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EFFECT OF EXERCISE COMBINED WITH MUSIC ON WORKING MEMORY AND MOOD IN YOUNG ADULTS WITH ANXIETY SYMPTOMS

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ABSTRACT

Exercise has positive effects on cognitive function and mood in young adults. It is unknown, however, if combinations of non-pharmaceutical interventions can produce more benefits than single ones. This study aimed to identify if exercise combined with music improves working memory and mood in young adults with anxiety symptoms more than exercise alone. A randomized controlled trial with pre-test and post-test study design was carried out to test the effect of music with exercise on working memory and mood. We enrolled 32 subjects (age 18-25 years old). Sixteen subjects performed exercise (three times a week for 15 minutes with physiotherapists) with musical accompaniment (experimental group). Three relaxing pieces of music were used. 16 subjects performed the same exercise without music (control group). Working memory was assessed using Dual n-Back task (Level 3) and mood was assessed using Short Version of Mood and Feelings Questionnaire. Two ways mixed-method ANOVA was used to determine the effect of time (pre-test & post-test), groups (experimental & control) and interaction between time and control on working memory and mood. The findings support facilitating effect of music with exercise on working memory performance ($p<0.001$). No statistically significant difference was found in mood. Exercise combined with music produced more positive effects on working memory in people with anxiety symptoms than exercise alone. We attributed this improvement to the multifaceted nature of combining physical exercise with music.

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INTRODUCTION

Anxiety disorders become the sixth major cause of disability worldwide in high-income and middle-income countries. Prevalence of anxiety among adults is strongly associated with various factors such as depression, serious problems at work, unhappy relationship with family and low self-esteem[1]. Nowadays, anxiety disorders are common among young adults. According to Bandelow et al. (2015), one third (33.7%) of the population is influenced by the anxiety disorder in their lifetime [2]. Generalized Anxiety Disorder (GAD) is a long-term condition that causes you to feel anxious about a wide range of situations and issues, rather than one specific event. People with GAD feel anxious most days and often struggle to remember the last time they felt relaxed. Although psychological and pharmacological treatments are the most commonly utilized interventions for anxiety disorders, most of the individuals do not fully respond to these treatments. In addition, lack of awareness of the anxiety disorder among adults leads to aggravate the condition and become an illness burden to the government. Neurocognitive studies of mood and anxiety disorders also suggest a general disturbance of cognitive control as they regularly identify large-scale deficits in stopping and changing responses in a variety of tasks[3]. Anxiety disorders are associated with alterations in fear neurocircuitry such that 'bottom-up' processes in the amygdala which respond to threat are exaggerated, and regulation of these processes by the prefrontal cortex (PFC) and hippocampus is impaired. Chronic stress exposure similarly alters fear neurocircuitry by enhancing amygdalar functioning while causing structural degeneration in the PFC and hippocampus thereby inhibiting PFC/hippocampus control over the stress response. It has been shown that anxiety disrupts cognitive performance, including WM[4]. WM refers to the cognitive process through which complex information is retained and manipulated over a short period of time, and it is essential to the integration of information [5]. and the optimal performance of goal-oriented behaviors[6]. According to the basic tenets of Attentional Control Theory, anxiety is believed to bias the attentional system in favor of bottom-up processing over top-down control exaggerating the impact of emotional (threat-related) stimuli [7] and concurrent load [8] on working memory.

Mood is an emotional condition that is not that intense and not that specific. Depression is a common mood disorder. Mood disorders are characterized by a serious change in mood that causes disruption to life activities. Depression and anxiety disorders are among the most common illnesses in the community and in primary care. Clients with anxiety disorders often have features of depression, and those with depression commonly also have anxiety. Both disorders may occur together, meeting criteria for both. It can be difficult to discriminate between them [9].

There are a number of treatments designed to reduce the symptoms experienced by those afflicted with anxiety disorders. The mainstay of treatment as approved by the FDA for this disorder is pharmacological treatment with anxiolytics or antidepressants. Alternative treatments include cognitive behavioral therapy, healthy eating, getting the proper amount of sleep, and relaxation techniques such as massage, deep breathing, meditation, yoga, music, and exercising. Recent studies on exercise depict a variety of mental health benefits, including improving mental focus, memory, cognitive flexibility, and helping the brain cope better with stress [10].

