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RESEARCH ARTICLE

A Study of the Effects of Learning and Practicing Motor Skills on Cognitive Abilities and Psychological Well-Being among Older Adults with Mild Cognitive Impairment

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Abstract

Background: Older adults' mild cognitive impairment (MCI) can affect their daily activities. Therefore, researchers have developed a variety of rehabilitation strategies for this impairment.

Aim: This study examines the impact of learning and practicing motor skills on the cognitive functioning and psychological well-being of patients suspected of being affected by MCI.

Method and results: For this purpose, 32 patients aged 55-75 year-old men were selected among people suspected of having MCI syndrome by interviewing and psychological evaluation by a psychologist and randomly divided into two experimental and control groups. Nejati cognitive ability tests (2013) (which evaluates seven cognitive abilities; memory, inhibitory control and selective attention, decision making, planning, sustained attention, social cognition, and cognitive flexibility) and the Oxford Happiness Questionnaire (1989) (which evaluates five psychological well-being factors; life satisfaction, happiness, self-esteem, self-control, and self-efficacy) was implemented on the groups. Three months and three weekly sessions were organized for the experimental group, in which movement skills (adapted from authentic martial arts) were taught and practiced. The multivariate covariance analysis (MANCOVA) statistical method analyzed the pre-and post-test data. The results revealed a substantial rise in the average scores of five categories of cognitive skills (memory, decision-making, inhibitory control, sustained attention, cognitive flexibility) and all five psychological well-being scales in the experimental group.

Conclusion: The results showed that learning and practicing movement skills impacted brain functioning, improving several cognitive abilities and aspects of psychological well-being in older adults who were believed to suffer from MCI syndrome. Furthermore, from a theoretical standpoint, these findings are consistent with the results of neuroscience and specific theories that see cognition as a type of movement-dependent brain functioning.

Keywords

Mild cognitive impairment (MCI), Motor skills, Cognitive abilities, Psychological well-being

Introduction

The aging process has physical, social, neurological, and psychological challenges. Although, of course, from a comprehensive viewpoint, it is impossible to draw a line between these fields; to some degree, these lines are contractual. This demarcation examines the problem from the standpoint of the sciences community, Man is a unified whole, and his plurality leads nowhere. Although issues associated with old age are expected to affect some older people, they are not likely to affect all of them. No! A person's history and current lifestyle may play a role in the onset or appearance of these disorders [1].

Nevertheless, some of these issues are brain related. Cognitive decline can sometimes occur as people age and can be brought on by neurological conditions like Alzheimer's [2]. In the same way as any other organ in the body, the central nervous system, specifically the brain, is subject to good and bad changes. Age-related brain changes might have undesirable effects on their own. These unfavorable alterations may result from

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decreased neurogenesis and plasticity processes or reflect issues with other systems, such as cardiovascular issues.

The researchers showed that one of the most prevalent aging illnesses that raise the risk of dementia is mild cognitive impairment (MCI) [3]. Mild cognitive impairment as a term entered the literature in 1988 by Reisberg et al. They defined MCI as a significant adverse change in cognitive abilities that could clinically be described and occurred during the past ten years. However, a considerable transition has happened over the past decade in the clinical description of cognitive impairment [4]. Due to ambiguities about this concept, one of the efforts of researchers in this field has been to clarify this concept and enumerate criteria for differential diagnosis of mild pathological syndrome with similar cases, such as dementia caused by old age, Alzheimer's, Etc.

MCI syndrome can be described as a clinical syndrome with an unanticipated cognitive deterioration relative to the person's age and literacy level that has little impact on every day activities by considering all the classifications that are currently accessible. It implies that a person is capable of handling everyday life. In other words, MCI is a condition in which a person's cognitive abilities, such as memory and reasoning skills, gradually but noticeably deteriorate. The afflicted individual, their family, and friends may all see these changes, yet they do not impact the person's ability to carry out everyday tasks. Although MCI does not exhibit other signs of dementia, such as impaired judgment or thinking, a person with MCI has more memory issues than expected as they age.

