The Effects of Chinese Archery Arts Program on Core Executive Functions in Elementary School Children in Shanghai China: A Quasi-experimental Study

Mr. Jianjun Liu

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ผลของโปรแกรมศิลปะการยิงธนูของจีนต่อกระบวนการทำงานทางความคิดของสมองส่วนหน้าในนักเรียนชั้นประถมศึกษาในเมืองเซี่ยงไฮ้ ประเทศจีน: การศึกษากึ่งทดลอง

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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาสาธารณสุขศาสตรดุษฎีบัณฑิต
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Thesis Title	The Effects of Chinese Archery Arts Program on Core Executive Functions in Elementary School Children in Shanghai China: A Quasi-experimental Study
By	Mr. Jianjun Liu
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Thesis Advisor	Professor SURASAK TANEEPANICHSKUL, M.D.

Accepted by the COLLEGE OF PUBLIC HEALTH SCIENCES, Chulalongkorn University in Partial Fulfillment of the Requirement for the Doctor of Philosophy

.... Dean of the COLLEGE OF PUBLIC HEALTH SCIENCES
(Professor CHITLADA AREESANTICHAI, Ph.D.)

DISSERTATION COMMITTEE

.... Chairman
(Professor RATANA SOMRONGTHONG, Ph.D.)

.... Thesis Advisor
(Professor SURASAK TANEEPANICHSKUL, M.D.)

.... Examiner
(Associate Professor NUTTA TANEEPANICHSKUL, Ph.D.)

.... Examiner
(Assistant Professor PRAMON VIWATTANAKULVANID, Ph.D.)

.... External Examiner
(Nipunporn Voramongkol, M.D,M.P.H)

เจียนจุน หลู :
ผลของโปรแกรมศิลปะการยิงธนูของจีนต่อกระบวนการทำงานทางความคิดของสมองส่วนหน้าในนักเรียนชั้นประถมศึกษาในเมืองเซี่ยงไฮ้ ประเทศจีน: การศึกษากึ่งทดลอง. (The Effects of Chinese Archery Arts Program on Core Executive Functions in Elementary School Children in Shanghai China: A Quasi-experimental Study) อ.ที่ปรึกษาหลัก : Pro.สุรศักดิ์ ฐานีพานิชสกุลM.D

วัตถุประสงค์ เพื่อศึกษาผลของโครงการศิลปะการยิงธนูแบบจีนในระยะเวลา 12 สัปดาห์ต่อกระบวนการทำงานทางความคิดของสมองส่วนหน้าของเด็กก่อนวัยรุ่นที่เซี่ยงไฮ้ ประเทศจีน

วิธีการศึกษา การศึกษานี้เป็นการวิจัยกึ่งทดลอง มีผู้เข้าร่วมที่มีคุณสมบัติครบจำนวน 68 คนโดยแบ่งเป็นกลุ่มทดลองฝึกศิลปะการยิงธนูแบบจีนเป็นเวลา 45 นาทีต่อคาบ จำนวน 4 คาบต่อสัปดาห์ จำนวน 34 คนและกลุ่มควบคุมที่ทำกิจกรรมนอกหลักสูตรตามปกติเป็นเวลา 45 นาทีต่อคาบ จำนวน 4 คาบต่อสัปดาห์ จำนวน 34 คน ระยะเวลาการศึกษาทั้งหมดรวมถึงการรักษา 12 สัปดาห์และการติดตามผล 6 สัปดาห์ การประเมินผลลัพธ์หลักของกระบวนการบริหารจัดการทางความคิดของสมองส่วนหน้า ประกอบด้วย การควบคุมการยับยั้ง ความจำในการทำงานและความยืดหยุ่นทางปัญญา ประเมินด้วยกระบวนทัศน์ทางจิตวิทยาของ Fish Flanker , N-Back และ Dimensional change card sort การประเมินผลลัพธ์รองประกอบด้วย การเคารพตนเอง คุณภาพการนอนหลับ ความวิตกกังวลและภาวะซึมเศร้า ประเมินด้วยวิธีของโรเซนเบิร์ก ดัชนีคุณภาพการนอนหลับของพิตต์สเบิร์ก (PSQI) การตรวจสอบพฤติกรรมเด็กของอาเชนบัค ประสิทธิภาพในการบริหารดำเนินการและคะแนนการเคารพตนเองได้รับการวิเคราะห์ข้อมูลโดยวิธี ANOVA, Bonferroni post-hoc analysis, paired T-test และ independent T-test. ทั้งสองกลุ่มได้รับการประเมินใน สัปดาห์ที่ 6 12 และ 18

ผลการศึกษา พบว่าระยะเวลาการตอบสนอง ในเรื่องการควบคุมการยับยั้ง ความจำในการทำงาน และความยืดหยุ่นทางปัญญา เมื่อเปรียบเทียบกับกลุ่มทดลอง มีระยะเวลาลดลงอย่างมีนัยสำคัญหลังจากฝึกศิลปะการยิงธนูแบบจีน 12 สัปดาห์ เมื่อเปรียบเทียบกับกลุ่มควบคุม และกลุ่มทดลองพบว่ามีการปฏิบัติที่เร็วขึ้นอย่างมีนัยสำคัญในเรื่องความจำในการทำงาน ความยืดหยุ่นทางปัญญา ที่เวลาสัปดาห์ที่ 6 12 และ18

ส่วนความแม่นยำ พบว่ามีการปฏิบัติดีขึ้นอย่างมีนัยสำคัญ ในด้านการควบคุมการยับยั้ง ความจำในการทำงาน และความยืดหยุ่นทางปัญญาภายในกลุ่มทดลองหลังจากเข้าโปรแกรมศิลปะการยิงธนูจีน 12 สัปดาห์ นอกจากนี้ พบว่าในช่วงเวลาสัปดาห์ที่ 6 12 และ 18 การปฏิบัติของกลุ่มทดลองในการควบคุมการยับยั้ง หน่วยความจำในการทำงาน และความยืดหยุ่นทางปัญญา สูงกว่ากลุ่มควบคุมอย่างมีนัยสำคัญ

นอกจากนี้พบว่าหลังจากเข้าโปรแกรมศิลปะการยิงธนูจีน 12 สัปดาห์คะแนนความเคารพตนเองของกลุ่มทดลองเพิ่มขึ้นอย่างมีนัยสำคัญในช่วงเวลาของสัปดาห์ที่ 6, 12 และ 18 คะแนนความเคารพตนเองของแต่ละกลุ่มเพิ่มขึ้นอย่างมีนัยสำคัญเช่นกัน หลังจากเข้าโปรแกรมศิลปะการยิงธนูจีน 12 สัปดาห์กลุ่มทดลองมีคะแนนคุณภาพการนอนหลับโดยรวม ดีขึ้น และความวิตกกังวลและภาวะซึมเศร้าลดลงอย่างมีนัยสำคัญทางสถิติ

บทสรุป จากการศึกษาสรุปได้ว่าโปรแกรมศิลปะการยิงธนูจีน 12 สัปดาห์มีผลต่อความสามารถในความเคารพตนเอง คุณภาพการนอนหลับและความวิตกกังวลและภาวะซึมเศร้าสำหรับเด็กก่อนวัยรุ่น

คำสำคัญ กิจกรรมทางกายภาพ ศิลปะการยิงธนูจีน การบริหารจัดการทางความคิดของสมองส่วนหน้า ความยึดมั่นผูกพันด้านปัญญา เด็กก่อนวัยรุ่น

สาขาวิชา	สาธารณสุขศาสตร์	ลายมือชื่อนิสิต ....
ปีการศึกษา	2565	ลายมือชื่อ อ.ที่ปรึกษาหลัก ....

