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Effectiveness of Aerobic Exercise and Meditation on Short-term Memory and Attention in Young University Students with Depression: A Randomized Control Trial

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Abstract

Introduction

Depression is commonly found to be negatively associated with memory and attention and results in poor academic performance. Psychological comorbidity among university students is a neglected problem and holds major implications for campus health services. Purpose of this study was to determine the effect of aerobic exercise and meditation on Short-term Memory (STM) and attention in young university students with depression.

Methods

Thirty participants in the age group of 18-25 years were recruited using Beck Depression Inventory version II (BDI-II) and randomly assigned to control (MG) and experimental groups (AG). MG listened to audio of Guided Mindfulness Meditation Series 1 except track 2 by Jon Kabat-Zinn for 10 minutes and AG was administrated with aerobic exercise (60%-70% of maximum heart rate) for 20 minutes. Both groups attended a total of 12 sessions, 3 sessions per week on alternate days for four weeks consecutively. Participants were tested 1-day prior and 1-day post intervention using Digit Span Forward and Backward Test for STM and Digit Symbol Substitution Test for attention.

Results

Participants mean age ± SD was 21.07 ± 1.1. Both the groups had significant improvement in STM (MG mean difference ± SD=-2.53 ± 1.06, p-value <0.001; AG mean difference ± SD=-5.86 ± 3.28, p-value <0.001) and attention (MG mean difference ± SD=-7.40 ± 3.98, p-value <0.001; AG mean difference ± SD=-26.64 ± 7.22, p-value <0.001). Between groups comparison showed significant differences in both STM and attention (p-value <0.002 and <0.001 respectively). In addition, AG exhibited much improvement compared to MG in terms of BDI-II score (MG mean difference ± SD=4.60 ± 1.40 *vs* AG mean difference ± SD=8.71 ± 6.60, p-value=0.038).

Conclusion

Both meditation and aerobic exercise can improve the short term memory and attention in young adults with depression but aerobic exercise seems to bring more beneficial effects as indicated by between group differences. Further study with large sample size needs to be carried out for making generalization.

Keywords Depression; Short-term memory; Attention; Aerobic exercise; Meditation

Introduction

According to the World Health Organization, more than 300 million people are affected by depression globally [1]. Concerns are increasing regarding the mental health of students in tertiary education as it is considered to be a highly stressful period which can affect physiological wellbeing and result in poor academic performance [2]. Trying to fit in, away from home, maintains good grades and plan for the future often causes anxiety [3]. As a reaction to this stress, some students get depressed. High prevalence of psychological comorbidity among university students have been reported worldwide, especially depression [4-8]. Depression has been found to negatively affect the cognitive function including the short-term memory and attention [9,10]. It is a neglected health problem and holds major implications for campus health services [8,11]. Mild to moderate depression can be managed non-pharmacologically by various approaches. Meditation and aerobic exercise have been found to enhance cognitive function; meditation improves visual and spatial processing thereby enhancing the efficiency in retrieving short and long-term memory in addition to

reducing anxiety and depression; on the other hand, aerobic exercise is strongly associated with improving and maintaining the memory and attention [12-15]. Studies have demonstrated that improvement in cognitive functions associated with aerobic exercise are preferentially by alterations in the peri-hippocampal region, anterior white matter tracks and anterior cingulate [16-18]. To our knowledge, no study till date has been carried out on university students with depression to find the effect of aerobic exercise and mindfulness meditation on short-term memory and attention in this population. Hence, there was a need for this investigation.

Materials and Methods

Thirty UTAR Sungai Long Campus undergraduate students of either gender between 18-25 years were recruited using Beck Depression Inventory Second Edition (BDI-II) which has high internal consistency reliability (α=0.89) [19]. Only those with a score of 14 and above in BDI-II were selected and randomly assigned to either control group (MG=15) or experimental group (AG=15). Randomization was done by drawing lots from a box filled with 15 papers written as "1" (control group) and 15 papers written "2" (experimental group). Exclusion criteria were; those involved in aerobic or resistance training from past 3 months, participation in relaxation activities such as yoga and meditation in the past 3 months, medication for depression, presence of cardiovascular, musculoskeletal or neurological disorders that would limit participants to engage in aerobic training. Short-term memory and attention were tested at baseline (1 day before intervention) and 1 day post intervention using Digit Span Forward and Backward Test for short-term memory and Digit Symbol Substitution Test for attention; these tests are a part of the Wechsler Adult Intelligence Scale (WAIS) [20]. Digit Span Forward Test was administrated first, which consisted of 2 sets of 7 series of numbers that were increased progressively from three digits to nine digits. The researcher gave the instruction; "*I will read a series of numbers, repeat after me after I have finished.*" The researcher read aloud to the participant the numbers at a rate of one digit per second monotonously and the participant had to repeat each number from memory immediately. Both sets of the same length of numbers were administrated during this test. The Digit Span Forward Test was completed when the participant made 2 consecutive mistakes on the numbers with the same length or when 2 sets of 9 digits had been repeated successfully. This was followed by Digit Span Backward Test which consisted of 2 sets of 7 series of numbers that were increased from two digits to eight digits. The participants were instructed; "*Repeat these numbers after me, but this time I want you to say them in a reversed order.*" The total score of both Digit Span Forward and Backward Test were summed for short-term memory score. Digit Symbol Substitution Test was carried out at last. This was printed out on a sheet of paper where there was a key numbered 1 to 9 with each number being ascribed with a symbol at the top of the paper. Below the key numbers and its associated symbol, there were 5 rows of 25 random distributed numbers between 1 and 9 with blank spaces below the numbers. Participants were asked to fill in as many symbols as possible into the blank spaces accordingly from the first row to the last row from left to right in 1 minute 30 seconds. The score for attention was given by counting the number of correct substitution of symbols inserted. This study was approved by the UTAR Scientific and Ethical Review Committee (SERC) before commencing the data collection (Figure 1).