MCI is viewed by some researchers [5] as a crucial step between dementia and cognitive impairment brought on by aging. There are two significant varieties of MCI: 1) The amnesiac type, which primarily impairs memory and may lead the individual to forget crucial information that was previously readily recalled, such as appointments, conversations, or recent occurrences, and 2) The non-amnesic variety, which has an impact on cognitive and intellectual abilities other than memory, such as the steps necessary to finish a difficult task or visual perception [6,7].

Numerous statistics on MCI have been gleaned from epidemiological research. As a result, it is difficult to distinguish this disease from comparable disorders due to their overlap. For instance, some illnesses, like Alzheimer's disease, are claimed to have their earliest stage in specific situations [4]. However, some studies have indicated that 10-20% of adults over 65 have this illness [8].

In any case, it has a minor impact on the rehabilitation aspect of treating MCI as an illness by itself or if it represents the early stage of neurological disorders like Alzheimer's. That is, treating these illnesses requires cognitive rehabilitation. Rehabilitative treatments frequently result in the recovery of lost abilities, increased quality of life, and improved mental health in aged people. Furthermore, if MCI is the first stage of a degenerative neurological problem, rehabilitation methods will slow the disease's progression.

What are rehabilitations, and how do they operate is the query. There have been many different approaches to cognitive rehabilitation, many of which claim to be able to slow, stop, or even reverse the progression of cognitive deficits. However, all rehabilitation techniques may utilize the brain's natural potential and capacities.

Neuroscience research has so far demonstrated that the brain is an organ that communicates with the world. If this point is emphasized particularly, the brain is a natural extension of the environment and part of it. This association impacts the brain's health, bio-damage, and optimality. In response to its surroundings, the brain develops its structure. Brain plasticity or neural plasticity is used to describe this brain characteristic. Neural plasticity may also be defined as the ability of the brain to adapt to its surroundings. Of course, a person's activities alter with aging. Many studies have demonstrated the advantages of cognitive rehabilitation for those with progressive brain diseases, including MCI [9]. However, the fact that those with MCI have more flexibility and learning capacity than those with more advanced illnesses may suggest that cognitive therapies will be more successful when they are still in the MCI phase.

Cognitive training is the most frequently suggested form of therapy for MCI. One factor that led to the focus on this form of rehabilitation was the observation that pharmacological treatment had little impact on those with cognitive impairment [10]. Cognitive exercises are a part of these rehabilitation techniques, and repetition and practice are believed to enhance or preserve a person's skills. The main objectives of these therapies are to slow the course of cognitive impairment, improve everyday activities and social interactions, and support carers.

Computer-based cognitive treatments are one of the most popular types of cognitive training and exercises. In treating neurological illnesses, computer-based cognitive therapies are regarded as an excellent therapeutic tool [11]. This cognitive intervention involves carrying or using a device designed with modern technology, such as a laptop, mobile phone, tablet, or personal computer. In addition to accessibility, adaptability, and affordability, researchers have noted the benefits of this approach to cognitive therapies [12]. There are no time or location restrictions on the use of these sorts of therapies, and their use does not require the ongoing assistance of a psychologist or facilitator.

In computer-based cognitive treatments, the patient can practice whenever and wherever after a learning session. However, this strategy does have several drawbacks as well. One of those scenarios concerns the accessibility and availability of these therapies in the area and the facilities there. In underdeveloped regions, some older individuals experience economic and cultural poverty, making it challenging to afford or use these modern instruments. Furthermore, this treatment method has two significant disadvantages: 1- Separation and deprivation from others. To accomplish the training, a person needs to be in an appropriate atmosphere and away from others to practice, and 2- Sedentary. Using this method, the person should accomplish the exercises on the device screen while sitting in a fixed position without being physically active.

Several studies have demonstrated that these two aspects (sociability and physical activity) are crucial to developing and maintaining the brain's health. These two sources are necessary for brain neuroplasticity and growth from the beginning and brain survival. These two elements are essential for preserving "brain fitness" throughout life. The brain is an organ that must communicate with its surroundings, especially with the social environment. For the brain, "The Second Factor" is equally crucial.

