The Effect of Lifetime Physical Activity on Working Memory in Older Adults

by
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ABSTRACT

The purpose of this study was to assess the relationship between lifetime physical activity levels and working memory ability into older adulthood. This study was conducted through a survey, in which 22 older adult participants reported how often they performed physical activity during 5 stages of life: currently, before the Covid-19 pandemic, at age 50, at age 30, and during the teenage years. Participants completed a working memory ability assessment rating how often they make common memory mistakes. Lifetime physical activity levels were significantly related to working memory scores after accounting for social interaction time with family *(beta = .001, p = .034)*. Lifetime physical activity, combined with social interaction time with family, significantly predicts working memory ability into later life. Therefore, participation in regular physical activity throughout life should be encouraged for all ages to improve working memory ability into older age.

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DEFINITION OF TERMS

Working Memory	An executive function that is responsible for short-term memory, allowing for the absorption and immediate use of information before the information is disposed.
Executive Function	A cognitive function that supports planning, selective attention, sustained attention, resistance to interference, volitional inhibition, working memory, and mental flexibility (Guiney & Machado, 2013).
Dementia	A detrimental disease that involves a decline in cognitive performance (Institute for Dementia Research & Prevention: Pennington Biomedical Research Center). The most common age-related forms are Alzheimer's disease and vascular dementia.
Physical Activity	Any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure (ACSM).
Exercise	A type of physical activity consisting of planned, structured, and repetitive bodily movement done to improve and/or maintain one or more components of physical fitness (ACSM).
Physically Active	Meeting the ACSM guidelines for physical activity, which is performing at least 30 minutes of moderate intensity activity during 5 days of the week (ACSM).

CHAPTER I

INTRODUCTION

Facing a cognitive function decline into older age is inevitable because the brain's structure deteriorates, much like the structure of the human body as a whole. The brain, like the body, alters itself in accordance with a person's physically active or sedentary lifestyle, for it modifies its function and structure according to its environment (Gomez-Pinilla & Hillman, 2013). In the literature, cognitive function is classified as global cognition, memory, executive function, reasoning, attention, and language (Law et. al., 2019).

Cognitive decline can be seen in one or more of these areas as people age, especially with executive function. In fact, working memory, which falls under executive function, is one of the first cognitive functions to decline (Law et. al., 2019). In extreme cases, cognitive functioning can decline to the point where it becomes irreversible dementia, such as Alzheimer's Disease or vascular dementia, which are the most prevalent forms of cognitive decline. Older adults show these signs when having a hard time with short term memory and losing their sense of space and time.

According to the Institute for Dementia Research and Prevention at Pennington Biomedical Research Center, at least 5 million older adults nationwide have dementia, with the estimate that 1 in 10 men, and 1 in 6 women, living past the age of 55 years will develop dementia. The number of dementia cases will continue to grow as the older population becomes larger, due to the older adults of the Baby Boom cohort turning 65 years of age beginning in 2011 (United States Census Bureau, 2016). The good news is that overall cognitive functioning can be preserved with the help of physical activity.

Unfortunately, only 27% of older adults report doing more than 30 minutes a day for 3 days a week (2019), while an additional 28% of older adults in the United States over the age of 50 years do not report any physical activity (2019). In fact, over 80% of adults in the United States do not meet the physical activity guidelines, while under 5% report doing 30 minutes of physical activity each day of the week (U.S. Department of Health and Human Services). Clearly, a large portion of the older adult population is not active enough to receive the potential mental health benefits of being physically active.

Research shows that the brain can maintain its "physically active" state with the help of regular physical activity, thus allowing a person to have the best quality of life with the ability to perform independent daily activities. Sanders et al. states that physical activity can promote brain plasticity and increase brain activation, leading to improvements in cognitive function (2019). As working memory is one of the brain's cognitive functions, it too can be improved and maintained with the help of physical activity as well.

In-depth research assessing the relationship of physical activity with each category of cognitive function has been conducted. Research suggests that there is a positive correlation

between physical activity and working memory, even after controlling for confounding variables such as socioeconomic status, educational level, new hobbies and levels of human interaction. However, more research is needed to determine how a lifetime of physical activity affects working memory (Guiney & Machado, 2012). As a result, this study will specifically analyze the relationship of lifetime physical activity with working memory, a subcategory of executive function.

While studies show an association between physical activity and working memory, little is known regarding lifetime physical activity and working memory. According to a meta-analysis and systematic review of randomized controlled studies analyzing the impact of acute and chronic physical activity on working memory in healthy individuals of any age, chronic physical activity is shown to improve working memory while acute physical activity is not shown to do the same (Rathore & Lom, 2017). In the Rathore & Lom (2017) study, chronic physical activity is defined as multiple 30-minute physical activity sessions in a single physical activity intervention over the course of 4 weeks to 6 months. While in-person assessments of chronic physical activity affect working memory, it is unknown if assessing lifetime physical activity through a survey in older adults will show a relationship to working memory. As a result, the current study will analyze the effect of overall lifetime physical activity on working memory in older adults.

CHAPTER II

LITERATURE REVIEW

Cognitive Function and Working Memory

Working memory is an important cognitive function that is responsible for short-term memory, allowing for the absorption and immediate use of information before the information is disposed or moved to be stored as long-term memory. The ability of working memory is what allows individuals to perform everyday tasks efficiently, such as copying down a phone number, remembering items on a grocery list, and remembering the name of a new friend.