Exercise may represent a promising, affordable, and easily accessible treatment option for individuals with anxiety. Exercise is distinguished from other forms of physical activity in that it is a planned, structured, repetitive endeavor with the goal of improving physical fitness [11]. A systematic review on the effect of exercise training on anxiety symptoms among patients concluded that exercise training significantly reduced anxiety symptoms [12]. Cycling is an exercise that is worth encouraging for people with anxiety. Previous studies have confirmed that cycling can increase positive emotions [13] and improve brain wave patterns [14].

Additionally, the alternative use of music in reducing anxiety has also been found to improve the body's immune system and brain function [15]. As a result, the development of cost-effective solutions to anxiety reduction has become a major undertaking of current research efforts. Music as a therapeutic approach was evaluated, and found to decrease anxiety[16]. Its low cost, ease of administration, and minimal (if any) adverse side effects make it an ideal treatment option[17]. Music can reduce sympathetic nervous system activity, decrease anxiety, blood pressure, heart and respiratory rate and may have positive effects via muscle relaxation and distraction from thoughts[18].

Given the considerable effect of music, we hypothesize that combining exercise with music will enhance mood and working memory. This study proposes exercise combined with music as a novel approach for clients with anxiety symptoms. In the present study, we investigated the effect of physical exercise with and without music on working memory and mood among young adults with anxiety symptoms.

METHODS

A randomized controlled trial with pre-test and post-test study design was carried out to investigate the effects of music in synchronization with exercise on mood and working memory among young adults with GAD. The subjects were university students of either gender aged 18 to 25 years, suffering from anxiety symptoms. Subjects with hearing disability, tinnitus, obesity (BMI $\geq$ 30) and those on anti-anxiety drugs were excluded from the study. The potential subjects were screened using Beck Anxiety Inventory (BAI) and Physical Activity Readiness Questionnaire (PAR-Q+). The height and weight of the subjects were measured for the characteristic references by using weighing scale with stadiometer. Sample size was calculated using Biomath software and a total of 32 subjects (14 males and 18 females) were recruited through convenient sampling method. A block randomization was performed by using computer-generated random numbers (Research Randomiser). Participants were randomly assigned into two groups i.e.; control group (n=16) and experimental group (n=16). This study followed single blinding as the subjects were not informed whether they were participated in either control group or experimental group. In both groups, there were 7 males and 9 females. At the beginning of the trial, all subjects were instructed to avoid changes in their daily activity, in particular, their physical activity, until the completion of the experiment. Subjects were also informed that they should not consume any supplement, eat or smoke for two hours prior to the research study period as it provides impact on the result of this study. None of the participants were professional athletes, bodybuilders, or musicians. This study was conducted at Gym Room of Universiti Tunku Abdul Rahman (UTAR), Sungai Long campus. The study was approved by Scientific and Ethical Review Committee (SERC) of UTAR. The researchers briefed the participants about the study and confidentiality was assured. Written consent was obtained from all participants.

Outcome Measures

1. Dual n-Back task (Level 3)

Dual 3n- back task is a test used to measure rking memory paradigm. Dual 3n-back task involves a sequence of spoken letters and a sequence of position in a 3x3 matrix. Both of spoken letter and position need to identify and remember when a letter or position matches the one that appeared earlier. Before the test, a short briefing of dual 3n- back task was given to every subject. The subjects need to wear the earphone connected to the laptop and adjust the volume by themselves. The test was conducted for two trials, and the mean value of two trials was recorded. The validity as an indicator of working memory is proved[19]. An illustration of the test is given in Figure: 1

