



Faculty of Cognitive Sciences and Human Development

**THE EFFECT OF PHYSICAL ACTIVITY ON WORKING
MEMORY PERFORMANCE**

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PERFORMANCE**

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ABSTRACT

This study aimed to identify the effect of physical activity on working memory performance, which mainly focus on the verbal and visuospatial working memory performance based on the total number of correct recalled and the total time taken. This research is utilize quantitative method with quasi experimental design. The participants were 30 undergraduate students from Universiti Malaysia Sarawak (UNIMAS). The study used 2 working memory test, Reading Span Test to measure the verbal working memory performance while Corsi Blocks Test to measure the visuospatial working memory performance. Independent T-Test and Mann-Whitney U test is used to analyze the results. The findings showed that the physical activity group had performed well for verbal working memory test based on the total number of correct recalled and the total time taken. The physical activity group also have a good performance than the non-physical activity group in visuospatial working memory test in term of total number of correct recalled, but there is no significant differences between both group in term of total time taken. This study also explained the limitations of study, the implications and the recommendation for future research.

Keywords: physical activity, working memory performance, Reading Span Test, Corsi Blocks Test

ABSTRAK

Kajian ini bertujuan untuk mengenal pasti kesan aktiviti fizikal terhadap prestasi ingatan kerja, yang memberi tumpuan terutamanya kepada prestasi ingatan kerja lisan dan visuospatial berdasarkan jumlah bilangan ingatan yang betul dan jumlah masa yang diambil. Penyelidikan ini menggunakan kaedah kuantitatif dengan reka bentuk kuasi eksperimen. Para peserta adalah 30 pelajar sarjana muda Universiti Malaysia Sarawak (UNIMAS). Kajian ini menggunakan 2 ujian memori kerja, Ujian Span Membaca untuk mengukur prestasi ingatan kerja lisan manakala Ujian Corsi Blocks untuk mengukur prestasi memori kerja visuospatial. Ujian Independent-T dan ujian Mann-Whitney U digunakan untuk menganalisis keputusan penyelidikan ini. Dapatan kajian telah menunjukkan bahawa kumpulan aktiviti fizikal menunjukkan prestasi yang baik untuk ujian ingatan kerja lisan berdasarkan jumlah bilangan ingatan yang betul dan jumlah masa yang diambil. Kumpulan aktiviti fizikal juga mempunyai prestasi yang baik berbanding kumpulan aktiviti bukan fizikal dalam ujian memori kerja visuospatial dari segi jumlah bilangan ingatan yang betul, tetapi tiada perbezaan yang signifikan antara kedua-dua kumpulan dari segi jumlah masa yang diambil. Kajian ini juga menjelaskan batasan kajian, implikasi dan cadangan untuk penyelidikan masa depan.

Kata kunci: aktiviti fizikal, prestasi memori kerja, Ujian Span Membaca, Ujian Corsi Blocks

CHAPTER ONE

INTRODUCTION

Researcher will explain the background of study and the problem statement in this chapter. Besides, the general and specific research objectives, research questions, research hypotheses, the conceptual framework of the study, the significance of the study, and the definition of terms will also be discussed.

1.1 Background of Study

Memory has an importance for all of us. Memory encompasses the structures that responsible for storing and subsequently recalling information (McLeod, 2023). Working memory can help people to retain information in their minds while doing hard tasks like thinking, understanding, and learning (Baddeley, 2010). There are different methods, both practical and theoretical, to study working memory. Working memory is a bridge between what people see, remember, and what they do, and it helps people think by keeping and storing information for a short time (Baddeley, 2003). Anggraini (2023) said that working memory is very essential for the memory system, and it can be affected by people's physical activity, age and sleep quality. Working memory capacity increases can help people perform better on a range of tasks, including studies. Hence, interventions including cognitive training, physical activity, meditation, and brain stimulation are important to improve working memory.

López-Vicente et al. (2017) reported that working memory is influenced by healthy lifestyle habits, such as physical activity. Physical activity also can be defined as a muscular

movement that consumes energy (National Heart, Lung and Blood Institute, 2022). World Health Organization (2022) indicated that physical activity is helpful for our health, regardless of its intensity. Some examples of physical activities that people can enjoy and do at any level are walking, cycling, sports, and active recreation. According to Russo et al. (2021), open-skills activities are characterized as physical and sporting activities that are carried out within an evolving environment. Football, basketball, and tennis are a few examples of open-skill activities. Athletes engage in such activities in response to evolving environmental conditions, absorb as much information as they can, and recall it when necessary. Running and cycling, on the other hand, are examples of closed-skill activities in which people engage in situations that are more consistent than before. According to Festa et al. (2023), physical activity can help the brain function more effectively, especially in the areas of executive, memory, and attention. Exercise can improve one's capacity to learn, think critically, solve problems, and maintain psychological balance. Additionally, it may decrease the likelihood of dementia and other forms of cognitive decline (CDC, 2021).

A study by O'Brien et al. (2020) demonstrates how different exercise types (open-skill or closed-skill) impact children's memory capacities. The study shows that verbal working memory is improved by open-skill activity while motor working memory is improved by closed-skill activity. Another similar study which conducted by Kamiyo et al. (2011) shows that working memory and academic ability in preadolescent children can be improved by physical activity. It emphasizes how engaging in physical activity can enhance memory performance by boosting the brain's supply of nutrients, oxygen, and blood while also promoting the development of new brain cells and connections. Gu et al. (2019) discovered that attention, memory, and processing speed, are affiliated differently by various physical activities.

In addition, many studies examined how working memory is influenced by physical activity from various angles. For instance, Serra et al. (2021) proposed that open-skill physical activity could enhance visuospatial working memory in young children. Additionally, similar finding was discovered in a previous study, as participants who were more physically active showed quicker reaction times during a test requiring visuospatial attention (Wang et al., 2014). This shows that increasing physical activity may improve mental and physical abilities. Physical activity also demonstrates a notable impact on working memory in old adults (Zhidong et al., 2021). Exercise frequency, intensity, type, duration, cognitive state, and other factors all had a moderating influence on how physical activity affected working memory.

Most research papers reveal that working memory is significantly affected by physical activity (Anggraini, 2023; Blomstrand & Engvall, 2020; Verburgh et al., 2013). Therefore, the purpose of this study is to examine the effect of physical activity on working memory performance, with the target group among undergraduate students at Universiti Malaysia Sarawak (UNIMAS).

1.2 Problem Statement

The existing literature presents conflicting findings on the effects of physical activity on working memory performance, which emphasizes an important research gap and the need for further research on the topic. Several studies have indicated that physical activity can boost working memory performance. However, not all physical activity has this effect; for instance, Rathore and Lom (2017) highlighted that acute physical activity, such as a single exercise session, cannot greatly increase working memory performance, whereas chronic physical activity (a highly demanding workout) can. It displays the erratic results of how

exercise affects working memory performance. Hence, a more objective and lucid research on how physical activity influences working memory is needed.

Furthermore, Zhu et al. (2023) indicate that physical activity and working memory ability are related in children (4–11 years old) and seniors (58–88 years old), except for young adults (18–35 years old). Besides, most research was conducted in children and seniors (Kamijo et al., 2011; O’Brien et al., 2020; Serra et al., 2021; Zhidong et al., 2021), but minors in young adults. Therefore, a study including young adults, such as university students, is essential to explore whether physical activity has a substantial effect on working memory performance.

According to well-known theory of Baddeley (1992), working memory is the short-term storage for information in connection with other cognitive activities as well as learning and problem-solving. The phonological loop and the visuospatial sketchpad, that process linguistic and spatial data, respectively are the slave systems of Baddeley’s model (Kessels et al., 2015). However, most of the past studies only conducted visuospatial tests to evaluate working memory performance. For example, there are several researches by Zhu et al. (2023) and Serra et al. (2021) showing that physical activity has a significant effect on visuospatial working memory performance. Hence, this study will utilize both verbal and visuospatial tasks to measure how physical activity can affect working memory performance.

Compared to conducting research in Asian cultures, especially in Malaysian contexts, the majority of literature that related physical activity and working memory were focused on Western cultures. In addition, English was primarily used in the research as the instruction language. However, Bahasa Melayu will be used as the medium of instruction since this study will be applied to a Malaysian context, and it will be studied to determine whether the results can vary due to cultural differences between the different countries.

Therefore, the study aims to investigate the effect of physical activity on working memory performance.

