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BMJ Open

Comparison of open- and closed-chain exercises in improving the inhibitory control ability of the elderly: a protocol for a randomized controlled clinical trial

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8 trial
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11 **Article Type:** Clinical Study Protocol
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14 **Keywords:** Elder; Open-chain exercise; Closed-chain exercise; Inhibitory control
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16 ability; Study protocol
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27 **Order of Authors:** Jian Zhang
28

29 **Abstract**

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32 **Introduction** As people age, they are more likely to experience a decline in their
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34 response inhibition ability, which interferes with daily life. Previous studies have
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36 shown that exercise intervention can improve the cognitive ability of the elderly, but
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38 research on open- and closed-chain exercises to improve the response inhibition in
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40 this age group is still limited. This study will explore the advantages of long-term
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42 intervention of table tennis (open-chain exercise) compared with fit aerobics
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44 (closed-chain exercise) on the inhibitory control ability of the elderly.
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51 **Methods and analysis** A single-blind randomized controlled trial will be conducted.
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55 following groups: table tennis, fit aerobics, and control. The interventions for the table
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57 tennis group and the fit aerobics group will be implemented in three 60-min sessions
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4 per week for 6 months; the control group will receive no exercise intervention. The
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6 primary assessment will be behavioral indicators of inhibitory control ability in the
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9
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18
19 Sport Research Ethics Committee (102772019RT012) and will provide reference for
20
21 the advantages of table tennis compared with other types of sports in improving the
22
23 inhibitory control ability of the elderly. The results of this study will provide a
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25 theoretical basis for choosing the best exercise program to improve the inhibitory
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27 control ability of the elderly.
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33 **Trial registration number** This study has been registered prospectively in the
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35 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).
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4 Cover letter
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9 Editor-in-Chief
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11 BMJ Open
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14 April 3, 2021
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19 Dear editor,
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22 We would like to submit our manuscript entitled “ **Comparison of open- and**
23 **closed-chain exercises in improving the inhibitory control ability of the elderly: a**
24 **protocol for a randomized controlled clinical trial**” for publication as a *protocol*
25 in BMJ Open.
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32 This study will be conducted in a single-blind randomized controlled trial, a
33 six-month open- and closed-chain exercises intervention will be used to study the
34 effects of long-term on the inhibitory control ability in elderly. The study is scheduled
35 to begin in August 2021. This study will use the stop signal task (SST) to explore how
36 different types of exercise experience affect the response inhibition ability in the
37 elderly. We will also explore whether sports involving open-chain exercises can
38 improve the cognitive level, depression state, and mental state of the elderly while
39 improving their inhibition and control ability.
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53 Through multi-dimensional measurements of the participants, we hope to provide a
54 more sufficient theoretical basis for the mechanism of improving the inhibition and
55 control ability of the elderly through exercise.
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4 We confirm that this manuscript has not been published elsewhere and is not under
5
6 consideration by another journal. All authors have approved the manuscript and agree
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9
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11
12 interest to declare.
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39 We look forward to hearing from you at your earliest convenience.
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52 Yours sincerely,

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54 Jia-Ning Wei, Comparison of open- and closed-chain exercises in improving the
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12 **Type of Manuscript:** Clinical Study Protocol
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4 **Abbreviations**
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6 SST, Stop signal task
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9 SSRT, stop signal response time
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11 SSD, stop signal delay
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14 MoCA, Montreal Cognitive Assessment
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17 BDI-II, Beck Depression Inventory (2nd edition);
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19 MMSE, Mini Mental State Examination
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14 **Abstract**

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19 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).
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22 **Strengths and limitations of this study**

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25 1. The results of this study will provide a choosing the best exercise program to
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27 improve the inhibitory control ability of the elderly.
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30 2. The patients will come from one geographic area which limits the generalisability.
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35 **Introduction**

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37 Response inhibition ability is a type of cognitive control ability that can achieve
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39 behavioral goals by adjusting perception and motor function in the changing
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41 environment as well as be used to solve conflicts. As people age, they are likely to
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43 experience a decline in their response inhibition ability,^[1-4] which can interfere with
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45 daily life and even the ability to live independently. Although some studies have
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47 shown that exercise intervention can improve the cognitive ability of the elderly, there
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49 are few studies on the effect of exercise intervention on reactive inhibition ability. In
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51 particular, research on the different types of exercise to improve the response
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53 inhibition ability of the elderly is still limited.
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4 Sports can be divided into closed kinetic chain activities and open kinetic
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6 chain activities.^[5] The operating environment of closed-chain exercises, such as fit
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8 aerobics, fitness running, etc., is stable; and the operating state is determined by the
9
10 operator. In contrast, the operating environment of open-chain exercises, including
11
12 those involved in the sports of table tennis, basketball, etc., is unstable; and the
13
14 operation state is determined by external conditions, such as a ball and opponents. In
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16 open-chain exercises, the participant must continuously adjust their behavior to
17
18 unpredictable stimuli and must invest more cognitive resources in the
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20 decision-making process. It has been demonstrated that intervention with long-term
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22 open-chain exercise can improve cognitive function better than closed-chain exercise,
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24 but whether it can improve inhibitory control ability better is not clear.
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32 As one of the classical paradigms to test response inhibition, the stop signal
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34 task (SST) tests the complete suppression of an ongoing action. The SST instructs the
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36 participant to perform a response when the go signal appears, but after a few go
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38 signals appear, a stop signal will appear at a specific time interval, and the individual
39
40 will be asked to stop the response as far as possible.^[6] The strengths of this test are
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42 that a stop signal to evoke controlling behavior is administered after a go signal is
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44 used, and the interval between these two signals dynamically changes regularly.^[7] In
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46 addition, the SST is capable of quantizing inhibitory control behavior. However, no
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48 response occurs when the participant holds up successfully. The stop signal response
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50 time (SSRT) is a more sensitive indicator to evaluate the inhibitory control ability.^[8]
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58 In short, to calculate the SSRT, all go-reactions (i.e., go-trials in which the response
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4 was missed) are rank-ordered and assigned the maximum response time in order to
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6 compensate for the lacking response. Afterwards, the most recent stop signal delay
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8 (SSD) is subtracted from the response time corresponding to the stop-signal response
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10 percentile. The resulting value is termed the SSRT.^[9,10] These results can be used as
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12 an important index to evaluate the inhibitory control ability.
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17 The proposed randomized clinical trial will examine the effects of table tennis
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19 (open-chain exercise) and fit aerobics (closed-chain exercise) on the primary outcome
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21 (behavioral task) of inhibitory control ability as well as on the secondary outcomes of
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23 cognitive ability, mental status, and depression in the elderly. We hypothesized that
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25 different types of exercise intervention can affect the inhibitory control ability to
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27 varying degrees and that the effect of open-chain exercises is better.
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35 **Methods**

36 **Study design**

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38 This study protocol of a pilot study is designed as a prospective, single-blind
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40 randomized controlled trial. Eligible participants will be randomized into table tennis,
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42 fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention
43
44 will be 6 months. The cognitive function test (questionnaire and behavioral task) will
45
46 be conducted before the intervention as well as at 3 months, 6 months, and 12 months
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48 after the intervention. Participants who meet the criteria will undergo baseline
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50 assessments. All evaluations will be done at baseline and immediately after the
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52 exercise intervention (See Figure 1). We will recruit healthy right-handed elderly
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4 participants with normal or corrected-to-normal vision and without a history of
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6 neurological diseases in the same way.
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10 11 **Ethics and dissemination**

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14 All participants who meet the inclusion and exclusion criteria will be required to sign
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16 an informed consent form prior to enrolling in the study. This study was approved by
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18 the Shanghai University of Sport Research Ethics Committee (102772019RT012).
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25 Figure 1 Flow diagram of the study design

26 27 **Participants**

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30 Any participants with chronic cardiovascular or neurological diseases will be
31
32 excluded. In addition, those with a regular exercise routine will be excluded. All
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34 participants will be between the ages of 60 and 70 years old and right-handed as
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36 assessed by the Edinburgh Handedness Inventory. Moreover, they must have normal
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38 or corrected-to-normal vision and no signs of depression or cognitive impairment as
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40 detected by the Beck Depression Inventory, 2nd edition (BDI-II) and the Mini Mental
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42 State Examination (MMSE).
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48 Before and after the intervention, all groups will have their demographics
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50 statistically analyzed for factors such as health status, physical fitness, and cognitive
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52 function (Table 1). Intergroup differences will be minimized before the intervention.
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58 Table 1 Demographic and clinical characteristics of the study participants
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	Open group	Closed group	Control
Age			
Gender (male:female)			
Hight			
Body mass index (kg/m ²)			
HRmax			
Score for self-reported habitual physical activity			
MoCA			
BDI-II			
MMSE			
Behavioral tests for cognitive ability (RT)			
Behavioral test about cognitive ability (ACC)			

MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental State Examination; Behavioral tests for cognitive ability: Stroop task testing, n-back task testing, task-switch task testing; RT, response time; ACC, accuracy.

Sample size

From our previous studies on the modulation of SST performance,^[11,12] we expected an effect of $r = 0.4$. Together with an α -value of 0.05 and a power of $1 - \beta = 0.9$, a sample of at least 72 participants (24/group) was planned to find a similar effect. Calculations were carried out using G*Power, version 3.1,^[13] with anticipation of a 20% attrition rate. Therefore, we plan to recruit 90 subjects (30/group).

Evaluation Procedures

Exercise intervention

The exercise intervention will last for 6 months. The participants will be divided into three groups: table tennis, fit aerobics, and control. The table tennis (open-chain) and fit aerobics (closed-chain) groups will train for 60 min, three times a week. The exercise intensity will be monitored, ensuring that the heart rate remains in the range of 60–70% of the maximum heart rate ($HR_{MAX} = 220 - \text{age}$). During the training period, the exercise intensity will be monitored by the experimenter through real-time heart rate monitoring and the subject's subjective reaction. The exercise load and heart rate responses of the subjects will be recorded at each training session and adjusted accordingly with an increase of aerobic capacity. The entire intervention process will be monitored in real time by health care professionals.

Table tennis group

Each session will consist of a warm-up for 10 min, table tennis practice under the guidance of a coach for 40 min, and relaxation for 10 min. The degree of difficulty of training throughout the program will be gradually increased. The training will consist of the following seven main parts: (1) footwork; (2) the serve; (3) forehand backhand attack; (4) forehand backhand loop; (5) kill shot; (6) continuous hitting of directional

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4 or nondirectional balls randomly sent by the server; and (7) comprehensive practice.
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6 All the technical movements will be from simple to complex.
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10 11 12 13 14 ***Fit aerobics group*** 15

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17 The participants in the closed-chain exercise group will attend a supervised fit
18 aerobics class of the same frequency, duration, and length as the open-chain exercise
19 group. Fit aerobics at 50–60% of the heart rate reserve for the first two weeks,
20 followed by 70–75% of the heart rate reserve. Each fit aerobics class will consist of
21 warm-up activities for 10 min, basic aerobics activities for 30 min, strength exercises
22 or mat exercises for 10 min, and relaxation and stretching for 10 min. The fit aerobics
23 training will involve the following: 1) jogging, rope skipping, and/or gymnastics to
24 warm up and achieve a slightly sweating body, and the heart rate will be slightly
25 faster; 2) stepping, side parallel step, side cross step, jumping jacks, lunging, kicking,
26 and so on. Following the rhythm of the music, each action will be reduced from four
27 sets to two sets and then to one set; 3) upper body exercises, lower body exercises,
28 core strength exercises, or yoga exercises related to them; 4) relax the shoulder, elbow,
29 hip, and knee joints by doing a few stretches to help relax the muscles.
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56 ***Control group*** 57 58 59 60

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4 For the control group, health testing, cognitive ability testing, and telephone or
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6 personal interviews will be carried out in addition to regular physical and mental
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8 health education lectures.
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10 11 12 13 14 15 *SST protocol*

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19 The SST was programmed using E-prime 2, in which the subjects will be asked to
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21 press a "←" button or a "→" button according to the left and right arrow directions. In
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23 25% of the trials, the arrow will turn red and a gray triangle will appear; the
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25 participants will press the button to stop or give no response. The interval of
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27 stimulation will be dynamically adjusted according to the tracking procedure. The
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29 task will be divided into four groups of 120 trials each. The task flow is shown in
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31 Figure 2. The execution go signal reaction time (GoRT), stop response reaction time
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33 (SRRT), SSD, and SSRT will be investigated.
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Figure 2 Stop signal task flow chart

The instructions for the experiment will be follows: Welcome to the
experiment. First, "+" will appear in the center of the screen to alert the user to begin
the keystroke reaction, and the right index finger should be placed on the "↓" to
prepare for the experiment. When the black arrow appears in the center of the screen,
use your right index finger to press the button. When the left arrow appears, use your

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4 index finger to press the "←" key on the keyboard. When the right arrow appears, use
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6 your index finger to press the "→" key on the keyboard. After each key response, the
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8 right index finger should quickly return to the "↓" key to wait for the next response.
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11 When the black arrow in the center of the screen turns red and a small gray triangle
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13 appears, please stop the keystroke reaction immediately. When the red arrow appears
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15 in the center of the screen, please do not perform any keystroke reaction. Let's move
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18 on to practice.
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26 **Outcomes**

27 **Primary outcome**

28 *Behavioral task*

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31 The task will include randomly interspersed no-go and stop-signal trials, which will
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33 enable us to examine both types of inhibition. A total of 480 trials will be performed,
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35 including 75% go trials and 25% stop trials. On go trials, the subjects will respond to
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37 a left/right black arrow (1000 ms) by pressing the buttons with their right hand.
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39 Responses will be made with the index finger (for the left or right arrow). In the
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41 stop-signal trials, a response will be initially cued by a left/right black arrow, but the
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43 arrow color will change to red concurrent with a gray triangle after a SSD, and the
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45 subjects will be asked not to respond. The SSD will be varied from trial to trial by
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47 using a step-up/down algorithm with an initial estimate of 250 ms to maintain 50%
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49 successful inhibition. The task flow chart is shown in Figure 3.
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Figure 3 Stop behavioral task

The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials will be performed (75% go, 25% stop).

Secondary outcomes

Secondary outcome measures will include the following: (1) Montreal Cognitive Assessment (MoCA); (2) BDI-II; (3) MMSE; (4) Stroop task testing; (5) n-back task testing; and (6) task-switch task testing (Table 2). The process of inhibitory control is the process of inhibition, refresh, and switching of the response task through cognitive function, so we will test the abilities of inhibition, refresh, and switching in the cognitive process of the elderly with different exercise types before and after the intervention by the Stroop task, the n-back task, and the task-switch task to compare their inhibitory control ability. The details of each outcome and instrument will be compiled as in Table 2.

Table 2 The differences among the three groups of subjects at various stages

Group	Baseline	6 months	12 months	18 months	24 months	F (P	F (P	F (P value)
						value)	value)	Interaction effect
Open						Time effect	Group effect	
MoCA								
Closed								

	Control
	Open
BDI-II	Closed
	Control
	Open
MMSE	Closed
	Control
	Open
Stroop	Closed
(RT)	Control
	Open
n-back	Closed
(ACC)	Control
Task-	Open
switch	Closed
(ACC)	Control

MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental

State Examination; RT, response time; ACC, accuracy.