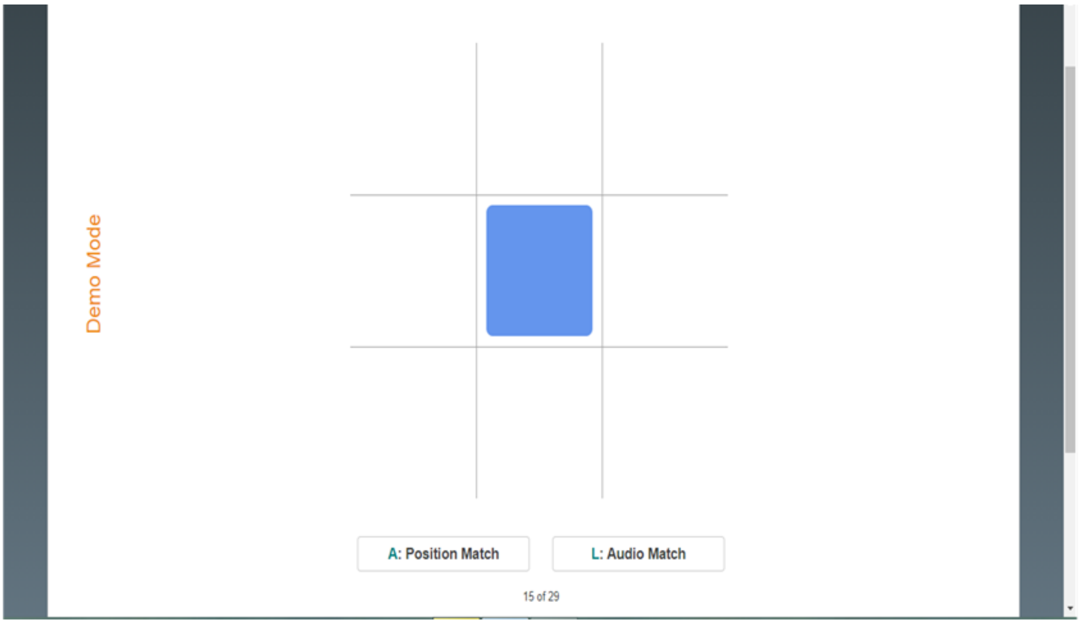

Figure 1: Dual n-Back task (Level 3)

2. Short Version of Mood and Feelings Questionnaire (SMFQ)

This instrument is used an indicator of depressive symptoms. SMFQ is a 13 descriptive phases according to the feeling or acting recently of the subject and also a screening tool for depression symptoms in young people. Each item is rated on a 3-point Likert scale that is 0= not true; 1= sometimes true; 2= true over past two weeks. A previous study reported it as a reliable and valid measure of depression[20]. The short version of adult self-report was used. The score ranges from 0 to 26. Subjects were assessed twice; on the day before and the day after intervention. During the pre-experimental screening session, the subjects who met the inclusion criteria were informed to complete all the tests. Participants completed the tests of working memory, attentional control as well as mood and feelings.

Procedure:

A warm up session was included with the resistance level of stationary bike gradually increased to achieve the targeted heart rate and ensure the subjects maintain the pedal at pace of 50 rpm during the training session. One group carried out the physical exercise with music accompaniment, and another without. Before and after the intervention period, neuropsychological assessment was carried out, and the results with and without musical accompaniment were compared. Participants of the experimental group performed stationary cycling listening music for 15 minutes and control group without any music. A selected music was provided. The music group was given a mobile phone which was prearranged by the researcher; all the participants affirmed that they took pleasure from music. The 20-minute tape consisted of 3 relaxing pieces of music: “Canon in D” composed by Johann Pachelbel; the theme from “Love story” played by Richard Clayderman and “Dance of the iguana” by Stevan Pasero. All the 3 pieces of music had 70–80 beats per minute and were based on slow and steady rhythms. The most relaxing music had a tempo of approximately 60–80 beats per minute. The tape was played through earphones from a mobile phone.

