, short-term memory is limited by a finite capacity ranging from 7-12 items, which can be relatively simple, such as numerical digits, or more intricate, such as words.[11]

The age range of adulthood is widely recognized as a period of high production, necessitating more studies to substantiate claims about the productivity levels of adult populations. The present study aims to investigate the potential disparity in short-term memory performance between women and men by examining the impact

of an intervention. It is hypothesized that women may exhibit lower spatial memory abilities than their male counterparts. Thus, this research seeks to discover and analyze the potential differences in short-term memory among women after the intervention.[12]

Several studies have examined the impact of Pilates exercise and transcendental meditation on a range of physiological, psychiatric, and psychological factors. However, previous studies have not identified any study that evaluates the combined impact of these factors on cognitive processes. Memory is a cognitive capacity that plays a significant part in the processes of learning and productivity. This statement underscores our research endeavor to conduct a more comprehensive investigation of the impact of Pilates exercise and transcendental meditation on short-term memory.

METHODS

Study design

The study was carried out at Jasmine Studio, situated in Sidodadi Timur 28, Karangtempel, Semarang Timur District, Semarang City, from August to September 2022. This experimental study used three parallel groups of pre-and post-test design.

Population and sample

The study sample consisted of 45 female individuals who satisfied the predetermined inclusion and exclusion criteria. The participants were selected using a purposive selection strategy, using a sample size formula designed for paired numerical analytical research. The inclusion criteria for participation in the study consisted of being of the female gender, aged between 25 and 55 years, and obtaining a minimum score of 9 on the SPMT. Individuals excluded from the study were those with visual, hearing, and speech impairments, a medical history of brain illnesses or traumas, a history of central nervous system infection, and other limitations.

Data collection

Before commencing the intervention, all participants signed informed consent for the intervention. They were divided into three groups consisting of 15 participants for each group. Researchers use a matched-subject approach in the determination of groups. Each group received equitable intervention by using a subject-matching ordinal pairing procedure. This strategy includes pairing comparable subjects with nearly identical pre-test SPMT scores in an ABC-CBA (zig-zag) pattern. Hence, in summary, the three groups in the study are intervention 1, intervention 2, and control. Each group had individuals with comparable levels of ability. The pre-test results of SPMT were arranged in descending order into a sequential pairing.[13] Intervention Group 1 was administered Pilates exercise and transcendental meditation as interventions, Intervention Group 2 got Pilates exercise, while the Control Group did not undergo any treatments.

The participants completed the SPMT pre-test before receiving their interventions and then completed the post-test under the direct supervision of the researchers via Google Meet and Zoom. Participants were advised to refrain from acquiring knowledge or committing to memory the visual stimuli that would be shown during the experimental trials. Consequently, they were exposed merely to the photos during the administration of the tests. The Pilates exercise regimen was conducted on 16 occasions over six weeks, with a frequency of three sessions each week.[23] Every session included a five-minute warm-up period, followed by two sets of 25-minute Pilates exercises, and concluded with a five-minute cool-down period. Subsequently, group 1 would engage in a 10-minute session of transcendental meditation.

Cognitive assessment

The SPMT utilized a line drawing depiction (Figure 1) of a living room within a residential setting. This drawing, encompassing 23 commonly encountered objects in daily life, was presented virtually on an A4-sized sheet of paper via platforms such as Google Meet or Zoom screen sharing. The objects depicted include a telephone, a bookshelf, books, a table, chairs, two cups with saucers, a flower vase, framed picture on the wall, a clock, a ceiling lamp, a couch, cushion, a cat, low table, hat on the table, briefcase, television, television desk, calendar on the wall, flower pot with a cactus, flower pot with a foliage plant, table lamp, and window. Scores were gathered at two distinct time points,

