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The Motor-cognitive Training on Cognition and Physical Performance in the Older Adults with Mild Cognition Impairment : A Literature Review

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Objective: Older adults with mild cognitive impairment (MCI) are more likely to progress to dementia. Motor-cognitive training is applied as a dual-task to improve the cognitive and physical functions of older adults with MCI. The purpose of the study was to know the recent trends in motor training types and outcome measures used for motor-cognitive training in older adults with MCI.

Design: Aliterature review

Methods: This literature review was conducted in Pubmed, MEDLINE® and Google Scholar with the following key words: older adults, mild cognitive impairment, motor-cognitive training, cognition, and dual-task. The 7 studies were found with the search tool and all studies were randomized controlled trials.

Results: In motor-cognitive training in older adults with MCI, 6 studies applied aerobic exercise. And 3 out of 6 studies also applied strengthening exercises. One study applied dual tasks without aerobic exercise. In the 6 studies, overall cognitive and executive function were used as outcome measures, and physical function was evaluated as gait performance. Memory and physical frailty were also used as measurement tools. As a result of all studies, when motor-cognitive training was applied, cognition and physical performance showed significant results.

Conclusions: A recent five-year study applied mainly aerobic exercise and strength training to older adults with MCI and found it to improve cognitive and physical performance.

Key Words: Cognition, Aged, Cognitive Dysfunction, Exercise Therapy

Introduction

Mild cognitive impairment (MCI) is an important predictive risk factor for dementia [1,2] and is an intermediate stage between normal aging and dementia [3]. Although active daily living(ADL) function can be maintained [4] motor impairment such as cognitive decline, gait and balance deterioration is a typical characteristic of the older adults with MCI [5,6]. Older adults with MCI are more likely to progress to dementia [7] and the conversion rate from MCI is depending on diagnostic criteria and assessment tools, the incidence of dementia is estimated at 10% to 15% per year [8].

The older adults with MCI complain of difficulties in situations where they have to multitask in real life because they have a memory impairment [9]. Daily life living in real life is complex, and most are given more than dual-task situations. Previous studies mainly applied the single-task of cognitive training or motor training [10-13], but recently studies related to the dual task are being conducted.

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There are previous studies that showed the effect of cognitive ability and physical function by applying exercise training with cognitive training for cognitive improvement of the older adults [9,14,15]. Motor-cognitive training is beneficial to enhance cognitive and physical function even for older adults with MCI [3,16]. In the method of applying motor-cognitive training, applying tasks at the simultaneous has an advantage in cognitive improvement than applying them sequentially [17].

Recently, dual-task training using virtual reality (VR) [18,19] and aerobic exercise [20] have been mainly implemented for motor-cognitive training. Aerobic exercise significantly increases functional activation of MCI brain regions and helps to effectively improve cognitive function [21]. The improvement of physical function and cognitive ability through exercise training has raised the possibility that biological pathways and neural substrates may be shared between them, but the exact mechanism has not yet been elucidated [9,22]. Nevertheless, studies that improve cognition through exercise training continue to be published.

Therefore, this study intends to identify the latest trends by reviewing recent studies related to motor-cognitive training, which is mainly conducted in an environment similar to real life. And to suggest what the ideal motor-cognitive training is for in the older adults with MCI.

Methods

Data sources and study criteria

The collection of theses was conducted by 3 physical therapists using selected keywords, and the collected documents were organized, compared, and analyzed through a bibliographic information program (EndNote 20, Thomson Reuters, USA). In the case of inconsistency between the abstract and the main text of the thesis during the selection process, it was excluded from the collection process(Figure 1).

