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Original Article

Effect of walking physical exercise on the executive functions of educators and education staff at Nusa Cendana University

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ABSTRACT

Walking requires high-level cognitive processes such as executive function, consisting of several processes such as interlimb coordination, perception, postural control, muscle strength, and motivation to move to the desired destination location. The aim of this study was to prove the effect of walking physical exercise on improving the executive function of educators and education staff at the University of Nusa Cendana. The research design is quasi-experimental with a nonequivalent control group design method conducted on educators and educational staff at Nusa Cendana University, divided into two groups, the experiment and the control group. Walking physical exercise was given to the experiment group 3 times a week for 4 weeks with 30 min duration, starting with 5 min of warming up and ending with 5 min of relaxation in each training session. The executive function was measured before and after treatment for both groups using Trail Making Test part B (TMT-B). Analysis of the data used paired *t*-test and unpaired *t*-test. This study showed a significant disparity in the difference of pre-test and post-test scores of the TMT-B towards the experiment group compared to the control group ($P = 0.011$). Walking physical exercise significantly affects the executive function improvement of educators and education staff at Nusa Cendana University.

Keywords: Education staff, educators, executive functions, physical exercise, walking

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INTRODUCTION

Physiological cognitive function can decrease, marked by reduced neurotransmitters, brain volume, and the number of neurons. A cognitive function consists of several elements: attention, memory, communication/language, movement (motor), and executive function. The previous studies have estimated that about a third of adults will experience a gradual decline in cognitive function as they age. Cognitive abilities decline with age, often considered a normal thing to happen to people who are entering old age.[1]

In the late twenties, the previous studies showed maturity in executive function but will also experience a decline in function with age and decreased brain development.[2] Disorders of one cognitive function can disrupt social functioning, work, and daily activities. One of the essential cognitive functions owned by an educator and educational staff to avoid errors in work is the executive function. An educator and education staff needs reasoning, planning, evaluation, analytical power, and appropriate strategies to complete a job. All of these things are part of the executive function.[3]

The executive function describes various self-regulation processes including behavior to detect an error and obtain conflict resolution. This function also includes a group of processes that enable people to focus their attention and control their minds to engage in purposeful and directed action. Based on a study, the role of executive function from childhood until old age must be accompanied by good environmental stimulation.[4] Regular physical exercises such as tai chi or aerobics help increase and improve cognitive and executive function.[5]

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Walking is one of the aerobic physical exercises that can stimulate cognition, namely, the ability to think, work, learn, and remember clearly, which involves aspects of memory, attention, perception, executive function, language, and psychomotor function.[5] Aerobic exercise can improve the processing speed of cognitive function among tasks demanding the level of executive functioning. Several studies have investigated the increase in executive function after aerobic exercise in older adults at various exercise intensities.[6]

Walking was until recently seen as an automatic motor task requiring minimal cognitive resources. In addition, walking is suitable physical exercise for workers who spend most of their time sedentary and do not compensate for long hours of sedentary behavior by increasing physical activity outside of work. However, several studies have shown that walking requires higher-order cognitive processes, such as executive function. Walking consists of several processes, such as interlimb coordination, perception, postural control, muscle strength, and motivation to move to the desired destination location.[7]

Based on data from the 2018 Riset Kesehatan Dasar (Rikesdas) report, 33.5% of the Indonesian population was declared to lack physical activity.[8] Preliminary medical check-up data for the Health Promoting University of Nusa Cendana University in 2021 showed 58% of 41 educators and education staff respondents rarely did regular sports or physical exercise in the last week before data collection. Respondents who answered did not exercise as much (29.3%) or <10 min (29.3%) of the time used to exercise each day. As many (56.1%) of respondents also answered that they exercised only once per week. Physical exercise walking is very light and simple, if done systematically, programmed, and structured, it will get positive results on health and fitness levels. Therefore, based on the above matters and data, the authors are interested in researching whether walking physical exercise affects the executive function of educators and education staff at Nusa Cendana University.

MATERIALS AND METHODS

The design of this study was a quasi-experimental study with a nonequivalent control group research design. The sample of this research is educators and educational staff at Nusa Cendana University, with a purposive sampling technique that met the inclusion criteria. This study will be divided into two groups, the intervention group and the control group. The executive function test used the Trail Making Test – part B (TMT B).[9]

Each group carried out an initial executive function test. The intervention group carried out the physical exercise of moderate intensity walking with a minimum of 3.000 feet with a duration of 30 min, starting with a 5 min warm-up and ending with a 5 min cool down, carried out 3 times a week for 4 weeks. In the control group, no treatment was given. After being given treatment for 4 weeks, the intervention and control groups carried out a post-executive function test. Data were collected and processed using predetermined data analysis techniques.

Ethical clearance was obtained from the Ethical Commission of the Faculty of Medicine, UNDANA, Kupang.