Working memory falls into the larger realm of overall cognitive function, which describes everything the active mind is responsible for, from just thinking to remembering important information to speaking. The main functions of cognition are as follows: memory, executive function, reasoning, attention, and language (Law et. al., 2019). Although working memory can classify as a form of memory, it falls under the executive function classification of cognition, since executive functioning is what supports planning, selective attention, sustained attention, resistance to interference, volitional inhibition, working memory, and mental flexibility (Guiney & Machado, 2013). The state of cognitive functioning, especially working memory, determines one's quality of life by how quickly and how efficiently one can process information and carry out tasks. The speed and efficiency of cognitive functioning ability changes as one ages.

Aging and Working Memory

Unfortunately, the state of overall cognitive functioning is destined to decline with aging, often beginning with a decline in working memory (Law et. al., 2019). This is inevitable because the brain's structure deteriorates with age, much like the structure of the human body as a whole. In fact, the brain's structure begins to deteriorate during the third decade of life (Colcombe et. al., 2006). In extreme cases, cognitive functioning into older age can decline to the point where it becomes irreversible dementia, such as Alzheimer's Disease or vascular dementia, which are the most prevalent forms of cognitive decline. Older adults show these signs when having a hard time with short term memory and losing their sense of space and time. According to the Institute for Dementia Research and Prevention at Pennington Biomedical Research Center, at least 5 million older adults nationwide have dementia, with the estimate that 1 in 10 men, and 1 in 6 women, living past the age of 55 years will develop dementia. The number of dementia cases will continue to grow as the older population becomes larger, due to the older adults of the Baby Boom cohort turning 65 years of age beginning in 2011 (United States Census Bureau, 2016).

Physical Activity and Working Memory

As cognitive decline is inevitable with age, performing regular physical activity can serve as a helpful measure to slow down the declination process. The reason that physical activity helps to preserve cognitive functioning is that the brain, like the body, alters itself in accordance with a person's physically active or sedentary lifestyle. The brain, also like the body, modifies its function and structure according to its environment (Gomez-Pinilla & Hillman, 2013). Sanders et al.

(2019) states that physical activity can promote brain plasticity and increase brain activation, leading to improvements in cognitive function. As a result, a person with a physically active lifestyle may have a sharper mind with better working memory ability than his or her sedentary neighbor. Better working memory ability will help an individual maintain independence well into older age.

Physical Activity and Aging

Despite this extraordinary health benefit that comes with physical activity, the amount of time spent doing physical activity decreases with age in correlation with working memory and overall cognitive performance. Older individuals spend less time doing physical activity in their older age than they did during the earlier phases of their lives. Unfortunately, only 27% of older adults report doing more than 30 minutes a day for 3 days a week (2019), while an additional 28% of older adults in the United States over the age of 50 years do not report any physical activity (2019). In fact, over 80% of adults in the United States do not meet the physical activity guidelines, while under 5% report doing 30 minutes of physical activity each day of the week (U.S. Department of Health and Human Services). Clearly, a large portion of the older adult population is not active enough to receive the cognitive benefits of being physically active.

Lifetime Physical Activity and Working Memory

Physical activity is defined as any bodily movement produced by the contraction of skeletal muscles that results in a substantial increase in caloric requirements over resting energy expenditure (ACSM). Physical activity can be performed in everything that involves movement, such as in walking, biking, dancing, and even in doing chores

around the house. To be considered physically active for each phase of life, an individual must meet specific guidelines for the minimum weekly amount of minutes. Overall lifetime physical activity is the conglomeration of physical activity levels throughout the entire lifespan. While lifetime physical activity can be measured in just about any age group, more time can be assessed in the older adult population, from childhood, young adulthood and middle adulthood to the current late adulthood.

Regular physical activity is defined as meeting the physical activity guidelines of the American College of Sports Medicine. These guidelines state that an individual must perform at least 30 minutes of moderate intensity physical activity for at least five days a week or at least 20 minutes of vigorous intensity physical activity for at least 3 days a week in order to be considered physically active. Moderate and vigorous intensity physical activity can also be combined to meet the guidelines (ACSM).

Meeting the physical activity guidelines offers many benefits such as weight control, increased life expectancy, bone and muscle strengthening, and disease prevention and treatment for morbidities such as obesity, diabetes, cardiovascular disease, and even some cancers (ACSM). As the American College of Sports Medicine states, “exercise is medicine.” Indeed, physical activity keeps the body and the mind in shape and in good health.

Particularly with the mind, physical activity attenuates the decline in cognitive functioning, including working memory, that comes with aging (Law et. al., 2019). Research suggests that there is a positive correlation between physical activity and working memory, even after controlling for confounding variables such as socioeconomic status, educational level, new hobbies and levels of human interaction

(Reas et. al., 2019). According to a meta-analysis and systematic review analyzing the impact of acute and chronic physical activity, defined as the impact of physical activity interventions in various studies that either included a single physical activity session or multiple sessions, on working memory in healthy individuals of any age, chronic physical activity is shown to improve working memory while acute physical activity is not shown to do the same (Rathore & Lom, 2017).

Chronic physical activity in the Rathore & Lom (2017) study is defined a physical activity intervention that included multiple physical activity sessions lasting from 4 weeks to 6 months. This type of physical activity contrasts with lifetime physical activity in the current study, as lifetime physical activity is the sum of physical activity sessions from over the entire lifetime. While this meta-analysis, along with other physical activity research, show a direct relationship between chronic physical activity and working memory, no research has assessed lifetime physical activity in older adults completing a questionnaire. It is unknown whether survey assessments show this same relationship. This study reflects lifetime physical activity through a survey in older adults to see if there is a relationship to working memory.