The frequency of training was 1 session per day, 3 days per week, extending 4 weeks. Stationary cycling was used as the mode of exercise because it is suitable exercise equipment for subjects of all ages. Subjects were informed to pedal at a pace of 50 rpm (revolution per minute) which was clearly shown on the display screen of the stationary bike. The oxi-5 finger oximeter (GIMA) was used to monitor oxygen saturation and pulse rate through the subject’s finger (10-22mm finger thickness). The pulse rate of subject was measured and monitored in every 5 minutes of cycling to ensure the targeted exercise pulse rate was maintained. During cycling, the heart rate of the subjects was recorded from the pulse oximeter every 5 minutes to make sure the targeted heart rate was maintained. Training session was followed by 3-minutes cool-down with free workload. Participants were instructed that they can withdraw and terminate the training in case of any discomfort and fatigue feeling. Subjects were instructed to wear comfortable clothes and sport attire (for example, t-shirt, sweat pants, sneakers) in which they can move freely without restriction during the training session.

Calculations are required before the exercise shown as below:

i. Maximal Heart Rate = 208 - (0.7 x Age)

ii. Heart Rate Reserve = Maximal Heart Rate – Resting Heart Rate

iii. Target Exercise Heart Rate = 50% of Heart Rate Reserve + Resting Heart Rate

DATA ANALYSES

Independent samples t test and Chi-square test were used for analyzing the characteristics of subjects. Significance level was set at <0.05. Two ways mixed-method ANOVA was used to determine the effect of time (pre-test & post-test), groups (intervention & control) and interaction between time and control on WM and SMFQ. All statistical analyses were performed by IBM SPSS Statistics software.

RESULTS

Table 1 shows the both groups experimental and control at the baseline are matched in term of age, gender distribution, alcohol drinking, height, weight and BMI. Besides, all the participants are Chinese and non-smokers.

Table 1: Characteristics of Subjects (n=32) at Baseline

Characteristics	Control (n=16)	Experimental (n=16)	p
	m (sd) / n (%)	m (sd) / n (%)	
Age (years)[A]	20.50 (1.03)	20.13 (0.81)	0.262
Gender [B]			
Male	7 (43.8%)	7 (43.8%)	1.00
Female	9 (56.3%)	9 (56.3%)	
Alcohol Drinking [B]			
Yes	2 (50.0%)	2 (50.0%)	1.00
No	14 (50.0%)	14 (50.0%)	
Height (cm) [A]	166.03 (6.86)	166.41 (7.44)	0.883
Weight (kg) [A]	69.56 (22.97)	61.54 (19.15)	0.292
BMI (kg/m²) [A]	25.29 (8.36)	22.00 (5.61)	0.203

[A] Independent samples t test, [B] Chi-square test, significance level at <0.05

The results of paired samples t-test and the findings showed significant differences in WM between pre-test and post-test for both intervention and control group are summarised in Table 2. Similarly, there was significant difference between the pre-test and post-test for both intervention and control groups on SFMQ score.

Table 2: The difference between pre-test and post-test scores

Measurements	Groups	Time of Test		Mean Difference	p
		Pre-test (n=16)	Post-test (n=16)		
		m (sd)	m (sd)		
BAI	Intervention	26.63 (10.24)	14.19 (8.06)	12.43	<0.001*
	Control	22.13 (9.01)	15.69 (7.76)	6.43	0.007*
WM	Intervention	0.17 (0.09)	0.37 (0.15)	-0.19	<0.001*
	Control	0.16 (0.10)	0.25 (0.09)	-0.09	<0.001*
SMFQ	Intervention	6.50 (4.57)	5.44 (4.92)	1.06	0.222
	Control	9.06 (6.43)	7.69 (3.80)	1.37	0.324

Paired samples t test, significance level at <0.05, BAI = Beck Anxiety Inventory Score, WM=Working Memory, SMFQ= Short Version of Mood and Feelings Questionnaire.

Assessing the assumptions to prepare the data set for the two ways mixed ANOVA we started with assessing the distribution of the data set and the existing of the outliers which were assessed by generating the box-plot and the Shapiro-Wilk test of normality. Regarding the data set of WM, and SFMQ score in both pre-test and post-test levels, the results showed there were no outliers in the data of and the data set were normally distributed. The measurements within subjects in two levels (pre-test and post-test) only therefore, there were no need to assess the post-hoc test and assumption of sphericity.