1.3 Research Objectives

1.3.1 General Objective

To investigate the differences between physical activity and non-physical activity group on working memory performance.

1.3.2 Specific Objectives

- To investigate the differences between physical activity and non-physical activity group on verbal working memory performance based on the total number of correct recalled.
- To investigate the differences between physical activity and non-physical activity group on verbal working memory performance based on the total time taken.
- To investigate the differences between physical activity and non-physical activity group on visuospatial working memory performance based on the total number of correct recalled.
- To investigate the differences between physical activity and non-physical activity group on visuospatial working memory performance based on the total time taken.

1.4 Research Questions

- Is there any significant difference between the physical activity and non-physical activity group on verbal working memory performance based on the total number of correct recalled?
- Is there any significant difference between the physical activity and non-physical activity group on verbal working memory performance based on the total time taken?
- Is there any significant difference between the physical activity and non-physical activity group on visuospatial working memory performance based on the total number of correct recalled?
- Is there any significant difference between the physical activity and non-physical activity group on visuospatial working memory performance based on the total time taken?

1.5 Research Hypotheses

H1: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total number of correct recalled.

H2: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken.

H3: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled.

H4: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken.

1.6 Conceptual Framework

Figure 1.1: *Conceptual framework of the physical activity and working memory performance.*

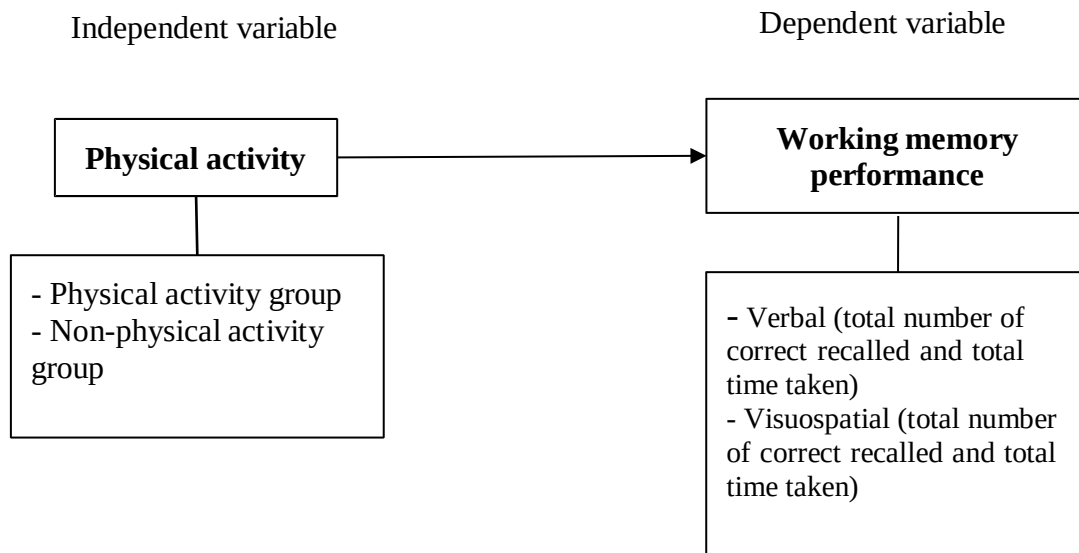


Figure 1.1 illustrates the independent variables are the physical activity group and the non-physical activity group whereas the dependent variable is working memory performance. The physical activity variable consists of a physical activity group (experiment group) and a non-physical activity group (control group) while working memory performance will be measured by two tasks: the reading span task will evaluate verbal working memory and the Corsi Blocks will measure visuospatial working memory. The total amount of correctly recalled items and the total length of time participants took in response to the tasks will use as a standard for measuring working memory.

1.7 Significance of Study

The project aims at investigating the effect of physical activity on working memory performance among the undergraduates of Universiti Malaysia Sarawak (UNIMAS). This study aims to determine whether its findings align more with the advantageous or adverse

effects of physical activity on the working memory performance of university students. This research can contribute to a pool of body knowledge on the possible impact of physical activity on working memory. The study will help people have a better understanding of how important physical activity can be for memory capacity and performance. Therefore, it has an opportunity to produce a beneficial impact on people of all ages and to assist in the larger effort to improve cognitive well-being and general quality of life. In order to support future research, the study will also provide more insight and exploration into how working memory and exercise are related.

1.8 Definition of Terms

1.8.1 Physical activity

Conceptual Definition: Physical activity is engaging the body's muscles and requiring energy entails an energy expenditure measured in kilocalories (Caspersen et al., 1985). Common physical activity encompasses occupational, sporting, household, and other activities.

Operational Definition: The physical activity in this study refers to a cardiovascular physical activity, which is walking around stadium UNIMAS for 10 minutes.

1.8.2 Working Memory

Conceptual Definition: Working memory not accord short-term memory, which generally accredit to storing knowledge throughout a short while, typically a few seconds (Alloway & Copello, 2013).

Operational Definition: In this research, working memory performance is considered by the reading span test (verbal working memory test) and the Corsi Blocks test (visuospatial working memory test) to see how well the participants can recall the items as well as the total time taken.

1.9 Summary

In conclusion, this chapter introduces the topic, the background of the study, and the issues to be addressed. In addition, the chapter discusses the study's objectives, research questions, research hypothesis, theoretical framework, and significance.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

This chapter will demonstrate the theories, the past studies that discussed the effect of physical activity on working memory performance, and the improvement in the present study.

2.1 Physical Activity

2.1.1 Theory Related Physical Activity

2.1.1.1 Social Cognitive Theory

The Social Cognitive Theory (SCT) explains how individual experiences, other people's behaviors, and external factors affect an individual's health behaviors. This theory has been extensively used in the creation and assessment of interventions that target enhancing physical activity intensity. Bandura (2004) highlighted that SCT encourages people to effectively manage their wellness behaviors to maintain health throughout their lives. Social Cognitive Theory also provides guidelines for informing, enabling, guiding, and motivating people to change unhealthy habits and increase healthy ones. In addition to acquiring an understanding of maintaining a healthy lifestyle, most people require other self-influence to help them overcome the challenges of forming and sustaining healthy lifestyle habits. Therefore, a key component of personal development is believing in one's efficacy.

The most essential element in this Social Cognitive Theory framework is self-efficacy, which characterize people's belief in their capacity to choose their health behaviors (Bandura, 2004). Young et al. (2016) indicated that individuals with higher self-efficacy also had higher

likelihood of the beneficial effects of physical activity. They were more determined to involve in regular physical activity and reported stronger family support for physical activity.

2.1.1.2 Self-determination Theory

Sustained exercise is linked to significant health benefits, and motivation is crucial in facilitating this. Regular engagement in physical activity and exercise is extremely beneficial to both mental and physical health. Self-determination Theory (SDT) is a theoretical framework for human motivation that concentrates on the differences in the impact of qualitatively distinct motivational types that might influence behavior (Ryan&Deci, 2017). According to Teixeira et al. (2012), this theory makes a distinction between the two main motivational systems that control behaviour which are extrinsic and intrinsic motivation. Intrinsic motivation is an activity performed for innate advantages while extrinsic motivation is an activity followed for a benefit or to escape a punishment.

Most physical activity can be driven by both internal and external factors when Self-determination Theory is employed. Based on the theory, participating in physical activity serves as a satisfying activity that enhances individual happiness and enjoyment (Ryan et al., 2009). Hence, people who find physical activity engaging, entertaining, and difficult are intrinsically motivated. On the other hand, the majority of people keep exercising as they would like to achieve a certain goal rather than because they find the exercises fascinating or enjoyable in the first place. People are extrinsically motivated, for instance, when they desire to become healthier or look prettier. Therefore, a person's behavior is more self-directed when they do something that they find useful and meaningful rather than enjoyable in itself.

2.2 Working Memory

2.2.1 Background of Working Memory

Working memory involves elements that briefly hold a small set of information, prepared for immediate use in cognitive tasks. (Cowan, 2017). According to Shipstead et al. (2012), working memory is closely linked to an individual's capacity to concentrate on information that is associated with their goals with novel knowledge. It is essential to intelligent thinking because it allows knowledge to be maintained and modified continuously. Mental arithmetic is a significant example, where we mentally store numbers, alternately focus on various subsets of numbers, employ our long-term mathematical expertise, and substitute the solution for the operands (Nee et al., 2012).