MoCA

The MoCA is an assessment tool for the rapid screening of cognitive dysfunction. It includes 11 items in 8 cognitive domains: attention and concentration, executive

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4 function, memory, language, abstract thinking, and computation. The highest possible
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6 total score is 30, and a score of 26 or more is normal. It has a high sensitivity and a
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8 short test time, so it is suitable for clinical application.
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11 12 13 14 *BDI-II*

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16 The BDI-II contains 21 topics, which are suitable for people older than 13 years old.
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18 The areas of focus include symptoms of depression, such as despair, sensitivity, ways
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20 of understanding things, and physical characteristics, such as fatigue, weight loss, and
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22 decreased sexual ability.
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30 31 *MMSE*

32 The MMSE scale includes the following seven aspects: time orientation, place
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34 orientation, immediate memory, attention and calculation, delayed memory, language,
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36 and visual space. There are a total of 30 questions asked in the exam, with 1 point
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38 awarded for each correct answer, and 0 points given for each wrong answer or
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40 unanswered question. The total score range of the scale is 0–30 points. The test scores
41
42 are closely related to the educational level of the subject. The normal cut-off values
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44 are as follows: illiterate subjects, >17; primary school education only, >20; junior
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46 high school education and above, >24.
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56 57 *Stroop task*

58 After a period of exercise intervention, comparison of the Stroop task response time
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4 between the open-chain, closed-chain, and control groups will be used to explore
5
6 which types of exercise can improve cognitive inhibition ability.
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9

10 11 *N-back task*

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13
14 By comparing the n-back task accuracy of the elderly in the three groups, the
15
16 improvement of the cognitive refresh ability of each group will be compared under
17
18 different cognitive loads.
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22 23 24 *Task-switch task*

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26
27 By comparing the task-switch accuracy of the three groups under different stimulus
28
29 conditions, we will determine which type of exercise can improve the cognitive
30
31 transformation ability most significantly.
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35 36 37 **Patient and public involvement**

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39
40 Participants have not been involved in the study recruitment. The authors conceived
41
42 the initial research questions and outcome measures, and modified according to the
43
44 telephone interviews with patients and their guardians by a research assistant. In order
45
46 to assure the safety and feasibility of the intervention, we invited six elderly peoples
47
48 to learn and practise the table tennis and fit aerobics exercise before designing the
49
50 RCT. Table tennis and fit aerobics exercise were revised based on the exercise
51
52 performance and feedback provided by the participants. The burden of the
53
54 intervention will be assessed by patients and their advisors through face-to-face
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4 interviews before signing informed consent. The findings of the study will be
5
6 disseminated to the participants and their guardians.
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10 11 **Statistical analysis**

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14 Repeated-measures analysis of variance will be used to determine the effects of
15
16 different types of exercise (open, closed, or control) on the primary outcomes (GoRT,
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18 SRRT, SSD, and SSRT) as well as on the secondary outcomes (MOCA score, BDI-II
19
20 score, MMSE score, Stroop response time, n-back accuracy, task-switch accuracy),
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22 with group and time serving as factors.
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30 31 **Discussion**

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33 Previous studies have shown that open-chain exercises require more regulating
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35 capacity than closed-chain exercises.^[14] First, a study comparing the cognitive control
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37 of sports involving open-chain exercises with that of closed-chain exercises has
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39 revealed that athletes engaging in open-chain exercises have an advantage in
40
41 cognitive control.^[15] Then some researchers found that athletes participating in
42
43 open-chain exercises have a faster switching speed, fewer cognitive resources, and a
44
45 higher efficiency in the inhibition process.^[16] At the same time, another study has
46
47 demonstrated that athletes who engage in open-chain exercises have a stronger
48
49 reaction switching capability.^[17] Based on this evidence, participating in sports
50
51 involving open-chain exercises can improve the ability of inhibition, refresh, and
52
53 conversion in the inhibitory control process. Therefore, in this study, the Stroop task,
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4 n-back task, and task-switch task were selected as secondary outcomes to investigate
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6 the inhibition, refresh, and transformation abilities, respectively, of the participants.
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9 Determining the effect of long-term intervention of different types of sports on the
10
11 inhibitory control ability of the elderly will improve our understanding of inhibitory
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13 control degradation and support the development of diversified training programs.
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17 This study will use the SST to explore how different types of exercise
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19 experience affect the response inhibition ability in the elderly. Because of the
20
21 interactions of the cognitive level, depressive state, and mental state with the
22
23 inhibitory control ability, we will perform multiple MoCA, BDI-II, MMSE
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25 measurements before and after each intervention. We will also explore whether sports
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27 involving open-chain exercises can improve the cognitive level, depression state, and
28
29 mental state of the elderly while improving their inhibition and control ability.
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31 Through multi-dimensional measurements of the participants, we hope to provide a
32
33 more sufficient theoretical basis for the mechanism of improving the inhibition and
34
35 control ability of the elderly through exercise.
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43 This study will have several limitations. The effect of long-term exercise
44
45 intervention on cognitive control is greatly influenced by the screening and control of
46
47 subjects. How to select and control participants in a longitudinal study is one of the
48
49 difficulties of this project. In this research, the screening principles of the subjects will
50
51 be determined in the longitudinal study, and the inclusion criteria and exclusion
52
53 criteria will be strictly defined, especially the experimental groups and the control
54
55 group in terms of age, physical level, intervention time, and intensity. In addition,
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4 because the exercise that will serve as an intervention will be widely known to the
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6 participants, the single-blind design may expose the study to risks of bias stemming
7
8 from performance and evaluation, which may potentially lead to overestimation of the
9
10 effects of exercise.
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17 Funding: This study was supported by grants from the National Natural
18
19 Science Foundation of China (3197070657) .
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24

25 **Contributorship statement**

26
27 Ke Liu: Conceptualization, Methodology, SoftwarePriya. Lanlan Zhang:Writing-
28
29 Reviewing and Editing. Jian Zhang: Visualization, Investigation. Jia-Ning Wei: Data
30
31 curation, Writing- Original draft preparation.
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38 **References**

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41 [1] Darowski Emily S, et al."Age-related differences in cognition: the role of distraction control.." *Neuropsychology* 22.5(2008):. doi:10.1037/0894-4105.22.5.638.
42
43 [2] Chen T Y,et al."Cognitive Aging and Executive Decline Hypothesis." *Advances in Psychological*
44
45 *Science* .05(2004):729-736. doi:CNKI:SUN:XLXD.0.2004-05-011.
46
47 [3] Fergus I.M. Craik, ,and Ellen Bialystok."Cognition through the lifespan: mechanisms of change." *Trends in*
48
49 *Cognitive Sciences* 10.3(2006):. doi:10.1016/j.tics.2006.01.007.
50
51 [4]Timothy A. Salthouse."Aging and measures of processing speed." *Biological Psychology* 54.1(2000):.
52
53 doi:10.1016/S0301-0511(00)00052-1.
54
55 [5] Voss Michelle W., et al."Plasticity of Brain Networks in a Randomized Intervention Trial of Exercise Training
56
57 in Older Adults." *Frontiers in Aging Neuroscience* .(2010):. doi:10.3389/FNAGI.2010.00032.
58
59 [6] Logan G D, et al."On the ability to inhibit simple and choice reaction time responses: a model and a method.." *Journal of experimental psychology. Human perception and performance* 10.2(1984):. doi:.
60
[7] Janette L. Smith, et al."Motor and non-motor inhibition in the Go/NoGo task: An ERP and fMRI study." *International Journal of Psychophysiology* 87.3(2013):. doi:10.1016/j.ijpsycho.2012.07.185.

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4
5 [8] Frederick Verbruggen, and Gordon D. Logan. "Response inhibition in the stop-signal paradigm." *Trends in Cognitive Sciences* 12.11(2008):. doi:10.1016/j.tics.2008.07.005.
6
7 [9] Verbruggen Frederick, Chambers Christopher D.,and Logan Gordon D.. "Fictitious Inhibitory Differences: How Skewness and Slowing Distort the Estimation of Stopping Latencies." *Psychological Science* 24.3(2013):. doi:.
8
9 [10] Frederick Verbruggen, et al."A consensus guide to capturing the ability to inhibit actions and impulsive behaviors in the stop-signal task." *eLife* 8.(2019):. doi:10.7554/eLife.46323.
10
11 [11] Friehs Maximilian A.,and Frings Christian."Pimping inhibition: Anodal tDCS enhances stop-signal reaction time.." *Journal of Experimental Psychology: Human Perception and Performance* 44.12(2018):. doi:10.1037/XHP0000579.
12
13 [12]Maximilian A. Friehs, ,and Christian Frings."Cathodal tDCS increases stop-signal reaction time." *Cognitive, Affective, & Behavioral Neuroscience* 19.5(2019):. doi:10.3758/s13415-019-00740-0.
14
15 [13] Faul, F., ErdFelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3.1 manual. *Behav. Res. Methods* 39 (2), 175–191.
16
17 [14] Michelle W. Voss, et al."Are expert athletes ‘expert’ in the cognitive laboratory? A meta - analytic review of cognition and sport expertise." *Applied Cognitive Psychology* 24.6(2010):. doi:10.1002/acp.1588.
18
19 [15] Chun-Hao Wang, et al."Open vs. Closed Skill Sports and the Modulation of Inhibitory Control." *PLOS ONE* 8.2(2013):. doi:10.1371/journal.pone.0055773.
20
21 [16]Di Russo Francesco, et al."Benefits of sports participation for executive function in disabled athletes.." *Journal of neurotrauma* 27.12(2010):. doi:10.1089/neu.2010.1501.
22
23 [17] Bjoern Krenn, et al."Sport type determines differences in executive functions in elite athletes." *Psychology of Sport & Exercise* 38.(2018):. doi:10.1016/j.psychsport.2018.06.002.
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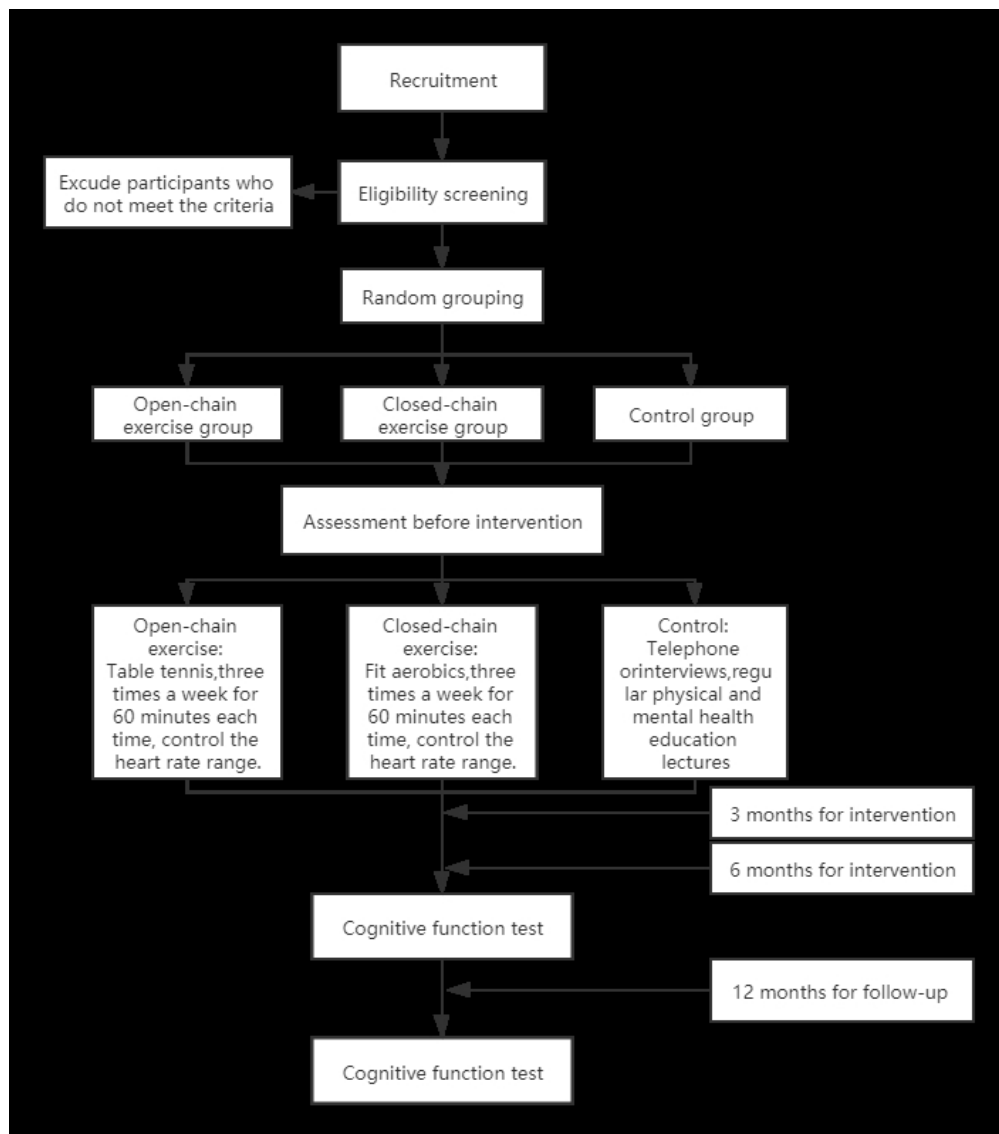


Figure 1. Flow diagram of the study design

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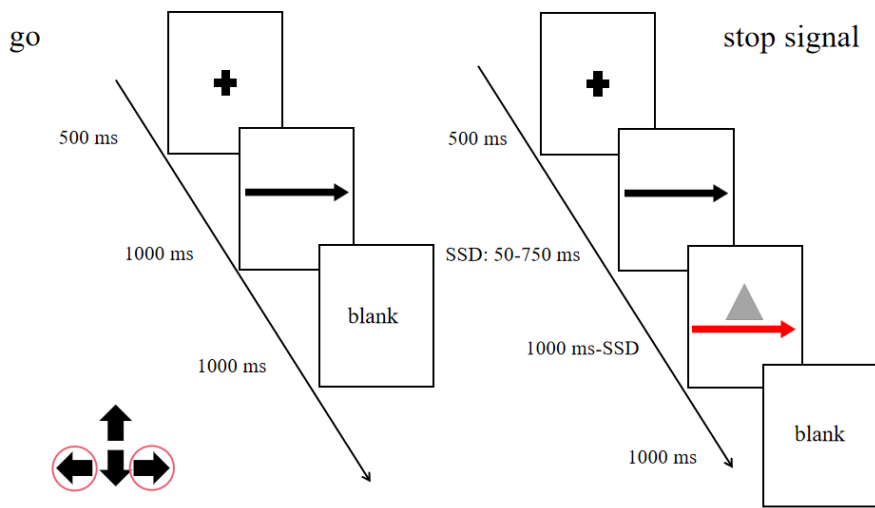


Figure 2. Stop signal task flow chart

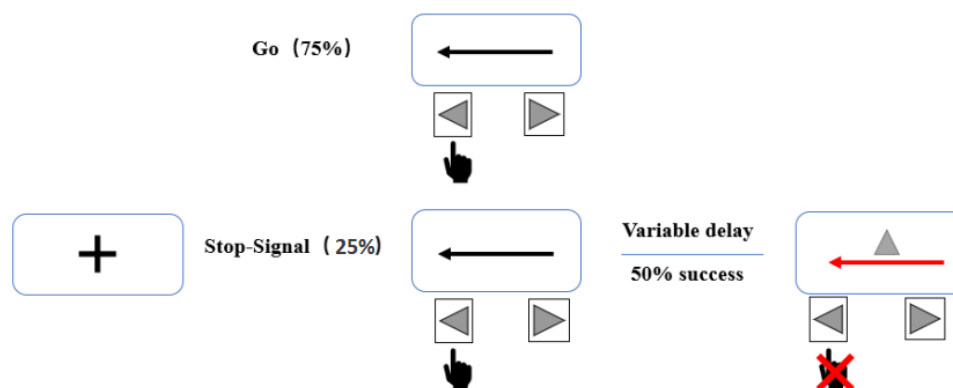


Figure 3. Stop behavioral task

The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials will be performed (75% go, 25% stop).

