Differences in Motor Cortex Synaptic Plasticity Across Different Exercise Modalities in Older Adults: Evidence from TMS Studies

Authors: Meng Haijiang, Chen Lei, Wang Gang, Zhang Jian, Meng Haijiang

Date: 2023-06-27T00:00:00+00:00

Abstract

Although research has demonstrated that exercise can induce plastic changes in the motor cortex, little is known regarding the differential effects of various exercise modalities on synaptic plasticity in the primary motor cortex of older adults. The present study utilized transcranial magnetic stimulation to conduct a cross-sectional comparison of motor evoked potentials and short-interval intracortical inhibition before and after paired associative stimulation (PAS25) among older adults who regularly engage in table tennis, practice Tai Chi, and those who are sedentary. The results demonstrated that motor evoked potential amplitudes were persistently enhanced following PAS25 in both table tennis and Tai Chi practitioners, with the magnitude of enhancement being significantly greater in the table tennis group compared to the Tai Chi group. No differences in short-interval intracortical inhibition were observed at any time point after PAS25 across the three groups. These findings suggest that the enhancement of synaptic plasticity in the primary motor cortex among older adults exhibits exercise modality-specific differences.

Full Text

Differences in Motor Cortex Synaptic Plasticity Associated with Different Forms of Exercise in Older Adults: Evidence from TMS Studies

MENG Haijiang[1], CHEN Lei[1], WANG Gang[1], ZHANG Jian[2] [1]School of Sports, Anqing Normal University, Anqing 246133, China
[2]Department of Psychology, Shanghai University of Sport, Shanghai 200438, China

Abstract

Although previous research has demonstrated that exercise training can induce plastic changes in the motor cortex, little is known about how different forms of exercise influence synaptic plasticity in the primary motor cortex of older adults. This study employed transcranial magnetic stimulation (TMS) to compare changes in motor evoked potentials and short-interval intracortical inhibition before and after paired associative stimulation (PAS25) among older adults who regularly participated in table tennis, older adults who regularly practiced tai chi, and sedentary older adults. The results revealed that both table tennis and tai chi practitioners showed sustained enhancement of motor evoked potential amplitudes following PAS25, with significantly greater enhancement observed in the table tennis group compared to the tai chi group. No differences in short-interval intracortical inhibition were found across the three groups at any post-PAS25 time point. These findings suggest that different forms of exercise enhance primary motor cortex synaptic plasticity in older adults in a sport-specific manner.

Keywords: physical exercise, older adults, transcranial magnetic stimulation, motor evoked potential, motor cortex

Introduction

Similar to cognitive function, motor control capabilities gradually decline with advancing age, interfering with daily activities and even compromising independent living. The human motor cortex plays a primary role in motor control, and impaired synaptic plasticity in this region provides a theoretical explanation for age-related motor control deterioration. Effective neural activation of the motor cortex is a prerequisite for rapid and stable execution of external motor behaviors, yet the level of motor cortex neural activation decreases to varying degrees with age. Therefore, understanding motor control capabilities in older adults necessitates investigation of motor cortex synaptic plasticity.

The human motor cortex can undergo transient or sustained plastic changes, with the most well-known neural mechanisms being long-term potentiation (LTP) and long-term depression. Research on brain plasticity in Parkinson's disease patients indicates that motor impairments are associated with compromised motor cortex synaptic plasticity, manifested primarily as weakened LTP-like effects in the motor cortex. Studies of elite athletes have found that their precise motor skill control is closely related to enhanced LTP-like effects in the motor cortex.

The human brain exhibits remarkable plasticity, with its structure and function adapting to environmental changes. Increasing evidence suggests that brain plasticity changes may be related to physical exercise. For instance, exercise training can increase gray matter volume and white matter integrity, while positively influencing intrinsic neural plasticity and connectivity of brain networks. However, despite these documented positive effects of exercise on brain structure and function, little is known about how different forms of exercise specifically affect synaptic plasticity changes in the primary motor cortex (M1) of older adults. M1 is a critical brain region for motor output and control, regulating neural plasticity and ultimate motor output through the balance and interaction of intracortical excitatory and inhibitory circuits in constantly changing environments. Therefore, using TMS to examine changes in motor cortex excitability and intracortical inhibition in older adults who regularly participate in different forms of exercise may provide important insights into the characteristics of neural plasticity changes associated with regular exercise and their relationship with motor control capabilities.