On the one hand, a person's self-awareness is supplied through engagement with others and social relationships. The brain will not function at its best without regular social connections. In contrast, the brain is active during movement and maintains and modifies its direction toward the body and surroundings. Indeed, some researchers even contend that cognition starts with exercise and activeness. This approach is supported by the definitions and phases of early cognitive development in Jean Piaget's theory. According to Piaget's hypothesis, the sensory-motor stage is the initial stage of cognitive development. Neuroscientists believe mobility and skill training cause the human brain to reorganize structurally and change its functions. In terms of development and assuming that neuronal plasticity persists throughout life, it is crucial to use techniques to accelerate this process, particularly in adults.

This issue has been studied extensively. For example, a meta-analysis of 29 randomized controlled trials (n = 2,049) found that aerobic exercisers demonstrated refinements in attention, processing speed, memory, and executive function [13].

Another meta-analysis of 15 prospective trials (33,168 individuals without dementia) revealed that physical activity had a protective effect at all activity levels [14].

Research results on students unmistakably demonstrated a beneficial relationship between vigorous physical exercise and excellent academic achievement [15]. Furthermore, excellent cardiorespiratory fitness and a greater hippocampus volume are connected to superior memory function in children [16]; similar findings have been confirmed in teenage samples [17]. Moreover, research on the function of motor learning in brain plasticity has demonstrated that learning motor skills is one of the critical components of brain plasticity. It was shown by Lakhanian, et al. that learning motor skills improve myelin plasticity in the brain. According to the findings of this study, white matter circuitry's speed of guiding and ideal timing enhanced after acquiring motor abilities. Furthermore, a survey by Kai, et al. in 2014 displayed the importance of movement exercises in brain plasticity. Debas, et al.'s [18] study on brain plasticity also revealed that brain plasticity plays a role in the consolidation of motor sequence learning and motor adaptation.

Furthermore, some studies have shown that physical exercises, specifically those combined with learning and performing rhythmic movements, or psychomotor activities, increase or improve executive functions. The prefrontal cortex is well known for its processes related to administrative positions. A study by Abrahamson also demonstrated that physical exercises could result in brain plasticity in various manners. According to Chu, et al., Taekwondo training for 16 weeks significantly increased biochemical and biological factors (BDNF, VEGF, IGF-1), promoting neuroplasticity.

As a result, the effects of physical activity on neuroplasticity can be linked to changes in the brain's cognitive capabilities. The issue of what biochemical processes in the brain lead to neural plasticity may be posed in light of the previous sentence. According to Phillips, some of these biochemical mechanisms in the interneuron region of the brain that either directly or indirectly influence the actions that trigger neural plasticity in the brain include 1- Neurotropic synthesis, 2- Neurogenesis, 3- Preventing brain inflammation, 4- Coping with Stress, and 5- Increasing antioxidant activity. Moreover, studies have demonstrated that the post-synaptic membrane undergoes modifications. For example, the formation of clusters of new spines in the areas next to the dendrites of the mouse motor cortex neurons is one of these structural modifications. The stability of these new dendritic spines has been linked to the persistence of memory [19].

According to the existing research literature, some of which were mentioned, it is concluded that movement and social interactions play an essential role in keeping the brain healthy and rebuilding it. Also, learning is vital to keeping the brain fit. Today, participating in an activity where these three elements-movement, social contact, and education-are somehow interwoven will be advantageous for persons with MCI syndrome. Hence, group learning and motor skill practice were considered in this study. Therefore, the research question of this study is whether learning and practicing motor skills will be able to affect the cognitive functions and characteristics related to the psychological well-being of people suspected of MCI.