Besides, short-term memory and additional processing techniques that facilitate short-term memory utilization are included in working memory. Working memory, in Engle's (2002) opinion, solely refers to the parts of short-term memory that are associated with attention. In his view, traditional measurements of short-term memory primarily represent memory processes like chunking, grouping, and rehearsing, whereas measures of working memory capacity indicate both executive memory as well as attention tasks (Engle, 2002).

Baddeley and Hitch (1974) indicated that working memory temporarily stores and modifies input to handle complicated jobs. Additionally, they clarified how working memory functions as an instrument in problem-solving, information flow management, and decision-making. In 1974, the multifaceted model of working memory was introduced by Baddeley and Hitch, which suggests that every component has limited space that can be assigned between controlling processing demands and storing information. The working memory model included the central executive, the phonological loop and the visuospatial sketchpad. Following that, Baddeley (2000) revised his first model to make it more reliable and visually

appealing to the multi-component model after it was found to be unable to explain the findings of many studies.

2.2.2 Theory Related to Working Memory Performance

2.2.2.1 Baddeley and Hitch's Model of Working Memory

Baddeley and Hitch (1974) presented a model comprising different components: the central executive, responsible for managing cognitive functions; the visuospatial sketchpad, dedicated to processing visual and spatial information; and the phonological loop, focused on handling auditory data.

According to McCabe et al. (2010), the central executive is a working memory controller that controls the phonological loop and the visuospatial sketchpad includes decision-making, attention direction, and memory retrieval. Collette and Van der Linden (2002) considered that the attentional control mechanism, central executive chooses strategies and coordinates the different processes involved in more broad processing tasks as well as short-term storage. The process of updating is another task traditionally assigned to the central executive. Working memory is constantly being updated with new information, either sensory input (external) or long-term memory retrieval (internal).

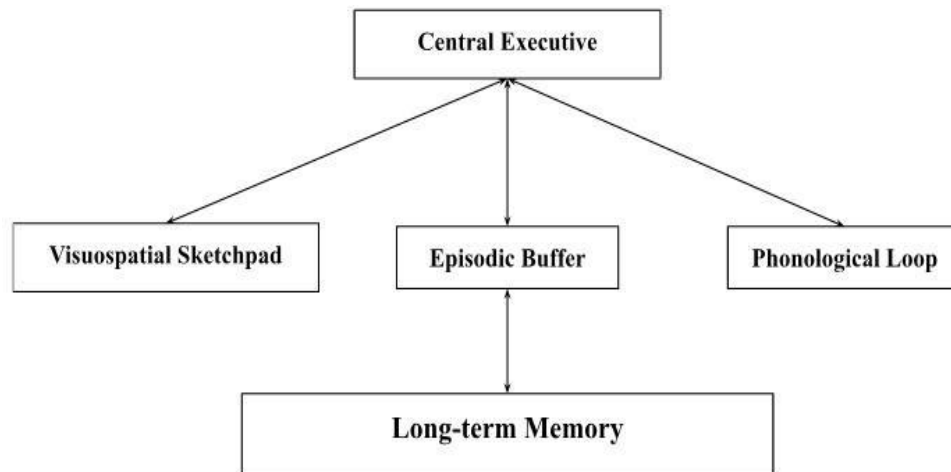
Buchsbaum and D'Esposito (2008) noted that the phonological loop, representing the verbal aspect of working memory, is commonly regarded as a supportive system that the central executive can engage when there is a need to retain verbal information in memory for an unspecified duration. Speech-based data can be passively buffered in the phonological store for about two seconds. Besides, as longer-lasting memories are developed, the phonological loop enables the retention of novel sound patterns in memory, which makes it essential for word learning (Baddeley et al., 1998). Baddeley (1966) mentioned that there is a distinction between two elements of the phonological loop. For example, an articulatory

rehearsal structure, demonstrated by the word length effect, which shows that subjects' immediate memory for word sequences decreases as words get longer, and a phonological store, which was utilized by the phonological similarity effect, which means that subjects recall sequences of phonologically similar letters or words less correctly.

The visuospatial sketchpad is another slave system in the working memory framework which is essential for the online preservation of objects and spatial information. The visuospatial sketchpad, which is specifically designed for tasks that involve creating and modifying mental representations, is directed by the central executive. According to Buchsbaum and D'Esposito (2008), comparable to the phonological loop, whereby articulatory suppression prevents the retention of verbal information, an additional processing demand in the visuospatial domain can be caused by insignificant visual information being provided when learning, following an animated spot on a screen, or random eye motions. Furthermore, Bull et al. (1999) believed that the visuospatial sketchpad consists of two distinct parts: a spatial system that stores information about spatial interactions between objects and dynamic data about movement, and a receptive visual element that stores material like color and shape.

However, there are still many incidents that the initial framework was unable to fully describe. The episodic buffer, the fourth component of the working memory model, was introduced by Baddeley and Hitch in 2000. It is accepted that data can be stored in a multi-dimensional coding by the episodic buffer (Baddeley, 2000). Hence, it offers an infrequent connection between long-term memory and the slave systems. Besides, the episodic buffer is under the control of the central executive, which is in charge of compiling data from multiple sources into cohesive episodes (Baddeley, 2000).

Figure 2.2.2.1: *Working Memory Model by Baddeley and Hitch*



2.3 Previous Findings Related to Physical Activity and Working Memory

The effect of physical activity on healthy individuals' visuospatial working memory (VSWM) was investigated in a study by Zhu et al. (2023). The results of the study illustrated that physical activity significantly improves visuospatial working memory performance in healthy persons after physical activity. Several variables, including the participant's age and gender, as well as the kind, level, duration, and density of physical activity, influence how physical activity affects VSWM. For instance, the authors discovered that acute exercise, a high-intensity aerobic exercise involving less than 30 minutes, and exercise in older people and females had a greater impact on VSWM than other types of exercise. Additionally, Zhu et al. (2023) discovered that physical activity was strongly influenced the visuospatial working memory (VSWM) tasks using more complicated object-based spatial information. Hence, the research indicates that physical activity can improve VSWM and implies that the most effective kind, level of intensity, length, and frequency of physical activity for improving VSWM may differ based on the individual's characteristics and the VSWM tasks. Furthermore, a research by Serra et al. (2021) seek to study the visuospatial memory of

school-age children participating in artistic gymnastics. The study involved 28 preadolescent girls who practiced artistic gymnastics and those who did not participate in sports participated in the experiment. The study's results demonstrated that the gymnasts mostly outscored the control group on tasks that measured working memory capabilities, like within-phase errors and spatial span. According to the results of another study (Ji et al., 2017), physical activity improves visuospatial working memory. Participants who engage in physical activity appear to require a short while to guarantee accurate functioning of visuospatial working memory.

According to Li et al.'s (2014) research, the study's objectives included investigating the impact of acute aerobic exercise (exercise performed in a single session) on executive function's working memory component and, concurrently, to examine on the underlying brain process as determined by functional magnetic resonance imaging. With a counterbalanced order, the research applied the within-subjects design. Working memory task, which is N-back task, was given to every participant separately in two different functional MRI scan sessions in the lab. The findings of the study suggested that engaging in moderate acute aerobic exercise had only a little effect on working memory.

In a prior study (Sibley & Beilock, 2007), the connection between brief bouts of physical activity and healthy individuals' cognitive performance was examined. The authors suggested that this relationship might vary based on the individual differences in the cognitive capacities. Individuals in the research study were randomized such that some participated during the baseline session and others during the activity session initially. Results showed that an acute activity session helped those with the lowest levels of working memory. Therefore, Sibley and Beilock (2007) recommended that individual variability in cognitive capacities should be included when investigating the connection between cognition and physical activity. Furthermore, a previous study by Mora-Gonzalez et al. (2019)

examined the relationships between children's working memory, neuroelectric activity, and physical fitness, sedentary time, and physical activity. The authors provided evidence that enhancements in various fitness and physical activity components result in enhanced working memory and fundamental brain functions.

Open-skill activity and closed-skill activity are the two categories of physical activity modes. Previous research that completely assesses the body of knowledge about how the open-skill and closed-skill can affect on cognitive performance. The findings showed that open-skill activity had a better impact on improving cognitive function than closed-skill did. Similar to the research, open-skill activity improved cognitive performance more in older individuals and children (Crova et al., 2013; Tsai et al., 2017). O'Brien et al. (2020) investigated the influence of open-skill and closed-skill exercise on multi-sensory perception, and on various aspects of working memory in 51 children. The Backward Digit Span was used to evaluate verbal working memory, which was one of the working memory aspects. The analysis demonstrated that the open-skill group positively influenced verbal working memory.