The study criteria used in the analysis of this study

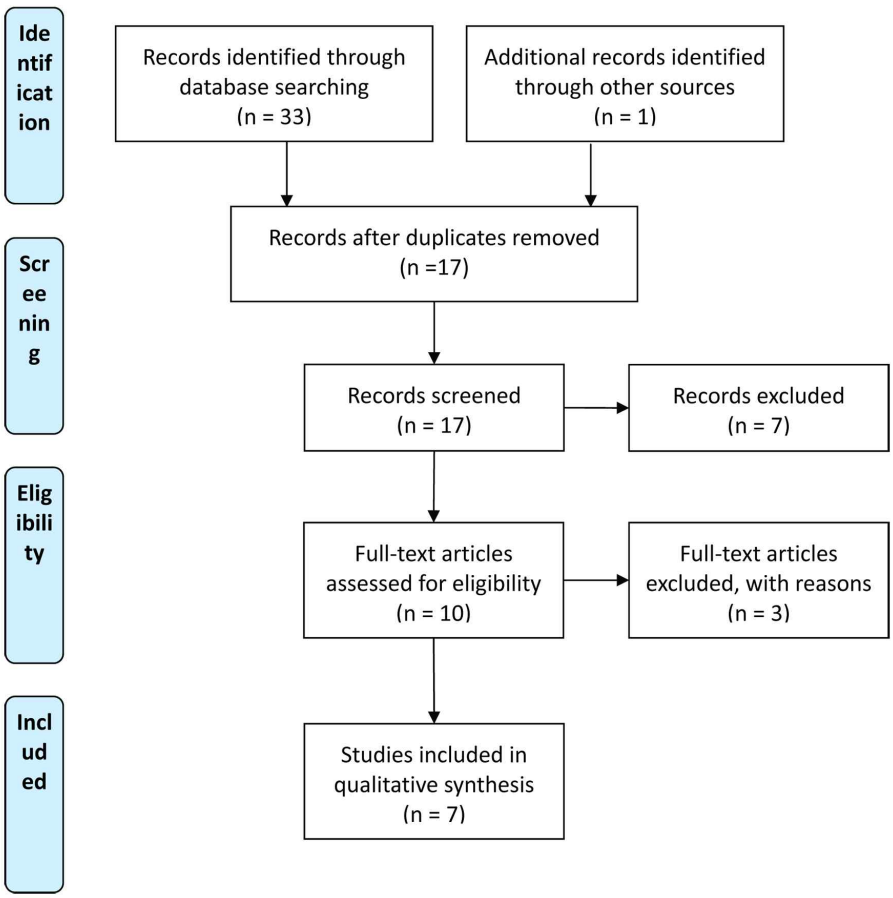

Figure 1. flow diagram

were as follows: (1) studies in which subjects were diagnosed with MCI, (2) a study applying dual-task for motor-cognitive training, (3) a study that included cognitive and physical function as an outcome according to each intervention method, (4) a study conducted as a randomized control trails study. In addition, studies on cognitive enhancement of neurological diseases other than MCI, a study written in languages other than English and Korean, and studies that could not accurately explain the effect of motor-cognitive training due to the study design were excluded. In this literature review study, studies from 2016 were searched using the databases of PubMed, MEDLINE® and Google Scholar.

Search terms

The keywords used in the search were as follows and were used either in combination or independently: 'older adults', 'elderly', 'elderly cognition', 'cognitive decline','mild cognitive impairment', 'motor-cognitive training', 'exercise', 'aerobic exercise', 'physical training', 'dual-task', 'cognition', 'cognitive task', and 'physical function'. As a result, the 7 studies were found with the search tool and all studies were randomized controlled trials.

Study selection process

For studies collected through the database, duplicate studies were removed using a reference management program (EndNote 20, Thomson Reuters, USA). After screening through the abstract and title, the original text of the thesis was reviewed according to the selection criteria. In the process of data extraction, general characteristics, specific interventions, and research results were extracted. If the data do not match, the original text was reviewed and finally selected and summarized.

Results

According to our selection criteria, 7 studies were classifiedusing the PICO search strategy(Table 1) (Figure 1). As a result of all studies, when motor -cognitive training was applied, cognition and physical performance showed significant results.

In motor-cognitive training in older adults with MCI, 6 studies applied aerobic exercise. And 3 out of 6 studies also applied strengthening exercises. One study applied dual tasks without aerobic exercise.

In study of Park JH [23], motor training in motor -cognitive training was applied simultaneously with cognitive training such as range of motion (ROM), TheraBand strengthening (low intensity), passing/throwing a ball. And for aerobic exercise, wrist, elbow, shoulder, ankle, knee range of motion exercise and walking motion were sequentially applied for during intervention program.

Kwan et al. [19] was the under-desk ergometer with adjustable cycling resistance was applied alone without combining with other exercises as a motor training during cognitive training using virtual reality program.

Park HT et al. [3] was motor training, aerobic exercise combined activity program was applied. The combined activity program includes a warm-up, stretching training, aerobic exercise, balance exercise, aerobic and cognitive training, resting time with feedback and encouraging active daily living physical education, and cool-down exercise. And the aerobic exercise applied was stair stepping, endurance walking and stair climbing, and walking on an agility ladder. During aerobic exercise, the target heart rate zone was at 55% to 80% of the maximum heart rate in the intervention [24].

Lia et al. [18] were also applied motor training combined with aerobic exercise. And the program was composed of a simplified 24-form Yang-style Tai Chi, resistance exercise, aerobic exercise, ADL relating functional tasks, and included for that to improve upper and lower extremity balance, stability, strength, and endurance.

The motor training applied in the study of Law et al. [25] is warm-up of light stretching, moderate-intensity aerobic exercise, whole-body movement exercise, bicycle, arm ergometry, cool-down exercise. The functional task exercise group was appliedwarm-up, core functional tasks exercise, and cool-down exercise.