CHAPTER III

METHODS

Participants

This survey study recruited older adult participants over the age of 65 years through word of mouth, email, and Facebook. The number of participants included in the analysis of the study was 22, providing a variety of physical activity levels. Participants were excluded from the analysis if they did not complete all of the questions in the survey and if they were diagnosed with clinical dementia, such as the most common forms, Alzheimer's disease and vascular dementia. This study was done with the approval of the IRB.

Procedures

This study was completed remotely with the use of an online Qualtrics survey. After consenting to participate in the study, participants completed a physical activity level questionnaire. This questionnaire assessed how often and for how long, during a regular week, each individual performed moderate and vigorous intensity physical activities throughout each life phase (see Appendix B). The life phases assessed include the teenage years, at age 30, and at age 50 while also assessing pre-Covid and current activity levels.

Participants then completed the Multifactorial Memory Questionnaire (MMQ) Ability Assessment, which scored their working memory ability. This assessment provided 20 different common memory mistakes where participants rated how often they make those memory mistakes, such as forgetting to pay a bill or take a medication. These

memory mistakes were rated on a scale from 0 to 4; 0 being “never” and 4 being “all the time.” To assess the confounder of social interaction, a questionnaire was administered to have participants assess how many hours, on average, during the week they spend time with family or the people they live with versus the time they spend with friends (see Table 1).

Data Analysis

The data for each participant was retrieved from the physical activity level questionnaire as well as the Ability Assessment from the Multifactorial Memory Questionnaire. From the physical activity level questionnaire, a variety of physical activity levels was reported. The physical activity data was collected as minutes per week for both moderate and vigorous physical activity. The American College of Sports Medicine states that minutes of vigorous intensity can be converted to minutes of moderate intensity by multiplying vigorous physical activity minutes by 2 (ACSM). Following this rule, vigorous intensity minutes from each life phase were converted into moderate intensity minutes and added together in order to estimate the total average moderate intensity hours performed over the entire lifetime.

The data from the Ability Assessment of the Multifactorial Memory Questionnaire presented different levels of working memory ability. It was scored on a scale from 0 to 4, 0 being the participant makes the memory mistake all the time and 4 being the participant never makes the memory mistake. The rated numbers from each of the 20 questions were added together to get the total working memory ability score. Total scores ranging from 40 to 60 classified as average working memory ability (MMQ).

To compare the relationship between the lifetime physical activity levels and working memory, a multifactorial regression analysis was completed using SPSS version 23 (IBM, Armonk, NY). Significance was set at a p-value of <0.05. The confounders of social interaction time spent with both family, friends, and hobbies were initially included in the regression analysis.

CHAPTER IV

RESULTS

A multifactorial regression was used to assess the relationship between physical activity and working memory (MMQ Ability Assessment). Initially, there were 31 participants that completed the survey. However, 8 participants were excluded from the analysis because they did not fully complete the questions regarding physical activity levels and working memory ability. An additional participant was excluded as an outlier. The number of participants included in the analysis of the study was 22, providing a variety of physical activity levels. Table 1 displays the characteristics of the participants, including age and how many other individuals live in their household. First, the confounding variables of social interaction with family and friends were assessed, followed by the assessment of lifetime physical activity (see Table 2). Significance was found between time spent with family and working memory *(beta = .117, p = .001),* but significance was not found between time spent with friends and working memory. Social interaction time with family and lifetime physical activity levels were significantly related to working memory scores *(beta = .001, p = .034).* The social interaction of family time explained 45.7% of the variation, while adding total physical activity to the model explained an additional 57.5% of the variation (see Figure 1). This shows that physical activity levels, after accounting for social interaction time with family, is significantly related to working memory ability.

TABLE

Table 1. Participant Characteristics (n=22)

	Mean ± SD; % (N)
Age (yrs)	75.64 ± 7.014
Living Status	
Spouse or 1 Individual	72.7 (16)
2 or More Individuals	8.7 (2)
Alone	17.4 (4)