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KEYWORD: Physical activity, Chinese archery art, Core executive functions, Cognitive engaging, Preadolescent children

Jianjun Liu : The Effects of Chinese Archery Arts Program on Core Executive Functions in Elementary School Children in Shanghai China: A Quasi-experimental Study. Advisor: Prof. SURASAK TANEEPANICHSKUL, M.D.

Objective: This study aimed to demonstrate the effect of a 12-week Chinese archery art program on core executive functions in preadolescent children in Shanghai, China.

Methods: A quasi-experimental design was conducted in the present study. All 68 eligible participants were purposively assigned to a Chinese archery intervention group (45 minutes/session, 4 sessions/week, n=34) or extracurricular activity-based control group (45 minutes/session, 4 sessions/week, n=34); The whole study period included a 12-week treatment and a 6-week follow-up.

The primary outcome was the performance of core executive functions (*inhibition control, working memory, and cognitive flexibility*), assessed with psychological paradigms: *Fish Flanker Task, N-Back Task, and Dimensional change card sort （DCCS border version）*, respectively. The secondary outcomes included self-esteem, sleep quality, and anxiety/depression, evaluated with *Rosenberg Self-Esteem Scale (RSRS), Pittsburgh Sleep Quality Index (PSQI), Achenbach Child Behaviour Checklist (CBCL)*, respectively; Performance of core executive functions and global self-esteem scores, and sleep quality were analysed with *a repeated measurement ANOVA, Bonferroni post-hoc analysis, paired T-test and independent T-test*; Anxiety/depression scores were analysed by *paired T-test and independent T-test*. Both groups were evaluated at the baseline, 6^{th}, 12^{th} and 18^{th} week time points.

Results: Considering reaction time, there was a considerable reduction in the performance of inhibition control (*incongruent trials*), working memory (*1-back trials, 2-back trials*), cognitive flexibility (*color trials, shape trials, and border trials*) within the intervention group after a 12-week Chinese archery art program. Moreover, compared with the control group, there was a significantly faster performance in working memory (*1-back trials*), cognitive flexibility (*color trials, shape trials, and border trials*) in intervention groups at 6^{th}, 12^{th}, 18^{th} week time points.

Regarding accuracy, there were significant improvements in the performance of inhibition control (*congruent trials*), working memory (*1-back trials, 2-back trials*), and cognitive flexibility (*shape trials, and border trials*) within the intervention group after a 12-week Chinese archery art program. Additionally, significantly higher performance of inhibition control (*congruent trials*), working memory (*2-back trials*), and cognitive flexibility (*shape trials, and border trials*) was revealed in the intervention group than the control group at 6^{th}, 12^{th}, 18^{th} week time points.

Meanwhile, there was an impressive improvement in self-esteem scores within the intervention group after a 12-week Chinese archery art program and between groups at the 6^{th}, the 12^{th}, and the 18^{th} week time points; Similarly, A considerable benefit in the global sleep quality scores and anxiety/depression were supported within intervention group with a 12-week Chinese archery art program.

Conclusion: The finding concluded that a 12-week Chinese archery art program effectively benefits three subdomains (*inhibition control, working memory, and cognitive flexibility*) of core executive functions, self-esteem, sleep quality, and anxiety/depression in average preadolescent children.

Field of Study:	Public Health	Student's Signature ....
Academic Year:	2022	Advisor's Signature ....

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Jianjun Liu

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ABBREVIATIONS

ADHD: Attention Deficit Hyperactivity Disorder

ANOVA: Analysis of Variance

ASD: Autism Spectrum Disorders

BD: Bipolar Disorder

BDNF: Brain-derived Neurotrophic Factor

CBCL: Child Behavior CheckList

CE: Cognitive Engagement

CBV: Cerebral Blood Volume

CFA: Confirmatory Factor Analysis

DCCS: Dimensional Change Card Sort Test

ECF: Executive Cognitive Function

EF: Executive Function

fMRI: Functional Magnetic Resonance Imaging

IGF-1: Insulin-like Growth Factor-1

IQ: Intelligence Quotient

MDD: Major Depression Disorder

MVPA: Moderate to Vigorous Physical Activity

OCD: Obsessive Compulsive Disorder

PA: Physical activity

PFC: Prefrontal Cortex

PSQI: Pittsburgh Sleep Quality Index

RCT: Randomized Controlled Trial

RSRS: Rosenberg Self-Esteem Scale

SD: Standard Deviation

SB: Sedentary Behavior

SUIBE: Shanghai University of Business and Economic

VEGF: Vascular Endothelial Growth Factor

VO_{2max}: Maximum Oxygen Consumption

VPA: vigorous physical activity

WM: Working Memory

WCST: The Wisconsin Card Sorting Task

OPERATION DEFINITIONS

Chinese martial arts: Chinese martial arts are an important part of Chinese traditional culture, the main content includes techniques of fighting, offensive and defensive strategies, and weapon use. Generally, include basic skills, routines, internal skills and external techniques, there are a lot of classification of Chinese martial arts at present such as Taiji, Qinggong, Chinese archery art program.

Internal skills: is regarded as the one of the most important components of Chinese martial arts, internal skill usually refer the practice of the methods in breathing, exhalation which benefit to concentrate the mind and coordinate with the body movements to strengthen the effect of attack and defense

External techniques: Mainly refer to techniques which use to enhance the strength of the bones and skin with exercise and practice the techniques of hands, eyes, body, steps, shoulders, elbows, wrists, hips, knees and other parts to strengthen the power of attack and defense.

Chinese archery: is a traditional Chinese archery game which developed from one of the six arts of archery which has been regarded benefit to cultivate temperament and character of individual since the Western Zhou Dynasty. The shooter has to shoot the feather arrow towards the target with a Chinese bow (traditional Chinese bow) follow specific procedures and actions. The Chinese archer arts always includes posture, etiquette, mental training and cultivation and the externally physical techniques training.

Executive function: Encompass those cognitive processed that underlie goal directed behavior and are orchestrated by activity within the prefrontal cortex.

Core executive functions: It is foundational components of EF that incorporates inhibitory control which includes self-control and interference control, working memory and cognitive flexibility which also is called set shifting, mental flexibility, or mental set shifting, and those components always are foundation which develop into higher-order EFs such as reasoning, problem solving and planning.

Core executive function performance: in this study, the accuracy and reaction time will be the main evaluable indicators of EF performance during the relevant psychological tasks such as the Flank fish task for inhibitory control, N-back task for working memory, DCCS task for cognitive flexibility.

Self-esteem: is confidence in one's own worth or abilities. Self-esteem encompasses beliefs about oneself as well as emotional states. Self-esteem is typically assessed using self-report inventories. One of the most widely used instruments, the Rosenberg self-esteem scale (RSES) is a 10-item self-esteem scale score that requires participants to indicate their level of agreement with a series of statements about themselves.