BMJ Open

Comparison of open- and closed-chain exercises in improving the response inhibitory ability of the elderly: a protocol for a randomized controlled clinical trial

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Manuscript ID	bmjopen-2021-051966.R1
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Primary Subject Heading:	Public health
Secondary Subject Heading:	Mental health, Public health
Keywords:	Old age psychiatry < PSYCHIATRY, MENTAL HEALTH, Biophysics < NATURAL SCIENCE DISCIPLINES, PUBLIC HEALTH

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4 **Title:** Comparison of open- and closed-chain exercises in improving the response
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6 inhibitory ability of the elderly: a protocol for a randomized controlled clinical
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8
9 trial
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11 **Article Type:** Clinical Study Protocol
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14 **Keywords:** Elder; Open-chain exercise; Closed-chain exercise; Response inhibitory
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16 ability; Study protocol
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19 **Corresponding Author:** Jia-Ning Wei
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22 **Corresponding Author's Institution:** Shanghai University of Sport
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25 **First Author:** Ke Liu, Lan-Lan Zhang
26

27 **Order of Authors:** Jian Zhang
28

29 **Abstract**

30
31
32 **Introduction** As people age, they are more likely to experience a decline in their
33
34 response inhibition ability, which interferes with daily life. Previous studies have
35
36 shown that exercise intervention can improve the cognitive ability of the elderly, but
37
38 research on open- and closed-chain exercises to improve the response inhibition in
39
40 this age group is still limited. This study will explore the advantages of long-term
41
42 intervention of table tennis (open-chain exercise) compared with fit aerobics
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44 (closed-chain exercise) on the response inhibitory ability of the elderly.
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51 **Methods and analysis** A single-blind randomized controlled trial will be conducted.
52
53 A total of 90 elderly subjects will be recruited and allocated randomly to the
54
55 following groups: table tennis, fit aerobics, and control. The interventions for the table
56
57 tennis group and the fit aerobics group will be implemented in three 60-min sessions
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4 per week for 6 months; the control group will receive no exercise intervention. The
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6 primary assessment will be behavioral indicators of response inhibitory ability in the
7
8 elderly based on the stop signal task (SST). The secondary outcomes will include
9
10 cognitive ability, mental status, and depression in the elderly. Assessments will be
11
12 conducted at baseline, 3 months, 6 months, and 12 months.
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16
17 **Ethics and dissemination** This study was approved by the Shanghai University of
18
19 Sport Research Ethics Committee (102772019RT012) and will provide reference for
20
21 the advantages of table tennis compared with other types of sports in improving the
22
23 response inhibitory ability of the elderly. The results of this study will provide a
24
25 theoretical basis for choosing the best exercise program to improve the response
26
27 inhibitory ability of the elderly.
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33 **Trial registration number** This study has been registered prospectively in the
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35 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021)
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6 inhibitory ability of the elderly: a protocol for a randomized controlled clinical trial
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14 **Authors:** Ke Liu^{1†}, Lan-Lan Zhang^{2†}, Jian Zhang³, Jia-Ning Wei^{3*}
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32 † These authors contributed equally to this work.
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36
37 **Figures and tables:** 3 figures and 3 tables
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40 **Number of Words:** Abstract: 264 words; Manuscript: 4,177 words; 27 pages
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45 *** Corresponding author:**
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Abbreviations

SST, Stop signal task

SSRT, stop signal response time

SSD, stop signal delay

MoCA, Montreal Cognitive Assessment

BDI-II, Beck Depression Inventory (2nd edition);

MMSE, Mini Mental State Examination

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4 Comparison of open- and closed-chain exercises in improving the
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6 response inhibitory ability of the elderly: a protocol for a
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8 randomized controlled clinical trial
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14 **Abstract**

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18
19 response inhibition ability, which interferes with daily life. Previous studies have
20
21 shown that exercise intervention can improve the cognitive ability of the elderly, but
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23 research on open- and closed-chain exercises to improve the response inhibition in
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25 this age group is still limited. This study will explore the advantages of long-term
26
27 intervention of table tennis (open-chain exercise) compared with fit aerobics
28
29 (closed-chain exercise) on the response inhibitory ability of the elderly.
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36
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38
39 following groups: table tennis, fit aerobics, and control. The interventions for the table
40
41 tennis group and the fit aerobics group will be implemented in three 60-min sessions
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43 per week for 6 months; the control group will receive no exercise intervention. The
44
45 primary assessment will be behavioral indicators of response inhibitory ability in the
46
47 elderly based on the stop signal task (SST). The secondary outcomes will include
48
49 cognitive ability, mental status, and depression in the elderly. Assessments will be
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51 conducted at baseline, 3 months, 6 months, and 12 months.
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5
6 the advantages of table tennis compared with other types of sports in improving the
7
8 response inhibitory ability of the elderly. The results of this study will provide a
9
10 theoretical basis for choosing the best exercise program to improve the response
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12 inhibitory ability of the elderly.
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16
17 **Trial registration number** This study has been registered prospectively in the
18
19 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).
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22 **Strengths and limitations of this study**

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24 1. The results of this study will provide a choosing the best exercise program to
25
26 improve the response inhibitory ability of the elderly.
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30 2. The effect of long-term exercise intervention on cognitive control is greatly
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32 influenced by the screening and control of subjects.
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- 35
36 3. How to select and control participants in a longitudinal study is one of the
37
38 difficulties of this project.
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- 41
42 4. The patients will come from one geographic area which limits the generalisability.
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44

45 **Introduction**

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48 Response inhibition ability is a type of cognitive control ability that can achieve
49
50 behavioral goals by adjusting perception and motor function in the changing
51
52 environment as well as be used to solve conflicts.^[1] As people age, they are likely to
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54 experience a decline in their response inhibition ability,^[2-5] which can interfere with
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56 daily life and even the ability to live independently. Although some studies have
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4 shown that exercise intervention can improve the cognitive ability of the elderly,^[6]
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6 there are few studies on the effect of exercise intervention on reactive inhibition
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8 ability. In particular, research on the different types of exercise to improve the
9
10 response inhibition ability of the elderly is still limited.
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14 Sports can be divided into closed kinetic chain activities and open kinetic
15
16 chain activities.^[7] It is different from Open kinetic chain exercise (OKCE) and closed
17
18 kinetic chain exercise (CKCE) in exercise prescription.^[8] The open and closed
19
20 mentioned here refer to the movement environment and movement methods, not the
21
22 fixed point of the extremity during movements. The operating environment of
23
24 closed-chain exercises, such as fit aerobics, fitness running, etc., is stable; and the
25
26 operating state is determined by the operator. In contrast, the operating environment
27
28 of open-chain exercises, including those involved in the sports of table tennis,
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30 basketball, etc., is unstable; and the operation state is determined by external
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32 conditions, such as a ball and opponents. In open-chain exercises, the participant must
33
34 continuously adjust their behavior to unpredictable stimuli and must invest more
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36 cognitive resources in the decision-making process. Previous studies have shown that
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38 open-chain exercises require more regulating capacity than closed-chain exercises.^[9]
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40 First, a study comparing the cognitive control of sports involving open-chain
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42 exercises with that of closed-chain exercises has revealed that athletes engaging in
43
44 open-chain exercises have an advantage in cognitive control. It has been demonstrated
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46 that intervention with long-term open-chain exercise can improve cognitive function
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4 better than closed-chain exercise,^[10] but whether it can improve response inhibitory
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6 ability better is not clear.
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9 As one of the classical paradigms to test response inhibition, the stop signal
10 task (SST) tests the complete suppression of an ongoing action. The SST instructs the
11 participant to perform a response when the go signal appears, but after a few go
12 signals appear, a stop signal will appear at a specific time interval, and the individual
13 will be asked to stop the response as far as possible.^[11] The strengths of this test are
14 that a stop signal to evoke controlling behavior is administered after a go signal is
15 used, and the interval between these two signals dynamically changes regularly.^[12] In
16 addition, the SST is capable of quantizing inhibitory control behavior. However, no
17 response occurs when the participant holds up successfully. The stop signal response
18 time (SSRT) is a more sensitive indicator to evaluate the response inhibitory
19 ability.^[13] In short, to calculate the SSRT, all go-reactions (i.e., go-trials in which the
20 response was missed) are rank-ordered and assigned the maximum response time in
21 order to compensate for the lacking response. Afterwards, the most recent stop signal
22 delay (SSD) is subtracted from the response time corresponding to the stop-signal
23 response percentile. The resulting value is termed the SSRT.^[14,15] These results can be
24 used as an important index to evaluate the response inhibitory ability.
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50 The proposed randomized clinical trial will examine the effects of table tennis
51 (open-chain exercise) and fit aerobics (closed-chain exercise) on the primary outcome
52 (behavioral task) of response inhibitory ability as well as on the secondary outcomes
53 of cognitive ability, mental status, and depression in the elderly. We hypothesized that
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4 different types of exercise intervention can affect the response inhibitory ability to
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7 varying degrees and that the effect of open-chain exercises is better.
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10 11 **Methods**

12 13 **Study design**

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16 This study protocol of a pilot study is designed as a prospective, single-blind
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18 randomized controlled trial. Eligible participants will be randomized into table tennis,
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20 fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention
21
22 will be 6 months. The cognitive function test (questionnaire and behavioral task) will
23
24 be conducted before the intervention as well as at 3 months, 6 months, and 12 months
25
26 after the intervention. Participants who meet the criteria will undergo baseline
27
28 assessments. All evaluations will be done at baseline and immediately after the
29
30 exercise intervention (See Figure 1). We will recruit healthy right-handed elderly
31
32 participants with normal or corrected-to-normal vision and without a history of
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34 neurological diseases in the same way. The study is scheduled to begin in August 2021
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36 and continue until August 2023.
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48 Figure 1 Flow diagram of the study design
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50 51 **Participants**

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53 Any participants with heart disease, neurological disorder, musculoskeletal disorders,
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55 and other conditions not suitable for physical activity, contraindications to fMRI or
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57 TMS will be excluded. In addition, those with a regular exercise routine will be
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4 excluded. All participants will be between the ages of 60 and 70 years old and
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6 right-handed as assessed by the Edinburgh Handedness Inventory. Moreover, they
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8 must have their own residence.
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11 Before and after the intervention, all groups will have their demographics
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13 statistically analyzed for factors such as health status, physical fitness, and cognitive
14
15 function (Table 1). Intergroup differences will be minimized before the intervention.
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22 Table 1 Demographic and clinical characteristics of the study participants
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	Open group	Closed group	Control
27 Age			
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29 Gender (male:female)			
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34			
35 Body mass index (kg/m ²)			
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37 HRmax			
38			
39			
40 Score for self-reported habitual physical activity			
41			
42			
43 MoCA			
44			
45 BDI-II			
46			
47			
48 MMSE			
49			
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51 Behavioral tests for cognitive ability (RT)			
52			
53 Behavioral test about cognitive ability (ACC)			
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56 MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental

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58 State Examination; Behavioral tests for cognitive ability: Stroop task testing, n-back task testing, task-switch task
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4 testing; RT, response time; ACC, accuracy.
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9 **Sample size**

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12 From our previous studies on the modulation of SST performance,^[16,17] we expected
13 an effect of $r = 0.4$. Together with an α -value of 0.05 and a power of $1 - \beta = 0.9$, a
14 sample of at least 72 participants (24/group) was planned to find a similar effect.
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16 Calculations were carried out using G*Power, version 3.1,^[18] with anticipation of a
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20% attrition rate. Therefore, we plan to recruit 90 subjects (30/group).

27 **Randomisation**

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Eligible participants will be randomized into table tennis, fit aerobics, or control
groups at a 1:1:1 ratio after consenting and baseline assessment. I will use The Excel
software to code the subjects in 1-90 according to the recruitment time, and then use
the formula '=RAND()' to generate the corresponding random sequence. By sorting
the random sequence and then grouping it, 90 subjects will be randomly grouped.

45 **Exercise intervention**

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The exercise intervention will last for 6 months. The participants will be divided into
three groups: table tennis, fit aerobics, and control. The table tennis (open-chain) and
fit aerobics (closed-chain) groups will train for 60 min, three times a week. The
exercise intensity will be monitored, ensuring that the heart rate remains in the range
of 60–70% of the maximum heart rate ($HR_{MAX} = 220 - \text{age}$). During the training

period, the exercise intensity will be monitored by the experimenter through real-time heart rate monitoring and the subject's subjective reaction. The exercise load and heart rate responses of the subjects will be recorded at each training session and adjusted accordingly with an increase of aerobic capacity. The entire intervention process will be monitored in real time by health care professionals. Specific intervention methods are shown in Table 2.

Table 2 Exercise intervention TIDieR

Item NO	Brief name	Group		
		Table tennis group	Fit aerobics group	Control group
1	Why	Table tennis	Fit aerobics	Control
2	What	Participants will be led by professional table tennis coaches for 6 months of table tennis exercise.	Participants will be led by professional fit aerobics coaches for 6 months of fit aerobics exercise.	Keep the original living habits, do not have regular exercise, regularly attend health lectures and accept telephone follow-up. Participants will attend biweekly health talks and will be interviewed by phone once a month.
3	What (materials)	Participants will do 60 minutes of exercise three times a week. Specific exercises will be described later.		
4	What (procedures)	Each participant received a test report before and at 3, 6, and 12 months after the start of the exercise so that they could understand their physical and psychological changes.		
5	Who provided	Table tennis coaches is the second level table tennis athlete in China from Shanghai University of Sport. The psychology-related tests were completed by ph. D. students majoring in psychology at Shanghai University of Sport.	Fit aerobics coaches is the second level fit aerobics athlete in China from Shanghai University of Sport. The psychology-related tests were completed by ph. D. students majoring in psychology at Shanghai University of Sport.	The health lecture was completed by ph. D. students majoring in physical Education and training in Shanghai University of Sport, and the telephone return visit was completed by ph. D. students majoring in psychology.

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4				Health lectures will be
5				conducted face to face
6	6	How	The exercise intervention will take place in a stationary gym, where the instructor will direct the whole group face to face.	in a group format, and
7				telephone return visits
8				will be conducted one
9				by one.
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11			Table tennis training is held in	Fit aerobic trianing is conducted
12			China Table Tennis College of	in the School of Physical
13			Shanghai Sport	Education and Training of
14	7	Where	University. There is a	Shanghai Sport University. There
15			professional table tennis	is a professional aerobics training
16			training ground.	ground.
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20			The table tennis (open-chain) and fit aerobics (closed-chain) groups	
21			will train for 60 min, three times a week. The exercise intensity will	
22			be monitored, ensuring that the heart rate remains in the range of	
23			60–70% of the maximum heart rate (HRMAX = 220 – age).	
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27			Each session will consist of a	The participants in the
28			warm-up for 10 min, table	closed-chain exercise group will
29			tennis practice under the	attend a supervised fit aerobics
30			guidance of a coach for 40	class of the same frequency,
31			min, and relaxation for 10	duration, and length as the
32			min. The degree of difficulty	open-chain exercise group. Fit
33			of training throughout the	aerobics at 50–60% of the
34			program will be gradually	maximum heart rate for the first
35			increased. Table tennis at 50–	two weeks, followed by 60–70%
36			60% of the maximum heart	of the maximum heart rate. Each
37	8	When	rate for the first two weeks,	fit aerobics class will consist of
38		and how	followed by 60–70% of the	warm-up activities for 10 min,
39		much	maximum heart rate. The	basic aerobics activities for 40
40			training will consist of the	min., and relaxation and
41			following seven main parts:	stretching for 10 min. The fit
42			(1) footwork; (2) the serve; (3)	aerobics training will involve the
43			forehand backhand attack; (4)	following: 1) jogging, rope
44			forehand backhand loop; (5)	skipping, and/or gymnastics to
45			kill shot; (6) continuous hitting	warm up and achieve a slightly
46			of directional or	sweating body, and the heart rate
47			nondirectional balls randomly	will be slightly faster; 2)
48			sent by the server; and (7)	stepping, side parallel step, side
49			comprehensive practice. All	cross step, jumping jacks,
50			the technical movements will	lunging, kicking, and so on.
51			be from simple to complex.	Following the rhythm of the
52				music, each action will be
53				reduced from four sets to two sets
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and then to one set; 3) relax the shoulder, elbow, hip, and knee joints by doing a few stretches to help relax the muscles.

Exercise interventions were performed at 50-60% of maximum heart rate for the first two weeks, followed by 60-70% of maximum heart rate. In order to ensure the safety of participants, the exercise intensity will be gradually increased, and the first two weeks will be mainly acclimatization.

How well (planned) Feedback will be given to each participant on a regular basis, including their physical and psychological data, as well as their motor skills learning performance. Keep them up to date on their progress and status to keep them engaged.