RESULTS

This study was conducted from August to September 2022 at Nusa Cendana University. This study involved 36 research subjects obtained from the Faculty of Medicine and Veterinary Medicine (FKKH), Faculty of Law (FH), Faculty Public Health, Teaching and Science Faculty (FKIP), and Institute for Research and Community Service (LP2M), Nusa Cendana University.

Characteristics of the Research Subject

Table 1 shows that the number of male samples was more than females in both the control and intervention groups. Gender in the control and intervention groups had the same number of men as ten people (55.6%) and women as many as eight people (44.4%). It was found that the middle adult group dominated the intervention group, while the early adult age group dominated the control group. The level of education that all samples in this study have taken, both the control and intervention groups, is 100%, having taken higher level of education. The most significant samples came from the FKKH Medicine, both from the control and intervention groups, namely, ten people or around 55.6%. The sample in the control group, educators and education staff, was the same nine people, or around 50%. Most of the percentage of around 66.7% of the intervention group is the educational staff.

Table 2 shows a significant difference in the Trail Making Test part B (TMT-B) scores in the post-test control group ($P = 0.005$).

Table 3 showed a significant difference in the results of the Trail Making Test part B (TMT-B) scores in the intervention group ($P = 0.000$).

Table 4 shows a significant difference between the pre-test and post-test scores with the Trail Making Test part B (TMT-B) intervention group compared to the control group in the post-test ($P = 0.011$). This description shows that the difference in mean pre-test and post-test time in the intervention group is more significant than in the control group. In the intervention group, physical exercise was given, and there was an effect on the speed of executive function test results so that the executive function of the intervention group became better than the control group who did not get walking physical exercise.

Table 1: Characteristics of the research subjects

Variable	Control group		Intervention group	
	Frequency, *n*=18	Percentage	Frequency, *n*=18	Percentage
Gender				
Male	10	55.6	10	55.6
Female	8	44.4	8	44.4
Age				
Young adults (18–40 years)	10	55.6	7	38.9
Middle Adulthood (41–60 years)	8	44.4	11	61.1
Level of education				
Basic education	0	0	0	0
Middle education	0	0	0	0
Higher education	100	100	100	100
Faculty/Institution	10	55.6	10	55.6
Faculty of Medicine and Veterinary	3	16.7	4	22.2
Medicine	1	5.6	2	11.1
Faculty Public Health	1	5.6	0	5.6
Faculty of Law	2	11.1	1	0
Teaching and Science Faculty	1	5.6	1	5.6
Institute for Research and Community Service				
Rectorate				
Work				
Educators	9	50.0	6	33.3
Educational staff	9	50.0	12	66.7

Table 2: Control group executive functions

Variable Trail Making Test part B (TMT-B)	Control Group			*P*
	Pre test (mean)	Post test (mean)	Average difference	
Executive function	62.11 s	52.11 s	10.00 s	0.005*

Paired *t*-test $*P \leq 0.05$

Table 3: Intervention group executive functions

Variable Trail Making Test part B (TMT-B)	Intervention group			*P*
	Pre test (mean)	Post test (mean)	Average difference	
Executive function	76.83 s	52.06 s	24.77 s	0.000*

Paired t-test $*P \leq 0.05$

Table 4: The difference in the pre-post test values of the control group and the intervention group

Variable	Group		*P*
	Control (average difference)	Intervention (average difference)	
Trail Making Test part *B* (TMT-B)			
Pre test–Post test	10.00 s	24.77 s	0.011*

Unpaired *t*-test. $*P \leq 0.05$

DISCUSSION

Control Group

There was a significant change in the executive function test in the control group because the form of the TMT-B test given was not different from that given in the pre-test. So the research subjects, when doing the post-test, were better prepared and had memorized according to the method used when doing the test. This is called the existence of a testing effect.[10] In addition, significant changes could also be due to educational level factors. Education would positively influence higher cognition, consistent with the principles of experience-dependent brain plasticity, from which one would predict repeated increases in executive skills.[11]

In this study, the sample of educators and education staff had a high education level, so that this factor could be the cause of the increase in post-executive function test results in the control group. Intelligence quotient (IQ), nutrition, and sleep quality in this study cannot be fully controlled by researchers and can influence significant changes in the control group's executive function tests.

The executive function is also essential and can be affected by the management of intelligence resources. High intelligence has the potential for high cognitive function influenced by interactions between complex factors such as genetics and the environment. Intelligence and executive function are closely related. Both play a crucial role in understanding how people consciously regulate their thoughts and behavior and are also related to academic performance.[12]

Nutrition also affects the performance of executive functions. A person who consumes foods rich in nutrients, such as vitamins, polyunsaturated fatty acids (PUFA), and flavonoids, has an essential role in improving cognitive performance.[13] Flavonoid mechanisms are mediated through the inhibition of cholinesterase, including Acetylcholinesterase (AChE), Butyrylcholinesterase (BChE), Beta-secretase 1 (BACE1), free radicals, and modulation of signaling pathways involved in cognitive and neural functions.[13]

Sustained and regular sleep, allowing for adequate progression through the sleep stages and the NREM-REM cycle, is essential for supporting executive function. Both components, namely sleep and executive function, experience changes in healthy older people. The prefrontal brain's susceptibility to sleep deprivation and executive function in older adults provides evidence of an interaction between these functions in healthy ageing. Studies show that changes in sleep may play an essential role in the extent to which healthy older adults show decreased executive function.[14] In the control group, it was found that there was a healthier early adult age group, with no executive function decline physiologically, so sleep quality can strongly predict significant changes in executive function improvement in the control group.