Sleep quality: is defined as an individual's self-satisfaction with all aspects of the sleep experience. Sleep quality has four attributes: sleep efficiency, sleep latency, sleep duration, and wake after sleep onset.

Physical activity: Any muscular movement requiring substantial energy expenditure.

Physical fitness: A set of attributes describing an individual’s ability to perform physical activity, including physiological (e.g., blood sugar levels), health-related (e.g., oxygen supply), and skill-related (e.g., coordination of motor responses) parameters.

Exercise: A series of physical activity program characterized by the intention to develop physical fitness

Sedentary behaviors: Anybody activity behavior characterized by an energy expenditure ≤1.5 METs, while in a sitting, reclining or lying posture

Cognitive engagement: The degree to which cognitive effort or challenge is needed to master difficult skills

Chronic exercise: A repeated and regular number of bouts of exercise or PA program during long-term period of time.

Acute exercise: A single bout of exercise or physical activity program.

Anxiety/depression: they will be corporates anxious/depressed, social problems and the scores assessed with Child Behavior Checklist will represent the level of the anxious/depressed in this study.

Participants (10-11 years): According the regulation from educational minister of China, the normal children' age threshold is 6 (Born before Sep of the year) or 7 (Born after Sep of the year) years older when they start to register primary school. So, the most students of the 4th grade are range from 10 to 11 years old.

CHAPTER 1: INTRODUCTION

1.1 Background and Rational

Executive functions (EFs) presents a family of top-down mental processes needed when you have to concentrate and pay attention, when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible [1]. Best and Miller Broadly defined that executive functions involve those cognitive processes that underlie goal directed behavior and are orchestrated by activity within the prefrontal cortex[2].

The EFs incorporate core EF[inhibitory control, working memory and cognitive flexibility] [3] and higher-order EFs such as reasoning, problem solving and planning[4, 5]. EFs are essentially influence whole life of individual such as mental and physical health academic performance, career success, cognitive, social and psychological development [6-13].

Given the significance of EFs in development, health, wealth, and quality of life, it would be clearly warranted to pay attention to increase effectiveness of approach of training. Diversity of subpopulations who are associated with EFs deficits such as attention deficit hyperactivity disorder(ADHD), autism, the elderly [14, 15] have been improved EFs by a wide variety of training activities, such as computerized training [16-19], school curricula [20-22], physical activity [23-45]. Overall, training effects seem highly inconsistent and the transfer of EFs are always scarce[2, 46, 47].the studies' approaches, design, diverse target groups and the diversity of interventions may be responsible for these mixed results[48]. Furthermore, research on the effectiveness of program designed to improve EFs is still in its early stage, thus it is necessary to develop the research on approach of enhancing EFs. PA program may possess high presential to improve EFs.

PA research have shown significant association with variables of cognitive functions since the past decades[49], moreover recently, EFs in particular[48, 50, 51]. Generally, exercises are classified as acute exercise and chronic exercise. There are a significantly increased number of aerobic exercise intervention identified the role of exercise on EFs recently after acute exercise[37, 38, 44, 45, 52] and chronic exercise[23-32, 34]. Although, the corresponding causal conclusion cannot be drawn due to the different quality of studies at present. the positive impact on EFs after PA program practice have been discovered. However, considering the PA program and interventions, which PA program is the optimal candidates? And how long do benefit? More studies are necessary for those questions mentioned[22, 51, 53, 54].

Those research on association between PA program and EF derived from the elderly and specific patient group. Nonetheless, the extreme importance to young children with good executive functioning because EFs early in life predict success, health, wealth, and quality of life in the whole life. Hence, it is very necessary to explore effective approach which improve the EFs of children in educational setting. Indeed, there is a recently increasing interest in the association between PA program and EFs in school-aged children [49, 55-69].

Even the significant benefit on EFs, evidence indicates that not all modalities of PA programs benefit EFs [21, 51, 54]. Hence, an increased interest for the effects of quantitative and qualitative characteristics of PA program on EFs has presented [21, 38, 48, 51, 54, 65, 70, 71].

Modality of PA programs as significant variable on transfer of EFs in children have confirmed [72] and more relevant studies have been advocated to determine which characteristic of PA program is the vital factor. Unless the dose of exercise, modalities of the PA program with interconnection of cognitive, emotional, social, and motor coordination demands also should pay attention in the relevant research [51]. Meanwhile, Diamond emphasize the address and sustainability of EF challenge, the good emotional, social, and physical health during PA intervention [54]. Moreover, more transfer in EFs have been identified after PA program with cognitive engaging(CE) than PA program without CE both acute PA [37, 38, 73, 74] and chronic PA [35, 38].

Chinese archery art program is regarded as representative Chinese martial arts and developed from one of the six arts which have been regarded benefit to cultivate temperament and character of individual since the Western Zhou Dynasty. Chinese archery arts always include posture, etiquette, mental training and cultivation and the externally physical techniques training. it is embedded not only PA but also cultural cultivation and cognitive control compared with archery exercise. even the literature about archery exercise health is limited, convictive evidence revealed that archery exercise is positively related to physical, mental and cognitive benefits [75-77]. Therefore, Chinese archery art program as modality of PA interventions probably be better to improve the EFs in children than modern PA interventional programs [48]. As vigorously promotional Chinese traditional exercise program by Shanghai government, it is valuable to seek benefit of Chinese archery art program on core EF in children. Considering the foundational significance of core EFs in childhood, this study aims to investigate the effect of Chinese archery art program on core EFs in normal children during education setting. Moreover, it probably is a significant exploration on exercise prescription for those subpopulations who are impaired in core EFs if it is effective enough.

View of this perspective which PA programs with EFs challenge enhance EFs in major ways and the advantage of Chinese archery art program, this study aimed to explore the effect of Chinese archery art program intervention on core EFs in healthy children in Shanghai elementary school with a quasi-experimental design.

1.2 Research gap

1.2.1 Lack of studies regarding the alternative interventional approaches to improve EFs in children through the Chinese traditional PA program, such as traditional archery arts, even high potential.

1.2.2 Lack of the studies to explore whether Chinese archery art practice program effect on self-esteem, sleep quality and anxiety/depression?

1.2.3 Few studies to assess how long benefits will be lasted after the PA program intervention to improvement of EFs in elementary school children?

1.3 Research Questions

Is there any significant effect of Chinese archery art program on core executive function in elementary school children in Shanghai? Is there any significant effect of Chinese archery art program on self-esteem, sleep quality and anxiety/depression in elementary school children in Shanghai? How long the benefit last if the intervention is effective?

1.4 Research Objectives

1.4.1 General Objective

This study aimed to explore the effect of Chinese archery art program on core executive functions in children of elementary school in Shanghai

1.4.2 Specific Objectives

1.4.2.1 To evaluate difference in accuracy and reaction time of core executive function performance in children of elementary school in Shanghai with chronic Chinese archery art program within subjects in present study.

1.4.2.2 To compare the difference in scores of self-esteems, sleep quality and anxiety/depression in children of elementary school in Shanghai with chronic Chinese archery art program within subjects in present study.