FIGURE

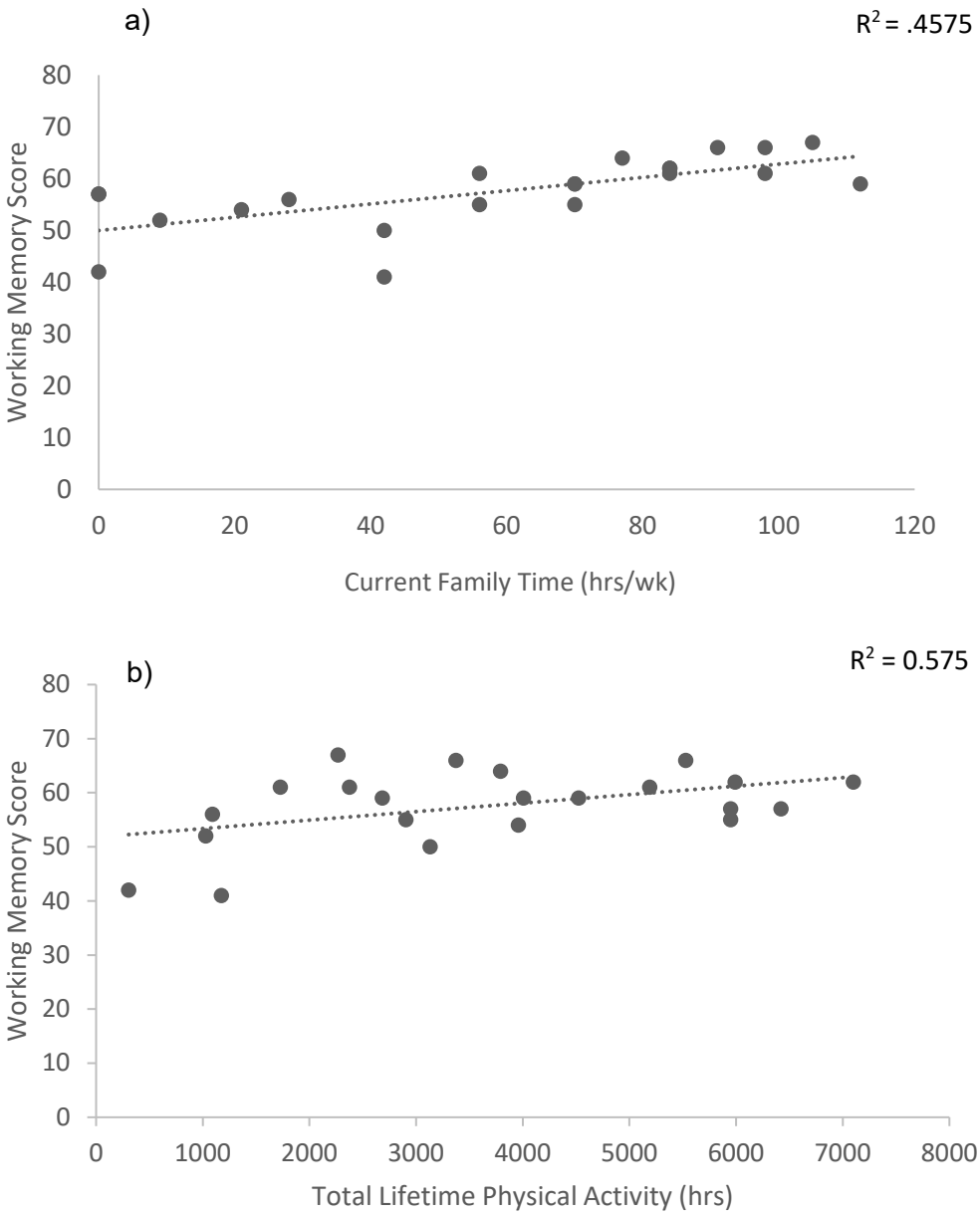

Figure 1. The relationship between a) current family time and b) total lifetime physical activity on working memory scores. Current family time was significantly related to working memory scores.
After accounting for current family time, total lifetime physical activity was also significantly related to working memory scores.

CHAPTER V

DISCUSSION

This study administered a survey to adults, 65 years and older, to assess physical activity levels over the entire lifetime as well as working memory ability by rating how often memory mistakes occur. The confounding variables of social interaction time with both family and friends were included in the main assessment. The main outcome resulting from this study is that lifetime physical activity significantly predicts working memory ability into older age. Physical activity along with the confounding social interaction time is significantly related to working memory ability.

An association between physical activity and cognitive functioning, one of those functions being working memory ability, has been suggested through previous research (Sanders et. al., 2019). As working memory is one of the brain's cognitive functions, it makes sense as to why physical activity impacts working memory, as was found in this study. In fact, physical activity in older age alone attenuates cognitive decline and lowers the rate of dementia (Reas et. al., 2019). As short-term physical activity offers cognitive benefit, longer-term physical activity has an even greater benefit for cognition because it improves cognitive functions such as working memory, while short-term physical activity does not (Rathore & Lom, 2017). As the Rathore & Lom (2017) systematic review and meta-analysis of randomized controlled trials observed "long-term" physical activity as only a single physical activity intervention with multiple exercise sessions lasting from 4 weeks to 6 months, the "long-term" physical activity was still found to have a significant impact on working memory. However, the current study looked at the ultimate version of long-term physical activity, which is overall lifetime physical activity from 5 life phases.

It corroborates with the Rathore & Lom (2017) meta-analysis by showing that overall lifetime physical activity significantly predicts working memory ability into late adulthood.

The limitations of this study begin with the small sample size of only 22 participants, which puts the study at risk for not having enough variety in physical activity and social interaction levels. However, the sample size was large and variable enough to assess the physical activity and working memory relationship. However, a larger sample size may be needed to assess the effect of friend time on working memory. Next, a handful of the participants may include married couples or groupings of people that live in the same household. Participants that are coupled or grouped together may have increases the homogeneity of the physical activity and social interaction levels these individuals may be on the same schedule.

Another limitation is that the study was conducted through a survey, which puts the study at risk for memory bias. A likely explanation for any memory bias is it could have been difficult for older adults to recall exactly how often they performed physical activity at certain periods in their lives. The confounding variable of medications was also not included in the assessment of the study, which could have had an influence on working memory ability. Finally, the physical activity level questionnaire used for this survey was a self-assessment tool since the study had to be done remotely, whereas previous research used interview mediated protocols to record physical activity levels. As the study was not able to use an interview approach for the physical activity level questionnaire, it also puts the study at further risk for memory bias.

In conclusion, after assessing older adults, a significant relationship between lifetime physical activity levels and its effect on working memory ability was found. Physical activity levels throughout the entire lifespan, along with social interaction time, was found to significantly predict the state of working memory ability into older age. Therefore, it is important to be physically active throughout life in order to have good working memory ability and to maintain cognitive wellness.