Increased motor evoked potential (MEP) amplitude following long-term exercise may be related to enhanced synaptic plasticity, but could also reflect functional changes in intracortical neuronal structures, increased numbers of recruited motor neurons, or enhanced motor neuron firing rates. To exclude these confounding factors and more purely investigate differences in motor cortex synaptic plasticity among older adults engaged in different exercise modalities, low-frequency, non-invasive paired associative stimulation (PAS) represents an optimal technique for inducing synaptic plasticity changes in human M1. Research has shown that PAS can alter synaptic efficacy in specific regions of M1, with changes exhibiting characteristics similar to LTP or long-term depression, thus inducing LTP-like or LTD-like synaptic plasticity in human M1. When an electrical stimulus is delivered to the peripheral median nerve, followed 25 ms later by a TMS pulse to the hand muscle representation area in the contralateral M1, these two stimuli arrive at M1 approximately simultaneously and can induce sustained enhancement of motor cortex excitability. This paradigm is termed PAS25. When single-pulse TMS is delivered to M1 with sufficient intensity, MEPs can be recorded in target muscles to reflect cortical excitability levels. Double-pulse TMS can be used to test intracortical inhibitory circuits in M1. When the interval between a subthreshold conditioning stimulus and a subsequent suprathreshold test stimulus is 1-5 ms, short-interval intracortical inhibition (SICI) can be elicited. SICI is the most commonly used method for studying intracortical circuits in M1 and represents the primary inhibitory circuit of M1.

To investigate how different forms of exercise affect M1 synaptic plasticity in older adults, we selected older adults who regularly participated in table tennis, older adults who regularly practiced tai chi, and sedentary older adults as participants. The rationale for these three groups was as follows: First, given that PAS25-induced plasticity effects are specific to the cortical representation of the abductor pollicis brevis (APB) muscle and that TMS assessment of M1 synaptic plasticity can only be evaluated through MEPs recorded from specific hand muscles, we selected table tennis and tai chi practitioners. Table tennis primarily relies on small hand muscle groups (such as APB and the first dorsal interosseous muscle) for fine motor control, whether chopping, slicing, driving, or looping, while tai chi requires strength, flexibility, and coordination of these small hand muscles to complete fine manipulations including grasping, pressing, lifting, and pinching. Repeated execution of these movements induces specific functional changes in the cortical representation areas of the involved muscles. Second, a recent study indicated that different forms of exercise produce substantially different physical and mental benefits, and generalizing from the benefits of table tennis alone to all sports would be insufficiently supported. Research comparing multiple exercise modalities would be more valuable. Therefore, we included a non-ball sport group (tai chi) as a control to explore differences in M1 synaptic plasticity associated with different exercise forms.

Based on these considerations, we proposed two hypotheses: (1) Compared to sedentary older adults, those who regularly participate in table tennis or tai chi would show enhanced synaptic plasticity in the motor cortex representation of the APB muscle; and (2) Different forms of exercise would produce differential changes in motor cortex synaptic plasticity among older adults.

Methods

Participants

Fifty-four healthy older adults aged 60-70 years participated in this study. All participants were right-handed, as confirmed using the Oldfield handedness inventory. The study was approved by the Human Research Ethics Committee of Shanghai University of Sport (102772019RT012) and conducted in accordance with the standards established by the Declaration of Helsinki. The inclusion and exclusion criteria for all participants are presented in Table 1 .