1.4.2.3 To evaluate difference in accuracy and reaction time of core executive function performance in children of elementary school in Shanghai with chronic Chinese archery art program between intervention group and control group in present study.

1.4.2.4 To compare the difference in scores of self-esteems, sleep quality, and anxiety/depression in children of elementary school in Shanghai with chronic Chinese archery art program between intervention group and control group in present study.

1.5 Research Hypothesis

1.5.1 There are statistically significant difference in accuracy and reaction time of core executive function performance in children of elementary school in Shanghai with chronic Chinese archery art program within subjects in present study.

1.5.2 There are statistically significant difference in scores of self-esteems, sleep quality, and anxiety/depression in children of elementary school in Shanghai with chronic Chinese archery art program within subjects in present study.

1.5.3 There are statistically significant difference in accuracy and reaction time of core executive function performance a single bout of Chinese archery art program and chronic Chinese archery art program between intervention group and control group in present study.

1.5.4 There are statistically significant difference for scores of self-esteems, sleep quality, and anxiety/depression with chronic Chinese archery art program between intervention group and control group in present study.

1.6 Conceptual framework

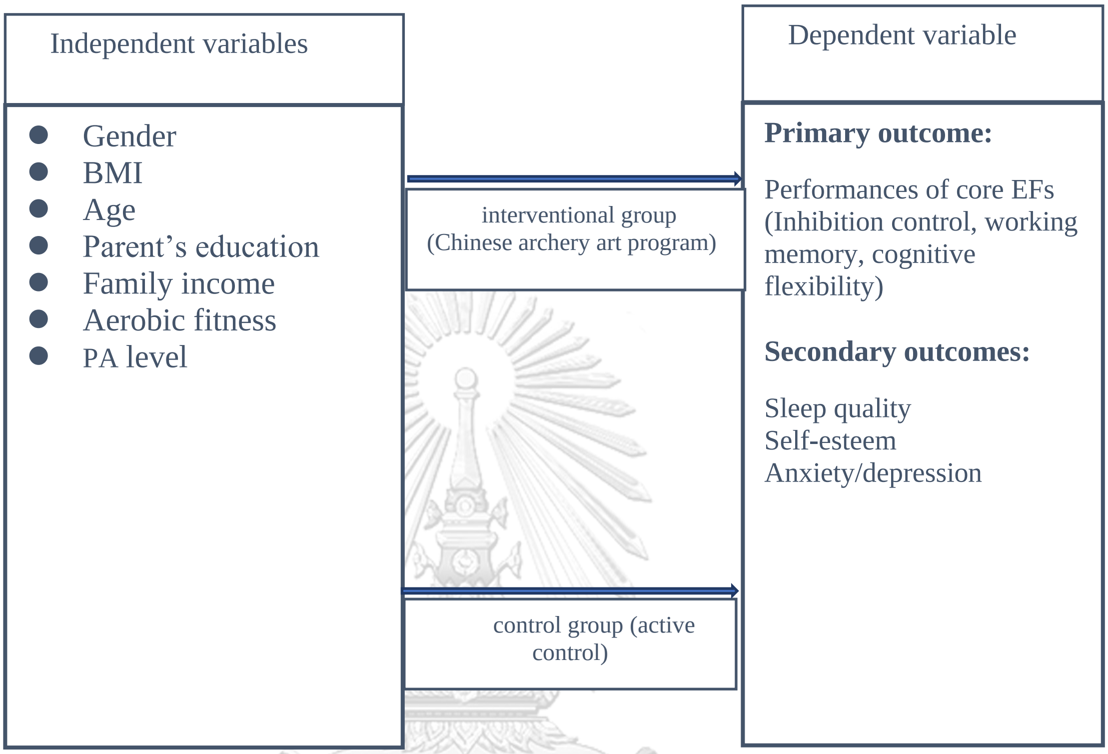


Figure 1, Conceptual framework

CHAPTER 2: REVIEW OF LITERATURE

2.1 Definition and components of core executive functions

Executive functions presents a family of top-down mental processes needed when you have to concentrate and pay attention, when going on automatic or relying on instinct or intuition would be ill-advised, insufficient, or impossible[1]. Best and Miller Broadly defined that executive functions involve those cognitive processes that underlie goal directed behavior and are orchestrated by activity within the prefrontal cortex [2]. Executive functions are higher-level cognitive processes which allow us to make adaptive response to the environment: to get rid of habits, make decisions and assess risks, have a schedule for the future, prioritize and sequence actions, and cope with novel situations[78]. One prominent theoretical framework described the EF construct as unity and diversity [3]. With their seminal study in young adults, three corelated latent variables after several commonly used EF tasks were extracted with confirmatory factor analysis (CFA). These latent variables represented inhibition, working memory (WM) and cognitive flexibility as EF components. Those studies with children have investigated the EF construct and supported for an integrative framework [79-82]. The EFs incorporate core EF[inhibition, working memory [83]and cognitive flexibility] [3] and higher-order EFs such as reasoning, problem solving and planning [4, 5].

2.2 Importance of core executive functions

EFs are essentially influence whole life of individual such as mental and physical health[6-13], academic performance[84-87], career success [88], cognitive, social, and psychological development[88-91].

About addiction, Baler & Volkow explored the impact on the neural substrates of self-control, and nature of the brain changes caused by chronic drug abuse[92]; EFs deficits in children with ADHD show the cognitive and behavioral problems and the academic deficits. Because the fundamental function to understand and improve the cognitive abilities, the academic performance is very important to the children with ADHD[7, 93]; In a antisocial behavior research, IQ, EF and related decision-making process from the criminal adolescent and their age-matched peers were assessed with risk choice task(RCT), WCST and CANTAB in a study, the findings show impairments of working memory and planning, and results support the notion of EF difficulties are associated with dorsolateral and ventromedial prefrontal cortex functioning[94]; Taylor-Tavares et al conducted a study to demonstrated neuropsychological deficits across a variety of cognitive domains in depression. Assessed 22 major depression disorder(MDD) and 17 bipolar disorder (BD) and 25 healthy control subjects(HC) with a battery of neuropsychological tests, and matched for age and IQ, the finding support the impairment on test of spatial working memory and attentional shifting in the MDD group [10]; patient with obsessive compulsive disorder(OCD) and schizophrenia studies show a disorder in working memory, executive control etc. [95, 96].

There are other predictors such as EFs obesity, overeating, substance abuse, and poor treatment adherence which associated with poorer. A study aimed at the relation between executive cognitive function (ECF) and substance use, food intake, PA level, and sedentary behavior in 1587 fourth grade children. Findings show that ECF performance was negatively related to substance use, high-calorie food, and sedentary behaviors and positively related to green food intake and PA after school [97]. Crescioni et al tracked the association between self-control and weigh loss with a 12 weeks weight loss program, the result support that trait self-control significantly predict health behaviors [98].

The EFs influence the quality of life. A trials with double-blind RCT design aimed at the correlation between improvement in EFs and health-related quality of life in adults with ADHD, it conclude that reported improvement in EF all 5 individual cluster were significant associated with health-related quality of life [99].