CHAPTER VI

SUMMARY

The purpose of this study was to assess the effect of lifetime physical activity on working memory ability in older adults. Included in the main analysis, which contributed to the significant results of the study, was the confounding variables of social interaction time with both family and friends.

The significance of this study lies in the fact that no study has attempted to assess the association between overall lifetime physical activity and the specific cognitive function of working memory. Previous research has confirmed a positive correlation between physical activity and cognitive functioning, such as in Sanders et al., which states that physical activity promotes brain plasticity and increases brain activation, leading to improvements in cognitive function, including working memory (2019). However, previous research has not assessed lifetime physical activity. This study is unique in the fact that no previous studies have looked at physical activity levels from over the entire lifespan and how it impacts working memory into older age.

After adjusting for social interaction time with family, a significant relationship was found between physical activity levels over the entire lifespan and working memory ability. The main outcome suggests that it is not physical activity alone that predicts working memory ability into older age. Further research on different factors that impact working memory ability is needed to better answer the question of what it is that predicts working memory into older age. However, the significant results from this study suggest that being physically active throughout the entire lifetime, and being socially interactive

social, is very important for the state of working memory and, in turn, overall cognition into older age.

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APPENDIX A: THE SURVEY

Current Physical Activity Level

Moderate Physical Activity is any activity that is somewhat hard and makes you feel like you do when you walk fast (3-4 mph).

Examples of Moderate Physical Activity:

Walking (3-4 mph)	Bicycling (less than 12 mph)	Vigorous Stretching
Gardening	Water Aerobics	Washing a Car
Carpentry	Yoga	Golf
Mowing the Lawn	Skateboarding	Horseback Riding
Frisbee	Playing with Children (kneeling, lifting)	Dancing
Baseball or Softball	Bowling	Fishing
Rowing	Sailing	Housework (mopping, sweeping)
Low impact aerobics	Weight Lifting	Volleyball
Lifting or carrying moderate loads (5-15 lbs.)	Ping Pong	Tai Chi
Qi Gong	Gymnastics	Calisthenics (light)

During the last 7 days, on how many days did you do a **Moderate** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Moderate** physical activities?

_____ Minutes/Day

Vigorous Physical Activity is any activity that is hard and makes you feel like you do when you run or jog.

Examples of Vigorous Physical Activity:

Jogging	Running	High Impact Aerobics
Stair Climbing	Bicycling (more than 12 mph)	Basketball
Jumping Rope	Kickboxing	Soccer
Football	Swimming Laps	Karate
Ski Machine (Nordic Track)	Tennis	Roller Skating or Blading
Judo	Racquetball	Zumba
Hockey	Hiking	Calisthenics (vigorous)

During the last 7 days, on how many days did you do a **Vigorous** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Vigorous** physical activities?

_____ Minutes/Day

Pre-COVID-19 Physical Activity Level

Moderate Physical Activity is any activity that is somewhat hard and makes you feel like you do when you walk fast (3-4 mph).

Examples of Moderate Physical Activity:

Walking (3-4 mph)	Bicycling (less than 12 mph)	Vigorous Stretching
Gardening	Water Aerobics	Washing a Car
Carpentry	Yoga	Golf
Mowing the Lawn	Skateboarding	Horseback Riding
Frisbee	Playing with Children (kneeling, lifting)	Dancing
Baseball or Softball	Bowling	Fishing
Rowing	Sailing	Housework (mopping, sweeping)
Low impact aerobics	Weight Lifting	Volleyball
Lifting or carrying moderate loads (5-15 lbs.)	Ping Pong	Tai Chi
Qi Gong	Gymnastics	Calisthenics (light)

Before the COVID-19 pandemic, how many days a week did you do a **Moderate** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Moderate** physical activities?

_____ Minutes/Day

Vigorous Physical Activity is any activity that is hard and makes you feel like you do when you run or jog.

Examples of Vigorous Physical Activity:

Jogging	Running	High Impact Aerobics
Stair Climbing	Bicycling (more than 12 mph)	Basketball
Jumping Rope	Kickboxing	Soccer
Football	Swimming Laps	Karate
Ski Machine (Nordic Track)	Tennis	Roller Skating or Blading
Judo	Racquetball	Zumba
Hockey	Hiking	Calisthenics (vigorous)

Before the COVID-19 pandemic, how many days a week did you
do a **Vigorous** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Vigorous** physical activities?

_____ Minutes/Day

Physical Activity Level at 50 Years of Age

Moderate Physical Activity is any activity that is somewhat hard and makes you feel like you do when you walk fast (3-4 mph).

Examples of Moderate Physical Activity:

Walking (3-4 mph)	Bicycling (less than 12 mph)	Vigorous Stretching
Gardening	Water Aerobics	Washing a Car
Carpentry	Yoga	Golf
Mowing the Lawn	Skateboarding	Horseback Riding
Frisbee	Playing with Children (kneeling, lifting)	Dancing
Baseball or Softball	Bowling	Fishing
Rowing	Sailing	Housework (mopping, sweeping)
Low impact aerobics	Weight Lifting	Volleyball
Lifting or carrying moderate loads (5-15 lbs.)	Ping Pong	Tai Chi
Qi Gong	Gymnastics	Calisthenics (light)

At **50 years old**, how many days in a week did you do a **Moderate** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Moderate** physical activities?

_____ Minutes/Day

Vigorous Physical Activity is any activity that is hard and makes you feel like you do when you run or jog.