Shimada et al. [8] was applied an activity program that combines aerobic exercise, and also included muscle strengthening, and postural balance training. Aerobic exercise includes climbing stairs, endurance walking, and walking on a balance board. Average aerobic exercise intensity was 60% to 80% of maximum heart rate (HR) identically with previous studies [24].

Table 1. Classification of patient, intervention(s), comparison, outcome method

Author	Patient	Intervention		Comparison	Outcome
		Motor training	Cognitive training		
Park JH [23]	MCI (EG: 18, CG:18) 65 ages over MoCA < 23	EG: ROM, Theraband strengthening (low intensity), passing/throwing a ball	EG: cognitive tasks verbal fluency, attention, memory, game of rock-paper-scissors, and calculation tasks	TMT-B, PFC, K-IADL,	the EG was a significantly higher improvement in the TMT-B and decreased activity in the PFC during TMT-B
		CG: no applicated	CG: single cognitive training RehaCom		
Kwan et al. [19]	MCI (EG: 9, CG: 8) 60 ages over MoCA ≤ 25	EG: aerobic exercise Cycle on an ergometer	EG: using VR program orientation, finding a bus stop, reporting lost items, finding a supermarket, grocery shopping, cooking, finding a travel hotspot, and bird watching	MoCA, FFP, TUG, VRSQ	EG was improvement cognitive function, walking speed. Physical frailty of EG was similar CG.
		CG: aerobic exercise cycle on the ergometer	CG: non-VR program Cognitive game		

MCI: mild cognitive impairment, MoCA: montreal cognitive assessment, EG: experimental group. CG: control group, ROM: range of motion, TMT-B: trail making test – B, PFC: prefrontal cortex, K-IADL: Korea version of instrumental activities of daily living, VR: virtual reality, FFP: fried frailty phenotype, TUG: timed up and go, VRSQ: virtual reality sickness questionnaire

Table 2. Classification of patient, intervention(s), comparison, outcome method (continued)

Author	Patient	Intervention		Comparison	Outcome
		Motor training	Cognitive training		
Park JS et al. [1]	MCI (VRCMR group: 20, CCR group: 20) 65 ages over MMSE-K >16	VRCMR group: ROM and strength exercise(U/E)	VRCMR group: VR for performing activities driving, bathing, cooking, and shopping, enabling attention, memory, problem-solving, and executive training	MoCA, TMA-A/B, DST-forward/ backward, Interest, motivation	VRCMR group was greater improvement in the MoCA, TMT-A/B, and DST-forward. Interest and motivation of VRCMR group was significantly higher than CCR group.
		CCR group: no applicated	CCR group: tabletop activities puzzles, wood blocks, card play, stick construction activity, maze and pencil-paper		
Park HT et al. [3]	MCI (EG: 25, CG: 24) 60 ages over	EG: combined physical activity Warm-up, stretching, aerobic exercise (stair stepping, endurance walking, stair climbing, and work on an agility ladder), balance training	EG: dual-task training fast simple numerical calculations, and played a simple memory span game	ADAS-Cog, DST, DSST, MMSE-K	EG had a significant positive effect on both cognitive and physicaloutcomes in ADAS-Cog, working memory, executive function
		CG: no applicated	CG: no applicated		

MCI: mild cognitive impairment, MMSE-K:Korea version of mini-mental state examination, VRCMR: virtual rality-vased cognitive-motor rehabilitation, CCR: conventional cognitive rehabilitation, ROM: range of motion, U/E: upper extremity, MoCA: montreal cognitive assessment, TMT-A/B: trail making testA and B, DST: digit span test forward and backward,EG: experimental group, CG: control group, ADAS-Cog: alzheimer's disease assessment scale-cognitive subscale, DSST: digit symbol substitution test

Table 3. Classification of patient, intervention(s), comparison, outcome method (continued)

Author	Patient	Intervention		Comparison	Outcome
		Motor training	Cognitive training		
Lia et al. [18]	MCI (VR group: 21, CPC group: 21) 65 age and over MoCA < 26	VR group: Yang-style Tai Chi, resistance exercise, aerobic exercise, and functional tasks to daily activities, balance, stability, strength, and endurance	VR group: cognitive training VR games simulated IADL tasks	SCWT, TMT-A/B, gait performance, DTCs	Both groupswere improvement in the SCWT. VR group was improvement in the TMT-B, DTC of cadence than CPC group.
		CPC group: resistance, aerobic and balance exercise Theraband, stepping in sitting and standing, foam mat in standing	CPC group: cognitive abilities functional task reciting poems, naming flowers and animals while crossing obstacles, solving math questions, drawing a circle in the air in the clockwise or counterclockwise direction with the right or left hand		