Method

The current study approach is semi-experimental, using a pre-and post-test design. This study's statistical population comprised 55-75 year-old males who were members of the Bonab City Senior Citizens Organization. The research sample was selected using the available and voluntary sampling method in 32 people suspected of MCI syndrome. This group was randomly divided into two groups of 16 people, the experimental group and the waiting group (control). For the experimental group, the program of learning and practicing movement skills (derived from authentic martial arts, especially Kung Fu) was held for twelve weeks and three 45-minute sessions each week. The session moderator was a cognitive neuroscience specialist with adequate professional skills in martial arts. In this research, two questionnaires of the Nejati cognitive abilities test [20] (which evaluates seven cognitive abilities; memory, inhibitory control and selective attention, decision making, planning, sustained attention, social cognition, and cognitive flexibility) and the Oxford happiness questionnaire (1989) (which evaluates five factors of psychological well-being; life satisfaction, happiness, self-esteem, self-control, self-efficacy) was carried out as a pre-and post-test on the groups.

Tools

As a pre-and post-test, this study administered two assessments of Oxford's cognitive abilities and happiness to the experimental and control groups (pending). Furthermore, the experimental group was given a curriculum for acquiring and practicing motor skills.

1) Nejati's Cognitive Abilities Test: Nejati created and standardized this questionnaire in Iran. The questionnaire has 30 Likert scale responses that assess seven cognitive abilities: memory, inhibitory control and selective attention, decision-making, planning, sustained attention, social cognition, and cognitive flexibility. Except for questions 24, 25, and 26, which are evaluated in reverse, the allotted score for each question ranges from 1 to 5. The lowest and most excellent possible scores are 36 and 180, respectively. The questionnaire's validity and reliability have been demonstrated in studies. According to one research, this test's Cronbach's alpha was 0.83, and its validity using Pearson's correlation coefficient was 0.0001 [20].

2) Oxford happiness questionnaire (1989): Oxford happiness test was developed by Argyle, Martin, and Crosland; This test is based on the Beck depression questionnaire. This test defines happiness as the strength of pleasant feelings, satisfaction, and the absence of negative emotions. This questionnaire has 29 questions, each of which includes four statements as a response scale and is evaluated on a Likert scale from zero to three (not at all, rarely, sometimes, always). This quiz has a score range of zero to 87, with 87 being the highest level of happiness. Alipour, Nurbala, Ejei, and Matiyan translated and standardized the questionnaire for Iranian society. The reliability of this questionnaire has been shown in independent studies to be between 0.80 and 0.90, while its validity is about 0.70. [21].

3) Learning and practicing Motor skills program: The program for learning and practicing movement skills was adapted from regular training sessions and martial arts learning, with revisions to adapt the sessions to the participants' ages. In this study, martial arts are sports with historical origins and forms of forms or official forms made up of sub-movements, movements, axes, and, eventually, forms. Learning forms takes time and a coach's supervision. Therefore, it is necessary to divide each state into sub-movements, movements, and axes and study and rehearse them separately.

In the training program, the coach did preliminary exercises at the start of each session by modifying and considering the sample's age. Then, following the physical preparation of the model, he examined their acquired skill movements collectively and repaired the issues (Table 1). Finally, the coach demonstrated some exercises and had the sample group repeat them numerous times. This three-month learning and practicing movement skills program for the experimental group included three sessions per week.

Table 2 shows the average scores obtained from two implementations of the cognitive questionnaire in the pre-and post-test phases to study the influence of the independent variable (learning and practicing motor abilities) on the subscales of cognitive skills.

Furthermore, Table 3 reveals that after applying the independent variable, i.e., learning and practicing movement skills, the average scores of all happiness subscales rise.

To evaluate the assumptions made in this study, multivariate covariance analysis was performed. To do this, the premises of multivariate covariance analysis were initially investigated. The Kolmogorov-Smirnov test was used for this purpose to check the normality of the distribution of pre-and post-test scores, the homogeneity of the error variance of the dependent variables from the Levene's test, the uniformity of the regression slope from the analysis of the interactive

Table 1: Five stages of the program for learning and practicing movement skills.