2.4 Improvement in Present Study

The researcher discovered that prior research has indicated limitations. This study aims to address the limitations of earlier research. Researcher observed a prevalence of children and older individuals among the participants in past studies. (Crova et al., 2013; O'Brien et al., 2020). The beneficial effects of physical activity on working memory in children and the elderly have been revealed by studies, but researchers have also recognized the need to incorporate young adults in the research, especially university students. Furthermore, numerous previous studies (Ji et al., 2017; Serra et al., 2021; Zhu et al., 2023) have adopted the visuospatial approach to assess working memory performance, with

comparatively fewer researches studying the relationship between physical activity and working memory and physical activity on verbal working memory. Therefore, to obtain more conclusive results, the researcher should perform both verbal and visuospatial working memory assessments to evaluate the effect of physical activity on working memory performance.

2.5 Summary

In conclusion, this chapter explains the theories related to variables, the past studies that discussed the effect of physical activity on working memory performance, and the improvement in the present study.

CHAPTER THREE

METHODOLOGY

3.0 Introduction

In this chapter, researcher will demonstrate the research design, population of study and sample size, the instruments that will be utilized, the procedures, pilot study, ethics of the study, and data analysis procedures.

3.1 Research Design

This present study will be organized based on the quantitative method with the application of a quasi-experimental design which is a design that non-randomizes individuals or groups into treatment and control groups (White & Sabarwal, 2014). This research design will be applied to investigate the differences between physical activity and non-physical activity groups on working memory performance.

3.2 Population and Sample

Hanlon and Larget (2011) stated that a population is an individual or unit of interest, while a sample is a chosen group of the population. The sample size in this study will consist of thirty (30) participants and it will be two (2) groups: fifteen (15) participants each in the experimental and control groups. The researcher applied convenience sampling, a non-probability sampling method, in this study, in which the researcher selects participants who are easily accessible or interested.

3.3 Instruments

3.3.1 Instrument Structure

The instrument will include four (4) parts which are the informed consent form, demographic information of the participants, and two tests for measuring verbal and visuospatial working memory.

3.3.1.1 Informed Consent Form

The first part is the informed consent form which will state the researcher's profile (name, year of study, program), research title, purpose of the study, engaged time in the experiment, potential risks and benefits of participating, confidentiality, voluntary participation, and researcher's contact information.

3.3.1.2 Demographic Information

The researcher included the personal information of the participants, such as gender, age, race, year of study, and program in a questionnaire using Google Forms. The researcher also collected data about the physical activity habits of participants in the last 7 days.

3.3.1.3 Verbal Working Memory Test

Reading Span Task will be utilized to test the verbal working memory in this experiment. The task will be adapted from Daneman and Carpenter (1980) and Waters and Caplan (1996) were used to evaluate the reading span. This task used a presentation slide to give participants a test. The verbal working memory test required the participant to read aloud all the sentences accordingly in the series and they need to determine whether the

sentence was correct (logic or not logic) after reading a sentence. Upon completion of the reading task, the participants are required to retrieve the final word of every sentence. The total correct recalled and the total time taken in the test will be recorded.

3.3.1.4 Visuospatial Working Memory Test

The experiment employed the Corsi Blocks Test as a evaluate of the participants' visuospatial working memory. According to Guariglia (2007), maintaining a movement series and a visuospatial pattern is essential for this test. The researcher was adopted an online test from the website My Brain Test (2016). The Corsi Blocks Test will require the participants to observe and remember the objects that will randomly show on the screen. The participants will need to recall the objects by clicking on the position where the objects had just appeared. Besides that, the order of the clicking must be the same as the order in which the objects have just appeared. The accuracy as the correctly number of recalled and the time taken will be recorded.

3.4 Procedures

Before engaging in the experiment, participants were required to fill an informed consent form and a survey form that includes their demographics, and physical activity habits. The researcher will remind the participants about the time to experiment based on what they choose before to avoid any ad hoc events. On the day of the experiment, the researcher will organize every instrument, including a laptop.

In this study, the participants will be introduced to the types of tests that are conducted. They will be separated into the treatment group, which will engage in physical

activities prior to the working memory tests, and the control group, which will not. The treatment group will be required to walk around the stadium UNIMAS for ten minutes and three minutes rest before starting the working memory tests.

Two tests will be conducted to measure the participants' working memory in the experiment. The first test is Reading Span Task that measuring the verbal working memory performance. Participants will be asked to read aloud an ordered set of sentences and determine whether or not each sentence in the sequence was acceptable. After completing the series of sentences, the participants are expected to retrieve the final word of each sentence. Before the real session begins, the participants will be given two trial tests. Every participant in this study will be required to complete testing on span sizes ranging from one to five. The participants in both of the sessions will be asked to recollect the terms in the required sequence, however, they may recall any information or words they may have, even if they are unable to remember the whole set or the order. During the test, participants will not be allowed to record or write anything as a note.

Visuospatial working memory was measured by the Corsi Blocks Test which is conducted online. The test had a grid (four rows and four lines) and involved the span sizes from 3 to 7. Before the real trial begins, the participants will be given two trial tests. At the beginning of the test, the participants had to track the movement of the object and note which grid it appeared in, as it kept moving randomly. When the screen stopped, the participant had to use the mouse to indicate the position where each object had just appeared according to the sequence.

The experiment measured the total number of correct recalls and the total duration of both tests (Reading Span test and Corsi Block test) from the onset of the first real test to the termination of the last test. The participants' data will be gathered from the test results. The researcher will use a checklist to account the total number of correct recalls and the total duration of both verbal and visuospatial working memory tests for each participant. Researcher utilized the Statistical Package for the Social Sciences (SPSS) to enroll and analyze the data collected.

3.5 Pilot Study

A pilot study is a initial exploration that precedes a larger experiment to evaluate research methods, data collection, sampling plans, and various research aspects (Hassan et al., 2006). Before the real experiment, six (6) participants joined the pilot study to give suggestions to improve in the real trial. The participants were divided into two (2) groups which are the physical activity group (experiment group) and the non-physical activity group (control group). A survey form was administered to the participants after the completion of the pilot study to assess the reliability and validity of the experiment. According to their feedback, the instructions for both working memory tests were clear. For the Reading Span Test, two participants suggested that researcher should improve the test by adding the statement "*Logik atau tidak logik?*" below each section of the test while there is no comment on the Corsi Blocks Test.

3.6 Ethics of Study

The study's main ethical concerns were protecting the validity and integrity of the research while also giving the participants physical and mental health priority. Before the working memory test, the participants will receive a consent form, emphasizing the voluntary

nature of the study and the maintenance of confidentiality. Participants' privacy and confidentiality will be protected throughout the study. The test results and any other information gathered will only be utilized for academic research, and all data will be anonymized and securely preserved. Once the study is over, the researcher will give a debriefing and explain the rationale for conducting the experiment that seeks to investigate the differences between physical activity and non-physical activity groups on working memory among the undergraduates of Universiti Malaysia Sarawak (UNIMAS).

3.7 Data Analysis Procedures

3.7.1 Descriptive Data Analysis

Kaur et al. (2018) stated that descriptive statistics facilitate data organization by illustrating the associations among the variables in a sample. Variable types including nominal, ordinal, interval, and ratio are included in descriptive statistics. In the questionnaire, the demographic information of the participants will be analyzed by using descriptive statistics to explain the percentage, frequency and mean of the participants' background (gender, age, race, year of study, and program).

3.7.2 Inferential Data Analysis

Inferential statistics can be defined as the researchers can conclude their sample data using a range of statistical tests. These tests split into three main groups based on why they were designed: examining differences, investigating relationships, and developing predictions (Allua & Thompson, 2009). This research employed inferential statistics to examine the differences between the physical activity and the non-physical activity groups on working memory performance. Since the research will contrast the mean scores of the two groups

(physical activity and non-physical activity) on a ratio-level measure of working memory performance, the study will use an independent T-test.