SST protocol

The SST was programmed using E-prime 2, in which the subjects will be asked to press a "←" button or a "→" button according to the left and right arrow directions. In 25% of the trials, the arrow will turn red and a gray triangle will appear; the participants will press the button to stop or give no response. The interval of stimulation will be dynamically adjusted according to the tracking procedure. The task will be divided into four groups of 120 trials each. The task flow is shown in Figure 2. The execution go signal reaction time (GoRT), stop response reaction time (SRRT), SSD, and SSRT will be investigated. GoRT is how long it takes for the participant to respond after the GO (black arrow) appears. SRRT is the time to respond to the stop signal (arrow turning red) task. SSD is the time between the task stimulus and the stop signal.

Figure 2 Stop signal task flow chart

The instructions for the experiment will be follows: Welcome to the experiment. First, "+" will appear in the center of the screen to alert the user to begin the keystroke reaction, and the right index finger should be placed on the "↓" to prepare for the experiment. When the black arrow appears in the center of the screen, use your right index finger to press the button. When the left arrow appears, use your index finger to press the "←" key on the keyboard. When the right arrow appears, use your index finger to press the "→" key on the keyboard. After each key response, the right index finger should quickly return to the "↓" key to wait for the next response. When the black arrow in the center of the screen turns red and a small gray triangle appears, please stop the keystroke reaction immediately. When the red arrow appears in the center of the screen, please do not perform any keystroke reaction. Let's move on to practice.

Outcomes

Primary outcome

Behavioral task

The task will include randomly interspersed no-go and stop-signal trials, which will enable us to examine both types of inhibition. A total of 480 trials will be performed, including 75% go trials and 25% stop trials. On go trials, the subjects will respond to a left/right black arrow (1000 ms) by pressing the buttons with their right hand.

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4 Responses will be made with the index finger (for the left or right arrow). In the
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6 stop-signal trials, a response will be initially cued by a left/right black arrow, but the
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8 arrow color will change to red concurrent with a gray triangle after a SSD, and the
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10 subjects will be asked not to respond. The SSD will be varied from trial to trial by
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12 using a step-up/down algorithm with an initial estimate of 250 ms to maintain 50%
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14 successful inhibition. The task flow chart is shown in Figure 3.
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22 Figure 3 Stop behavioral task
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24 The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials
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26 will be performed (75% go, 25% stop).
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32 **Secondary outcomes** 33

34 Secondary outcome measures will include the following: (1) Montreal Cognitive
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36 Assessment (MoCA); (2) BDI-II; (3) MMSE; (4) Stroop task testing; (5) n-back task
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38 testing; and (6) task-switch task testing (Table 3). The process of inhibitory control is
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40 the process of inhibition, refresh, and switching of the response task through cognitive
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42 function, so we will test the abilities of inhibition, refresh, and switching in the
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44 cognitive process of the elderly with different exercise types before and after the
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46 intervention by the Stroop task, the n-back task, and the task-switch task to compare
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48 their response inhibitory ability. The details of each outcome and instrument will be
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50 compiled as in Table 3.
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Table 3 The differences among the three groups of subjects at various stages

	Group	Baseline	6 months	12 months	18 months	24 months	F (P value) Time effect	F (P value) Group effect	F (P value) Interaction effect
MoCA		Open							
		Closed							
		Control							
BDI-II		Open							
		Closed							
		Control							
MMSE		Open							
		Closed							
		Control							
Stroop (RT)		Open							
		Closed							
		Control							
n-back (ACC)		Open							
		Closed							
		Control							
Task-switch		Open							
		Closed							

(ACC) Control

MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental State Examination; RT, response time; ACC, accuracy.

MoCA

The MoCA is an assessment tool for the rapid screening of cognitive dysfunction. It includes 11 items in 8 cognitive domains: attention and concentration, executive function, memory, language, abstract thinking, and computation.^[19] The highest possible total score is 30, and a score of 26 or more is normal. It has a high sensitivity and a short test time, so it is suitable for clinical application.

BDI-II

The BDI-II contains 21 topics, which are suitable for people older than 13 years old. The areas of focus include symptoms of depression, such as despair, sensitivity, ways of understanding things, and physical characteristics, such as fatigue, weight loss, and decreased sexual ability.^[20]

MMSE

The MMSE scale includes the following seven aspects: time orientation, place orientation, immediate memory, attention and calculation, delayed memory, language, and visual space.^[21] There are a total of 30 questions asked in the exam, with 1 point awarded for each correct answer, and 0 points given for each wrong answer or

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4 unanswerd question. The total score range of the scale is 0–30 points. The test scores
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6 are closely related to the educational level of the subject. The normal cut-off values
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8 are as follows: illiterate subjects, >17; primary school education only, >20; junior
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10 high school education and above, >24.
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17 *Stroop task*

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19 After a period of exercise intervention, comparison of the Stroop task response time
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21 between the open-chain, closed-chain, and control groups will be used to explore
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23 which types of exercise can improve cognitive inhibition ability^[22].
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30 *N-back task*

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32 By comparing the n-back task accuracy of the elderly in the three groups, the
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34 improvement of the cognitive refresh ability of each group will be compared under
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36 different cognitive loads.^[23]
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43 *Task-switch task*

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45 By comparing the task-switch accuracy of the three groups under different stimulus
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47 conditions, we will determine which type of exercise can improve the cognitive
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49 transformation ability most significantly.^[24]
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56 **Patient and public involvement**

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58 Participants have not been involved in the study recruitment. The authors conceived
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4 the initial research questions and outcome measures, and modified according to the
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6 telephone interviews with patients and their guardians by a research assistant. In order
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8 to assure the safety and feasibility of the intervention, we invited six elderly peoples
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10 to learn and practise the table tennis and fit aerobics exercise before designing the
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12 RCT. Table tennis and fit aerobics exercise were revised based on the exercise
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14 performance and feedback provided by the participants. The burden of the
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16 intervention will be assessed by patients and their advisors through face-to-face
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18 interviews before signing informed consent. The findings of the study will be
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20 disseminated to the participants and their guardians.
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30 **Statistical analysis**

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32 In order to ensure no inter-group differences in all test indicators after random
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34 grouping, Independent-sample T test will be performed on each pretest data after
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36 random grouping. Repeated-measures analysis of variance will be used to determine
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38 the effects of different types of exercise (open, closed, or control) on the primary
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40 outcomes (GoRT, SRRT, SSD, and SSRT) as well as on the secondary outcomes
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42 (MOCA score, BDI-II score, MMSE score, Stroop response time, n-back accuracy,
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44 task-switch accuracy), with group and time serving as factors. The above data is
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46 analyzed by specialized PhD students, they analyse the data be blind to group
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48 allocation.
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58 **Discussion**

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4 Studies have found that elderly people who participate in ball and racket projects have
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6 higher health and physical awareness.^[25] Pilates exercises decreased depression and
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8 improved the balance related to falling in elderly,^[26] and also experienced significant
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10 improvement in physical, social spiritual, and emotional wellness.^[27] Korean scholars
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12 found the cognitive/exercise dual-task program was an effective intervention for
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14 improving cognitive function, health status, and life satisfaction, and for decreasing
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16 depression of the elderly living in the community.^[28]
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22 Then some researchers found that athletes participating in open-chain exercises
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24 have a faster switching speed, fewer cognitive resources, and a higher efficiency in
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26 the inhibition process.^[29] At the same time, another study has demonstrated that
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28 athletes who engage in open-chain exercises have a stronger reaction switching
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30 capability.^[30] Based on previous research, participating in sports involving open-chain
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32 exercises can improve the ability of inhibition, refresh, and conversion in the
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34 inhibitory control process. In the Stoop task, when two different dimensions of a
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36 stimulus interfere with each other, it is necessary for participants to inhibit the
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38 interfering stimulus, it looked at the participants' ability to suppress interference. In
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40 the n-back task, participants' attention capacity and memory capacity could be
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42 examined during the process of stimulus updating. In task-switch task, participants
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44 need to keep their attention focused when switching between different tasks, so it can
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46 investigate the transformation ability of participants in the cognitive process.
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48 Therefore, in this study, the Stroop task, n-back task, and task-switch task were
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50 selected as secondary outcomes to investigate the inhibition, refresh, and
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4 transformation abilities, respectively, of the participants. Determining the effect of
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6 long-term intervention of different types of sports on the response inhibitory ability of
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8 the elderly will improve our understanding of inhibitory control degradation and
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10 support the development of diversified training programs.
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14 This study will use the SST to explore how different types of exercise
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16 experience affect the response inhibition ability in the elderly. Because of the
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18 interactions of the cognitive level, depressive state, and mental state with the response
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20 inhibitory ability, we will perform multiple MoCA, BDI-II, MMSE measurements
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22 before and after each intervention. We will also explore whether sports involving
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24 open-chain exercises can improve the cognitive level, depression state, and mental
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26 state of the elderly while improving their inhibition and control ability. Through
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28 multi-dimensional measurements of the participants, we hope to provide a more
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30 sufficient theoretical basis for the mechanism of improving the inhibition and control
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32 ability of the elderly through exercise.
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40 This study will have several limitations. In this research, the screening
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42 principles of the subjects will be determined in the longitudinal study, and the
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44 inclusion criteria and exclusion criteria will be strictly defined, especially the
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46 experimental groups and the control group in terms of age, physical level, intervention
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48 time, and intensity. In addition, because the exercise that will serve as an intervention
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50 will be widely known to the participants, the single-blind design may expose the study
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52 to risks of bias stemming from performance and evaluation, which may potentially
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54 lead to overestimation of the effects of exercise.
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Ethics and dissemination

All participants who meet the inclusion and exclusion criteria will be required to sign an informed consent form prior to enrolling in the study. This study was approved by the Shanghai University of Sport Research Ethics Committee (102772019RT012).

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Contributorship statement

Ke Liu: Conceptualization, Methodology, SoftwarePriya. Lanlan Zhang: Writing- Reviewing and Editing. Jian Zhang: Visualization, Investigation. Jia-Ning Wei: Data curation, Writing- Original draft preparation.

References

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- [1] Logan Gordon D, et al. "On the ability to inhibit thought and action: general and special theories of an act of control.." *Psychological review* 121.1(2014): doi:10.1037/a0035230
- [2] Darowski Emily S, et al. "Age-related differences in cognition: the role of distraction control.." *Neuropsychology* 22.5(2008):. doi:10.1037/0894-4105.22.5.638.
- [3] Chen T Y, et al. "Cognitive Aging and Executive Decline Hypothesis." *Advances in Psychological Science* .05(2004):729-736. doi:CNKI:SUN:XLXD.0.2004-05-011.
- [4] Fergus I.M. Craik, ,and Ellen Bialystok. "Cognition through the lifespan: mechanisms of change." *Trends in Cognitive Sciences* 10.3(2006):. doi:10.1016/j.tics.2006.01.007.
- [5] Timothy A. Salthouse. "Aging and measures of processing speed." *Biological Psychology* 54.1(2000):. doi:10.1016/S0301-0511(00)00052-1.
- [6] Zhang, N. N. , et al. "Effect of long-term Tai Chi exercise on cognitive function of middle-aged and old people." *Chinese Journal of Clinical Rehabilitation* 26(2006):7-9. doi:CNKI:SUN:XDKF.0.2006-26-004..

- [7] Voss Michelle W., et al."Plasticity of Brain Networks in a Randomized Intervention Trial of Exercise Training in Older Adults." *Frontiers in Aging Neuroscience* .(2010):. doi:10.3389/FNAGI.2010.00032.
- [8] Soul Cheon, et al."Acute Effects of Open Kinetic Chain Exercise Versus Those of Closed Kinetic Chain Exercise on Quadriceps Muscle Thickness in Healthy Adults." *International Journal of Environmental Research and Public Health* 17.13(2020): doi:10.3390/ijerph17134669.
- [9] Michelle W. Voss, et al."Are expert athletes ‘expert’ in the cognitive laboratory? A meta - analytic review of cognition and sport expertise." *Applied Cognitive Psychology* 24.6(2010):. doi:10.1002/acp.1588.
- [10] Chun-Hao Wang, et al."Open vs. Closed Skill Sports and the Modulation of Inhibitory Control." *PLOS ONE* 8.2(2013):. doi:10.1371/journal.pone.0055773.
- [11] Logan G D, et al."On the ability to inhibit simple and choice reaction time responses: a model and a method.." *Journal of experimental psychology. Human perception and performance* 10.2(1984):. doi:10.1037/0096-1523.10.2.276.
- [12] Janette L. Smith, et al."Motor and non-motor inhibition in the Go/NoGo task: An ERP and fMRI study." *International Journal of Psychophysiology* 87.3(2013):. doi:10.1016/j.ijpsycho.2012.07.185.
- [13] Frederick Verbruggen, ,and Gordon D. Logan."Response inhibition in the stop-signal paradigm." *Trends in Cognitive Sciences* 12.11(2008):. doi:10.1016/j.tics.2008.07.005.
- [14] Verbruggen Frederick, Chambers Christopher D.,and Logan Gordon D.."Fictitious Inhibitory Differences: How Skewness and Slowing Distort the Estimation of Stopping Latencies." *Psychological Science* 24.3(2013):. doi:10.1177/0956797612457390:.
- [15] Frederick Verbruggen, et al."A consensus guide to capturing the ability to inhibit actions and impulsive behaviors in the stop-signal task." *eLife* 8.(2019):. doi:10.7554/eLife.46323.
- [16] Friehs Maximilian A.,and Frings Christian."Pimping inhibition: Anodal tDCS enhances stop-signal reaction time.." *Journal of Experimental Psychology: Human Perception and Performance* 44.12(2018):. doi:10.1037/XHP0000579.
- [17]Maximilian A. Friehs, ,and Christian Frings."Cathodal tDCS increases stop-signal reaction time." *Cognitive, Affective, & Behavioral Neuroscience* 19.5(2019):. doi:10.3758/s13415-019-00740-0.
- [18] Faul, F., ErdFelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3.1 manual. *Behav. Res. Methods* 39 (2), 175–191.
- [19] Gao,F. The application of moca test and DTI in mild cognitive impairment. Diss. 2008.*PLA Military Medical Training College*, MA thesis.
- [20] F Holländare, G. Andersson , and I Engström. "A Comparison of Psychometric Properties Between Internet and Paper Versions of Two Depression Instruments (BDI-II and MADRS-S) Administered to Clinic Patients." *Journal of Medical Internet Research* 12.5(2010):76-79.
- [21] SMD Azmeh, et al. *Mini-Mental State Examination (MMSE)*. Springer New York, 2011.
- [22] Chen, Ji, et al. "The Latest advances of the Stroop Effect-its theory, paradigms, affecting factors." *Journal of Psychological Science*. 02(2007):415-418+390. doi:10.16719/j.cnki.1671-6981.2007.02.042.
- [23] Song, HK. "The evolution and application of N-back paradigm." *Journal of Southwest University(Social Sciences Edition)*37.S1(2011):81-82. doi:10.13718/j.cnki.xdsk.2011.s1.065.
- [24] Shi, Y. , and X. Zhou . "Task Switching, A Paradigm in the Study of Executive Control." *Advances in Psychological Science*. 05(2004):672-679. doi:CNKI:SUN:XLXD.0.2004-05-004.
- [25] Ahn, C., & Lee, W. (2021). The Difference between exercise effect, health and fitness perception according to the degree of exercise participation of the elderly. *Journal of adapted physical activity and exercise*, 29(2), 245-254.
- [26] Mahyar Mokhtari, et al."The Effect of 12-Week Pilates Exercises on Depression and Balance Associated with Falling in the Elderly." *Procedia - Social and Behavioral Sciences* 70.(2013): doi:10.1016/j.sbspro.2013.01.246.
- [27] Roh Su Yeon."The effect of 12-week Pilates exercises on wellness in the elderly.." *Journal of exercise rehabilitation* 12.2(2016): doi:10.12965/jer.1632590.295.
- [28] Mahyar Mokhtari, et al."The Effect of 12-Week Pilates Exercises on Depression and Balance Associated with Falling in the Elderly." *Procedia - Social and Behavioral Sciences* 70.(2013): doi:10.1016/j.sbspro.2013.01.246.