Intervention

MG listened to 10 minutes audio of Guided Mindfulness Meditation Series 1– (Excerpt Track 2) by Jon Kabat-Zinn 3 times per week on alternate days (except weekend) continuously for 4 weeks. The meditation sessions were held in the morning 8.30am every day in the physiotherapy centre, UTAR Sungai Long Campus. During the meditation session, the participants were instructed to sit down on the floor with legs crossed, hands relaxed on their legs and eyes closed. They then listened to audio and followed the instructions of the audio [21]. AG performed aerobic exercise at 60%-70% of maximum heart rate for 20 minutes excluding 5 minutes warm up & 5 minutes cool down on the treadmill without inclination (model: American motion fitness, treadmill fitness 8800D) in UTAR Sungai Long Campus gymnasium. Warm up & cool down was carried out by brisk walk on treadmill at an intensity of 40%-60% of participants target heart rate. Before beginning the exercise, the resting heart rate of each participant was measured with the pulse oximeter (model:JD0486Z) in sitting position to calculate the target heart rate. Karvonen Formula [Target Heart Rate=60%-70%x(220–age–HRrest)+HRrest] was used to calculate the maximum heart rate for each participant.

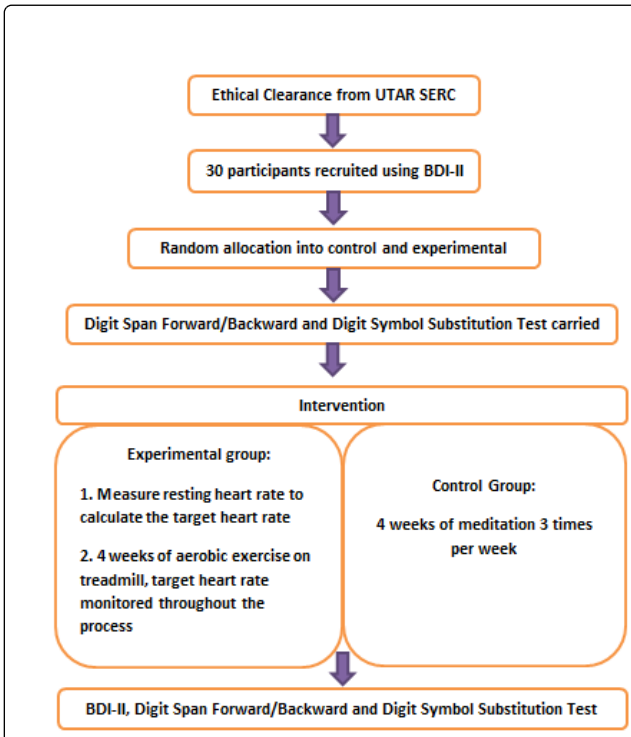

Figure 1: Flow chart of procedure.

Results

There were 11 male and 4 female in MG and 9 female and 5 male in AG. Mean age (SD) of participants in MG group was 20.71 (0.91) and AG was 21.40 (1.18). Most of the participants had mild (51.7%) to moderate (41.4%) depression, only 2 had severe depression at baseline and post-test showed 14 (48.3%) had fallen into minimal depression category, 11 (37.95%) had moderate depression and 1 severe depression as depicted in Table 1. Between group comparison exhibited significant difference in BDI-II scores (95% CI=-7.969 -

-0.259, t=-2.287, p=0.038); MG mean difference (SD) was 4.60 (1.40) and it was lower than BDI-II Score of AG 8.71 (6.59) indicating MG had better improvement compared to MG.

Severity of Depression	Frequency (%)
Pre-test level	
Mild Depression	15 (51.7)
Moderate Depression	12 (41.4)
Severe Depression	2 (6.9)
Post-test level	
Mild Depression	11 (37.9)
Moderate Depression	3 (10.3)
Severe Depression	1 (3.4)

Table 1: Distribution of the depression severity.

Descriptive analysis

There was significant improvement seen in short-term memory and attention scores in both AG and MG. AG had a mean difference (SD) of -5.86 (3.28) in memory score which was higher than the mean score of MG -2.53 (1.06) as shown in Table 2.