Table 1 Inclusion and exclusion criteria for study participants

Inclusion Criteria	Exclusion Criteria
1. Age 60-70 years	1. Diagnosed with Alzheimer's disease or other neurodegenerative diseases
2. Voluntary participation in entire study	2. Mini-Mental State Examination score ≤ 26
3. Able to provide written informed consent	3. Unable to exercise due to neuromuscular or musculoskeletal limitations
4. Regular participation in table tennis or tai chi, or sedentary lifestyle	4. History of schizophrenia, affective disorders, or depression
	5. History of sleep disorders
	6. Alcohol dependence within past 2 years
	7. Cancer or other serious systemic disease within past 5 years

Inclusion Criteria	Exclusion Criteria
	8. Hypertension, coronary heart disease, or other organic heart disease 9. Endocrine/metabolic disorders, diabetes 10. Regular participation in other forms of exercise besides table tennis or tai chi

Based on the International Physical Activity Questionnaire, we developed a questionnaire to assess older adults' participation in table tennis or tai chi and their sedentary behavior. The questionnaire included 12 items addressing sedentary time and the duration, intensity, and frequency of table tennis or tai chi practice. Eight experts in relevant fields confirmed good content validity. To more accurately reflect exercise participation levels, we required participants to have long-term, focused engagement in leisure-time exercise, emphasizing moderate-to-high intensity table tennis or tai chi. No participants reported long-term specialized use of both hands, such as playing musical instruments.

Participant grouping was determined based on exercise duration, intensity, frequency, and sedentary time. Participants were assigned to the table tennis group (n=18) or tai chi group (n=18) if they simultaneously met all four conditions: (1) regular participation in table tennis or tai chi; (2) moderate-to-high exercise intensity; (3) exercise frequency $\geq$ 3 times per week; and (4) exercise duration $\geq$ 60 minutes per session. Participants who did not meet these four conditions, had no exercise habits, and had sedentary time $\geq$ 360 minutes per day (Patterson et al., 2018) were assigned to the sedentary group (n=18). The three groups showed no significant differences in mean age [F(2, 51) = 0.64, p = 0.533], Mini-Mental State Examination scores [F(2, 51) = 0.31, p = 0.736], education years [F(2, 51) = 0.68, p = 0.513], or gender distribution (^{2} = 1.04, p = 0.595). The basic characteristics of the three groups are presented in Table 2 .

Table 2 Basic characteristics of participants in the three groups (M ± SD)

Characteristic	Table Tennis (n=18)	Tai Chi (n=18)	Sedentary (n=18)
Age (years)	66.11 ± 3.36	65.61 ± 3.40	64.89 ± 3.03
Gender (n female)	11	10	9
Education (years)	11.83 ± 2.36	11.33 ± 3.34	12.39 ± 2.35
MMSE score	27.83 ± 0.86	27.78 ± 1.06	27.61 ± 0.70

Experimental Design

The study employed a 3 (group) × 4 (time point) mixed factorial design, with group (table tennis, tai chi, sedentary) and time point (baseline, post-stimulation 0, 30, 60 minutes) as independent variables, and MEP amplitude and SICI as dependent variables.

TMS and EMG Recording

Two Magstim 200 stimulators (Magstim, Whitland, Dyfed, UK) were connected via a BISTIM module to a figure-of-eight coil (9.5 cm external diameter per wing). The coil was positioned over the left M1 for magnetic stimulation. The coil was placed tangentially to the skull with the handle pointing posteriorly and oriented at a 45° angle to the sagittal plane, producing a posterior-to-anterior current flow.

The abductor pollicis brevis (APB) muscle, innervated by the median nerve and actively involved in both table tennis and tai chi, was selected as the target muscle. The optimal scalp position for activating the right APB was marked with a specialized pen as the motor hotspot. The optimal coil position for stimulating the right APB was determined by moving the coil in 1 cm increments until the maximal MEP was obtained.

Ag-AgCl surface electrodes (9 mm diameter) were used to record surface EMG from the right APB. The active electrode was placed over the muscle belly, the reference electrode over the metacarpophalangeal joint, and the ground electrode on the right wrist. Raw signals were amplified (1000×), band-pass filtered (20 Hz–2.5 kHz), digitized at 5 kHz (Micro 1401, Cambridge Electronics Design, Cambridge, UK), stored on computer, and analyzed offline using Signal 6.0 software.