Intervention Group

The benefits of physical exercise walking, namely, increasing cognitive abilities, can help prevent cognitive decline and reduce the risk of dementia.[15] An exercise-induced mechanism that may promote neuroplasticity is increased neurotrophic inhibitory factors. Brain-derived neurotrophic factor is Brain-Derived Neurotrophic Factor (BDNF). BDNF is associated with synaptogenesis and neurogenesis, which can drive cognitive enhancement.[16]

This increase is because walking is a complex process involving neuromuscular, sensory, and cognitive functions. The mechanisms responsible for cognitive improvement associated with aerobic exercise, current evidence points to the important role of neuroplasticity. Long-term potentiation is enhanced after regular exercise and is correlated with cognitive performance.[16]

Physical exercise, such as 30 min of moderate-intensity aerobics, has improved cognitive aspects. Physical exercise increases the blood supply to the brain, leading to increased cognitive test scores.[17] Other studies have shown using Functional Near-Infrared Spectroscopy (fNIRS) that brain activity increases during walking, especially in the pre-Frontal Cortex (PFC), the premotor cortex, and additional motor areas. Physical exercise that induces functional brain plasticity during walking in the sample group undergoing treatment has a significant impact on executive function.[18] Things that need to be considered so that walking physical exercise can improve executive function are the cognitive demands inherent in the training structure directed at a goal. Walking involves the cognition needed to carry out complex motor movements and the physiological changes in the brain caused by the physical exercise of walking.

Control Group versus Intervention Group

There was a significant difference between the pre-test and post-test executive function scores (TMT-B) in the intervention group compared to the control group ($P = 0.011$). This significant difference is in line with research by Byun and colleagues (2016) that physical exercise such as walking of light to moderate intensity can improve executive function by modulating cortical activation in task-related prefrontal sub-regions. In addition, there is increasing evidence that extracellular acetylcholine, a neurotransmitter that helps mediate arousal, attention and sleep, is released in the cerebral cortex during physical exercise such as walking.[18]

When walking, there is a role for several important executive function components, such as inhibition. Continuous postural control is needed when walking to prevent other unrelated information from focusing on maintaining body balance. The following component is switching, where while walking, the sensory input changes constantly and requires adaptation to changing situational factors and adjusting movement control in walking to suit. Another component that can support this is updating. When walking, one needs information about challenges that will appear at each future step, such as obstacles, stepping not to enter into holes or slippery floors. This information constantly changes from one step to the next, so fast and precise processing is essential for step-by-step planning.[7]

A possible exercise-induced mechanism that increases neuroplasticity is the increased release of neurotrophic factors such as BDNF. BDNF is associated with synaptogenesis and neurogenesis, which can promote increased cognition. Physical exercise will induce the neurophysiological processes fundamental to neuroplasticity, thereby cognitively stimulating neuroplastic processes and initiating new mechanisms in newborn cells. Complex mechanisms depend on the activation/stimulation of synapses or newly generated neurons. The activation/stimulation of synapses and neurons occurs due to the performance of a cognitive task. It allows the functional integration of new neuronal structures in the respective brains resulting in neuroplastic changes.[19]

Thus, the role of the components of the executive function when doing walking physical exercise improves and maintains better executive function. These results prove that walking physical exercise moderately affects executive function.[16,18,19] Based on the results of the study, the researchers believed that there was an effect of moderate-intensity walking physical exercise on executive function using the Trail Making Test part B (TMT-B) in the intervention sample, which could be seen in the pre and post test results, which were also statistically significant.

CONCLUSION

Walking physical exercise is proven to significantly affect the executive function of educators and education staff at the University of Nusa Cendana.

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CONFLICTS OF INTEREST

There are no conflicts of interest found during this study.

ETHICS

This study has received ethical approval from the Health Research Ethics Commission of the Faculty of Medicine, University of Nusa Cendana.

SUGGESTIONS

1. Researchers can then control nutrition, sleep quality for research samples, and examine if pausing or stopping walking affects executive function.
2. Future researchers can expand the range of samples to all faculties at Nusa Cendana University, including healthy samples and sick samples that require improvement of their executive function and elderly samples.
3. For the respondents and the community, this research is expected to provide input for all respondents who are educators and education staff as well as a community regarding the benefits of walking physical exercise on cognitive development so that respondents and the community can carry out regular physical walking exercises to support their executive functions.

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