Table 3.7.2: *Research Hypotheses and Statistical Test*

Research Hypotheses	Statistical Test
H1: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total number of correct recalled.	Independent T-test
H2: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken.	Independent T-test
H3: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled.	Independent T-test
H4: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken.	Mann-Whitney U Test

3.8 Summary

This chapter explains the research design, population and sample, instruments, procedures, pilot study, data collection procedures, and data analysis procedure.

CHAPTER FOUR

FINDINGS AND DISCUSSION

4.0 Introduction

Chapter 4 will illustrate the findings of the experiment. The frequency and percentage of the demographic data collected through Google Forms will be described. Then, the researcher will explain the inferential data, the normality data results, and the main findings of the verbal working memory test (Reading Span Test) and the visuospatial working memory test (Corsi Blocks Test).

4.1 Demographic Data

4.1.1 Gender

Table 4.1.1: *Frequency and Percent of Gender*

Gender	<i>n</i>	%
Male	14	46.7
Female	16	53.3
Total	30	100.0

Based on Table 4.1.1, 16 out of 30 participants, or 53.3%, were female, while 14 participants or 46.7%, were male.

4.1.2 Age

Table 4.1.2: *Frequency and Percent of Age*

Age	<i>n</i>	%
19-20	1	3.3
21-25	28	93.3
25 and above	1	3.3
Total	30	100.0

Most participants were aged 21-25, with 28 participants (93.3%). Only 1 participant, or 3.3%, was recorded for both age groups, those aged 19-20 and those aged 25 and above.

4.1.3 Race

Table 4.1.3: *Frequency and Percent of Race*

Race	<i>n</i>	%
Bumiputera Sabah	2	6.7
Bumiputera Sarawak	11	36.7
Chinese	9	30.0
Indian	3	10.0
Malay	5	16.7

Total	30	100.0
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Table 4.1.3 highlighted that most of the participants (11 participants or 36.7%) were Bumiputera Sarawak, followed by Chinese participants with 9 people or 30.0%. Next, 5 Malay participants (16.7%), 3 Indian participants (10.0%) and the least number 2 Bumiputera Sabah participants were engaged in the research experiment.

4.1.4 Year of Study

Table 4.1.4: *Year of Study*

Year of Study	<i>n</i>	%
1	11	36.7
2	7	23.3
3	11	36.7
4	1	3.3
Total	30	100.0

Table 4.1.4 showed that 11 participants, or 36.7%, were from both Year 1 and Year 3 UNIMAS students. Besides, 7 participants (23.3%) were Year 2 students, while only one or 3.3% participant was Year 4 student.

4.1.5 Programme

Table 4.1.5: *Frequency and Percent of Programme*

Race	<i>n</i>	%
Accounting	1	3.3
Animation	1	3.3
Anthropology and Sociology	1	3.3
Biotechnology Resources	1	3.3
Business Economics	1	3.3
Chemical Engineering	1	3.3
Computational Science	1	3.3
Corporate Management	1	3.3
Counselling	1	3.3
Design Technology	1	3.3
Human Resource Development	5	16.7
International Economic	1	3.3
International Relations	2	6.7
Linguistics	1	3.3
Marketing	2	6.7

Medicine	1	3.3
Network Computing	1	3.3
Psychology	2	6.7
Quantity Surveying	1	3.3
Science Computational	1	3.3
Service Economics	3	10.0
Total	30	100.0

Table 4.1.5 indicated the frequency and percent of participants' programmes. Most participants were Human Resource Development students, which consisted of 5 participants (16.7%), followed by Service Economics students with 3 participants (10.0%). Next, 3 programmes (International Relations, Marketing, and Psychology) have 2 participants (6.7%). The least number of participants' programmes, which is 1 participant (3.3%) studied Accounting, Animation, Anthropology and Sociology, Biotechnology Resources, Business Economics, Chemical Engineering, Computational Science, Corporate Management, Counselling, Design Technology, International Economic, Linguistics, Medicine, Network Computing, Quantity Surveying, and Science Computational).

4.1.6 During the last seven (7) days, did you engaged in any physical activities?

Table 4.1.6: *Frequency and Percent of the Statement “During the last seven (7) days, did you engaged in any physical activities?”*

	<i>n</i>	<i>%</i>
During the last seven (7) days, did you engaged in any physical activities?		
Yes	3	10.0
No	27	90.0
Total	30	100.0

According to Table 4.1.6, 90.0% or 27 participants stated that they engaged in any physical activities during the last seven (7) days. In contrast, only 3 participants (10.0%) did not engage in any physical activities during the last seven (7) days.

4.1.7 During the last seven (7) days, how much time did you spend sitting on a week day?

Table 4.1.7: *Frequency and Percent of the Statement “During the last seven (7) days, how much time did you spend sitting on a week day?”*

	<i>n</i>	<i>%</i>
During the last seven (7) days, how much time did you spend sitting on a week day?		
Less than 30 minutes per day	1	3.3
More than 1 hour per day	29	96.7

Total	30	100.0
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Table 4.1.7 demonstrated that 29 out of 30 participants or 96.7% participants had spent more than 1 hour per day on sitting during the last seven (7) days, while only 1 participant (3.3%) spent less than 30 minutes per day on sitting.

4.2 Inferential Data (Main Findings)

4.2.1 Normality Test

Table 4.2.1(a): *Descriptive Statistics for Variables*

Variables	<i>M</i>	<i>SD</i>	<i>Maximum</i>	<i>Minimum</i>
Reading Span Test_Total Correct Recall	11.43	1.870	7	14
Reading Span Test_Total Time Taken	105.57	19.362	150	79
Corsi Blocks Test_Total Correct Recall	20.73	3.258	13	25
Corsi Blocks Test_Total Time Taken	82.33	16.818	110	59

Table 4.2.1(b): *Results of Kolmogorov-Smirnov and Shapiro-Wilk Tests of Normality*

Variables	<i>Kolmogorov-Smirnov</i>		<i>Shapiro-Wilk</i>	
	<i>S</i>	<i>p</i>	<i>S</i>	<i>p</i>
Reading Span Test_Total Correct Recall	0.166	0.035	0.938	0.078
Reading Span Test_Total Time Taken	0.138	0.153	0.948	0.150
Corsi Blocks Test_Total Correct Recall	0.157	0.058	0.942	0.103
Corsi Blocks Test_Total Time Taken	0.152	0.073	0.911	0.016

Figure 4.2.1(c): Normal Q-Q Plot of Reading Span Test Based on the Total Number of Correct Recalled

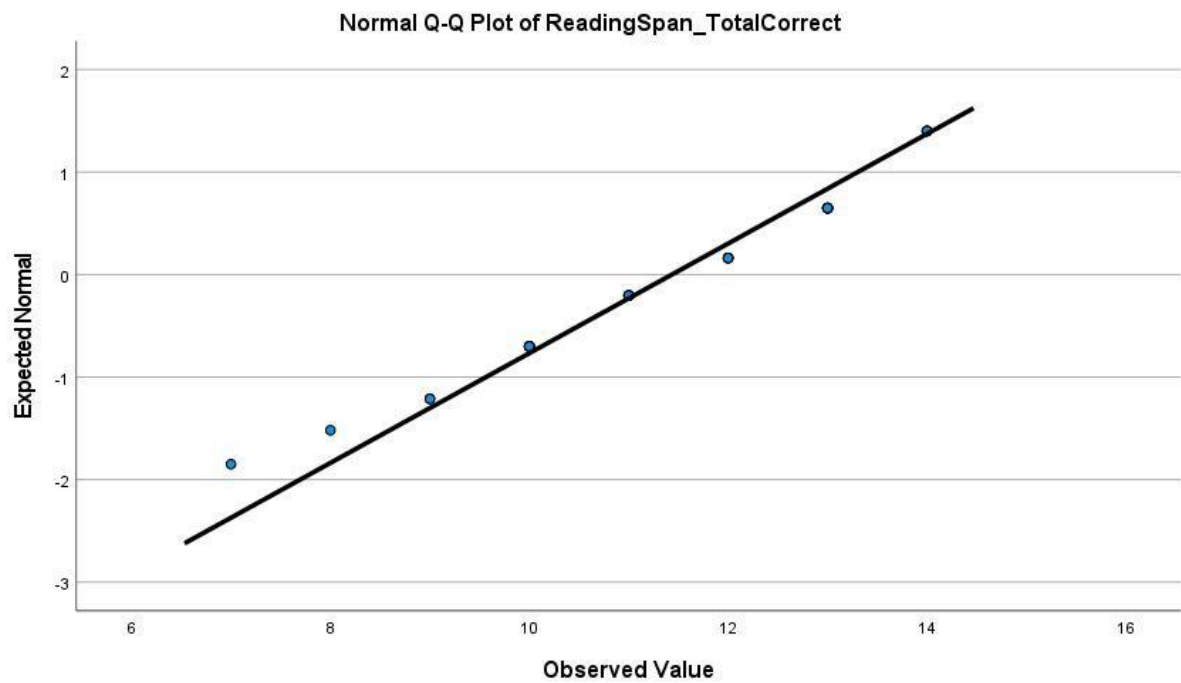


Figure 4.2.1(d): Normal Q-Q Plot of Reading Span Test Based on the Total Time Taken