Paired Associative Stimulation Protocol

Synaptic plasticity in the left M1 was induced using the PAS paradigm developed by Stefan et al. (2000). The PAS25 protocol consisted of an electrical stimulus delivered to the median nerve at the right wrist at an intensity of three times the sensory threshold, followed 25 ms later by a single-pulse TMS to the hand muscle representation area in the left M1 (at an intensity that evoked a 1 mV MEP). PAS25 was delivered at 0.1 Hz for a total of 90 pulses over 15 minutes. Median nerve stimulation used a standard bar electrode (cathode proximal) delivered by a digitized DS7A constant current stimulator (0.2 ms square wave pulses). The PAS25 paradigm is illustrated in Figure 1 [Figure 1: see original paper].

All participants (table tennis, tai chi, and sedentary groups) underwent the PAS25 protocol, with measurements of motor cortex excitability and inhibition obtained before (baseline) and immediately, 30 minutes, and 60 minutes after stimulation (T0–T60) to investigate changes in motor cortex synaptic plasticity.

All experiments were conducted between 2:00 and 5:00 PM to minimize effects of cortisol variations on plasticity induction. Participants were instructed to refrain from exercise on the experimental day but could exercise after completing the session.

Figure 1 Schematic diagram of paired associative stimulation with 25 ms interstimulus interval

Measurement of Cortical Excitability and Intracortical Inhibition

Key TMS parameters for measuring motor cortex excitability and intracortical inhibition included resting motor threshold (RMT), MEP amplitude, and SICI. RMT was defined as the minimum stimulation intensity required to evoke MEPs > 50 V in at least 5 of 10 consecutive TMS trials delivered while the APB was at rest. The 1 mV stimulation intensity was defined as the minimum intensity required to evoke MEPs > 1 mV in at least 5 of 10 consecutive trials with the APB at rest. Both RMT and 1 mV intensity were expressed as percentages of the maximum stimulator output.

Before PAS25 administration, the stimulation intensity required to evoke MEP amplitudes of 1 mV was determined for each participant. This intensity was then used to measure MEP amplitudes at different post-PAS25 time points to assess changes in motor cortex excitability. MEP amplitude was measured as the peak-to-peak value.

For SICI, the conditioning stimulus intensity was set at 70% RMT, the test stimulus intensity at 1 mV, and the interstimulus interval at 2 ms. The test stimulus intensity was adjusted at each time point to maintain the 1 mV response. SICI was expressed as the percentage of the conditioned MEP amplitude relative to the mean unconditioned test MEP amplitude. Values $< 100\%$ indicated intracortical inhibition, while values $> 100\%$ indicated intracortical facilitation. Larger SICI values indicated weaker intracortical inhibition.

Data Analysis

Two-way repeated measures ANOVA was used to evaluate the effects of group and time on MEP amplitude and SICI. When significant main effects or interactions were found, independent samples t-tests were conducted for post-hoc multiple comparisons to identify which time points showed differences in MEP amplitude and SICI among the three groups.

Statistical analyses were performed using SPSS 17.0 software (IBM, Armonk, NY, USA). The significance level was set at $p < 0.05$. Results are presented as mean $\pm$ standard error.

Results

Exercise Participation and Baseline Characteristics

Table 3 presents participants' leisure-time exercise participation and baseline characteristics. The table tennis and tai chi groups showed no differences in exercise duration [t(34) = 1.01, p = 0.32, Cohen's d = 0.34, 95% CI for difference = (−11.81, 35.15)], exercise frequency [t(34) = −1.34, p = 0.19, Cohen's d = −0.45, 95% CI = (−1.26, 0.26)], or exercise intensity (^{2} = 0.12, p = 0.729). In contrast, the sedentary group reported no participation in table tennis or tai chi and significantly greater daily sedentary time than both the table tennis group [t(34) = −7.46, p < 0.001, Cohen's d = −2.49, 95% CI = (−400.80, −229.20)] and tai chi group [t(34) = −8.83, p < 0.001, Cohen's d = −2.94, 95% CI = (−399.81, −250.19)].