Examples of Vigorous Physical Activity:

Jogging	Running	High Impact Aerobics
Stair Climbing	Bicycling (more than 12 mph)	Basketball
Jumping Rope	Kickboxing	Soccer
Football	Swimming Laps	Karate
Ski Machine (Nordic Track)	Tennis	Roller Skating or Blading
Judo	Racquetball	Zumba
Hockey	Hiking	Calisthenics (vigorous)

At **50 years old**, how many days in a week did you do a **Vigorous** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Vigorous** physical activities?

_____ Minutes/Day

Physical Activity Level at 30 Years of Age

Moderate Physical Activity is any activity that is somewhat hard and makes you feel like you do when you walk fast (3-4 mph).

Examples of Moderate Physical Activity:

Walking (3-4 mph)	Bicycling (less than 12 mph)	Vigorous Stretching
Gardening	Water Aerobics	Washing a Car
Carpentry	Yoga	Golf
Mowing the Lawn	Skateboarding	Horseback Riding
Frisbee	Playing with Children (kneeling, lifting)	Dancing
Baseball or Softball	Bowling	Fishing
Rowing	Sailing	Housework (mopping, sweeping)
Low impact aerobics	Weight Lifting	Volleyball
Lifting or carrying moderate loads (5-15 lbs.)	Ping Pong	Tai Chi
Qi Gong	Gymnastics	Calisthenics (light)

At **30 years old**, how many days in a week did you do a **Moderate** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Moderate** physical activities?

_____ Minutes/Day

Vigorous Physical Activity is any activity that is hard and makes you feel like you do when you run or jog.

Examples of Vigorous Physical Activity:

Jogging	Running	High Impact Aerobics
Stair Climbing	Bicycling (more than 12 mph)	Basketball
Jumping Rope	Kickboxing	Soccer
Football	Swimming Laps	Karate
Ski Machine (Nordic Track)	Tennis	Roller Skating or Blading
Judo	Racquetball	Zumba
Hockey	Hiking	Calisthenics (vigorous)

At **30 years old**, how many days in a week did you do a **Vigorous** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Vigorous** physical activities?

_____ Minutes/Day

Physical Activity Level During the Teenage Years

Moderate Physical Activity is any activity that is somewhat hard and makes you feel like you do when you walk fast (3-4 mph).

Examples of Moderate Physical Activity:

Walking (3-4 mph)	Bicycling (less than 12 mph)	Vigorous Stretching
Gardening	Water Aerobics	Washing a Car
Carpentry	Yoga	Golf
Mowing the Lawn	Skateboarding	Horseback Riding
Frisbee	Playing with Children (kneeling, lifting)	Dancing
Baseball or Softball	Bowling	Fishing
Rowing	Sailing	Housework (mopping, sweeping)
Low impact aerobics	Weight Lifting	Volleyball
Lifting or carrying moderate loads (5-15 lbs.)	Ping Pong	Tai Chi
Qi Gong	Gymnastics	Calisthenics (light)

During your **teenage years**, how many days in a week did you do a **Moderate** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Moderate** physical activities?

_____ Minutes/Day

Vigorous Physical Activity is any activity that is hard and makes you feel like you do when you run or jog.

Examples of Vigorous Physical Activity:

Jogging	Running	High Impact Aerobics
Stair Climbing	Bicycling (more than 12 mph)	Basketball
Jumping Rope	Kickboxing	Soccer
Football	Swimming Laps	Karate
Ski Machine (Nordic Track)	Tennis	Roller Skating or Blading
Judo	Racquetball	Zumba
Hockey	Hiking	Calisthenics (vigorous)

During your **teenage years**, how many days in a week did you do a **Vigorous** physical activity?

_____ Days

On those days, how much time did you spend on average doing **Vigorous** physical activities?

_____ Minutes/Day

Social Interaction Questionnaire

1. How many people do you live with? *Check the appropriate box.*

	Alone
	1 *(Spouse, Family Member, Friend, etc.)*
	2 or more *(Family, etc.)*

Think about the last 7 days...

2. How many days in the week do you spend with the person/people you live with? On those days, how many hours do you spend with them?

_____ days/week _____ hours/day

3. How many days in the week do you spend time alone without social interaction? On those days, how many hours are you alone?

_____ days/week _____ hours/day

4. How many days in the week do you spend interacting and visiting with other people that do not live with you? *(including phone calls)* On those days, how many hours are you visiting with them?