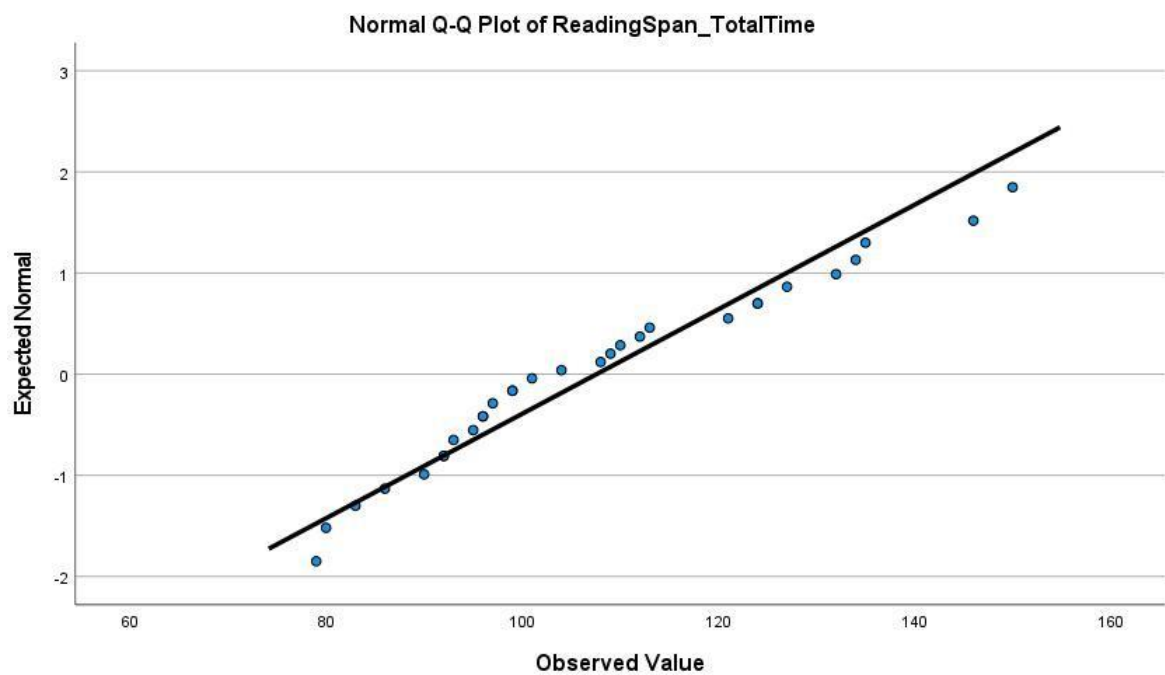


Figure 4.2.1(e): *Normal Q-Q Plot of Corsi Blocks Test Based on the Total Number of Correct Recalled*

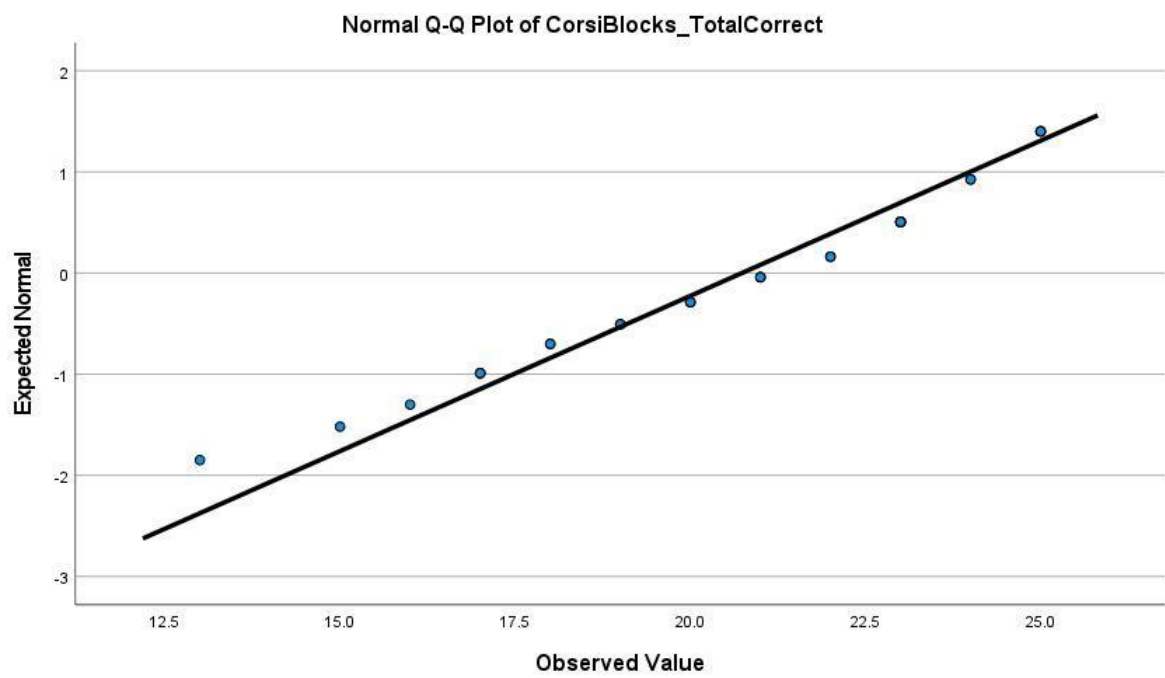
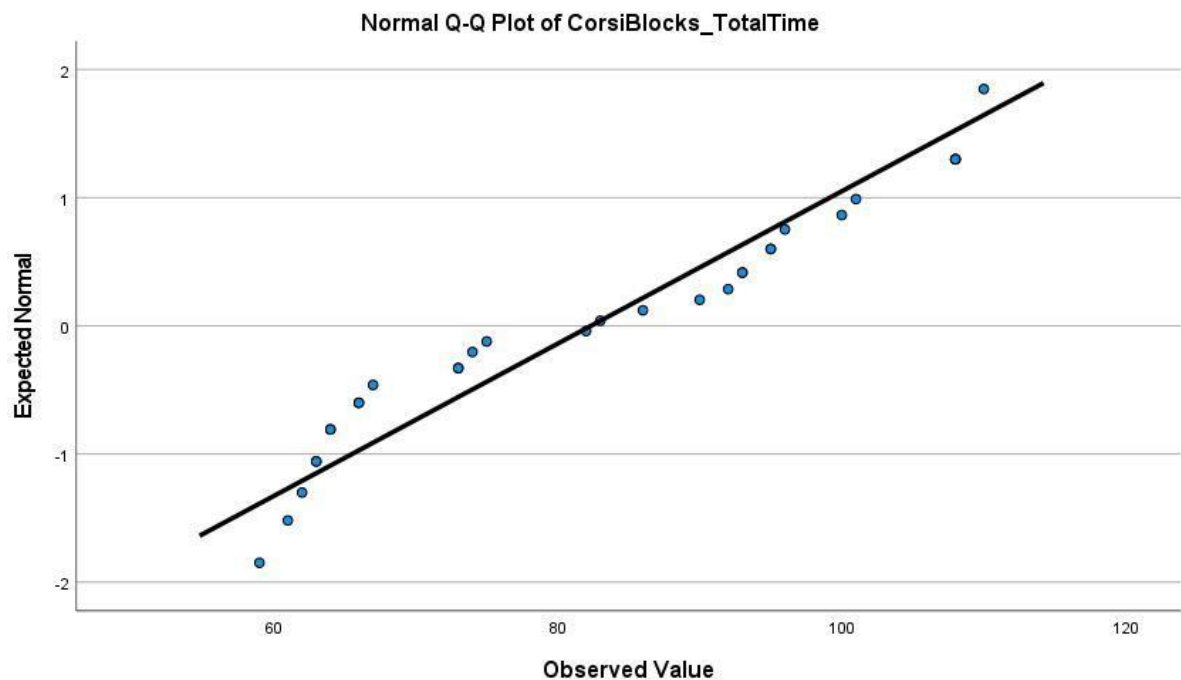


Figure 4.2.1(f): Normal Q-Q Plot of Corsi Blocks Test Based on the Total Time Taken



Shapiro-Wilk test of normality was conducted to determine whether the variables in the research is normally distributed. According to Table 4.2.1.3, the results highlight that the null hypothesis is rejected for Reading Span Test based on the total number of correct recalled with a p-value= 0.078 is more than 0.05 and the data is normally distributed. The results also indicate that the null hypothesis is rejected for Reading Span Test based on total time taken ($p=0.150>0.05$) and conclude that the data is normally distributed. The null hypothesis is also rejected since the Corsi Blocks Test based on total number of correct recalled with p-value= 0.103 is more than 0.05 and suggesting that the data is normally distributed. However, the results show that the null hypothesis is failed to be rejected when p-value= 0.016 is less than 0.05 for the Corsi Blocks Test based on total time taken, suggesting that the data is not normally distributed.