Table 3 shows the results of the mixed method ANOVA test for the BAI, WM, and SMFQ. Regarding to BAI, the main effect of time (test within subjects) showed there was statistically significant difference in mean of BAI at the different time points pre and post levels as $F (1, 30) = 30.56$, $p < 0.001$. However, there was insignificant effect of the groups (test of between subjects) on the BAI mean as $F (1, 30) = 0.329$, $p = 0.57$. Additionally, there was no significant interaction between the times and groups on the BAI mean as $F (1, 30) = 3.088$, $p = 0.089$.

The effect of time was significant on the mean of WM as $F (1, 30) = 52.159$, $p<0.001$. However, the groups intervention and control had no significant effect on the mean of WM as $F (1, 30) = 3.232$, $p= 0.082$. There was significant interaction between the time and the groups as $F (1, 30) = 6.727$, $p= 0.015$.

There was no effect of times of measurements (pre-test and post-test) on the MOOD score as $F (1, 30) = 2.366$, $p= 0.845$. The groups (intervention and control) also has no effect on the SMFQ score as $F (1, 30) = 2.287$, $p= 0.141$ and no interaction between the time and groups as $F (1, 30) = 0.039$, $p= 0.845$.

Table 3: Summary of two ways mixed-method ANOVA results on effect of time (pre-test & post-test), groups (intervention & control) and interaction between time and control on BAI, WM and SMFQ

Variables		*df*	*F*	*p*	partial η^2
Time Points	BAI	(1, 30)	30.56	<0.001*	0.505
(Test of within subjects)	WM	(1,30)	52.159	<0.001*	0.635
	SMFQ	(1,30)	2.366	0.845	0.073
Groups	BAI	(1,30)	0.329	0.57	0.011
(Test of between	WM	(1,30)	3.232	0.082	0.097
subjects)	SMFQ	(1,30)	2.287	0.141	0.071
Interceptions	BAI	(1,30)	3.088	0.089	0.883
Time & Groups	WM	(1,30)	6.727	0.015*	0.183
	SMFQ	(1,30)	0.039	0.845	0.001

BAI = Beck Anxiety Inventory Score, WM = Working Memory, SMFQ = Short Version of Mood and Feelings Questionnaire.

DISCUSSION

The present study suggests that exercise enhances working memory in young adults with anxiety symptoms when combined with music. Disorders of mood and anxiety account for almost 65 percent of psychosocial illness globally and represent a major threat to public health. Exercise has been shown to influence neurophysiological pathways that promote heightened post-exercise cognitive functioning such as processing speed, working memory, and executive function [21]. One mechanism that possibly explains acute exercise effects on cognitive function is through activation changes in the prefrontal cortex (PFC) of the brain [22]. The dorsal lateral prefrontal cortex (DLPFC) is thought to be responsible for cognitive control and goal-directed behavior. The DLPFC is highly active during memory retrieval and in response to mentally arduous tasks[23]. During low to moderate intensity exercise, there is an increase in cerebral blood flow and oxygenation, which may promote distribution of nutrients throughout the brain, and also induce arousal during subsequent cognitive testing[24]. Another proposed link between exercise and cognition is through Brain Derived Neurotrophic Factor (BDNF) induction. Secretion of cathepsin B and Irisin from the contracting muscle have been shown to stimulate BDNF production and improve memory after exercise [25]. Studies suggested that cardiovascular fitness is associated with executive control and its associated brain functions in the frontal, parietal, and temporal regions required for the inhibition and shifting aspects of executive control [26]. Notably, the activation of these regions is also associated with WM, suggesting that the beneficial effects of exercise could extend to WM. In a series of randomized controlled trials exploring the mood-exercise connection, Blumenthal and his colleagues assigned sedentary adults with major depressive disorder to one of four groups: supervised exercise, home-based exercise, antidepressant therapy or a placebo pill. After four months of treatment, participants in the exercise and antidepressant groups had higher rates of remission than did the clients on the placebo. It was concluded that exercise was generally comparable to antidepressants for clients with major depressive disorder [27]. Evidence is mounting for the benefits of exercise, yet psychologists rarely use exercise as part of their treatment arsenal. As evidence piles up, the exercise-mental health connection is becoming impossible to ignore. The basic idea is that any stimulus that improves how a person feels can in turn improve how they perform on a cognitive task. For the first time, a recent study by Janiri et al. (2019) reveals that clients with mood and anxiety disorders share the same differences in emotional and cognitive regulation regions of the brain [28]. The authors reported that people with mood and anxiety disorders exhibited abnormally low activity in the inferior prefrontal and parietal cortex, the insula and the putamen; regions that are central elements of the brain system for emotional and cognitive control and are responsible for stopping ongoing mental activities and switching to new ones.