_____ days/week _____ hours/day

Personal Mind-Engaging Hobbies Questionnaire

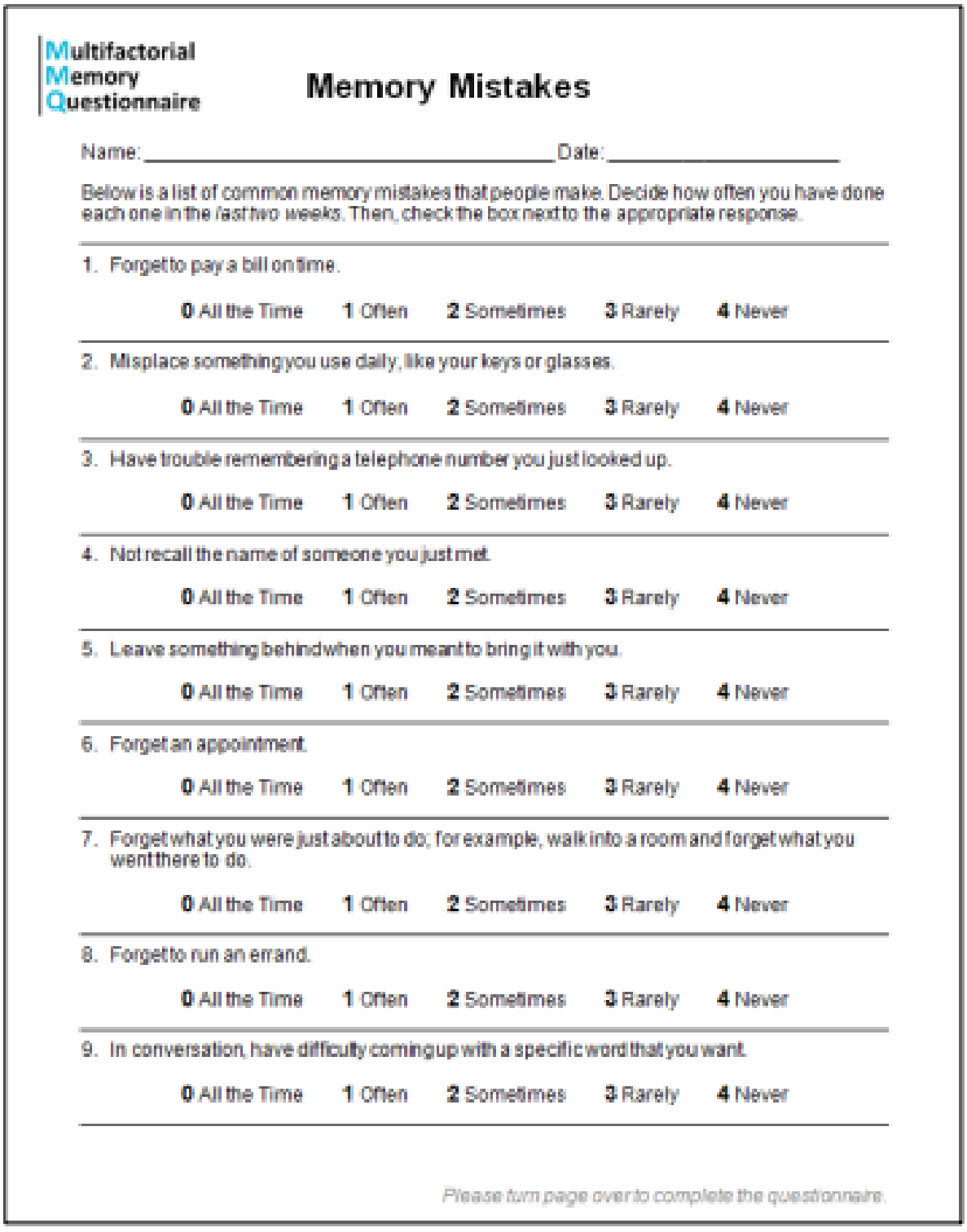
Painting/Pottery	Musical Instrument	Reading
Baking/Cooking	Gardening	Learning a New Language
Knitting/Sewing	Board/Card Games (*Scrabble, Chess, Poker, etc.)*	Puzzles
Crafting	Photography	Brewing

Think about the last 7 days...

1. How many days during the week do you engage in your hobby/hobbies? On those days, how much time do you spend on your hobby/hobbies?

_____ days/week _____ hours/day

Figure A2. MMQ-Ability



Multifactorial Memory Questionnaire

Memory Mistakes

Name: _____ Date: _____

Below is a list of common memory mistakes that people make. Decide how often you have done each one in the *last two weeks*. Then, check the box next to the appropriate response.

1. Forget to pay a bill on time.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

2. Misplace something you use daily, like your keys or glasses.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

3. Have trouble remembering a telephone number you just looked up.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

4. Not recall the name of someone you just met.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

5. Leave something behind when you meant to bring it with you.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

6. Forget an appointment.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

7. Forget what you were just about to do; for example, walk into a room and forget what you went there to do.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

8. Forget to run an errand.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

9. In conversation, have difficulty coming up with a specific word that you want.

   0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

Please turn page over to complete the questionnaire.

10. Have trouble remembering details from a newspaper or magazine article you read earlier that day.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

11. Forget to take medication.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

12. Not recall the name of someone you have known for some time.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

13. Forget to pass on a message.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

14. Forget what you were going to say in conversation.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

15. Forget a birthday or anniversary that you used to know well.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

16. Forget a telephone number you use frequently.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

17. Retell a story or joke to the same person because you forgot you already told him or her.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

18. Misplace something that you put away a few days ago.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

19. Forget to buy something you intended to buy.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

20. Forget details about a recent conversation.

0 All the Time **1** Often **2** Sometimes **3** Rarely **4** Never

Baycrest

APPENDIX B: IRB APPROVAL LETTER

IRB
INSTITUTIONAL REVIEW BOARD
Office of Research Compliance,
010A Sam Ingram
Building, 2269 Middle
Tennessee Blvd
Murfreesboro, TN
37129
FWA: 00005331/IRB Regn.. 0003571

MIDDLE TENNESSEE STATE UNIVERSITY

IRBN007 – EXEMPTION DETERMINATION NOTICE

Thursday, June 03, 2021

Protocol Title	***The Effect of Lifetime Physical Activity on Working Memory in Older Adults***
Protocol ID	**21-1194 2q**
Principal Investigator	**Marissa Gray** (Student)
Faculty Advisor	Vaughn Barry
Co-Investigators	NONE
Investigator Email(s)	*mrg5k@mtmail.mtsu.edu; vaughn.barry@mtsu.edu*
Department/Affiliation	Health and Human Performance