	Short Term Memory Test Scores Mean (SD)	95% CI	p value
Pre-Test (AG)	14.43 (1.99)	(-7.75) – (-3.96)	<0.001
Post-Test (AG)	20.29 (2.84)		
Pre-Test (MG)	14.60 (1.92)	(-3.12) – (-1.9)	<0.001
Post-Test (MG)	17.13 (1.69)		
Paired-sample t-test, level of significant at <0.05,			
CI=Confidence Interval			

Table 2: The differences in Short Term Memory Test Scores.

Similar results were observed in terms of attention scores. AG had a mean difference (SD) of -26.64 (7.22) and MG had -7.40 (3.98) in attention score (Table 3).

	Attention Test Score Mean (SD)	95% CI	P value
Pre-Test (AG)	63.29 (9.46)	(-30.81) – (-22.48)	<0.001
Post-Test (AG)	89.93 (11.96)		
Pre-Test (MG)	63.60 (7.95)	(-9.603) – (-5.197)	<0.001
Post-Test (MG)	71.00 (8.62)		
Paired-sample t-test, level of significant at <0.05,			
CI=Confidence Interval			

Table 3: The differences in Attention Test Scores.

Comparison of the memory and attention scores between groups can be seen in Table 4; AG had resulted in significant improvement compared to MG in both these outcome measures (memory; t=-3.621, attention; t=-8.805) exhibiting aerobic exercise was superior to meditation.

	Mean Difference (SD)	95% CI	p value
Memory (MG)	2.53 (1.060)	(-5.275) – (-1.373)	<0.002
Memory (AG)	5.86 (3.28)		
Attention (MG)	7.40 (3.98)	(-23.80) – (-14.68)	<0.001
Attention (AG)	26.64 (7.22)		
Independent samples t-test, level of significant at <0.05,			
CI=Confidence Interval			

Table 4: Comparison of short term memory & attention scores among AG & MG.

Discussion

To our knowledge, this is the first study to compare the effect of mindfulness meditation and aerobic exercise on short-term memory and attention in young adults affected by depression. Both the groups exhibited significant improvement in short-tern memory and attention, but AG was found to have much improved effects compared to MG indicating that aerobic exercise is superior among the two interventions used. Recently, the therapeutic use of meditation, including mindfulness-based techniques has become increasingly important in the treatment of psychological conditions [22]. Mindfulness meditation enhances attention [13,23,24] and improves the memory [12,25,26] and the results of these studies were similar to our findings. Neuro-scientific evidence suggests that meditation alters the function and structure of distributed neural processes underlying attention and memory. Although no direct measures of brain changes were investigated in this study, some previous studies suggest that changes in brain networks can occur. Kang et al. found long-term meditators have greater cortical thickness in the anterior regions of the brain, located in frontal and temporal areas, including the medial prefrontal cortex, superior frontal cortex, temporal pole and the middle and interior temporal cortices compared to controls [27]. Other mechanisms include increased cerebral perfusion in prefrontal, parietal and auditory cortex [25] and a protective effect on grey matter thickness [23]. In addition, meditation can improve myelination or re-structuralization of white-matter tracts in the involved areas such as anterior corona radiate associated with the anterior cingulate cortex [28]. Another explanation of the neuroprotective effect of meditation can be the decrease in cortisol level caused by stress [29], which may be the reason why we observed decrease in severity of depression in the post-test as long-term stress caused by elevated cortisol level can lead to depression.

Results of our study showed aerobic exercise were superior to meditation in improving the short-term memory and attention and our findings were consistent with previous literature [14,15]. Physiological basis how aerobic exercise enhances cognitive function is by promoting the blood supply to the brain, increase neural survivor and generate new brain cells [30,31]. The increase in blood supply of the brain is due to increase in cardiac output, arterial baroreflex and chemoreflex control besides cerebral neuronal activity and brain metabolism [32]. Moreover, the Brain-derived Neurotropic Factor (BDNF) important for memory, learning and higher thinking is found to increase in the hippocampus, cerebellum and cortex which support the survival of existing neurons, encourage growth of neurons and differentiation of new neurons and synapse [30]. Results of our study also indicated that aerobic group had benefited better in decreasing depression than meditation group. Depression decrease neurogenesis while the renewal or survival of neuron cells can reduce depressive symptoms and aerobic exercise plays an important role in neural survivor and generate new brain cells [30,33]. However, under normal conditions, these cells degenerate and die off before differentiation occurs.

Although aerobic exercise and meditation can improve memory and attention, larger effects have been determined following the combination of both. It has been demonstrated that aerobic exercise and meditation together has a better increase in neurogenesis than meditation and aerobic exercise alone [31,33]. We suggest using these two protocols in combination to investigate its effect on cognitive function among depression population. In addition, we suggest including another group who do not participate in either protocols and use direct measures of brain changes through Medical Resonance Imaging (MRI) to support the effects of aerobic exercise and meditation.

Conclusion

Both mindfulness meditation and aerobic exercise are helpful in reducing the depression and improving the short-term memory and attention, but aerobic exercise seems to be more beneficial based on our findings. Further study with large sample size needs to be carried out before making generalization.

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