EFs are more significant than IQ in school readiness and entry-level reading. Blair & Razza conducted a study to assess the correlation between EFs and academic ability in 41 children (3-5 years) from low-income homes, the result demonstrate that the various components of self-regulation accompany unique variance in the academic outcomes. Moreover the conclusion was made that early math and reading ability was a significantly corelated to general intelligence and inhibitory [100]. During this issue "self-regulation and academic achievement in the transition to school", Morrison et al underlined that behavioral regulation and its relevant cognitive components are significantly linked to academic achievement and their achievement is significantly associated with behavior regulation [101].

EFs are predictors to math and reading competence. Two studies were administered to school children (10-11 years), both 20 good (14 females) and 20 poor (10 females) comprehends and explored the association between inhibitory factors and poor comprehends' reading difficulties. Finding supported that the poor comprehends have a worse performance in working memory task and in inhibitory tasks. This result support that specific inhibitory problems reading comprehension difficulties are associated with [102]. Duncan et a [86] determined attention skills as significant predictor to later school reading and math achievement with a meta-analysis of 6 longitudinal data sets. In order to investigated association between working memory and both reading and mathematics abilities, and the possible mediator of fluid intelligence, verbal abilities, short-term memory, as well as phonological awareness, Gathercole et al conducted a study in a 46 children(6-11 years) with reading disabilities and discovered that WM skills represent an significant constraint on the acquisition of skill and knowledge in reading and mathematics[103]

EFs are always impact the individual business success. A review study on cognition, language, organizational culture, brain, behavior, and evolution support that applying executive functioning that associated with cognition, emotion, and organizational behaviour benefits to minimize the negative effects of random implantation of individual and cultural faith systems to business. And it benefits to reinforce cognitive accuracy and better communication and cooperation. Organizations operating with cognitive accuracy is associated with negative market pressures and positive overall level of performance and employee's satisfaction [88].

Poor EFs lead to social problems such as crime, reckless behaviors, violence, and emotional outbursts. A research on exploration of the provocation followed four relevant studies, these results reveal that rumination following an anger-inducing provocation reduces self-control and increase aggression [104].

2.3 Components of core EFs and representative psychological tasks

2.3.1 Inhibition control

As one of the core EFs, inhibition control involves ability that control one's attention, behavior, thoughts, and/or emotions to overcome a strong internal predisposition or external lure, and instead do what's more appropriate or need [1]. We would be governed at impulses, old thought or action and/or stimuli in the environment that impact us if the inhibitory control is impaired. Hence, inhibitory control aids us to change and improve ourselves so as to distinguish the unthinking creature of habit. Indeed, it is a true that human being always used to make decision according to old habit and stimuli from environment which are beyond our awareness far away. Fortunately, the inhibitory control make us to overcome the defect and evolve us [1].

Inhibition control involve interference control and self-control. Interference control is consisting of inhibitory control of attention and cognitive inhibition. Attentional inhibitory control is regarded as perceptional interference control which help us selectively focus on what is our priority and suppress attention to other stimuli. It is called attentional control or attentional inhibition, endogenous, top-down, active, goal-driven, voluntary, volitional, or executive attention [105]; Another aspect of interference control is cognitive inhibition which inhibit prepotent mental indication. This involves resisting extraneous or unwanted thoughts or memories, proactive interference from memories and retroactive interference [106, 107]. Cognitive inhibition tends to cohere more WM measures than other types of inhibition measures. It is usually in favors of supporting WM.

Self-control involves one's behavior and emotion control which usually term to resist lure and not act impulsively. The lure resisted might indulge in pleasures when one should not, for instance, to eat high-calorie food if you want to lose weight. The lure might be impulsive action or behavior regardless of social norms. Another aspect of self-control is to adhere to destination disciplined in spite of distractions or diverse temptations. It involves making yourself do something or keep at something although something else is preference. Delaying gratification (often termed delay discounting by neuroscientists and learning theorists) is the final aspect of self-control which make someone quit an immediate pleasure for a greater reward later [108, 109].

2.3.1.1 Representative psychological tasks to assess inhibitory control

Representative psychological tasks include the Stroop task, Simon task, ant saccade tasks, delay-of-gratification tasks, go/no-go tasks, and stop-signal tasks, Flanker task. Those are widely used to measure the inhibitory control although hot debate deem aspects of EFs is which components of EFs a tasks requires [110, 111]. During the Stroop task, we are required to read for meaning and to neglect facial characteristics of words such as color of the ink. Incongruent trials on the Stroop task appear color word presented in another ink, participants would be required to neglect the meaning of word and instead report the color of the ink, and the time and errors would be counted.

Simon tasks press two very simple rules: press on the left if stimulus A; press on the right if stimulus B. one stimulus presents at only a time; even location of the stimulus is irrelevant, people would emerged slower response when the stimulus presents in the side opposite its associated response, revealing that a proponent tendency to respond on the same side as a stimulus persecute us [112].

The go/no-go and stop-signal tasks are two popular psychological tasks to measures response inhibition. They are different from other assessing tasks of inhibition control in that subjects simply inhibit a response to do nothing rather than inhibit one response to make another. Go/no-go tasks require subjects usually press a button when a stimulus presents except of a certain stimulus emerges. During the stop-signal tasks, the go signal is appeared on all trials, a minority of stop trials would present after the go signal and then the participants should be responsible. Subjects should not press the button on that trial when a stop signal appears (usually a sound or symbol).

In cognitive psychology, the Eriksen Flanker task is a set of response inhibition tests that was first published since 1974 and most frequently use to assess the inhibition control that are inappropriate in a particular context[113]. The flanker task has proven its reliability in exposing the subpopulation in the lifespan[114, 115] and the different clinic population with deficits in cognitive control[116, 117]. In a typical flanker task, participants are required to identify a centrally presented directional stimulus. These stimuli may be congruent stimuli (>>>>>), or incongruent stimuli (>><>>). Participants are required to ignore the distracters and respond only to the centrally targeted stimuli. Inhibitory ability is assessed by comparing performance on trials [118]. With more sensitive to flanker interference at the encoding stage of the visual processing of the target arrow, a children-friendly version of the ANT task was developed. In the child version, the arrow arrays were changed into fish arrays. The accuracy percentage and reaction times of correct responses on both congruent and incongruent trials were identified as main evaluation index of inhibitory control performance[119].

2.3.2 Working Memory

Working memory is another core EFs which involves keeping information in mind and mentally manipulate it. The two types of WM are distinguished by content-verbal WM and nonverbal (visual-spatial) WM. WM is critical for making sense of anything that related to that will come later. And it very necessary to point in learning, speaking, thinking, updating, and reasoning [1].

WM is distinct from short-term memory. The maintaining and manipulation of information incorporated in WM in spite of just maintaining of information process of short-term memory. According to the proof from cluster studies on children, adolescents, and adults[120, 121], they are linked to different neural subsystems between WM and short-term memory. WM depends more on dorsolateral prefrontal cortex than short-term memory. Their development progressions also show different between WM and short-term memory. The short-term memory develops earlier and faster.