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5 [29]Di Russo Francesco, et al."Benefits of sports participation for executive function in disabled athletes.." *Journal*
6 *of neurotrauma* 27.12(2010):. doi:10.1089/neu.2010.1501.
7
8 [30] Bjoern Krenn, et al."Sport type determines differences in executive functions in elite athletes." *Psychology of*
9 *Sport & Exercise* 38.(2018):. doi:10.1016/j.psychsport.2018.06.002.
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For peer review only

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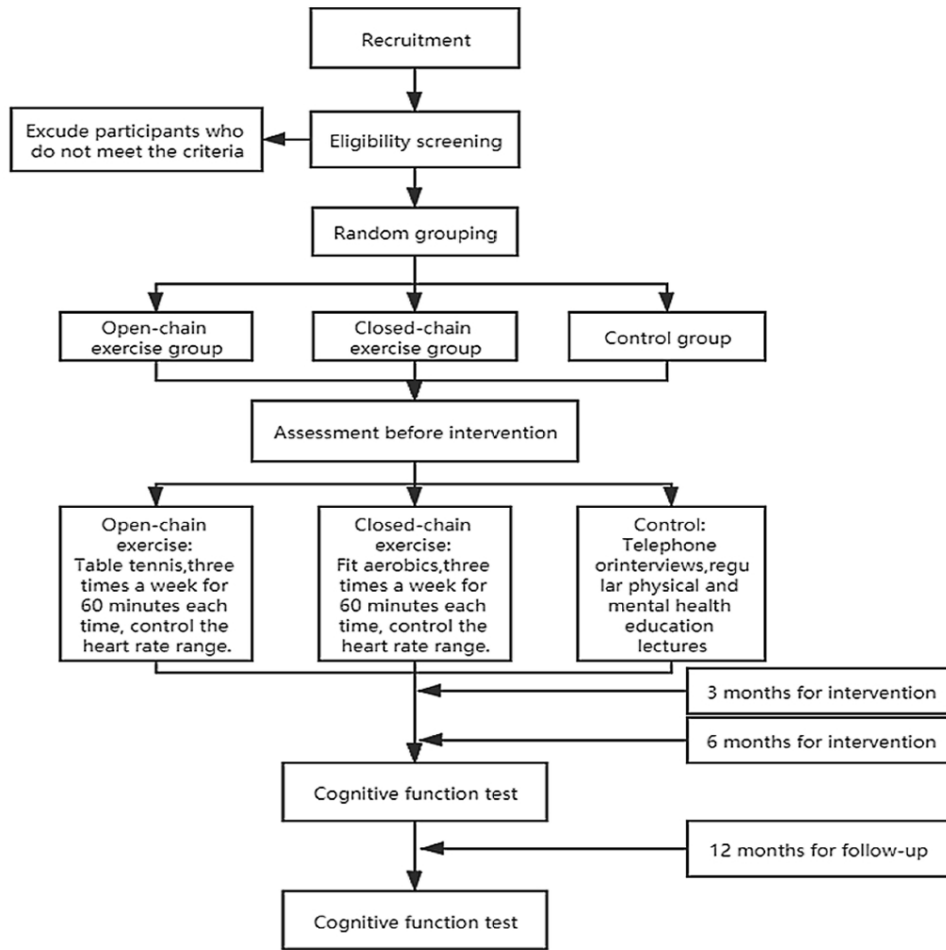


Figure 1 Flow diagram of the study design

90x90mm (300 x 300 DPI)

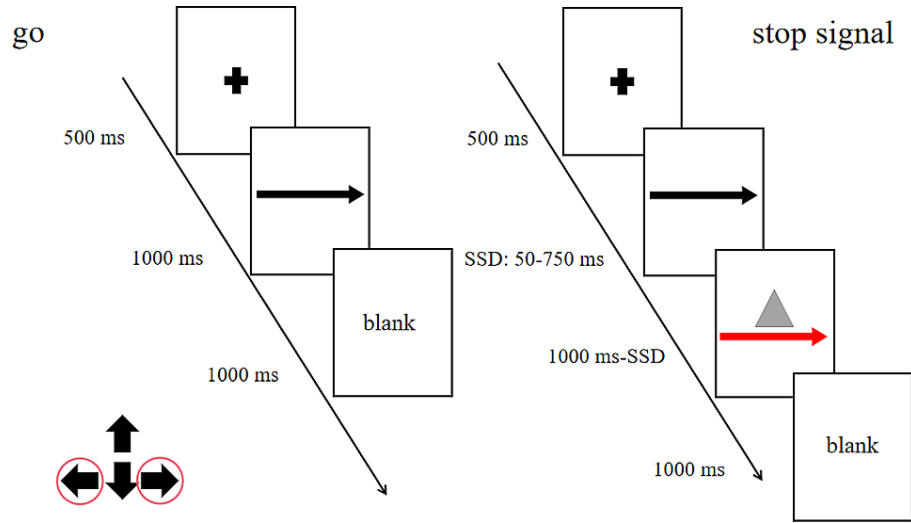


Figure 2. Stop signal task flow chart

90x90mm (300 x 300 DPI)

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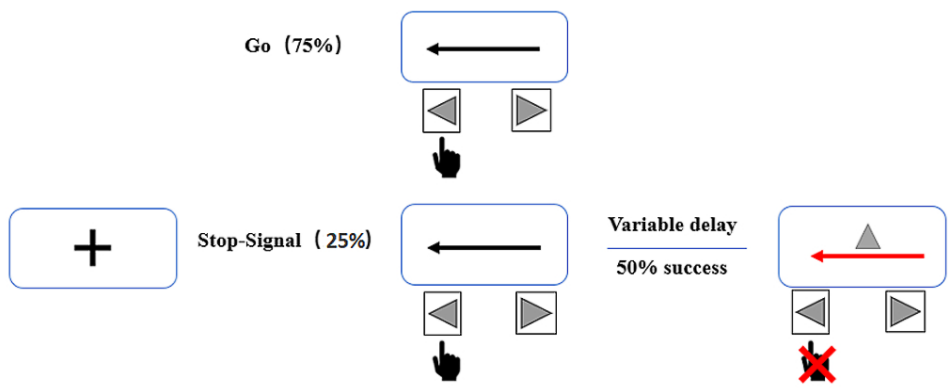


Figure 3. Stop behavioral task
The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials will be performed (75% go, 25% stop).

90x90mm (300 x 300 DPI)



SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description
Administrative information		
Title	1	Comparison of open- and closed-chain exercises in improving the response inhibitory ability of the elderly: a protocol for a randomized controlled clinical trial (page 8,line 4)
Trial registration	2a	This study has been registered prospectively in the Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021). (page 9,line 17)
	2b	
Protocol version	3	The study is scheduled to begin in August 2021 and continue until August 2023. (page 12,line 40)
Funding	4	This study was supported by grants from the National Natural Science Foundation of China (3197070657) . (page 26,line 22)
Roles and responsibilities	5a	Ke Liu; Shanghai Punan Hospital of Pudong New District, Shanghai, China; Conceptualization, Methodology, SoftwarePriya. (page 26,line 30)
	5b	
	5c	
	5d	Lan-Lan Zhang: Writing- Reviewing and Editing. Jian Zhang: Visualization, Investigation. Jia-Ning Wei: Data curation, Writing- Original draft preparation. (page 26,line 30)
Introduction		
Background and rationale	6a	As people age, they are more likely to experience a decline in their response inhibition ability, which interferes with daily life. Previous studies have shown that exercise intervention can improve the cognitive ability of the elderly, but research on open- and closed-chain exercises to improve the response inhibition in this age group is still limited. This study will explore the advantages of long-term intervention of table tennis (open-chain exercise) compared with fit aerobics (closed-chain exercise) on the response inhibitory ability of the elderly. (page 8,line 17)

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- 6b The elderly who choose not to exercise as the control group can compare the effects of exercise intervention with the intervention group. (page 15,line 21)
- Objectives 7 We hypothesized that different types of exercise intervention can affect the response inhibitory ability to varying degrees and that the effect of open-chain exercises is better. (page 11,line 58)
- Trial design 8 This study protocol of a pilot study is designed as a prospective, single-blind randomized controlled trial. Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention will be 6 months. The cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. Participants who meet the criteria will undergo baseline assessments. All evaluations will be done at baseline and immediately after the exercise intervention. (page 12,line 17)

Methods: Participants, interventions, and outcomes

- Study setting 9 School of Psychology, Shanghai University of Sport, Shanghai, China (page 15,line 21)
- Eligibility criteria 10 Any participants with heart disease, neurological disorder, musculoskeletal disorders, and other conditions not suitable for physical activity, contraindications to fMRI or TMS will be excluded. In addition, those with a regular exercise routine will be excluded. All participants will be between the ages of 60 and 70 years old and right-handed as assessed by the Edinburgh Handedness Inventory. Moreover, they must have their own residence. (page 12,line 53)
- Interventions 11a Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11b Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11c Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11d Table 2 Exercise intervention TIDieR (page 15,line 20)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	Outcomes	12	Primary outcome : Behavioral task (RT,ACC) Secondary outcome measures will include the following: (1) Montreal Cognitive Assessment (MoCA); (2) BDI-II; (3) MMSE; (4) Stroop task testing; (5) n-back task testing; and (6) task-switch task testing (Table 3). The process of inhibitory control is the process of inhibition, refresh, and switching of the response task through cognitive function, so we will test the abilities of inhibition, refresh, and switching in the cognitive process of the elderly with different exercise types before and after the intervention by the Stroop task, the n-back task, and the task-switch task to compare their response inhibitory ability. The details of each outcome and instrument will be compiled as in Table 3. (page 19,line 45)
17 18 19 20 21 22 23 24 25 26 27 28 29	Participant timeline	13	This study protocol of a pilot study is designed as a prospective, single-blind randomized controlled trial. Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention will be 6 months. The cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. Participants who meet the criteria will undergo baseline assessments. All evaluations will be done at baseline and immediately after the exercise intervention (See Figure 1). (page 12,line 17)
30 31 32 33 34 35 36 37 38 39	Sample size	14	From our previous studies on the modulation of SST performance,we expected an effect of $r = 0.4$. Together with an α -value of 0.05 and a power of $1 - \beta = 0.9$, a sample of at least 72 participants (24/group) was planned to find a similar effect. Calculations were carried out using G*Power, version 3.1, with anticipation of a 20% attrition rate. Therefore, we plan to recruit 90 subjects (30/group). (page 14,line 13)
40 41 42 43 44	Recruitment	15	All participants were recruited and counted through the School of Psychology, Shanghai Sport University, and intervened in Shanghai Sport University. (page 15,line 20)

Methods: Assignment of interventions (for controlled trials)

Allocation:

48 49 50 51 52 53 54 55 56 57 58 59 60	Sequence generation	16a	Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio after consenting and baseline assessment.I will use The Excel software to code the subjects in 1-90 according to the recruitment time, and then use the formula '=RAND()' to generate the corresponding random sequence. By sorting the random sequence and then grouping it, 90 subjects will be randomly grouped. (page 14,line 29)
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1			
2	Allocation	16b	Eligible participants will be randomized into table tennis, fit aerobics,
3	concealment		or control groups at a 1:1:1 ratio after consenting and baseline
4	mechanism		assessment. I will use The Excel software to code the subjects in 1-90
5			according to the recruitment time, and then use the formula '=RAND()'
6			to generate the corresponding random sequence. By sorting the
7			random sequence and then grouping it, 90 subjects will be randomly
8			grouped. (page 14,line 29)
9			
10			
11	Implementation	16c	Ke Liu will generate the allocation sequence, Jian Zhang will enrol
12			participants, and Jian Zhang will assign participants to interventions.
13			
14	Blinding	17a	The data is analyzed by specialized PhD students, they analyse the
15	(masking)		data be blind to group allocation. (page 23,line 48)
16			
17		17b	After the results are processed, the grouping can be announced.
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Methods: Data collection, management, and analysis

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21	Data collection	18a	In order to ensure no inter-group differences in all test indicators after
22	methods		random grouping, Independent-sample T test will be performed on
23			each pretest data after random grouping. Repeated-measures
24			analysis of variance will be used to determine the effects of different
25			types of exercise (open, closed, or control) on the primary outcomes
26			(GoRT, SRRT, SSD, and SSRT) as well as on the secondary
27			outcomes (MOCA score, BDI-II score, MMSE score, Stroop response
28			time, n-back accuracy, task-switch accuracy), with group and time
29			serving as factors. (page 23,line 32)
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33		18b	Feedback will be given to each participant on a regular basis,
34			including their physical and psychological data, as well as their motor
35			skills learning performance. Keep them up to date on their progress
36			and status to keep them engaged. (page 17,line 17)
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39	Data	19	The data is analyzed by specialized PhD students. (page 23,line
40	management		48)
41			
42	Statistical	20a	Repeated-measures analysis of variance will be used to determine the
43	methods		effects of different types of exercise (open, closed, or control) on the
44			primary outcomes (GoRT, SRRT, SSD, and SSRT) as well as on the
45			secondary outcomes (MOCA score, BDI-II score, MMSE score,
46			Stroop response time, n-back accuracy, task-switch accuracy), with
47			group and time serving as factors. (page 23,line 38)
48			
49			
50		20b	No
51			
52		20c	The data is analyzed by specialized PhD students, they analyse the
53			data be blind to group allocation. (page 23,line 48)
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55			

Methods: Monitoring

56			
57	Data monitoring	21a	The data is analyzed by specialized PhD students, they analyse the
58			data be blind to group allocation. (page 23,line 48)
59			
60			

	21b	The initiator of the experiment, Professor Zhang will have access to these interim results and make the final decision to terminate the trial
Harms	22	In the Participants gave an informed consent form.
Auditing	23	In the Participants gave an informed consent form.

Ethics and dissemination

Research ethics approval	24	This study was approved by the Shanghai University of Sport Research Ethics Committee (102772019RT012). (page 8,line 59)
Protocol amendments	25	Upload as attachment.
Consent or assent	26a	PhD students in charge of data collection will collect data within the cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. (page 12,line 24)
	26b	No
Confidentiality	27	Professor Zhang, who is in charge of recruitment, completes the participant information management.
Declaration of interests	28	The authors have no conflicts of interest to declare.
Access to data	29	The result will be made public by the person in charge of the National Natural Science Foundation of China (3197070657)
Ancillary and post-trial care	30	In the Participants gave an informed consent form.
Dissemination policy	31a	This study has been registered prospectively in the Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).It will be published in accordance with the standards of the Chinese Clinical Trial Registry.
	31b	It will be written in accordance with the standards of the Chinese Clinical Trial Registry.
	31c	It can be viewed in the Chinese Clinical Trial Registry.

Appendices

Informed consent materials	32	Upload as attachment.
Biological specimens	33	No.