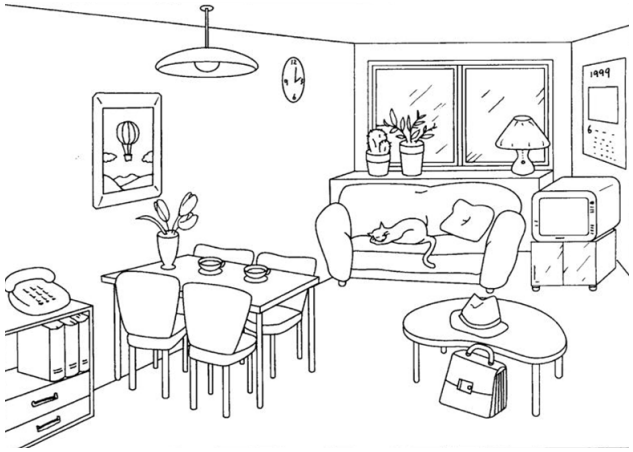

Figure 1. The Scenery Picture Memory Test incorporated a line drawing representation of a living room as a visual stimulus.[14]

that referred to as the "Pretest" and "Posttest". During the first trial, known as the Pretest, the participant is shown an image and given one minute to thoroughly observe and memorize the depicted elements according to the instructions. Following the encoding phase, participants were then engaged in a task designed to divert their attention. Specifically, they were instructed to do a quick digit forward test, which included recalling four-digit sequences composed of the numbers 4, 5, 6, and 7. Subsequently, participants recollected the things seen in the image without any imposed temporal constraints. The duration of this memory period often falls below one minute. The score for SPMT is determined by the number of objects remembered, excluding duplicates, and no additional credit is given for duplicates. Subsequently, after completing all therapies, the SPMT posttest scores were assessed. The question test has been previously verified by Takeuchi et al.[14] The researcher did not require a specific license to conduct the test.

Data analysis

The data were subjected to statistical analysis using the SPSS software. A normality test was performed using the Shapiro-Wilk test. The hypothesis testing used the paired t-test for data that followed a normal distribution, whereas the Wilcoxon test was used for data that did not meet the assumption of normality. The differences among the three groups were assessed using One-Way ANOVA where the data followed a normal distribution, and Kruskal-Wallis tests were used in cases when this assumption was violated.

Ethics

The study was approved to proceed since it was deemed ethically suitable by the Health Research Ethics Committee of the Faculty of Medicine, Diponegoro University (Ethical Clearance No. 209/EC/KEPK/FK-UNDIP/VI/2022). The identity of the individuals was maintained secretly, and all expenses related to this study were borne by the researchers.

RESULTS

Table 1 illustrates that each group consisted of 15 subjects: the group that received intervention via Pilates exercise plus transcendental meditation, the group that received intervention through Pilates exercise alone, and the control group. There

Table 1. Subjects' characteristics

Variables	Groups			p
	Intervention 1	Intervention 2	Control	
Age	35.60 ± 8.22	31.47 ± 8.16	37.07 ± 10.75	0.247‡
Weight	62.73 ± 4.68	61.20 ± 3.58	59.80 ± 4.34	0.177§
Height (m)	1.59 ± 0.25	1.59 ± 0.25	1.58 ± 0.22	0.291§
Body Mass Index	24.72 ± 1.96	23.99 ± 1.51	23.86 ± 1.90	0.386§

‡ Kruskal Wallis, § One Way ANOVA (Analysis of Variance)

were a total of 45 female adults included in the study. The average age of the participants was 34.71 ± 9.23, with the youngest individual being 25 years old and the oldest one being 55 years old. The average age of the control group was found to be greater than that of both intervention groups; however, this difference did not reach statistical significance (p=0.247).

Table 2 displayed the pre-test and post-test scores of the SPMT, as well as the corresponding differences. The pre-test score for the SPMT in the control group was 11.40 ± 0.99 and was the lowest compared to the Pilates plus transcendental meditation group (14.33 ± 2.58) and the Pilates group (14.20 ± 2.24). Given that the control group exhibited the highest mean age compared to the other two groups, it was plausible to consider that age disparities may have influenced the outcomes of the SPMT pre-test scores within the control group. However, it was essential to review since the findings of the Kruskal-Wallis test indicated no significant difference in the mean age among the three groups.