The ability to maintain information in mind develops very early, even infants and young children can keep some memory in mind for quite a long time, infants of 9-12 months can update the contents of their WM, as the finding after tasks such as A-not-B[122]. Nevertheless, it is far slower to develop and show a prolonged developmental progression when the WM developing process is completely mature[123-125]. WM declines during aging when declining inhibitory control make older adults more vulnerable to distraction[126], proactive and retroactive interference[127, 128]. And comparing to young adult, the young children also are disproportionately challenged by inhibition. How to improve ability to inhibit interference is critical to age-related improvements in WM in children just like how to prevent impairing ability to inhibit interference may portend WM decline in older adults[1]. Decline in WM with aging and improvement in WM during development are also highly corelated with decline in speed of processing with aging and its improvement during early development[129, 130]. How to determine the relation between speed of processing and EFs is still controversial, the direction of causality might imply a third factor or another thought [131].

2.3.2.1 Representative psychological tasks to assess working memory

The Corsi Block test is a widely used measure of visual-spatial WM. Subjects require to watches the tester touch a series of blocks and then touch the blocks in the same order. Now it was developed into advanced version such as computerized version of Automated Working Memory Assessment(AWMA) which have high validity in children ages from 5-6 years and 8-9 years from[132], computerized variant of the Corsi Block task as part of the CANTAB battery which normed for children adults [133].

N-back tasks are also used to assess WM[134]. During the task, the participants will be required to control a serious of stimuli and correct respond with. Whenever a stimulus is presented which is the same as the one presented n trials as soon as possible, usually n can be 0,1,2 or 3. Monitoring, updating, and manipulation of remembered information are required during the on-line task, therefore it is assumed to place demands on a number of key processes within working memory. Over the last decade, the N-back task is a frequently applied assessment of WM in cognitive neuroscience research contexts in children and adolescents[135]. The reliability of the task reach r=0.91[136]. Considering the different level, the more complex induce higher reliability coefficients[137].

2.3.3 Cognitive flexibility

The third core EFs is cognitive flexibility that is the ability to shift between mental states, rule sets, or tasks[2]. One aspect of cognitive flexibility is the capability to change perspective spatially (e.g., consider same question from a different direction) or interpersonally (e.g., how to assimilate the point of view from other people). The cognitive processes present to be substantial need for inhibition and WM processes for flexibility. In order to change perspective, we need inhibit previously mental set and activate WM a different perspective. Cognitive flexibility also involves flexible adjustment according to change of demands or priorities, admission of own wrong, and seizing sudden, unexpected opportunities.

There is much overlap between cognitive flexibility and creativity task, and set shifting. Cognitive flexibility is the opposite of rigidity [1].

The ability of cognitive flexibility increases during children's development period and declines during aging[138, 139]. Only 2-3 years children can successfully switch to response for the rules are placed in a well-understood context and demands on inhibition reduced[140, 141]. The ability to adjust where you shift stimulus-response set develops earlier than the ability to adjust how you consider the stimuli or adjust what aspect of the stimuli you participates [1].

Inhibition control and working memory are integrated and predicted complex task performance and cognitive flexibility was not associated with inhibition and working memory performance in preschoolers[81]. Nevertheless, shifting may be developed less than inhibition control at this age. Accuracy and reaction time during switch task are different developmental trajectories, the accuracy diminished through childhood and the reaction time increased until adulthood[82, 142]. The speed-accuracy weight indicates subjects were preferred to make certain responding accuracy in spite of slowing down their responses on tasks. Older adults' decrease on a mixed blocks was much greater than that of young adults [143, 144].

2.3.3.1 presentative tasks to assess cognitive flexibility

Cognitive flexibility is always assessed with a wide array of task-switching and set-shifting tasks. The Wisconsin Card Sorting Task (WCST) is one of classic tests of prefrontal cortex function. Each card in this test is sorted depend on color, shape, or number. The subjects deduce the correct sorting criterion according to feedback and present a flexibly shifting response on the basis of adjusted sorting criterion.

Zelazo ect., developed the simplest test of task switching called Dimensional Change Card Sort Test (DCCS) which contain only one switch during whole test, bivalent stimuli and the correct response for one task is incorrect for the other. In the standard version, it is sensitive to assess the children of 3-6 years[144-146]. the subjects will usually show two target card and sort a series of bivalent test cards according to one dimension. The more challenging version of the DCCS have been used to measure the older children even adults across the lifespan successfully, such as the border version[7, 147]. In this version, if the black border test card display, the participants were required to play the color game, otherwise the shape game has to conduct. During the task, switches are presented randomly (e.g., on 25 % of trials) and ensure that the same test card cannot display on the screen sequentially. Response will be trigged via visual stimuli, and participants may be instructed to respond as soon as possible.

2.4 Successful interventional programs and strategies to transfer EFs in children

Given the relevance of core EFs in educational settings, it is warranted of improvement of EFs on the exploration to the effective approaches. There are a wide variety of training interventions which aim at development and improvement of EFs in the different subpopulations, such as healthy children, specific person with impaired EFs, older adults.

Enough evidence have been confirmed to improve children's working memory after cogmed computer-based intervention [16, 17, 19] and reasoning improvement with combination of computerized and interactive games [148, 149], aerobic exercise[29, 35, 150-153] and combination of physical activity-based and mindful practice[23, 154, 155], classroom curricula: tools of the mind[156] and Montessori curriculum[157], add-ons to classroom curricula: Promoting Alternative Thinking Strategies[158] the Chicago School Reading Project[159, 160].

All the studies above mentioned were conducted with randomized controlled trials design which included interventional group with baseline and post-test and active control group. Those convincing evidence from objective measures indicated interventional effects are significant improvement than control group. So, studies proofed the benefits to children's EFs from aerobics, mindfulness, the Tools of the Mind early childhood curriculum and the Montessori curriculum.

2.5 General principles that apply to EFs improving intervention

We can figure out some principles regardless of the EFs program or intervention. The conclusion would be highlighted following points.

The children with the lowest EFs benefit the most from any effective EFs interventional programs [1, 46, 161]. Nevertheless, early EFs intervention program should be a worthy method for eliminating the gap of playing field and social disparities in EFs. Owing to the prediction in school readiness, later academic performance and mental and physical health, if EFs is narrowed in early disparity, the disparity in later academic performance and health outcomes should be narrowed as well.

They are narrow improving effects from certain international program. A program was conducted to improve WM performance in children, it can improve the WM performance during WM tasks not inhibition [17], reasoning, problem solving[16, 17, 149]. The intervention on reasoning improve reasoning performance but WM and processing speed[148]. The effects of intervention on nonverbal WM improved to other measure tasks of nonverbal WM but verbal WM[149]. The gain to specific EFs may be just as narrow, but the EFs transfer will be wider if the intervention program addresses more EFs components. Hence the reason why the global effects of interventions were transferred on task switching[46], traditional martial arts[155], and school curricula[158] would be explained

EFs improvement in children should accompany with EFs demand [149]. Two reasons may be interpreted that. First one, people will be drive themselves be better anytime if they hope improvement. Secondary one, the insipid activity will be unchallenged, it will be regarded as boring training and losing interest. This has been a criticism of the control conditions in Cogmed trials. So, children's EFs should be challenged throughout course.