*It is strongly recommended that this checklist be read in conjunction with the SPIRIT 2013 Explanation & Elaboration for important clarification on the items. Amendments to the protocol should be tracked and dated. The SPIRIT checklist is copyrighted by the SPIRIT

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For peer review only

BMJ Open

Comparison of open- and closed-chain exercises in improving the response inhibitory ability of the elderly: a protocol for a randomized controlled clinical trial

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Manuscript ID	bmjopen-2021-051966.R2
Article Type:	Protocol
Date Submitted by the Author:	21-Oct-2021
Complete List of Authors:	ke, liu; Shanghai Punan Hospital of Pudong New District lanlan, zhang; Guangzhou Sport University, School of Leisure Sport and Management jian, zhang; Shanghai University of Sport, School of Psychology jianing, wei; Shanghai University of Sport, School of Psychology
Primary Subject Heading:	Public health
Secondary Subject Heading:	Mental health, Public health
Keywords:	Old age psychiatry < PSYCHIATRY, MENTAL HEALTH, Biophysics < NATURAL SCIENCE DISCIPLINES, PUBLIC HEALTH

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4 **Title:** Comparison of open- and closed-chain exercises in improving the response
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6 inhibitory ability of the elderly: a protocol for a randomized controlled clinical
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9 trial
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11 **Article Type:** Clinical Study Protocol
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14 **Keywords:** Elder; Open-chain exercise; Closed-chain exercise; Response inhibitory
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16 ability; Study protocol
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19 **Corresponding Author:** Jia-Ning Wei
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22 **Corresponding Author's Institution:** Shanghai University of Sport
23

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25 **First Author:** Ke Liu, Lan-Lan Zhang
26

27 **Order of Authors:** Jian Zhang
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30 **Abstract**

31
32 **Introduction** As people age, they are more likely to experience a decline in their
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34 response inhibition ability, which interferes with daily life. Previous studies have
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36 shown that exercise intervention can improve the cognitive ability of the elderly, but
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38 research on open- and closed-chain exercises to improve the response inhibition in
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40 this age group is still limited. This study will explore the advantages of long-term
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42 intervention of table tennis (open-chain exercise) compared with fit aerobics
43
44 (closed-chain exercise) on the response inhibitory ability of the elderly.
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50 **Methods and analysis** A single-blind randomized controlled trial will be conducted.
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52 A total of 90 elderly subjects will be recruited and allocated randomly to the
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54 following groups: table tennis, fit aerobics, and control. The interventions for the table
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56 tennis group and the fit aerobics group will be implemented in three 60-min sessions
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4 per week for 6 months; the control group will receive no exercise intervention. The
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6 primary assessment will be behavioral indicators of response inhibitory ability in the
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8 elderly based on the stop signal task (SST). The secondary outcomes will include
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10 cognitive ability, mental status, and depression in the elderly. Assessments will be
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12 conducted at baseline, 3 months, 6 months, and 12 months.
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17 **Ethics and dissemination** This study was approved by the Shanghai University of
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19 Sport Research Ethics Committee (102772019RT012) and will provide reference for
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21 the advantages of table tennis compared with other types of sports in improving the
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23 response inhibitory ability of the elderly. The results of this study will provide a
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25 theoretical basis for choosing the best exercise program to improve the response
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27 inhibitory ability of the elderly.
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33 **Trial registration number** This study has been registered prospectively in the
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35 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021)
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4 **Title:** Comparison of open- and closed-chain exercises in improving the response
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12 **Type of Manuscript:** Clinical Study Protocol
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14 **Authors:** Ke Liu^{1†}, Lan-Lan Zhang^{2†}, Jian Zhang³, Jia-Ning Wei^{3*}
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19 **Affiliation:**
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22 ¹ Shanghai Punan Hospital of Pudong New District, Shanghai, China
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26 Guangzhou, China
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30 ³ School of Psychology, Shanghai University of Sport, Shanghai, China
31

32 [†] These authors contributed equally to this work.
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37 **Figures and tables:** 3 figures and 3 tables
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40 **Number of Words:** Abstract: 264 words; Manuscript: 4,177 words; 27 pages
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45 *** Corresponding author:**
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Abbreviations

SST, Stop signal task

SSRT, stop signal response time

SSD, stop signal delay

MoCA, Montreal Cognitive Assessment

BDI-II, Beck Depression Inventory (2nd edition);

MMSE, Mini Mental State Examination

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4 Comparison of open- and closed-chain exercises in improving the
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6 response inhibitory ability of the elderly: a protocol for a
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8 randomized controlled clinical trial
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14 **Abstract**

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19 response inhibition ability, which interferes with daily life. Previous studies have
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21 shown that exercise intervention can improve the cognitive ability of the elderly, but
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23 research on open- and closed-chain exercises to improve the response inhibition in
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25 this age group is still limited. This study will explore the advantages of long-term
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29 (closed-chain exercise) on the response inhibitory ability of the elderly.
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58 **Ethics and dissemination** This study was approved by the Shanghai University of
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4 Sport Research Ethics Committee (102772019RT012) and will provide reference for
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6 the advantages of table tennis compared with other types of sports in improving the
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17 **Trial registration number** This study has been registered prospectively in the
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19 Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).
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22 **Strengths and limitations of this study**

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25 1. Because it is a sports intervention, the safety of the elderly during exercise is worth
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27 worrying about.
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30 2. How to select and control participants in a longitudinal study is one of the
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32 difficulties of this project.
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35 3. The patients will come from one geographic area which limits the generalisability.
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40 **Introduction**

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42 Response inhibition ability is a type of cognitive control ability that can achieve
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44 behavioral goals by adjusting perception and motor function in the changing
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46 environment as well as be used to solve conflicts.^[1] As people age, they are likely to
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48 experience a decline in their response inhibition ability,^[2-5] which can interfere with
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50 daily life and even the ability to live independently. Although some studies have
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52 shown that exercise intervention can improve the cognitive ability of the elderly,^[6]
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54 there are few studies on the effect of exercise intervention on reactive inhibition
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4 ability. In particular, research on the different types of exercise to improve the
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6 response inhibition ability of the elderly is still limited.
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9 Sports can be divided into closed kinetic chain activities and open kinetic
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11 chain activities.^[7] It is different from Open kinetic chain exercise (OKCE) and closed
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13 kinetic chain exercise (CKCE) in exercise prescription.^[8] The open and closed
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15 mentioned here refer to the movement environment and movement methods, not the
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17 fixed point of the extremity during movements. The operating environment of
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19 closed-chain exercises, such as fit aerobics, fitness running, etc., is stable; and the
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21 operating state is determined by the operator. In contrast, the operating environment
22
23 of open-chain exercises, including those involved in the sports of table tennis,
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25 basketball, etc., is unstable; and the operation state is determined by external
26
27 conditions, such as a ball and opponents. In open-chain exercises, the participant must
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29 continuously adjust their behavior to unpredictable stimuli and must invest more
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31 cognitive resources in the decision-making process. Previous studies have shown that
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33 open-chain exercises require more regulating capacity than closed-chain exercises.^[9]
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35 First, a study comparing the cognitive control of sports involving open-chain
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37 exercises with that of closed-chain exercises has revealed that athletes engaging in
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39 open-chain exercises have an advantage in cognitive control. It has been demonstrated
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41 that intervention with long-term open-chain exercise can improve cognitive function
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43 better than closed-chain exercise,^[10] but whether it can improve response inhibitory
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45 ability better is not clear.
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58 As one of the classical paradigms to test response inhibition, the stop signal
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4 task (SST) tests the complete suppression of an ongoing action. The SST instructs the
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6 participant to perform a response when the go signal appears, but after a few go
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8 signals appear, a stop signal will appear at a specific time interval, and the individual
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10 will be asked to stop the response as far as possible.^[11] The strengths of this test are
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12 that a stop signal to evoke controlling behavior is administered after a go signal is
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14 used, and the interval between these two signals dynamically changes regularly.^[12] In
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16 addition, the SST is capable of quantizing inhibitory control behavior. However, no
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18 response occurs when the participant holds up successfully. The stop signal response
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20 time (SSRT) is a more sensitive indicator to evaluate the response inhibitory
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22 ability.^[13] In short, to calculate the SSRT, all go-reactions (i.e., go-trials in which the
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24 response was missed) are rank-ordered and assigned the maximum response time in
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26 order to compensate for the lacking response. Afterwards, the most recent stop signal
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28 delay (SSD) is subtracted from the response time corresponding to the stop-signal
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30 response percentile. The resulting value is termed the SSRT.^[14,15] These results can be
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32 used as an important index to evaluate the response inhibitory ability.
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43 The proposed randomized clinical trial will examine the effects of table tennis
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45 (open-chain exercise) and fit aerobics (closed-chain exercise) on the primary outcome
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47 (behavioral task) of response inhibitory ability as well as on the secondary outcomes
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49 of cognitive ability, mental status, and depression in the elderly. We hypothesized that
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51 different types of exercise intervention can affect the response inhibitory ability to
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53 varying degrees and that the effect of open-chain exercises is better.
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Methods

Study design

This study protocol of a study is designed as a prospective, single-blind randomized controlled trial. Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention will be 6 months. The cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. Participants who meet the criteria will undergo baseline assessments. All evaluations will be done at baseline and immediately after the exercise intervention (See Figure 1). We will recruit healthy right-handed elderly participants with normal or corrected-to-normal vision and without a history of neurological diseases in the same way. The study is scheduled to begin in August 2021 and continue until August 2023.

Figure 1 Flow diagram of the study design

Participants

Any participants with heart disease, neurological disorder, musculoskeletal disorders, and other conditions not suitable for physical activity, contraindications to fMRI or TMS will be excluded. In addition, those with a regular exercise routine will be excluded. All participants will be between the ages of 60 and 70 years old and right-handed as assessed by the Edinburgh Handedness Inventory. Moreover, they must have their own residence.

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4 Before and after the intervention, all groups will have their demographics
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6 statistically analyzed for factors such as health status, physical fitness, and cognitive
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8 function (Table 1). Intergroup differences will be minimized before the intervention.
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14 Table 1 Demographic and clinical characteristics of the study participants
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	Open group	Closed group	Control
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48 MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental
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50 State Examination; Behavioral tests for cognitive ability: Stroop task testing, n-back task testing, task-switch task
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52 testing; RT, response time; ACC, accuracy.
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58 Sample size

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4 From our previous studies on the modulation of SST performance,^[16,17] we expected
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6 an effect of $r = 0.4$. Together with an α -value of 0.05 and a power of $1 - \beta = 0.9$, a
7
8 sample of at least 72 participants (24/group) was planned to find a similar effect.
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10 Calculations were carried out using G*Power, version 3.1,^[18] with anticipation of a
11
12 20% attrition rate. Therefore, we plan to recruit 90 subjects (30/group).
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18 **Randomisation**

19
20 Eligible participants will be randomized into table tennis, fit aerobics, or control
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22 groups at a 1:1:1 ratio after consenting and baseline assessment. We will use The
23
24 Excel software to code the subjects in 1-90 according to the recruitment time, and
25
26 then use the formula '=RAND()' to generate the corresponding random sequence. By
27
28 sorting the random sequence and then grouping it, 90 subjects will be randomly
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30 grouped. The above tasks will be completed by professional computer workers after
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32 the participants are recruited. They are double-blind with recruitment and grouping.
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41 **Exercise intervention**

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43
44 The exercise intervention will last for 6 months. The participants will be divided into
45
46 three groups: table tennis, fit aerobics, and control. The table tennis (open-chain) and
47
48 fit aerobics (closed-chain) groups will train for 60 min, three times a week. The
49
50 exercise intensity will be monitored, ensuring that the heart rate remains in the range
51
52 of 60–70% of the maximum heart rate ($HR_{MAX} = 220 - \text{age}$). During the training
53
54 period, the exercise intensity will be monitored by the experimenter through real-time
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heart rate monitoring and the subject's subjective reaction. The exercise load and heart rate responses of the subjects will be recorded at each training session and adjusted accordingly with an increase of aerobic capacity. All the participants are not used to regular exercise before participating in the experiment. The control group just needs to maintain their old habits, and we will visit the control group regularly to evaluate their physical activity, so as to ensure that their physical activity does not meet the exercise standards. The entire intervention process will be monitored in real time by health care professionals. We will have coaches to monitor and record their attendance, and if they are absent, they will supplement the training at other times. Specific intervention methods are shown in Table 2.

Table 2 Exercise intervention TIDieR

Item NO	Brief name	Group		
		Table tennis group	Fit aerobics group	Control group
1	Why	Table tennis	Fit aerobics	Control
2	What	Participants will be led by professional table tennis coaches for 6 months of table tennis exercise.	Participants will be led by professional fit aerobics coaches for 6 months of fit aerobics exercise.	Keep the original living habits, do not have regular exercise, regularly attend health lectures and accept telephone follow-up. Participants will attend biweekly health talks and will be interviewed by phone once a month.
3	What (materials)	Participants will do 60 minutes of exercise three times a week. Specific exercises will be described later.		
4	What (procedures)	Each participant received a test report before and at 3, 6, and 12 months after the start of the exercise so that they could understand their physical and psychological changes.		

1				
2				
3				
4				The health lecture was
5		Table tennis coaches is the		completed by ph. D.
6		second level table tennis	Fit aerobics coaches is the second	students majoring in
7		athlete in China from	level fit aerobics athlete in China	physical Education
8		Shanghai University of	from Shanghai University of	and training in
9		Sport. The psychology-related	Sport. The psychology-related	Shanghai University
10	5	tests were completed by ph. D.	tests were completed by ph. D.	of Sport, and the
11	Who	students majoring in	students majoring in psychology	telephone return visit
12	provided	psychology at Shanghai	at Shanghai University of Sport.	was completed by ph.
13		University of Sport.		D. students majoring
14				in psychology.
15				Health lectures will be
16				conducted face to face
17				in a group format, and
18				telephone return visits
19				will be conducted one
20				by one.
21	6	The exercise intervention will take place in a stationary gym, where		
22	How	the instructor will direct the whole group face to face.		
23				
24				
25				
26		Table tennis training is held in	Fit aerobic training is conducted	The health lecture will
27		China Table Tennis College of	in the School of Physical	be held in the
28		Shanghai Sport	Education and Training of	conference room of
29	7	University. There is a	Shanghai Sport University. There	school of Psychology,
30	Where	professional table tennis	is a professional aerobics training	Shanghai University
31		training ground.	ground.	of Sport.
32				
33				
34		The table tennis (open-chain) and fit aerobics (closed-chain) groups		
35		will train for 60 min, three times a week. The exercise intensity will		
36		be monitored, ensuring that the heart rate remains in the range of		
37		60–70% of the maximum heart rate (HRMAX = 220 – age).		
38				
39				
40		Each session will consist of a	The participants in the	
41		warm-up for 10 min, table	closed-chain exercise group will	
42		tennis practice under the	attend a supervised fit aerobics	
43		guidance of a coach for 40	class of the same frequency,	Fortnightly health
44		min, and relaxation for 10	duration, and length as the	lectures of 30-50
45	8	min. The degree of difficulty	open-chain exercise group. Fit	minutes will be held.
46	When	of training throughout the	aerobics at 50–60% of the	
47	and how	program will be gradually	maximum heart rate for the first	A 10-minute return
48	much	increased. Table tennis at 50–	two weeks, followed by 60–70%	call once a month.
49		60% of the maximum heart	of the maximum heart rate. Each	
50		rate for the first two weeks,	fit aerobics class will consist of	
51		followed by 60–70% of the	warm-up activities for 10 min,	
52		maximum heart rate. The	basic aerobics activities for 40	
53		training will consist of the	min., and relaxation and	
54		following seven main parts:	stretching for 10 min. The fit	
55		(1) footwork; (2) the serve; (3)	aerobics training will involve the	
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forehand backhand attack; (4) following: 1) jogging, rope
 forehand backhand loop; (5) skipping, and/or gymnastics to
 kill shot; (6) continuous hitting warm up and achieve a slightly
 of directional or sweating body, and the heart rate
 nondirectional balls randomly will be slightly faster; 2)
 sent by the server; and (7) stepping, side parallel step, side
 comprehensive practice. All cross step, jumping jacks,
 the technical movements will lunging, kicking, and so on.
 be from simple to complex. Following the rhythm of the
 music, each action will be
 reduced from four sets to two sets
 and then to one set; 3) relax the
 shoulder, elbow, hip, and knee
 joints by doing a few stretches to
 help relax the muscles.

Exercise interventions were performed at 50-60% of maximum
 heart rate for the first two weeks, followed by 60-70% of maximum
 9 Tailoring: heart rate. In order to ensure the safety of participants, the exercise
 intensity will be gradually increased, and the first two weeks will be
 mainly acclimatization.

How Feedback will be given to each participant on a regular basis, including their physical and
 10 well psychological data, as well as their motor skills learning performance. Keep them up to date
 (planned) on their progress and status to keep them engaged.