The post-test score for the SPMT in the group that participated in Pilates exercise and transcendental meditation (18.00 ± 2.10) was found to be the highest when compared to the Pilates group (16.33 ± 2.09) and the control group (12.33 ± 1.05) (Table 2). Based on the paired difference test, statistically significant differences were seen across the three groups. Additionally, the unpaired tests indicated substantial differences within the pre-test, post-test, and difference values. All three groups exhibited significant differences in their SPMT pre-test and post-test scores. However, the control group had the lowest difference score compared to the other two groups.

The mean difference in pre-test and post-test scores across all groups was 0.93 ± 1.34 in the control group, 3.67 ± 1.11 in the Pilates exercise and transcendental meditation group, and 2.13 ± 1.19 in the third group. The Games-Howell post-hoc test revealed significant differences in the pre-test between the Pilates exercise and transcendental meditation group and the control group (p=0.002), as well as between the Pilates exercise group and the control group (p=0.001). The Games-Howell post-hoc test was conducted in the post-test, which indicated the presence of statistically significant differences between the Pilates and transcendental meditation group and the control group, as well as between the Pilates group and the control group. The post-hoc LSD test revealed statistically significant differences between the group that engaged in Pilates exercise and the group that practiced transcendental meditation, as well as between the Pilates exercise group and the control group.

DISCUSSION

This study indicated significant improvements in the short-term memory scores of the three groups, whether intervention with 16 sessions of both Pilates exercise and transcendental

Table 2. The SPMT scores of the intervention and control groups

Groups	Pre-test	Post test	p	Differences
Intervention 1	14.33 ± 2.58	18.00 ± 2.10	<0.001¶*	3.67 ± 1.11
Intervention 2	14.20 ± 2.24	16.33 ± 2.09	<0.001¶*	2.13 ± 1.19
Control	11.40 ± 0.99	12.33 ± 1.05	0.017¶*	0.93 ± 1.34
P	<0.001§*	<0.001§*		<0.001§*

* Significant (p < 0,05); ¶ paired t-test; § One Way ANOVA Analysis of Variance, SPMT: Scenery Picture Memory Test

Table 3. Post-hoc test result

Groups		Pre-test¥	Post-test¥	Differences£
I	II			
Pilates + transcendental meditation	Pilates	0.988	0.093	0.001*
	Control	0.002*	<0.001*	<0.001*
Pilates	Control	0.001*	<0.001*	0.010*

* Significant (p < 0,05); ¥ Games-Howell; £ LSD: Least Significant Difference

meditation or without transcendental meditation, as well as the control group. However, this study revealed that the group with the intervention of both Pilates exercise and transcendental meditation or without transcendental meditation had more differences compared to the control group.

The findings of this study are consistent with those of Hötting K et al., which elucidated that enhancements in cognitive processes may arise from neurogenesis and synaptic plasticity resulting from physical activity.[15] Neurogenesis is the biological process responsible for the new formation of neurons inside the brain, which subsequently undergo structural and functional modifications to align with intended outcomes.[16] Engaging in physical exercise has the potential to elicit brain stimulation, hence facilitating the initiation of cognitive processes involved in learning and thinking. Hence, it is possible to enhance short-term memory. In 2011, Patrick et al. performed a meta-analysis research that examined the impact of aerobic exercise on neurocognitive performance. The research included in this analysis was limited to randomized controlled trials. The findings of this study suggest that aerobic exercise training has shown minor enhancements in attention and processing speed, executive function, and memory. However, the impact of exercise on working memory seems inconsistent.[17] The observation that aerobic exercise enhances memory aligns with several animal studies that proposed an association between physical activity and heightened brain-derived neurotrophic factor (BDNF) production in the hippocampus and peri-hippocampal regions.[18–20] The research conducted by Tsai et al. yielded comparable findings about the impact of acute aerobic exercise on BDNF levels and task-switching performance in young people. This research demonstrated a noteworthy finding that acute aerobic exercise reduces response time among participants in the Exercise intervention group. This finding supports the hypothesis that the brain mechanisms underlying the benefits of aerobic exercise may be contingent upon an individual fitness level. The study found no significant correlation between BDNF concentrations and changes in neuropsychological and neurophysiological performances in either exercise-intervention group. Therefore, we suggest that serum BDNF is unlikely to serve as a contributing factor to the observed positive effects on neuropsychological and neurophysiological performance in young adults following acute aerobic exercise.[21]