Level	Type of Activity	Goal	The expected result at the brain level
1	Basic stretching movements	Initial warming up of joints and muscles	Joint-muscular preparation
2	Slow running	Increase cardiovascular activity	Increase blood supply to muscles and brain
3	Regular general exercises	General warming up of joints and muscles	mental-motor (muscular-brain) preparation
4	Practicing and reviewing movement units learned in previous sessions	streamlining cognitive skills in the brain, including Attention, learning, and memory	activation of neural plasticity processes (including its type of neurogenesis)
5	Design and implementation of new movement units by the class instructor	Increase in brain neural activity by learning and practicing new motor skills	Creating connections and brain circuits and using new neurons resulting from neurogenesis, especially in the hippocampus.

Table 2: Shows that, except for the average scores of the planning and social cognition subscales, the average scores of the five cognitive skill subscales have increased.

Groups of dependent variables	Pre-test		Post-test	
Cognitive skills	Control group mean (standard deviation)	Experimental group mean (standard deviation)	Control group mean (standard deviation)	Experimental group mean (standard deviation)
Memory	(0.78) 2.52	(0.80) 2.33	(0.74) 2.37	(0.60) 23.3
Inhibitory control and selective attention	(0.82) 2.08	(0.79) 2.03	(0.80) 2.09	(0.58) 3.07
Decision making	(0.63) 2.05	(0.68) 2.20	(0.60) 2.29	(0.55) 3.12
Planning	(0.67) 2.01	(0.69) 2.05	(0.70) 2/03	(0.66) 2.03
Sustained attention	(0.73) 2.13	(0.65) 2.04	(0.76) 2.15	(0.54) 3.17
Social cognition	(0.79) 2.06	(0.73) 2.10	(0.81) 2.13	(0.63) 2.09
Cognitive flexibility	(0.65) 2.00	(0.71) 2.04	(0.63) 2.07	(0.66) 3.08
Total score	14.85	14.79	47.93	19.79

Table 3: The meaning of happiness subscales of two control and experimental groups of older people suspected of MCI in pre- and post-test.

Groups The dependent variables	Pre-test		Post-test	
	Control group mean (standard deviation)	Experimental group mean (standard deviation)	Control group mean (standard deviation)	Experimental group mean (standard deviation)
Life satisfaction	(3.24) 17.03	(3.35) 17.24	(4.06) 17.15	(2.76) 18.02
Happiness	(1.19) 9.17	(2.23) 8.89	(2/62) 9/16	(1.65) 9.56
Self-esteem	(0.97) 8.93	(1.19) 8.59	(2.88) 9.02	(1.87) 9.61
Self-control	(1.16) 6.34	(1.54) 6.77	(1.68) 6.05	(1.65) 7.82
Efficacy	(0.89) 5.26	(1.07) 5.12	(1.55) 5.19	(1.44) 6.27
Mean total score	46.73	46.61	46.57	51.28

Table 4: The results of MANCOVA on the variable of cognitive abilities and happiness in the post-test stage in the groups.

Statistical indicators	Sum of squares	Df	F	Significance level
The dependent variable	354.234	1	157.763	0.001
Cognitive abilities	1825.981	1	139.251	0.001

effects of the pre-test, and the assumption of average correlation of the dependent variables. The results of Bartlett's and Mbox's tests, which were used to assess the homogeneity of the variance-covariance matrices of the dependent variables, demonstrated that the given assumptions are correct. Furthermore, evaluated and validated was the linearity of the correlations between the dependent variables.

Table 4 demonstrates that using the pre-test as a control, the significance levels in the two tests connected to the total scores of cognitive skills and happiness suggest a significant difference between the test and control groups in the dependent variables at the post-test stage. Furthermore, the rise in post-test scores demonstrates the influence of the independent variable (learning and practicing motor skills) on the dependent variables (cognitive abilities and happiness).

Discussion

The effects of learning and practicing movement skills on cognitive abilities and psychological well-being features of older adults suspected of mild cognitive impairment (MCI) were investigated in this study. The findings indicated that applying the independent variable (i.e., learning and practicing motor skills) effectively influenced the dependent variables considered in the study (i.e., some subscales of cognitive abilities and all the characteristics related to psychological well-being mentioned under the happiness title).