Dear Investigator(s),

The above identified research proposal has been reviewed by the MTSU Institutional Review Board (IRB) through the **EXEMPT** review mechanism under 45 CFR 46.101(b)(2) within the research category ***(2) Educational Tests, surveys, interviews or observations of public behavior*** *(Qualtrics Survey).* A summary of the IRB action and other particulars of this protocol are shown below:

IRB Action	**EXEMPT from further IRB Review** Exempt from further continuing review but other oversight requirements apply
Date of Expiration	**12/31/2022** *Date of Approval:* **6/3/21** *Recent Amendment:* NONE
Sample Size	TWO HUNDRED (200)
Participant Pool	**Healthy adults (18 or older) - Older adults who are NOT clinically diagnosed with dementia**
Exceptions	Online consent followed by internet-based survey using Qualtrics is permitted (Qualtrics links on file).
Type of Interaction	Non-interventional or Data Analysis Virtual/Remote/Online Interview/survey In person or physical– Mandatory COVID-19 Management (refer next page)
Mandatory Restrictions	**1. All restrictions for exemption apply.** **2. The participants must be 18 years or older.** **3. Mandatory ACTIVE informed consent. Identifiable information including, names, addresses, voice/video data, must not be obtained.** **4. NOT approved for in-person data collection.**
Approved IRB Templates	*IRB Templates:* Qualtrics Informed Consent *Non-MTSU Templates:* Recruitment Script
Research Inducement	NONE
Comments	NONE

Summary of the Post-approval Requirements: The PI and FA must read and abide by the post-approval conditions (Refer "*Quick Links*" in the bottom):

- ***Final Report:*** The Faculty Advisor (FA) is responsible for submitting a final report to close-out this protocol before **12/31/2022**; if more time is needed to complete the data collection, the FA must request an extension by email. REMINDERS WILL NOT BE SENT. **Failure to close-out (or request extension) may result in penalties** including cancellation of the data collected using this protocol or withholding student diploma.
- ***Protocol Amendments***: IRB approval must be obtained for all types of amendments, such as:
  - Addition/removal of subject population and sample size.
  - Change in investigators.
  - Changes to the research sites – appropriate permission letter(s) from may be needed.
  - Alternation to funding.
  - Amendments must be clearly described in an addendum request form submitted by the FA.
  - The proposed change must be consistent with the approved protocol and they must comply with exemption requirements.
- ***Reporting Adverse Events:*** Research-related injuries to the participants and other events , such as, deviations & misconduct, must be reported within 48 hours of such events to compliance@mtsu.edu.
- ***Research Participant Compensation:*** Compensation for research participation must be awarded as proposed in Chapter 6 of the Exempt protocol. The documentation of the monetary compensation must Appendix J and MUST NOT include protocol details when reporting to the MTSU Business Office.
- ***COVID-19:*** Regardless whether this study poses a threat to the participants or not, refer to the COVID-19 Management section for important information for the FA.

COVID-19 Management:

The FA must enforce social distancing guidelines and other practices to avoid viral exposure to the participants and other workers when physical contact with the subjects is made during the study.

- The study must be stopped if a participant or an investigator should test positive for COVID-19 within 14 days of the research interaction. This must be reported to the IRB as an "adverse event."
- The FA must enforce the MTSU's "Return-to-work" questionnaire found in Pipeline must be filled and signed by the investigators on the day of the research interaction prior to physical contact.
- PPE must be worn if the participant would be within 6 feet from the each other or with an investigator.
- Physical surfaces that will come in contact with the participants must be sanitized between use
- **FA's Responsibility:** The FA is given the administrative authority to make emergency changes to protect the wellbeing of the participants and student researchers during the COVID-19 pandemic. However, the FA must notify the IRB after such changes have been made. The IRB will audit the changes at a later date and the PI will be instructed to carryout remedial measures if needed.

Post-approval Protocol Amendments:
The current MTSU IRB policies allow the investigators to implement minor and significant amendments that would not result in the cancellation of the protocol's eligibility for exemption. ***Only THREE procedural amendments will be entertained per year*** *(changes like addition/removal of research personnel are not restricted by this rule).*

Date	Amendment(s)	IRB Comments
NONE	NONE.	NONE

Post-approval IRB Actions:
The following actions are done subsequent to the approval of this protocol on request by the PI or on recommendation by the IRB or by both.

Date	IRB Action(s)	IRB Comments
NONE	NONE.	NONE

Mandatory Data Storage Requirement:

All research-related records (signed consent forms, investigator training and etc.) must be retained by the PI or the faculty advisor (if the PI is a student) at the secure location mentioned in the protocol application. The data must be stored for at least three (3) years after the study is closed. Additionally, the Tennessee State data retention requirement may apply (refer "Quick Links" below for policy 129). Subsequently, the data may be destroyed in a manner that maintains confidentiality and anonymity of the research subjects. The IRB reserves the right to modify/update the approval criteria or change/cancel the terms listed in this notice. Be advised that IRB also reserves the right to inspect or audit your records if needed.

Sincerely,

Institutional Review Board
Middle Tennessee State University

Quick Links:

- Post-approval Responsibilities: http://www.mtsu.edu/irb/FAQ/PostApprovalResponsibilities.php
- Exemption Procedures: https://mtsu.edu/irb/ExemptPaperWork.php
- MTSU Policy 129: Records retention & Disposal: https://www.mtsu.edu/policies/general/129.php