All participants tolerated TMS without adverse effects. Before PAS25 administration, no differences were found among the table tennis, tai chi, and sedentary groups in RMT [F(2, 51) = 0.76, p = 0.474], stimulation intensity required to evoke 1 mV MEPs [F(2, 51) = 0.58, p = 0.562], or sensory threshold [F(2, 51) = 0.79, p = 0.46].

Table 3 Exercise participation and baseline characteristics of the three groups

Characteristic	Table Tennis (n=18)	Tai Chi (n=18)	Sedentary (n=18)
Exercise duration (min/session)	128.33 ± 9.01	116.67 ± 7.23	—
Exercise frequency (times/week)	5.78 ± 0.29	6.28 ± 0.24	—
Exercise intensity	Moderate or higher	Moderate or higher	—
Sedentary time (min/day)	281.67 ± 30.40	271.67 ± 22.29	596.67 ± 29.29**
RMT (%)	38.17 ± 1.28	39.67 ± 1.65	40.67 ± 1.38
1 mV intensity (%)	52.17 ± 1.55	54.44 ± 2.19	54.56 ± 1.47
Sensory threshold (mA)	2.18 ± 0.06	2.18 ± 0.09	2.29 ± 0.07

Note: **p < 0.001 compared with table tennis and tai chi groups.

Differences in Motor Cortex Excitability Among Different Exercise Groups

Figure 2 [Figure 2: see original paper] shows example average MEP amplitudes before and immediately, 30 minutes, and 60 minutes after PAS25 for one sedentary older adult, one tai chi practitioner, and one table tennis player. For the sedentary participant, MEPs recorded from the right APB showed minimal changes after PAS25. In contrast, both exercise groups exhibited significant MEP increases at all three post-stimulation time points.

Figure 2 Average MEP amplitudes before and after PAS25 for one sedentary older adult and two exercise-trained older adults

Figure 3 [Figure 3: see original paper] displays mean MEP amplitude changes before and after PAS25 for the table tennis, tai chi, and sedentary groups. Two-way repeated measures ANOVA revealed significant main effects of group [$F(2, 51) = 17.76$, $p < 0.001$] and time [$F(3, 153) = 5.11$, $p = 0.002$], as well as a significant group × time interaction [$F(6, 153) = 4.64$, $p < 0.001$]. Post-hoc analyses indicated that mean MEP amplitudes were significantly higher in the table tennis group (T0–T60: $p < 0.001$) and tai chi group (T0: $p = 0.037$; T30: $p = 0.012$) compared to the sedentary group following PAS25. Additionally, MEP amplitudes in the table tennis group were significantly higher than in the tai chi group at T0 ($p = 0.043$), T30 ($p = 0.043$), and T60 ($p = 0.001$).

Figure 3 Mean MEP amplitude changes before and after PAS25 in table tennis, tai chi, and sedentary groups

Note: *$p < 0.05$, **$p < 0.01$ for table tennis vs. tai chi; #$p < 0.05$ for tai chi vs. sedentary.

Differences in Short-Interval Intracortical Inhibition Among Exercise Groups

Figure 4 [Figure 4: see original paper] shows SICI changes before and after PAS25 for the three groups. Two-way repeated measures ANOVA revealed no significant main effects of time [$F(3, 150) = 1.64$, $p = 0.189$] or group [$F(2, 50) = 2.38$, $p = 0.103$], and no significant group × time interaction [$F(6, 150) = 1.09$, $p = 0.371$].

Figure 4 SICI changes before and after PAS25 in table tennis, tai chi, and sedentary groups

Discussion

Using TMS technology, this study compared changes in motor cortex excitability and intracortical inhibition before and after PAS25 among older adults who regularly participated in table tennis, those who practiced tai chi, and sedentary individuals, to explore differences in M1 synaptic plasticity associated with different exercise modalities. Consistent with our hypotheses, regular participation in table tennis or tai chi produced significant changes in motor cortex excitability compared to sedentary behavior, manifested as significantly enhanced MEP amplitudes induced by PAS25 in specific motor cortex regions, with enhancement lasting more than 30 minutes. Furthermore, the MEP amplitude enhancement was significantly greater in the table tennis group than in the tai chi group. These findings likely reflect adaptations to long-term regular exercise that are sport-specific.