The influence of the independent variable was seen in the case of seven cognitive variables tested: memory, inhibitory control and selective attention, decision-making, planning, sustained attention, social cognition, and cognitive flexibility. These have grown considerably in the experimental group, especially memory, inhibitory control, selective attention, decision-making, sustained attention, and cognitive flexibility. Following that, the MANCOA study revealed that these alterations are substantial. In keeping with these findings, a large body of scientific literature demonstrates that mobility is vital in brain development and maintenance. Many studies have shown that physical exercises can maintain or even improve cognitive abilities of the brain in old age by influencing the process of neural plasticity, increasing or modulating neurotransmitters, neurogenesis, increasing and facilitating cerebral blood flow, controlling the cardiovascular system, increasing myelination, and preserving newly born neurons. In addition, physical activity generally affects the function of the cerebral cortex and other bodily systems, including the neuromuscular system, which appears crucial in cognitive functioning.

As Hall and colleagues demonstrated, physical workouts favorably influence the activity of the left frontal area. Physical exercise has also been found in other studies to impact the movement of the frontal brain region. Mild, even short-term, exercise has been demonstrated in studies to improve brain function. However, only 10 minutes of intense movement improves cognitive performance. Studies have shown that physical activity increases the number of brain capillaries, hence improving blood circulation. It also raises the quantity of oxygen in the blood, which the brain needs as fuel. The capacity of the brain to accomplish activities is affected by oxygen concentration. Higher blood oxygen concentrations have been shown in studies to improve cognitive function in healthy young people. For instance, they can recall more words from a list and complete visual and spatial tasks more quickly. Furthermore, their cognitive function is strongly related to the amount of oxygen in the brain.

A new study at the University of Oregon discovered that a brief physical exercise increases the expression of a specific gene, increasing the synaptic connection between neurons and synaptic growth in the hippocampus. Thus, a short practice before educational activities, such as studying, helps to improve learning. Additionally, despite the influence of movement on entire brain activities and the overall chemical state of the brain, studies reveal that physical workouts change dopamine (DA), norepinephrine (NE), and serotonin (5-HT), the three primary monoamine neurotransmitters.

Furthermore, data from animal and human research shows that physical exercise enhances mental health, possibly through the actions of neurotransmitters. For example, physical workouts that influence the serotonin system efficiently alleviate anxiety and protect the brain against excessive stress.

Furthermore, a study published in the journal Neuroscience found that strenuous exercise might boost the levels of two essential neurotransmitters in the brain, glutamate, and GABA. The study of 38 healthy people found that eight to twenty minutes of activity on a stationary cycle, with the heart rate reaching 85% of the maximum attainable in each person, raises GABA and glutamate levels.

Furthermore, follow-up studies revealed that, while these effects diminish with time, they continue to a lesser level in the long term. People's glutamate levels at rest, for example, were shown to be related to the amount of physical activity they had done in the preceding week.

GABA and glutamate levels were higher in the visual and anterior cingulate cortex, essential for footplate control and specific emotional and cognitive processing.

Moreover, according to some studies above, martial arts offer the cognitive advantages observed in specific sports training and unique benefits. The brain is involved in intricate learning processes that are also musical when learning and performing martial arts techniques. On the one hand, based on the study findings, there is agreement that sports workouts are beneficial to people of all ages. Nevertheless, studies have shown that learning rigorous and challenging sports workouts, a type of skill acquisition may benefit brain health in terms of its plasticity.

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Author Contribution

GJ provided data, conducted all statistical analyses, and helped to write the manuscript, and SJ helped to design the study and write the manuscript. All authors reviewed the final manuscript.

Conflict of Interest

All co-authors have seen and agree with the manuscript's contents, and there is no financial interest to report. Therefore, we certify that the submission is an original work and is not under review at any other publication.

Transparency Declaration

The lead authors confirm that this publication is an honest, accurate, and transparent description of the study; that no critical components of the investigation have been omitted; and that any deviations from the intended research (and, if applicable, recorded) have been explained.

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