Music requires constant interaction between the two hemispheres and therefore encourages more harmonious cerebral activity[29]. Studies have also shown that music therapy improves cognitive functions, works on anxiety, depressive periods and aggressiveness, enhancing mood, communication and independence in brain-injured persons dramatically[30]. Several researchers attempted to identify the mechanisms that drive the association between music training and general cognitive abilities. Physical exercise combined with music might act as both cognitive and physical training simultaneously, which would cause a greater improvement in the WM. The parietal lobes might play a key role in the improvement that occurred with the musical accompaniment. It is well known that the parietal lobes participate in visuospatial and somatosensory function, including body image. Several activation [31] and case studies [32] have shown that the parietal lobes likely participate in music perception in the brain. Therefore, the stimulation of the parietal lobes by music and by the somatosensory inputs from physical exercise could cause improvements in visuospatial function. Although mental or perceptual speed may play a role, there has been more speculation that executive functions act as mediating variables [33]. Executive functions refer to a series of mechanisms involved in involved in conscious control of thought, including working memory, inhibiting inappropriate responses, planning ahead, flexibility, concentration, selective attention and ignoring irrelevant information, the ability to change strategies as needed by the situation, and so on.

Music has been shown to beneficially affect cognitive processes [34]. Healthy older adults demonstrated enhanced working memory following music stimuli relative to no music stimuli. Digit Span performance under music condition was significantly stronger than Digit Span performance under no music condition [35]. Janata, Tillman and Bharucha (2002) studied the effect of polyphonic music listening on working memory circuits using experimental neuroimaging. They concluded that attentive listening to polyphonic music stimulates neural circuits including those related to working memory and attention [36]. Therefore, exercise combined with music is an economical, non-invasive, and therapeutic method to manage cognitive problems due to anxiety. We attributed this improvement to the multifaceted nature of combining physical exercise with music. This study provides insight into the benefits and experiences of exercise combined with music in improving WM among people with anxiety symptoms.

In the present study, a statistically significant difference was not shown in the mean values of mood score and no differences comparing both conditions i.e. exercise with music and exercise without music. In our study, however, we used a music stimulus which had already been evaluated as relaxing in previous research [37], so we assumed that this stimulus had stress-attenuating capacity independent of individual preferences. Nevertheless, the way that music affects the brain is very complex. All aspects of music including pitch, tempo, and melody are processed by different areas of the brain. For instance, the cerebellum processes rhythm, the frontal lobes decode the emotional signals created by the music, and a small portion of the right temporal lobe helps understand pitch. Contradictory findings have been reported regarding the effects of familiarity and individual preferences of music and its emotional responses [38, 39]. However; the results of analysis of SMFQ score call for further examination of control variables and methodology. Finally, it is suggested that exercise combined with music may not be appropriate in every situation to enhance mood and therapists should be aware of individual client abilities to adapt their approach.

This study has several limitations. First, the number of the subjects was not very large. Further study with a larger number of participants might show better positive effects. The intervention period was four weeks. A longer intervention period may produce more effects. Further studies are needed to clarify the effects and mechanism of action of combining multiple intervention strategies for the improvement of working memory and mood among young adults with anxiety symptoms.

CONCLUSION

Physical exercise combined with music produced more positive effects on working memory in young adults with anxiety symptoms than exercise alone. We attributed this improvement to the multifaceted nature of combining physical exercise with music.

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CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest in this work.

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