SST protocol

The SST was programmed using E-prime 2, in which the subjects will be asked to
 press a "←" button or a "→" button according to the left and right arrow directions. In
 25% of the trials, the arrow will turn red and a gray triangle will appear; the
 participants will press the button to stop or give no response. The interval of
 stimulation will be dynamically adjusted according to the tracking procedure. The
 task will be divided into four groups of 120 trials each. The task flow is shown in
 Figure 2. The execution go signal reaction time (GoRT), stop response reaction time

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3
4 (SRRT), SSD, and SSRT will be investigated. GoRT is how long it takes for the
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6 participant to respond after the GO (black arrow) appears. SRRT is the time to respond
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8 to the stop signal (arrow turning red) task. SSD is the time between the task stimulus
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10 and the stop signal.
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FOR
Figure 2 Stop signal task flow chart

23 The instructions for the experiment will be follows: Welcome to the
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25 experiment. First, "+" will appear in the center of the screen to alert the user to begin
26
27 the keystroke reaction, and the right index finger should be placed on the "↓" to
28
29 prepare for the experiment. When the black arrow appears in the center of the screen,
30
31 use your right index finger to press the button. When the left arrow appears, use your
32
33 index finger to press the "←" key on the keyboard. When the right arrow appears, use
34
35 your index finger to press the "→" key on the keyboard. After each key response, the
36
37 right index finger should quickly return to the "↓" key to wait for the next response.
38
39 When the black arrow in the center of the screen turns red and a small gray triangle
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41 appears, please stop the keystroke reaction immediately. When the red arrow appears
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43 in the center of the screen, please do not perform any keystroke reaction. Let's move
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45 on to practice.
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58 **Outcomes**

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Primary outcome

Behavioral task

The task will include randomly interspersed no-go and stop-signal trials, which will enable us to examine both types of inhibition. A total of 480 trials will be performed, including 75% go trials and 25% stop trials. On go trials, the subjects will respond to a left/right black arrow (1000 ms) by pressing the buttons with their right hand. Responses will be made with the index finger (for the left or right arrow). In the stop-signal trials, a response will be initially cued by a left/right black arrow, but the arrow color will change to red concurrent with a gray triangle after a SSD, and the subjects will be asked not to respond. The SSD will be varied from trial to trial by using a step-up/down algorithm with an initial estimate of 250 ms to maintain 50% successful inhibition. The task flow chart is shown in Figure 3.

Figure 3 Stop behavioral task

The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials will be performed (75% go, 25% stop).

Secondary outcomes

Secondary outcome measures will include the following: (1) Montreal Cognitive Assessment (MoCA); (2) BDI-II; (3) MMSE; (4) Stroop task testing; (5) n-back task testing; and (6) task-switch task testing (Table 3). The process of inhibitory control is the process of inhibition, refresh, and switching of the response task through cognitive

function, so we will test the abilities of inhibition, refresh, and switching in the cognitive process of the elderly with different exercise types before and after the intervention by the Stroop task, the n-back task, and the task-switch task to compare their response inhibitory ability. The details of each outcome and instrument will be compiled as in Table 3.

Table 3 The differences among the three groups of subjects at various stages

Group	Baseline	6 months	12 months	18 months	24 months	F (P value)	F (P value)	F (P value)
						Time effect	Group effect	Interaction effect
MoCA	Open							
	Closed							
	Control							
BDI-II	Open							
	Closed							
	Control							
MMSE	Open							
	Closed							
	Control							
Stroop (RT)	Open							
	Closed							

	Control
	Open
n-back	Closed
(ACC)	Control
Task-	Open
switch	Closed
(ACC)	Control

MoCA, Montreal Cognitive Assessment; BDI-II, Beck Depression Inventory (2nd edition); MMSE, Mini Mental

State Examination; RT, response time; ACC, accuracy.

MoCA

The MoCA is an assessment tool for the rapid screening of cognitive dysfunction. It includes 11 items in 8 cognitive domains: attention and concentration, executive function, memory, language, abstract thinking, and computation.^[19] The highest possible total score is 30, and a score of 26 or more is normal. It has a high sensitivity and a short test time, so it is suitable for clinical application.

BDI-II

The BDI-II contains 21 topics, which are suitable for people older than 13 years old.

The areas of focus include symptoms of depression, such as despair, sensitivity, ways of understanding things, and physical characteristics, such as fatigue, weight loss, and decreased sexual ability.^[20]

MMSE

The MMSE scale includes the following seven aspects: time orientation, place orientation, immediate memory, attention and calculation, delayed memory, language, and visual space.^[21] There are a total of 30 questions asked in the exam, with 1 point awarded for each correct answer, and 0 points given for each wrong answer or unanswered question. The total score range of the scale is 0–30 points. The test scores are closely related to the educational level of the subject. The normal cut-off values are as follows: illiterate subjects, >17; primary school education only, >20; junior high school education and above, >24.

Stroop task

After a period of exercise intervention, comparison of the Stroop task response time between the open-chain, closed-chain, and control groups will be used to explore which types of exercise can improve cognitive inhibition ability^[22].

N-back task

By comparing the n-back task accuracy of the elderly in the three groups, the improvement of the cognitive refresh ability of each group will be compared under different cognitive loads.^[23]

Task-switch task

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4 By comparing the task-switch accuracy of the three groups under different stimulus
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6 conditions, we will determine which type of exercise can improve the cognitive
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8 transformation ability most significantly.^[24]
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11 12 13 14 **Patient and public involvement**

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17 Participants have not been involved in the study recruitment. The authors conceived
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19 the initial research questions and outcome measures, and modified according to the
20
21 telephone interviews with patients and their guardians by a research assistant. In order
22
23 to assure the safety and feasibility of the intervention, we invited six elderly peoples
24
25 to learn and practise the table tennis and fit aerobics exercise before designing the
26
27 RCT. Table tennis and fit aerobics exercise were revised based on the exercise
28
29 performance and feedback provided by the participants. The burden of the
30
31 intervention will be assessed by patients and their advisors through face-to-face
32
33 interviews before signing informed consent. The findings of the study will be
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35 disseminated to the participants and their guardians.
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46 **Statistical analysis**

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48 The outcome assessor will be completed by the designated medical institution
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50 (Shanghai Punan Hospital of Pudong New District, Shanghai, China), when the
51
52 participants go for the assessment, there will be no labels, so the outcome assessors
53
54 will be blind the group allocation. In order to ensure no inter-group differences in all
55
56 test indicators after random grouping, Independent-sample T test will be performed on
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4 each pretest data after random grouping. Repeated-measures analysis of variance will
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6 be used to determine the effects of different types of exercise (open, closed, or
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8 control) on the primary outcomes (GoRT, SRRT, SSD, and SSRT) as well as on the
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10 secondary outcomes (MOCA score, BDI-II score, MMSE score, Stroop response
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12 time, n-back accuracy, task-switch accuracy), with group and time serving as factors.
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17 Data will be analyzed by PhD students who are blind to group allocation.
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22 **Discussion**

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24 Studies have found that elderly people who participate in ball and racket projects have
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26 higher health and physical awareness.^[25] Pilates exercises decreased depression and
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28 improved the balance related to falling in elderly,^[26] and also experienced significant
29
30 improvement in physical, social spiritual, and emotional wellness.^[27] Korean scholars
31
32 found the cognitive/exercise dual-task program was an effective intervention for
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34 improving cognitive function, health status, and life satisfaction, and for decreasing
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36 depression of the elderly living in the community.^[28]
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43 Then some researchers found that athletes participating in open-chain exercises
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45 have a faster switching speed, fewer cognitive resources, and a higher efficiency in
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47 the inhibition process.^[29] At the same time, another study has demonstrated that
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49 athletes who engage in open-chain exercises have a stronger reaction switching
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51 capability.^[30] Based on previous research, participating in sports involving open-chain
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53 exercises can improve the ability of inhibition, refresh, and conversion in the
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55 inhibitory control process. In the Stoop task, when two different dimensions of a
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4 stimulus interfere with each other, it is necessary for participants to inhibit the
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6 interfering stimulus, it looked at the participants' ability to suppress interference. In
7
8 the n-back task, participants' attention capacity and memory capacity could be
9
10 examined during the process of stimulus updating. In task-switch task, participants
11
12 need to keep their attention focused when switching between different tasks, so it can
13
14 investigate the transformation ability of participants in the cognitive process.
15
16 Therefore, in this study, the Stroop task, n-back task, and task-switch task were
17
18 selected as secondary outcomes to investigate the inhibition, refresh, and
19
20 transformation abilities, respectively, of the participants. Determining the effect of
21
22 long-term intervention of different types of sports on the response inhibitory ability of
23
24 the elderly will improve our understanding of inhibitory control degradation and
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26 support the development of diversified training programs.
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35 This study will use the SST to explore how different types of exercise
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37 experience affect the response inhibition ability in the elderly. Because of the
38
39 interactions of the cognitive level, depressive state, and mental state with the response
40
41 inhibitory ability, we will perform multiple MoCA, BDI-II, MMSE measurements
42
43 before and after each intervention. We will also explore whether sports involving
44
45 open-chain exercises can improve the cognitive level, depression state, and mental
46
47 state of the elderly while improving their inhibition and control ability. Through
48
49 multi-dimensional measurements of the participants, we hope to provide a more
50
51 sufficient theoretical basis for the mechanism of improving the inhibition and control
52
53 ability of the elderly through exercise.
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4 This study will have several limitations. In this research, the screening
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6 principles of the subjects will be determined in the longitudinal study, and the
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8 inclusion criteria and exclusion criteria will be strictly defined, especially the
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10 experimental groups and the control group in terms of age, physical level, intervention
11
12 time, and intensity. In addition, because the exercise that will serve as an intervention
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14 will be widely known to the participants, the single-blind design may expose the study
15
16 to risks of bias stemming from performance and evaluation, which may potentially
17
18 lead to overestimation of the effects of exercise.
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27 **Ethics and dissemination**

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29 All participants who meet the inclusion and exclusion criteria will be required to sign
30
31 an informed consent form prior to enrolling in the study. This study was approved by
32
33 the Shanghai University of Sport Research Ethics Committee (102772019RT012).
34
35 Study findings will be disseminated via publications in peer-reviewed journals and
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37 presentations at international conferences.
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49
50 Science Foundation of China (3197070657) .
51
52
53
54

55 **Contributorship statement**

56
57 Ke Liu: Conceptualization, Methodology, SoftwarePriya. Lanlan Zhang:Writing-
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4 Reviewing and Editing. Jian Zhang: Visualization, Investigation. Jia-Ning Wei: Data
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6 curation, Writing- Original draft preparation.
7
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10 11 12 **References**

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- 13
14
15 [1] Logan Gordon D, et al."On the ability to inhibit thought and action: general and special theories of an act of
16 control.." *Psychological review* 121.1(2014): doi:10.1037/a0035230
- 17 [2] Darowski Emily S, et al."Age-related differences in cognition: the role of distraction control.." *Neuropsychology* 22.5(2008):. doi:10.1037/0894-4105.22.5.638.
- 18 [3] Chen T Y,et al."Cognitive Aging and Executive Decline Hypothesis." *Advances in Psychological*
19 *Science* .05(2004):729-736. doi:CNKI:SUN:XLXD.0.2004-05-011.
- 20 [4] Fergus I.M. Craik, ,and Ellen Bialystok."Cognition through the lifespan: mechanisms of change." *Trends in*
21 *Cognitive Sciences* 10.3(2006):. doi:10.1016/j.tics.2006.01.007.
- 22 [5]Timothy A. Salthouse."Aging and measures of processing speed." *Biological Psychology* 54.1(2000):.
23 doi:10.1016/S0301-0511(00)00052-1.
- 24 [6] Zhang, N. N. , et al. "Effect of long-term Tai Chi exercise on cognitive function of middle-aged and old
25 people." *Chinese Journal of Clinical Rehabilitation* 26(2006):7-9. doi:CNKI:SUN:XDKF.0.2006-26-004..
- 26 [7] Voss Michelle W., et al."Plasticity of Brain Networks in a Randomized Intervention Trial of Exercise Training
27 in Older Adults." *Frontiers in Aging Neuroscience* .(2010):. doi:10.3389/FNAGI.2010.00032.
- 28 [8] Soul Cheon, et al."Acute Effects of Open Kinetic Chain Exercise Versus Those of Closed Kinetic Chain
29 Exercise on Quadriceps Muscle Thickness in Healthy Adults." *International Journal of Environmental Research*
30 *and Public Health* 17.13(2020): doi:10.3390/ijerph17134669.
- 31 [9] Michelle W. Voss, et al."Are expert athletes ‘expert’ in the cognitive laboratory? A meta - analytic review
32 of cognition and sport expertise." *Applied Cognitive Psychology* 24.6(2010):. doi:10.1002/acp.1588.
- 33 [10] Chun-Hao Wang, et al."Open vs. Closed Skill Sports and the Modulation of Inhibitory Control." *PLOS ONE*
34 8.2(2013):. doi:10.1371/journal.pone.0055773.
- 35 [11] Logan G D, et al."On the ability to inhibit simple and choice reaction time responses: a model and a method.." *Journal*
36 *of experimental psychology. Human perception and performance* 10.2(1984):.
37 doi:10.1037/0096-1523.10.2.276.
- 38 [12] Janette L. Smith, et al."Motor and non-motor inhibition in the Go/NoGo task: An ERP and fMRI study." *International Journal of Psychophysiology* 87.3(2013):. doi:10.1016/j.ijpsycho.2012.07.185.
- 39 [13] Frederick Verbruggen, ,and Gordon D. Logan."Response inhibition in the stop-signal paradigm." *Trends in*
40 *Cognitive Sciences* 12.11(2008):. doi:10.1016/j.tics.2008.07.005.
- 41 [14] Verbruggen Frederick, Chambers Christopher D.,and Logan Gordon D.."Fictitious Inhibitory Differences:
42 How Skewness and Slowing Distort the Estimation of Stopping Latencies." *Psychological Science* 24.3(2013):.
43 doi10.1177/0956797612457390:.
- 44 [15] Frederick Verbruggen, et al."A consensus guide to capturing the ability to inhibit actions and impulsive
45 behaviors in the stop-signal task." *eLife* 8.(2019):. doi:10.7554/eLife.46323.
- 46 [16] Friehs Maximilian A.,and Frings Christian."Pimping inhibition: Anodal tDCS enhances stop-signal reaction
47 time.." *Journal of Experimental Psychology: Human Perception and Performance* 44.12(2018):.
48 doi:10.1037/XHP0000579.
- 49 [17]Maximilian A. Friehs, ,and Christian Frings."Cathodal tDCS increases stop-signal reaction time." *Cognitive,*
50 *Affective, & Behavioral Neuroscience* 19.5(2019):. doi:10.3758/s13415-019-00740-0.
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5 [18] Faul, F., Erdfelder, E., Lang, A.-G., Buchner, A., 2007. G*Power 3.1 manual. *Behav. Res. Methods* 39 (2),
6 175–191.
- 7 [19] Gao, F. The application of moca test and DTI in mild cognitive impairment. Diss. 2008. *PLA Military Medical*
8 *Training College*, MA thesis.
- 9 [20] F. Holländare, G. Andersson, and I Engström. "A Comparison of Psychometric Properties Between Internet
10 and Paper Versions of Two Depression Instruments (BDI-II and MADRS-S) Administered to Clinic Patients."
11 *Journal of Medical Internet Research* 12.5(2010):76-79.
- 12 [21] SMD Azmeh, et al. *Mini-Mental State Examination (MMSE)*. Springer New York, 2011.
- 13 [22] Chen, Ji, et al. "The Latest advances of the Stroop Effect-its theory, paradigms, affecting factors." *Journal of*
14 *Psychological Science*. 02(2007):415-418+390. doi:10.16719/j.cnki.1671-6981.2007.02.042.
- 15 [23] Song, HK. "The evolution and application of N-back paradigm." *Journal of Southwest University (Social*
16 *Sciences Edition)* 37.S1(2011):81-82. doi:10.13718/j.cnki.xdsk.2011.s1.065.
- 17 [24] Shi, Y., and X. Zhou. "Task Switching, A Paradigm in the Study of Executive Control." *Advances in*
18 *Psychological Science*. 05(2004):672-679. doi:CNKI:SUN:XLXD.0.2004-05-004.
- 19 [25] Ahn, C., & Lee, W. (2021). The Difference between exercise effect, health and fitness perception according to
20 the degree of exercise participation of the elderly. *Journal of adapted physical activity and exercise*, 29(2),
21 245-254.
- 22 [26] Mahyar Mokhtari, et al. "The Effect of 12-Week Pilates Exercises on Depression and Balance Associated with
23 Falling in the Elderly." *Procedia - Social and Behavioral Sciences* 70.(2013): doi:10.1016/j.sbspro.2013.01.246.
- 24 [27] Roh Su Yeon. "The effect of 12-week Pilates exercises on wellness in the elderly.." *Journal of exercise*
25 *rehabilitation* 12.2(2016): doi:10.12965/jer.1632590.295.
- 26 [28] Mahyar Mokhtari, et al. "The Effect of 12-Week Pilates Exercises on Depression and Balance Associated
27 with Falling in the Elderly." *Procedia - Social and Behavioral Sciences* 70.(2013):
28 doi:10.1016/j.sbspro.2013.01.246.
- 29 [29] Di Russo Francesco, et al. "Benefits of sports participation for executive function in disabled athletes.." *Journal*
30 *of neurotrauma* 27.12(2010):. doi:10.1089/neu.2010.1501.
- 31 [30] Bjoern Krenn, et al. "Sport type determines differences in executive functions in elite athletes." *Psychology of*
32 *Sport & Exercise* 38.(2018):. doi:10.1016/j.psychsport.2018.06.002.
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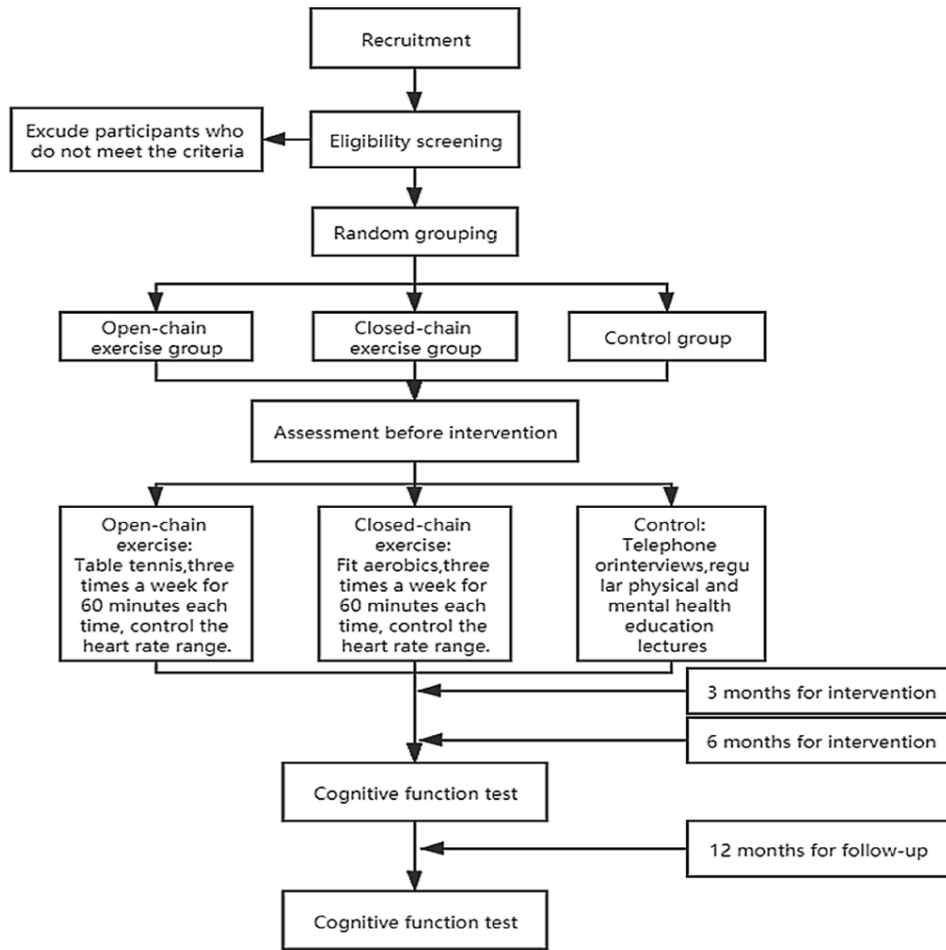