If you want the expected result, repeated practice is key during training. EFs gains depend on the amount of time children spend on skill practices, it is very necessary to push themselves to improve[16]. Consistent evidence reinforced this perspective which is repeated practices must be try and master beyond your current level of competence and comfort, if you want to be truly excellent at anything[162]. In the school curricula training studies, similar evidence were strengthened furtherly, the relevant training pushed children's EFs throughout the day, implanting practice in all activities in spite of in isolated, single module[156, 157]

EFs depend on how an activity is done. A study with adolescent juvenile delinquents took in point [163], different tae kwon do as intervention programs, all adolescent were assigned to traditional tae kwon do group either modern martial arts group. Traditional tae kwon do intervention highlights physical techniques, character development and self-control. modern martial arts intervention prefers the competitive character training. Compared with the results between two groups, subjects in traditional tae kwon do group showed less aggression and anxiety and more social ability and self-esteem than those in modern martial arts group.

The largest difference is consistently found on the most demanding EF tasks and task conditions. It is often only in pushing the limits of children's EF skill that group differences emerge[1].

2.6 The association between PA and children's EFs

2.6.1 The experimental evidence which PA impact children's EFs

It is necessary to introduce some terms frequently used in PA research. It includes physical fitness, PA, and exercise. Physical fitness is as a set of attribution describing an individual's ability to perform PA, including physiological, health-related, and skill-related parameters[164]. PA refer to any muscular movement requiring substantial energy expenditure and has various subcategories (e.g., leisure activities or exercise). Exercise is exclusively characterized by the intention to develop physical fitness.[164]. PA and exercise are regarded as process variables indicating behavior capable of impacting product variables, such as attribute of physical fitness or health[164]. Hence, PA and exercise are usually as intervention approaches and physical fitness is frequently applied as an outcome measure. Presentation of PA can vary in terms of format (e.g., walking, complex aerobic training program), intensity (oxygen uptake, heart rate, or lactate level will use to assess the intensity), and duration (e.g., acute and chronic interventions).

Over last decade, relevant literature confirmed that chronic aerobic exercise is effective on the executive functions [165]. Davis et al [166] detected that there is a significantly improvement (p=.03) of the planning scores in the intervention group with the high-dose (40 min/day) than the low-dose (20/min) and control condition in 94 overweight children (Age $_{mean}$=9.2 years, BMI>=85th percentile). Using a randomized between-subjects pretest-posttest design, the planning scores was assessed with the cognitive assessment system (CAS) after a 15-week intervention with 5 day/week session. More recently, accumulating evidence from empirical outcomes declared the subdomains of core executive functions are sensitive to chronic exercise [167-171]. Hillman ect al. [27] confirmed a higher response accuracy percentage on inhibition (3.2%, 95% CI: .0-6.5, d=.27) and cognitive flexibility (4.8%, 95% CI: 1.1-8.4, d=.35) in the intervention participants than wait-list group with a 9-month FITKids physical activity program in 221 preadolescents (Mean $_{age}$ =8.8 years). Using a randomized between-subjects pretest-posttest design, the inhibition and cognitive flexibility performance were evaluated with attentional inhibition and cognitive flexibility tasks, respectively. Overall, physical activity has a beneficial impact on core executive functions with different effect sizes (ranging from highly positive to detrimental) [56, 169, 172, 173].

As a critical question, increasing evidence demonstrated that it is not equally improved in executive functions following different modalities of physical activity[48, 51, 53, 70, 154, 167]. Best [174] suggested that the aerobic activity with cognitive engagement has stronger effect on executive functions than aerobic activity alone. Moreover, Tomporowski, McCullick, and Pesce [65] pointed that context interference, mental control, and discovery induced from physical activity program are the three crucial principles which effectively transfer the executive functions. Indeed, Schmidt et al [35] revealed an importantly improvement in shifting performance in the intervention group with a high physical exertion and high cognitive engagement (team games) than aerobic exercise group (p=.039) and control condition group (p=.012) with a 6-week physical education program in 181 preadolescents (Mean $_{age}$ =11.35(± .60) years, 54.9% female). Using a cluster-randomized pretest-posttest design, the subdomains of core executive functions were assessed with computer-based non-spatial n-back task for updating, a child-adapted Flanker task for inhibition, and an extra block included in the Flanker task for shifting. Similarly, Crova et al [32] displayed a significant difference in inhibition in group with cognitively demanding physical activity than control group with a curricular physical education program after a 6-month physical education program in 70 overweigh children (Mean $_{age}$ =9.6 (± .50) years).

Recently, Contreras-Osorio et al.,[175] demonstrated a distinct benefit on all subcomponents of core executive functions on sports programs: working memory (ES=−1.25; CI=−1.70, −0.79; $p < 0.00$); inhibitory control (ES=−1.30; CI=−1.98, −0.63; $p < 0.00$); and cognitive flexibility (ES= −1.52; CI=−2.20, −0.83; $p < 0.00$). In contrast, a divergent conclusion has been postulated in previous meta-analyses [171]. The inconsistent findings are largely explained by those potential considerations which include the small quantity of studies, the physical activity regimes (e.g., type of physical activity, intensity, duration), the timing of assessment administration, and duration, sample characteristics (e.g., baseline performance, age, aerobic fitness, health status), methodological variables (e.g., experimental design, control condition, and statistical power) [171, 176-178]. Furthermore, As the literature advances, the type of physical activity program is probably regarded as a primary contributor that induces the transfer of executive functions[48, 57]. Although, the issue remains intense argument [53, 70]. Diamond and Ling [179] reviewed all methods to enhance executive functions in 179 studies. Eventually, mindfulness movement activity (such as yoga [180, 181], t'ai chi [182-184], Chinese mind-body practices [185], and Quadrato motor training [186]) shows the most robust result to benefit executive functions among all the ways (computer and noncomputer cognitive training, neurofeedback, school programs, physical activities, mindfulness practices, and miscellaneous approach)[187].

2.6.2 The mechanism of PA and children's EFs

There is some general pathway which may transfer EFs in children by PA programs: (1) the cognitive components inherent in the structure of exercise activity. (2) the cognitive engagement required to execute complex motor movements. (3) the physiological changes in the brain induced by PA programs. (4) the improvement of mental or health condition induced by PA programs.

2.6.2.1 The cognitive components inherent in the structure of exercise activity

People have paid little attention to fact that many forms of PA programs are cognitively-engaging activities which might be the main contributors to any EF benefit[70]. Even though researchers have realized that the cognitive components inherent in exercise activities may help explain how PA impacts cognitive[64, 65, 165, 188]. There are many forms of exercise which require complex cognition to cooperate with teammates, employ strategies, adapt novel situation and anticipate the behaviors of teammates or opponents during the activities. Similarly, EFs tasks place demand on children's executive process by requiring them to create, monitor and change a cognitive plan to meet task demands[189]. So, some PA programs and EFs tasks require a similar way of thinking and cognitive skill. Perhaps cognitive skills induced during PA programs result in the EF gain just like the EF tasks.

If this is the case, participant in cognitive-engaging training even sedentary activity should also positively affect children's EFs. Enough evidence have been confirmed this proposition by existing for cogmed computer-based training for working memory[16, 17, 19] and combination of computerized and interactive games for reasoning[148, 149], classroom curricula: tools of the mind[156] and Montessori curriculum[157], add-ons to classroom curricula: Promoting Alternative Thinking Strategies[158] and the Chicago School Reading Project[159, 160] which are significant effect on children's EFs.