Differences in Motor Cortex Excitability Among Different Exercise Modalities

Long-term exercise can induce functional reorganization of the human cerebral cortex. Neuroimaging studies have shown that expert basketball players exhibit higher activation levels in the inferior parietal lobule and inferior frontal gyrus when observing and predicting free throws compared to novices with stronger predictive abilities. TMS research has demonstrated that long-term training enhances motor cortex excitability. The present study similarly found that MEP amplitudes recorded from the target APB muscle were significantly higher in regular table tennis and tai chi practitioners compared to sedentary older adults. This result indicates that older adults who regularly exercise exhibit stronger motor cortex excitability and higher levels of intracortical neuronal recruitment, suggesting that exercise-induced cortical plasticity changes in older adults primarily manifest as functional reorganization of M1.

In this study, the sedentary, table tennis, and tai chi groups were matched for age, gender, education years, and cognitive status (see Table 2). However, based on our questionnaire assessing exercise and sedentary behavior, the sedentary group differed significantly from the exercise groups in exercise intensity, frequency, duration per session, and sedentary time. These results suggest that enhanced excitability in specific motor cortex regions of regular exercisers may be related to long-term physical activity. Previous research has shown that chronic exercise increases blood flow and neurotrophic factors in M1, providing a more favorable neural environment for neuronal survival and differentiation. Therefore, with long-term regular exercise, the improved cortical environment may promote neuronal survival and increased neural density in M1, leading to changes in corticospinal function and excitability in those who regularly exercise.

Long-term exercise can produce functional adaptations in human corticospinal and spinal motor neurons. For example, MEP amplitudes recorded from muscles involved in play are significantly larger in high-level tennis players, and professional musicians show higher motor cortex excitability. These changes in cortical excitability were assessed in active muscles involved in the specific tasks, demonstrating task-specific adaptation of motor representations in M1. Based on this perspective, we selected table tennis and tai chi as our exercise modalities—activities with deep popular roots in China that are suitable for older adults. Table tennis technique relies on instantaneous force generation from the wrist and fingers to achieve speed, accuracy, and varied ball trajectories, while tai chi requires comprehensive use of finger and wrist muscle strength, flexibility, and coordination to achieve both offensive and defensive capabilities and internal-external cultivation. The APB, innervated by the median nerve and controlling thumb movement, is an active muscle in both table tennis and tai chi movement patterns, providing an opportunity to investigate sport-specific neural plasticity. Our finding that both table tennis and tai chi practitioners showed significantly enhanced excitability in the APB motor cortex representation confirms the concept of task-specific excitability changes in active muscle representations. Through long-term exercise, the function of these muscles is enhanced, and the excitability of their cortical representation areas increases accordingly to meet specific task demands.

A more intriguing finding was that table tennis practitioners exhibited stronger excitability in the APB motor cortex representation compared to tai chi practitioners. This result provides neurophysiological support (based on TMS) for the conclusion that different exercise modalities produce substantially different physical and mental benefits. The differential use frequency and intensity of the APB muscle during table tennis versus tai chi may be the primary reason for this outcome: table tennis requires frequent APB activation to control racket and ball direction, achieving varied, rapid, and accurate shots with relatively high demands on APB force control and usage frequency, whereas tai chi emphasizes slowness, softness, continuity, and circularity, requiring coordinated action of APB and other small hand muscles with relatively less frequent and lower intensity APB use.

Additionally, long-term specialized hand use habits could potentially influence results. First, our study design excluded participants with both long-term specialized hand use (such as playing musical instruments) and table tennis or tai chi habits. Second, table tennis and tai chi involve fundamentally different patterns of hand use, with table tennis being predominantly unilateral and tai chi using both hands. One might speculate that the stronger excitability in specific cortical regions of table tennis practitioners could be due to bilateral hand use in tai chi hindering M1 excitability enhancement induced by right hand use. However, substantial TMS evidence indicates that unilateral hand muscle activation enhances excitability in the ipsilateral M1. Therefore, we consider the potential influence of long-term hand use habits on our results to be minimal.