MCI: mild cognitive impairment, MoCA: a montreal cognitive assessment, VR: virtual reality, IADL: instrumental activities of daily living, CPC: combined physical and cognitive training, SCWT: stroop color word test, TMT-A/B: trail making test A and B, DTCs: dual-task costs, EG: experimental group, CG: control group

Table 4. Classification of patient, intervention(s), comparison, outcome method (continued)

Author	Patient	Intervention		Comparison	Outcome
		Motor training	Cognitive training		
Law et al. [25]	MCI (EG 1: 15, EG 2: 16, EG 3: 14, EG 4: 14) 60 ages over	EG 1: functional task exercise	EG 1: functional task exercise	NCSE, CVVLT, TMT-A/B, Lawton IADL, ZBI	EG 1 was improvement in memory compared to EG 2 and 3. EG 1 had higher improve in functional status than EG 2 and EG 4.
		EG 2: no applicated	EG 2: cognitive training computer cognitive training program		
		EG 3: exercise training stretching, moderate intensity aerobic exercise, whole body movement exercise, bicycle and arm ergometry	EG 3: no applicated		
		EG 4: normal activity or exercise pattern	EG 4: normal activity or exercise pattern		
Shimada et al. [8]	MCI (EG: 154, CG: 154) 65 ages over	EG: combined activity group aerobic exercise, muscle strength training, postural balance retraining	EG: combined activity group word games	MMSE, WMSRLMII, RAVL	EG was significantly greater MMSE, WMSRLM II.
		CG: health education aging, nutrition, oral care, frailty, and uri- nary incontinence	CG: health education aging, nutrition, oral care, frailty, and uri- nary incontinence		

MCI: mild cognitive impairment, EG: experimental group, NCSE: neurobehavioral cognitive status examination, CVVLT: chinese version verbal learning test, TMT-A/B: trail making test-part A and B, Lawton IADL: lawton instrumental activities of daily living scale, ZBI: zarit burden interview, WMSRLM II: wechsler memory scale-revised logical memory II, RAVL: rey auditory verbal learning test

In the 6 studies, overall cognitive and executive function were used as outcome measures, and physical function was evaluated as gait performance. Memory and physical frailty were also used as measurement tools. Of the 7 studies, 3 studies [18,19,23] were using a montreal cognitive assessment (MoCA) as eligibility criteria were, and 1 study [1] was using a Korean version of mini-mental state examination (MMSE-K). For cognitive evaluation of motor-cognitive training, a trail making test A and B (TMT-A/B), the stroop color-word test (SCWT) to evaluate executive function were mainly used, and MoCA, modified alzheimer's disease assessment scale-cognitive subscale (ADAS-Cog), and MMSE were used for overall popular intelligence. Memory function was evaluated by a digit span test forward and backward (DST) and Chinese version verbal learning test (CVVLT).

Discussion

As a result of analyzing a recent study applied for motor-cognitive training to older adults with MCI, it was confirmed that the dual-task was applied simultaneously, and that motor training was applied either alone or in combination with aerobic exercise as an activity program. Therefore, simultaneous application of aerobic exercise and cognitive tasks will be an intervention method that can lead to improvement in cognitive ability and physical function.

In the study of Park HT et al. [3], the physical and cognitive combined intervention program applied increased the prefrontal cognitive function of MCI, and Shimada et al. [8] was find out the volume loss in the left brain hemisphere was smaller than the right during of the motor-cognitive exercise. Park JH [23] described a significant decrease in HbO_2 in the prefrontal lobe during executive function tests as an increase in the neural efficiency. According to the results of these previous studies, the brain volume over 65 years of age decreases by 0.5% to 1% annually due to normal aging, and the hippocampal volume decreases by 1% to 2% even in the absence of dementia [26], resulting in a higher risk of cognitive impairment. Therefore motor-cognitive training could expect applied as a good arbitration method.In particular, executive function can improve through aerobic exercise, and neural activation improves neural efficiency in areas where aerobic training supports executive processes of selective attention and response inhibition [27].

The MoCA, which was used the most in previous studies analyzed in this study, was developed to distinguish mild cognitive impairment [28] and is said to show higher diagnostic accuracy than MMSE [29,30]. And a TMT-A/B used to evaluate executive function is the most famous neuropsychological test and can be applied in various ways considering age and educational level [31]. It was confirmed that most studies evaluated cognitive function using similar outcome measures.

A recent motor-cognitive training study for MCI was conducted in virtual reality, but it was also conducted with content related to daily life tasks. In any environment, positive effects of cognitive ability and physical ability can be derived by applying the combination of body movements including aerobic exercise and tasks related to real life. It is believed that good results can be drawn if future experimental studies are conducted with these results as a reference.

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Conflict of interest

The authors of this study declare that there are no potential conflicts of interest with respect to the research, authorship, and publication.

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