4.2.2 Finding 1: The differences between the physical activity and non-physical activity group in the Reading Span Test based on the total number of correct recalled.

Table 4.2.2: *Group Statistics and Independent Samples Test for the Reading Span Test Based on the Total Number of Correct Recalled*

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i> (28)	<i>p</i>
Physical Activity	15	12.87	0.990	6.590	<0.001
Non-Physical Activity	15	10.00	1.363		

H₀: There is no significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total number of correct recalled.

H_a: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total number of correct recalled.

Independent-sample t-test was employed to test the means between the physical activity and non-physical activity group in the Reading Span Test based on the total number of correct recalled. The verbal working memory test involved 30 participants divided into two groups, and each group contained 15 participants. As can be seen in Table 4.2.2, there was a significant difference in scores for the physical activity group ($M = 12.87$, $SD = .990$) and the non-physical activity group ($M = 10.00$, $SD = 1.363$); conditions; $t(28) = 6.590$, $p = < .001$. Since $p = < 0.001$ is less than 0.05 level of significance, the null hypothesis is rejected, indicating sufficient evidence to conclude that the mean scores differ significantly between the two groups. Hence, the result suggests that physical activity effectively affects verbal working memory performance.

4.2.3 Finding 2: The differences between the physical activity and non-physical activity group on the Reading Span Test based on the total time taken.

Table 4.2.3: *Group Statistics and Independent Samples Test for the Reading Span Test Based on the Total Time Taken*

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i> (28)	<i>p</i>
Physical Activity	15	94.33	9.933	-5.117	<0.001
Non-Physical Activity	15	120.80	17.395		

H₀: There is no significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken.

H_a: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken.

An independent-sample t-test was utilized to evaluate the means between the physical activity and non-physical activity group in the Reading Span Test based on the total time taken. There was a significant difference in the scores for the physical activity group ($M = 94.33$, $SD = 9.933$) and the non-physical activity group ($M = 120.80$, $SD = 17.395$); conditions; $t(28) = -5.117$, $p = < .001$. Since $p = < 0.001$ less than 0.05 level of significance, the null hypothesis is rejected, indicating that there is a significant difference between the physical activity and non-physical activity group in the Reading Span Test based on the total time taken. Hence, participants who experienced physical activity (walking) had faster verbal working memory performance than those who did not.

4.2.4 Finding 3: The differences between the physical activity and non-physical activity group in the Corsi Blocks Test based on the total number of correct recalled.

Table 4.2.4: *Group Statistics and Independent Samples Test for the Corsi Blocks Test Based on the Total Number of Correct Recalled*

Group	<i>n</i>	<i>M</i>	<i>SD</i>	<i>t</i>(28)	<i>p</i>
Physical Activity	15	23.40	1.242	7.949	<0.001
Non-Physical Activity	15	18.07	2.282		

H₀: There is no significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled.

H_a: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled.

An independent-sample t-test was employed to evaluate the means among the physical activity and non-physical activity group in the Corsi Blocks Test based on the total number of correct recalled. There is a significant difference in the scores for the physical activity group ($M = 23.40$, $SD = 1.242$) and the non-physical activity group ($M = 18.07$, $SD = 2.282$); conditions; $t(28) = 7.949$, $p = < .001$. Since $p = < 0.001$ less than 0.05 level of significance, the null hypothesis is rejected, suggesting that there is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled. Therefore, the results

show that the physical activity group have a better visuospatial working memory performance than the non-physical activity group.

4.2.5 Finding 4: The differences between physical activity and non-physical activity group on the Corsi Blocks Test based on the total time taken.

Table 4.2.5: *Mean Ranks and Mann-Whitney U Test Statistics for the Corsi Blocks Test Based on the Total Time Taken*

Group	<i>n</i>	<i>Mean Rank</i>	<i>U</i>	<i>z</i>	<i>p</i>
Physical Activity	15	16.60	96.00	-0.685	0.493
Non-Physical Activity	15	14.40			

H₀: There is no significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken.

H_a: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken.

Since Table 4.2.1(b) showed that the data is not normally distributed, a Mann-Whitney U test was performed to measure whether the visuospatial working memory performance based on the total time taken differed by the physical activity and non-physical activity group. The results indicated that there is no significant difference in the Corsi Blocks Test based on the total time for the physical activity group (mean rank= 16.60) compared to the non-physical activity group (mean rank= 14.40), $U = 96.00$, $z = -0.685$, $p = 0.493$. Since $p = 0.493$ is more than 0.05, the null hypothesis failed to be rejected, suggesting that there is no

significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken. Thus, the results show that physical activity did not affect visuospatial working memory performance as there was no significant improvement in the total time taken on the test.

4.3 Discussion

4.3.1 Discussion Finding 1

Results tabulated in Table 4.2.2 illustrated a significant difference between the physical activity group and the non-physical activity group in verbal working memory performance based on the total number of correct recalled. According to the table above, it was clearer that the physical activity group had a higher number of correct recalled in the Reading Span Test, with 12.87 words on average, than the non-physical activity group recorded 10.00 words on average.

The findings are align with the past research, in which the physical activity group performed better in the verbal working memory test than the non-physical activity group. According to Lambourne (2006), there is a significant difference in verbal working memory performance between the individuals who experienced physical activity and those who did not. This previous research supported the idea that physical activity was correlated to verbal working memory performance in youngsters.

4.3.2 Discussion Finding 2

According to the result tabulated in Table 4.2.3, there was a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken. The total time taken was measured by the researcher throughout the experiment. The total time taken refers to the participants' response time to read and identify the logic of the sentence and recall the last word of each sentence. The table highlighted that the physical activity group spent less time, 94.33 seconds on average, compared to the non-physical activity group, which spent around an average of 120.80 seconds to complete the Reading Span Test.

The findings align with the previous study, which highlighted that the physical activity group is more performed well in verbal working memory test based on the total time taken. Previous study showed that both younger and older adults who had experienced physical activity responded more quickly to the verbal working memory task (Carpenter, 2008). In the study, Carpenter (2008) mentioned that although the findings indicate that the physical activity group had a faster performance, that is not the main effect but depends on the age.

4.3.3 Discussion Finding 3

Based on the result tabulated in Table 4.2.4, there was a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled. According to the table above, the physical activity group performed better than the non-physical activity group since

the physical activity group scored an average of 23.40 objects. In comparison, the non-physical activity group recorded an average of 18.07 objects in the Corsi Blocks Test.

The findings in the current research were align with the previous studies in which the physical activity group scored more than the non-physical activity group in the visuospatial working memory test. Bainter (2022) highlighted that physical activity increases the visuospatial working memory test score (Corsi Block-Tapping). Besides, Drozdowska et al. (2021) conducted research among children and indicated that the child's performance in visuospatial working memory would improve with increased physical activity.

4.3.4 Discussion Finding 4

Based on the result tabulated in Table 4.2.5, there was no significant difference between the physical activity group and the non-physical activity group in the Corsi Blocks Test based on the total time taken. There were 25 objects will randomly appear on the screen. The total time taken was measured by the researcher throughout the experiment. The total time taken refers to the response time to observe objects moving and recall the objects according to the sequences.