Physical exercise with Pilates can maximize concentration and self-confidence. By doing Pilates exercise, the body becomes more flexible and fit, thus achieving optimal health. Cognitive function also improves as health improves and initiates short-term memory.[22]

The hippocampus is a crucial component of the brain that plays a significant role in the cognitive process of memory consolidation and retrieval. The potential for its activity to enhance post-exercise may be due to the presence of BDNF in the serum.[23] Elevation of serum BDNF is associated with memory function improvement through neurogenesis induction, synaptic plasticity, and modulation of synaptic structures during physical training.[24] A study stated that physical activity increases the peripheral and central circulation, two of which are the anterior cingulate cortex (ACC) and the hippocampus.[25] The surge of circulation would influence the neuron's viability. Memory can improve from the synergism of ACC and hippocampus due to increased blood flow.[22]

In addition to engaging in physical exercise, transcendental meditation has the potential to influence several cognitive processes of the human body. Meditation comprises a collection of approaches that center on one's attention and awareness development, with the primary objective of attaining heightened states of comfort, tranquility, and concentration. In a relaxed body state during meditation, a significant rise in alpha wave leads to the release of endorphins. This hormone possesses various functions, such as mediating pain, relieving stress, anti-aging, and improving immunity.[26] As a result, achieving optimal physiology will launch undisturbed information that leads to better cognitive functions.

The findings of this study indicated that the groups exposed to Pilates, with or without transcendental meditation, had a significant improvement in their short-term memory score. The control group also showed enhancements in short-term memory, which might be attributed to several variables such as genetics, diet, physical activity, stress levels, or uncontrolled activities. Nutrition is a basic need to fulfill for performing optimal activities. Lack of nutrition can cause

functional, structural, or neurochemical changes within the central nervous system. This may lead to alterations in cognitive development. Individuals with a lack of nutrition can have decreased short-term memory. Psychological disruptions such as stress can also influence the capability of storing memory.[16] The control of cortisol response under stress and its impact on memory performance is mediated by the hippocampus and prefrontal cortex, which function in a feedback loop with the hypothalamus-pituitary-adrenal (HPA) axis. This axis contains a multitude of cortisol receptors.

This research had some limitations as the researchers could not fully control the activities of each subject outside the given interventions. Other activities that may cause ambiguity affect the stress level, nutritional intake, physical condition, or any other acts may impact short-term memory as explained. Besides, online data collection makes it difficult to control the subjects' side activities during data retrieval.

CONCLUSION

Both Pilates exercise and transcendental meditation are effective in improving short-term memory. Comparison between the short-term memory scores of both intervention groups showed significant differences. Therefore, the combination of Pilates exercise and transcendental meditation can be more effective in improving short-term memory. Additional investigation is necessary to enhance comprehension of the impact of Pilates exercise and transcendental meditation on short-term memory. The recommendation for future study is to extend the treatment durations and to use diverse short-term memory function assessment techniques.

CONFLICT OF INTEREST

The authors assert no conflicts of interest from external entities throughout the investigation. The research was conducted autonomously, without any external influence from the sponsoring entity.

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AUTHOR CONTRIBUTION

YS served as a research supervisor, offering guidance, oversight, and intellectual input to researchers under his supervision. AFAZ served as the chairwoman in the study, while MRWE was a part of the research team. The chairwoman and members collaboratively engaged in activities such as sourcing references, drafting research publications, conducting research, and submitting research findings. The article had been reviewed and endorsed by all authors.

LIST OF ABBREVIATIONS

CRP: C-Reactive Protein; NFκB: Nuclear Factor-kappa B; BDNF: Brain-Derived Neurotropic Factor; MRI: Magnetic Resonance Imaging; GH: Growth Factor; HPA: Hipothalamus-Pitutary-Adrenal; ACC: Anterior Cingulate Cortex; IGF-1: Insulin Growth Factor-1; 5-HT: 5-hydroxytryptamine, SPMT: Scenery Picture Memory Test; EEG: Electroencephaloraph; REM: Rapid Eye Movement

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