Figure 1 Flow diagram of the study design

90x90mm (300 x 300 DPI)

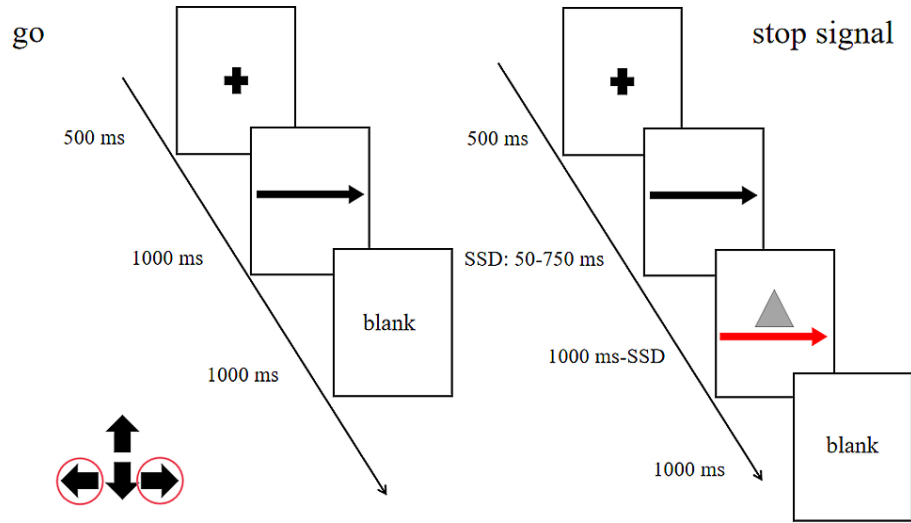


Figure 2. Stop signal task flow chart

90x90mm (300 x 300 DPI)

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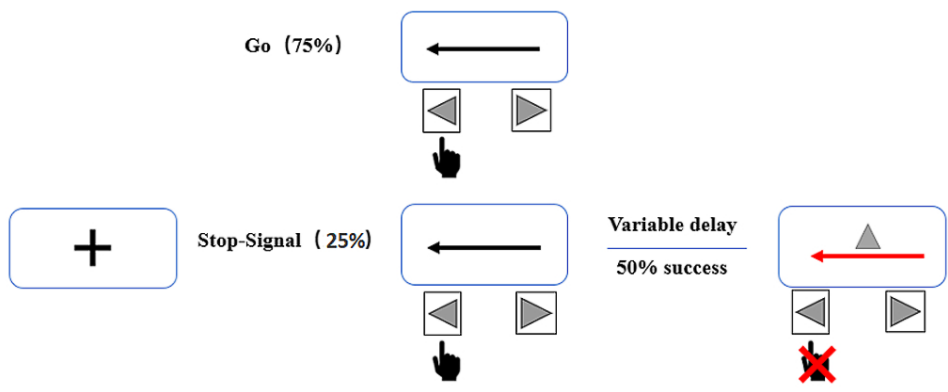


Figure 3. Stop behavioral task

The task will consist of randomly interspersed no-go and stop-signal trials. A total of 480 trials will be performed (75% go, 25% stop).

90x90mm (300 x 300 DPI)



SPIRIT 2013 Checklist: Recommended items to address in a clinical trial protocol and related documents*

Section/item	Item No	Description
Administrative information		
Title	1	Comparison of open- and closed-chain exercises in improving the response inhibitory ability of the elderly: a protocol for a randomized controlled clinical trial (page 8,line 4)
Trial registration	2a	This study has been registered prospectively in the Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021). (page 9,line 17)
	2b	
Protocol version	3	The study is scheduled to begin in August 2021 and continue until August 2023. (page 12,line 40)
Funding	4	This study was supported by grants from the National Natural Science Foundation of China (3197070657) . (page 26,line 22)
Roles and responsibilities	5a	Ke Liu; Shanghai Punan Hospital of Pudong New District, Shanghai, China; Conceptualization, Methodology, SoftwarePriya. (page 26,line 30)
	5b	
	5c	
	5d	Lan-Lan Zhang: Writing- Reviewing and Editing. Jian Zhang: Visualization, Investigation. Jia-Ning Wei: Data curation, Writing- Original draft preparation. (page 26,line 30)
Introduction		
Background and rationale	6a	As people age, they are more likely to experience a decline in their response inhibition ability, which interferes with daily life. Previous studies have shown that exercise intervention can improve the cognitive ability of the elderly, but research on open- and closed-chain exercises to improve the response inhibition in this age group is still limited. This study will explore the advantages of long-term intervention of table tennis (open-chain exercise) compared with fit aerobics (closed-chain exercise) on the response inhibitory ability of the elderly. (page 8,line 17)

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- 6b The elderly who choose not to exercise as the control group can compare the effects of exercise intervention with the intervention group. (page 15,line 21)
- Objectives 7 We hypothesized that different types of exercise intervention can affect the response inhibitory ability to varying degrees and that the effect of open-chain exercises is better. (page 11,line 58)
- Trial design 8 This study protocol of a pilot study is designed as a prospective, single-blind randomized controlled trial. Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention will be 6 months. The cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. Participants who meet the criteria will undergo baseline assessments. All evaluations will be done at baseline and immediately after the exercise intervention. (page 12,line 17)

Methods: Participants, interventions, and outcomes

- Study setting 9 School of Psychology, Shanghai University of Sport, Shanghai, China (page 15,line 21)
- Eligibility criteria 10 Any participants with heart disease, neurological disorder, musculoskeletal disorders, and other conditions not suitable for physical activity, contraindications to fMRI or TMS will be excluded. In addition, those with a regular exercise routine will be excluded. All participants will be between the ages of 60 and 70 years old and right-handed as assessed by the Edinburgh Handedness Inventory. Moreover, they must have their own residence. (page 12,line 53)
- Interventions 11a Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11b Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11c Table 2 Exercise intervention TIDieR (page 15,line 20)
- 11d Table 2 Exercise intervention TIDieR (page 15,line 20)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	Outcomes	12	Primary outcome : Behavioral task (RT,ACC) Secondary outcome measures will include the following: (1) Montreal Cognitive Assessment (MoCA); (2) BDI-II; (3) MMSE; (4) Stroop task testing; (5) n-back task testing; and (6) task-switch task testing (Table 3). The process of inhibitory control is the process of inhibition, refresh, and switching of the response task through cognitive function, so we will test the abilities of inhibition, refresh, and switching in the cognitive process of the elderly with different exercise types before and after the intervention by the Stroop task, the n-back task, and the task-switch task to compare their response inhibitory ability. The details of each outcome and instrument will be compiled as in Table 3. (page 19,line 45)
17 18 19 20 21 22 23 24 25 26 27 28 29	Participant timeline	13	This study protocol of a pilot study is designed as a prospective, single-blind randomized controlled trial. Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio. The duration of exercise intervention will be 6 months. The cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. Participants who meet the criteria will undergo baseline assessments. All evaluations will be done at baseline and immediately after the exercise intervention (See Figure 1). (page 12,line 17)
30 31 32 33 34 35 36 37 38 39	Sample size	14	From our previous studies on the modulation of SST performance,we expected an effect of $r = 0.4$. Together with an α -value of 0.05 and a power of $1 - \beta = 0.9$, a sample of at least 72 participants (24/group) was planned to find a similar effect. Calculations were carried out using G*Power, version 3.1, with anticipation of a 20% attrition rate. Therefore, we plan to recruit 90 subjects (30/group). (page 14,line 13)
40 41 42 43 44	Recruitment	15	All participants were recruited and counted through the School of Psychology, Shanghai Sport University, and intervened in Shanghai Sport University. (page 15,line 20)

Methods: Assignment of interventions (for controlled trials)

Allocation:

48 49 50 51 52 53 54 55 56 57 58 59 60	Sequence generation	16a	Eligible participants will be randomized into table tennis, fit aerobics, or control groups at a 1:1:1 ratio after consenting and baseline assessment.I will use The Excel software to code the subjects in 1-90 according to the recruitment time, and then use the formula '=RAND()' to generate the corresponding random sequence. By sorting the random sequence and then grouping it, 90 subjects will be randomly grouped. (page 14,line 29)
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2	Allocation	16b	Eligible participants will be randomized into table tennis, fit aerobics,
3	concealment		or control groups at a 1:1:1 ratio after consenting and baseline
4	mechanism		assessment. I will use The Excel software to code the subjects in 1-90
5			according to the recruitment time, and then use the formula '=RAND()'
6			to generate the corresponding random sequence. By sorting the
7			random sequence and then grouping it, 90 subjects will be randomly
8			grouped. (page 14, line 29)
9			
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11	Implementation	16c	Ke Liu will generate the allocation sequence, Jian Zhang will enrol
12			participants, and Jian Zhang will assign participants to interventions.
13			
14	Blinding	17a	The data is analyzed by specialized PhD students, they analyse the
15	(masking)		data be blind to group allocation. (page 23, line 48)
16			
17		17b	After the results are processed, the grouping can be announced.
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Methods: Data collection, management, and analysis

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21	Data collection	18a	In order to ensure no inter-group differences in all test indicators after
22	methods		random grouping, Independent-sample T test will be performed on
23			each pretest data after random grouping. Repeated-measures
24			analysis of variance will be used to determine the effects of different
25			types of exercise (open, closed, or control) on the primary outcomes
26			(GoRT, SRRT, SSD, and SSRT) as well as on the secondary
27			outcomes (MOCA score, BDI-II score, MMSE score, Stroop response
28			time, n-back accuracy, task-switch accuracy), with group and time
29			serving as factors. (page 23, line 32)
30			
31		18b	Feedback will be given to each participant on a regular basis,
32			including their physical and psychological data, as well as their motor
33			skills learning performance. Keep them up to date on their progress
34			and status to keep them engaged. (page 17, line 17)
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39	Data	19	The data is analyzed by specialized PhD students. (page 23, line
40	management		48)
41			
42	Statistical	20a	Repeated-measures analysis of variance will be used to determine the
43	methods		effects of different types of exercise (open, closed, or control) on the
44			primary outcomes (GoRT, SRRT, SSD, and SSRT) as well as on the
45			secondary outcomes (MOCA score, BDI-II score, MMSE score,
46			Stroop response time, n-back accuracy, task-switch accuracy), with
47			group and time serving as factors. (page 23, line 38)
48			
49		20b	No
50			
51		20c	The data is analyzed by specialized PhD students, they analyse the
52			data be blind to group allocation. (page 23, line 48)
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Methods: Monitoring

56			
57	Data monitoring	21a	The data is analyzed by specialized PhD students, they analyse the
58			data be blind to group allocation. (page 23, line 48)
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	21b	The initiator of the experiment, Professor Zhang will have access to these interim results and make the final decision to terminate the trial
Harms	22	In the Participants gave an informed consent form.
Auditing	23	In the Participants gave an informed consent form.

Ethics and dissemination

Research ethics approval	24	This study was approved by the Shanghai University of Sport Research Ethics Committee (102772019RT012). (page 8,line 59)
Protocol amendments	25	Upload as attachment.
Consent or assent	26a	PhD students in charge of data collection will collect data within the cognitive function test (questionnaire and behavioral task) will be conducted before the intervention as well as at 3 months, 6 months, and 12 months after the intervention. (page 12,line 24)
	26b	No
Confidentiality	27	Professor Zhang, who is in charge of recruitment, completes the participant information management.
Declaration of interests	28	The authors have no conflicts of interest to declare.
Access to data	29	The result will be made public by the person in charge of the National Natural Science Foundation of China (3197070657)
Ancillary and post-trial care	30	In the Participants gave an informed consent form.
Dissemination policy	31a	This study has been registered prospectively in the Chinese Clinical Trial Registry (ChiCTR2100043616, 23 February 2021).It will be published in accordance with the standards of the Chinese Clinical Trial Registry.
	31b	It will be written in accordance with the standards of the Chinese Clinical Trial Registry.
	31c	It can be viewed in the Chinese Clinical Trial Registry.

Appendices

Informed consent materials	32	Upload as attachment.
Biological specimens	33	No.

*It is strongly recommended that this checklist be read in conjunction with the SPIRIT 2013 Explanation & Elaboration for important clarification on the items. Amendments to the protocol should be tracked and dated. The SPIRIT checklist is copyrighted by the SPIRIT

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