The table above showed that the physical activity group spent around 16.60 on the mean rank, while the non-physical activity group spent 14.40 on the mean rank to complete the Corsi Blocks Test. The findings did not align with the previous study. According to Hatch et al. (2021), the response time taken in the visuospatial test was improved after exercising. In the study, those experiencing physical activity had faster response time (20 seconds to 40

seconds) than those who had not experiencing. However, the findings in the current research showed that the time taken in the Corsi Blocks Test in both groups was similar.

4.4 Conclusion

Table 4.4: *Hypotheses and Analysis Results*

Research Hypotheses	Results
H1: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total number of correct recalled.	The alternative hypothesis was supported
H2: There is a significant difference between the physical activity and non-physical activity group in verbal working memory performance based on the total time taken.	The alternative hypothesis was supported
H3: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total number of correct recalled.	The alternative hypothesis was supported
H4: There is a significant difference between the physical activity and non-physical activity group in visuospatial working memory performance based on the total time taken.	The alternative hypothesis was not supported

CHAPTER FIVE

LIMITATION, IMPLICATION, RECOMMENDATION AND CONCLUSION

5.0 Introduction

Chapter 5 explains the research's limitations that might affect the findings, the implications of the research findings and the recommendations that can be modified in future studies.

5.1 Limitations of Study

First, the small sample size in this study is one of the limitations. In the research, there are only thirty participants, the study may lack the statistical power required to identify the significant differences or generalize the findings to a larger population. Since thirty participants were divided into two groups, which are fifteen people for physical activity group and another fifteen people for non-physical activity group), the study might fail to detect a true effect of physical activity on working memory performance. Hence, the researcher managed the small sample size by ensuring a representative combination of participants. For example, the researcher selected participants based on different genders and races to accurately represent the population and enhance the study's external validity.

Language barrier also became a limitation in this research study. Since the researcher used Bahasa Melayu as the medium of instruction in the experiment, some participants, especially non-native speakers, may not fully understand the language used. For example, they felt confused with the words used in the Reading Span Test, which led to an inaccuracy in assessing their working memory performance as they will take a long time to identify the logic of the sentences and remember the words. To minimize the language barrier limitation

found in this research, the researcher explained the instructions to ensure participants can understand and respond in Bahasa Melayu accurately, thereby decreasing inaccuracies in working memory performance assessments.

Another limitation of the study is the different testing environments. Researcher conducted the experiment in different settings. For example, the physical activity group experimented at the stadium UNIMAS (outdoor environment) while the non-physical activity group completed the working memory tests at PeTARY UNIMAS (indoor environment). This setting can lead to factors that could influence the participants' working memory performances, such as weather conditions and noisy surroundings for the physical activity group. Since the physical activity group completed the task at stadium UNIMAS, they might be influenced by people who also exercise, and the preparation works for an event at that time. For the non-physical activity group, the participant might be influenced by indoor distractions, such as ambient noise from the movement of a chair or occasional conversations. Hence, researcher managed this limitation by assigning the participants to complete the working memory tests in a place that is far from crowds to maintain participants' concentration and reduce distractions.

The other limitation found is the independent variable used, which is the type of physical activity. The physical activity group only did the walking task for 10 minutes in this study, which is considered the sole physical activity intervention. However, physical activity frequency, intensity, type, duration, and other factors moderated the working memory performance. Therefore, the research is limited in drawing a comprehensive conclusion about the effect of physical activity on working memory performance. Researcher should design

different physical activities and longer durations for the participants to assess their effects on working memory performance comprehensively.

5.2 Implications

The research provided valuable understanding into the immediate outcome of a short physical activity session on working memory performance, which can be strongly related to the theoretical foundation. Despite the limitations, a significant effect observed in such a short period in this study aligns with theories proposing that even shorter physical activity sessions can have an immediate positive impact on cognition through processes including fostering short-term neuroplasticity and increasing blood flow to the brain, which enhance brain function (Lulic et al., 2017; Olivo et al., 2021).

Besides, the implication of the study also emphasizes the importance of environmental factors in cognitive performance research. According to the cognitive load theory (CLT), the whole mental workload necessary for processing new information can have an impact on working memory function, and it also supports the research's implication (Asma & Dallel, 2020). Hence, environmental distraction can increase mental workload, worsening working memory performance. This implication might result in future research using more standardized and controlled experiment conditions to examine the effect of physical activity on working memory performance.

Language barrier identified in this research study also highlights an implication related to the theoretical basis of cognitive psychology. Cognitive psychology proposes that working memory and language comprehension are essential components of cognitive functions. Baddeley's (1966) working memory model suggests that language comprehension

and production functions heavily rely on the phonological loop which is liable for processing and storing verbal data. Participants' phonological loops become overloaded when they struggle with language comprehension, which might influence the findings of working memory assessments.

The implication of this study for future research into the effects of consistent physical activity over time on working memory performance is deeply rooted in theoretical foundation such as self-determination theory (SDT) (Ryan & Deci, 2017). SDT highlights a significance of internalizing the benefits of physical activity for cognitive health. By establishing a clear link between regular physical activity and sustained improvements in cognitive function, future research could encourage the public to maintain cognitive health throughout the lifespan by regular physical activity. People will be motivated by intrinsic factors and internalize physical activity as a part of their identity and way of life when they acknowledge and value the cognitive advantages of regular physical activity.

5.3 Recommendations

Further research in a variety of domains can be conducted to look into the more general consequences of physical activity on working memory. In educational settings, A brief physical activity session can be applied and researched to improve students' academic performance and memory. For instance, future research can conduct a ten-minute physical activity break into the classroom routine to examine whether it may help improve students' learning outcomes. In the workplace, similar interventions can be used to assess the effect of physical activity on employees' cognitive performance and overall productivity. Short walking breaks during work hours might enhance task performance, supporting the development of more efficient workplaces.

Future research should focus on several key areas to address the current study's limitations. The sample size needs to increase to enhance the statistical power and generalizability of the findings. Future researchers can obtain more representative and dependable results by increasing the participant base, which includes individuals from various age groups and fitness levels. Besides, it is also recommended for future researchers to control the environmental variables to discard confounding factors in the study. For example, future researchers should ensure that the working memory tests are conducted in a uniform and controlled environment. Next, language barriers need to be managed in future studies. To increase the accuracy of measures of cognitive function, future researchers should ensure all participants are competent in the language used for the memory test. Future researchers should also conduct longitudinal studies to observe the effects of consistent physical activity over time on the working memory by tracking participants over several months or years.

5.4 Conclusion

In conclusion, the research highlights how physical activity might enhance cognitive function, particularly working memory. By solving the identified limitations and expanding the scope of future research, the cognitive benefits of physical activity can be better understood and harnessed. The research can lead people to reconsider integrating physical activity into daily routines, emphasizing the potential to impact cognitive well-being significantly.

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Appendix A

Instruments

Reading Span Test

https://www.canva.com/design/DAF_xO8fK6c/Bv-v_4qoQgCHswrMabk8uA/edit?utm_content=DAF_xO8fK6c&utm_campaign=designshare&utm_medium=link2&utm_source=sharebutton

Corsi Blocks Test

<https://www.memorylosstest.com/visual-span/>

Appendix B

Test Results

Reading Span Test

1=Non-physical activity group; 2=Physical activity group

Group	Total number of correct recalled	Total time taken (sec)
2	10	150
2	7	108
2	10	127
2	10	132
2	11	124
2	9	146
2	11	110
2	9	124
2	12	134
2	10	96
2	12	97
2	10	121
2	10	113
2	8	135
2	11	95
1	13	83

1	13	92
1	12	99
1	14	104
1	12	99
1	14	86
1	13	79
1	13	109
1	11	112
1	13	80
1	11	90
1	13	92
1	14	96
1	14	93
1	13	101

Corsi Blocks Test

1=Non-physical activity group; 2=Physical activity group

Group	Total number of correct recalled	Total time taken (sec)
2	15	95
2	18	64
2	19	82
2	20	66
2	18	64
2	17	83
2	16	108
2	20	59
2	21	63
2	17	110
2	19	61
2	20	100
2	21	73
2	13	74
2	17	101
1	23	62
1	21	93
1	23	86
1	25	108
1	23	108
1	25	66
1	23	73
1	24	67
1	23	63
1	23	75
1	22	90
1	25	92
1	22	96
1	25	93
1	24	95