Enhanced cortical excitability in older exercisers may benefit external motor control. Previous research suggests that increased MEP amplitude may reflect strengthened synaptic connections in the motor cortex. The sustained increase in MEP amplitude in long-term exercisers implies enhanced synaptic connectivity within the motor cortex, which could accelerate motor information encoding and skill retrieval, enabling individuals to produce required motor responses more quickly and accurately in complex environments and thereby control motor skills more precisely. Thus, effective neural connectivity in the motor cortex may underlie the ability of long-term exercisers to rapidly and stably execute external motor behaviors. Our findings may also provide a neurophysiological explanation for why older adults who exercise regularly demonstrate superior motor control compared to sedentary peers.

Enhanced Motor Cortex Synaptic Plasticity in Regular Exercisers

Paired associative stimulation is a commonly used method in neurophysiological research to induce plastic changes in human cerebral cortex. Previous studies have shown that PAS25 delivered to the motor cortex can induce sustained enhancement of cortical excitability lasting approximately 30-60 minutes, which is thought to primarily reflect LTP-like synaptic plasticity in human M1. Our results demonstrate that PAS25 induced sustained enhancement of cortical excitability in older adults who regularly participated in table tennis or tai chi, suggesting that this sustained enhancement likely reflects LTP-like synaptic plasticity changes in the motor cortex. Synaptic plasticity in the human motor cortex plays an important role in motor control, as supported by extensive evidence. For instance, motor impairments in Parkinson's disease are associated with reduced LTP-like effects in the motor cortex, while precise motor skill control in elite athletes is closely related to enhanced LTP-like effects. Thus, enhanced LTP-like plasticity in the motor cortex of long-term exercisers may provide physiological support for their ability to perform motor skills effectively during long-term training.

Intracortical inhibition plays a crucial role in regulating motor cortex excitability and plasticity. Pharmacological studies have shown that SICI is mediated by GABA_A receptors. Pharmacological research in humans has found that lorazepam, which enhances GABA_A receptor transmission, reduces PAS25-induced motor cortex plasticity. Non-pharmacological TMS studies have also demonstrated that GABA_A receptor-modulated SICI blocks PAS25-induced motor cortex plasticity. Based on these findings, differences in PAS25-induced plasticity among table tennis practitioners, tai chi practitioners, and sedentary individuals might be related to SICI. However, our examination of SICI changes revealed no differences among the three groups at any time point. We speculate that changes in GABA_A receptor-modulated inhibitory circuits are not the sole factor underlying PAS25-induced synaptic plasticity enhancement in regular exercisers, and that interactions with other intracortical circuits may ultimately determine motor cortex output—a hypothesis requiring further experimental verification.

This study used a cross-sectional design to investigate the effects of regular table tennis or tai chi participation on motor cortex synaptic plasticity in older adults, and potential confounding factors may have influenced PAS25-induced cortical excitability enhancement. First, enhanced synaptic plasticity in exercisers compared to sedentary individuals could be related to participant age, attention to procedures, or experimental timing. However, these factors were similar between sedentary and exercising groups in our study, making it unlikely they affected our results. Second, recent exercise history could be a factor. It has been established that prior motor learning focused on the same muscle group can interact homeostatically with subsequent PAS25-induced plasticity, though it remains unclear whether recent limb activity interacts homeostatically with PAS25-induced plasticity in motor cortex representations of exercised muscles. Given that PAS25 effects are short-lasting and participants were instructed to refrain from exercise on the experimental day, we believe this factor had minimal impact on our findings.

Regular participation in table tennis or tai chi can induce sustained enhancement of primary motor cortex excitability in older adults, with sport-specific differences in this enhancement effect. Enhanced motor cortex synaptic plasticity may play an important role in skill acquisition and facilitation during exercise in older adults.

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Note: Figure translations are in progress. See original paper for figures.