Two features are deserved to pay attention to current discussion. First one, similarly, the sedentary EF training mentioned above, and PA program induced demand on cognition required shifting behavior and decision-making in a novel situation or environment. Second one, challenging training even sedentary game which require shifting and goal-directed behavior can effectively realize EF gain. There is strong evidence support it, the computerized training and curriculum training acquired not only improvement of performance during training but also transfer to novel EF tasks, such as inhibition tasks, WM tasks. In one study the EF gain lasted three months after training terminated was explored[16].

Contextual interference involved EF may be critical point to explain how engaging training or PA activities realized the EFs gain[190]: the components of a task are emerged in a simple and repetitious manner in spite of rapid skill acquisition, the retention and transfer of those skill are reinforced on account of contextual interference. Children's engaging training or PA activities often contains contextual interference which are emerged in a complex and quiz-random manner. Contextual interference put demand on executive process as a creative, supervised, and adjustable motor action plan according to the continually changing task requirement. Hereby, more effortful and elaborative processing of relevant information, greater learning improvement.

2.6.2.2 Cognitive engagement of complex motor movement

Specific neural circuitry involved the execution of complex motor movements is associated with EF. A review conducted Diamond made a conclusion that a close neural link between the cerebellum and dorsa-lateral PFC(DL-PFC), the cerebellum and DL-PFC are critical for complex, coordinated motor function and complex cognitive function[39]. Moreover, Diamond alleged the brain and the mind by extension operates on a global-default mode, and both cognitive and motor activity that depend on non-automatic and selective processing require the effortful overriding of that default[191], The execution of bimanual coordination tasks was offered as A proof supported. Hereby the executions of complex motor movements present as inherently cognitively engaging task, once the execution of simpler repetitive exercise were mastered by the child, the processing would be relied on a global-default mode of operation. May less engaging cognition demand.

Furthermore, animal model support morphological changes to the brain was induced by complex motor activity rather than simple motor activity. The executions of complex motor movement develops significant neural growth in the hippocampus, cerebellum, and cerebral cortices than do simple motor movement in rodents and nonhuman primates[192].

2.6.2.3 The physiological changes induced aerobic exercise

The cardiovascular system of body, also brain, benefit aerobic exercise, such as increase of blood flow, the amount oxygen and the brain-derived neurotrophic factor (BDNF) levels in the brain. Meanwhile aerobic exercise induces physiological changes in brain where impact cognition or cognitive components of the exercise. During to the different impact in physiological changes, the acute and chronic aerobic exercises will be discussed separately.

1. Chronic aerobic exercise

Findings from rodents model support that changes in brain regions where are critical to learning and memory after several session of regular exercise[193, 194]. It is general agreement that these changes are mediated by up-regulation of growth factors, including IGF-1, VEGF, and BDNF. Particularly, BDNF is regarded as critical activity-dependent modulator of synaptic transmission and plasticity. Additionally, BDNF present to mediate exercise-induced neurogenesis, such as the process by which new neurons proliferate and develop[195].

Exercise-induced neurogenesis in the hippocampus of adult mice was confirmed and this finding certainly reinforced learning and memory on tasks such as the Morris water maze and radial arm maze.[196]. Even though, it is still controversial that the newborn hippocampal neurogenesis, it is a general agreement that short-term and long-term potentiation are reinforced with exercise and those potentiation as the synaptic parallel of learning in the hippocampus is mediated by the up-regulation and interplay of IGF-1 and BDNF[194].

In view of the difference of age, a study of adolescent rats indicated that regular treadmill running enhanced cell survival which increased visuo-spatial memory and hippocampal cell density.[197]. And a juvenile rates model explored that exercise-induced neurogenesis and expression of growth factors(e.g., BDNF) was intensify-dependent, a more significant improvement rely on low- and moderate-intensify exercise rather than high-intensify exercise of equivalent duration[198]. Thus, evidence support that exercise positively impacts the developing brain is consistent in spite of age, and regular moderate exercise is most beneficial rather than intense.

Regardless of age, intense of exercise, context of exercise is associated with the neurogenesis in brain. The exercise with an engaging context present a robust and enduring neurogenesis in the learning and memory center of the brain[199]. So, exercise in a complex and social environment may result in more significant morphological changes than exercise in a simpler context. The perspective above was supported with the results from a freewheel running in conjunction with group housing interventional study[200]. The evidences from other study indicated that individual freewheel running rather than sedentary behavior increases angiogenesis in the hippocampus, and enriched context are benefit angiogenesis in hippocampus and PFC in adult rats.[201]. It may be that regular exercise in a complex and novel situation motivates EF gains via specific morphological changes in the PFC.

Those extant evidence on human support that exercise-induced cognition is mediated by similar mechanisms. Evidence show the regional cerebral blood volume(CBV) was increased in a specific area of the hippocampus in both mice and humans[202]. The CBV increased was predicted struggling memory performance in human and indicated a direct association with neurogenesis in mice. Further evidence show that aerobic exercise positively induces the morphological changes of brain in human. A study with RCT design in older audlt 60-80 years old) was conducted, results determined white and gray matter volume were enhanced after 6 months of aerobic training via structural MRI, and frontal brain regions where implicated in EF was the most remarkable in brain volume enhanced. Moreover, aerobic exercise induces functional changes to brain in human. A study in overweight children explored the improvement of frontal activation and decrease of parietal activation via an fMRI anti-saccade paradigm[57]. Thus, synthetic evidence supports that regular aerobic exercise in human also has a direct impact on the neural substrate underlying cognition.

2. Acute aerobic exercise

Aerobic exercise also induces immediate neurochemical changes which may be response to the central nervous system for concurrent or subsequent skill acquisition[203]. There was mild increase of expression of Myrna BDNF in exercise plus motor skill training condition, it is signified that up-regulation of growth factors may highlight the priming effect[204].

The study in human also indicated that exercise has a immediate priming effect. A study explored that learning was enhanced accompanied with acute, intense running rather than moderately intense running or behavior of relaxation[205]. This effect may reinforce by increase of peripheral levels of BDNF and monoamine which are regarded as predictor of retention of the learned material. Another evidence explored the acute exercise induced more significant effect in norepinephrine response and EF task performance than in repetitive exercise[206]. A study with preadolescent children found that acute treadmill walking increased P3 amplitude which very possibly emerged the improvement of attentional allocation[45]. Hence, aerobic exercise induces not only morphological changes by regular aerobic exercise but also the immediate chemical changes by acute aerobic exercise and both changes lead by different model of exercise likely improve cognitive performance. Hence, both acute and chronic exercise may benefit improvement of EFs through different physiological pathways.

2.6.2.4 The improvement of mental or health condition induced by PA programs

EFs rely on prefrontal cortex and interconnection with other neural regions. Prefrontal cortex is the newest area of the brain and the most vulnerable. Prefrontal cortex and EFs firstly and mostly suffer from stress[207, 208], sadness[209, 210], loneliness[211-213], poor sleep[214, 215], or poor physical health[48, 59, 216]. In addition, self-confidence and self-efficacy are characterized the benefit to performance of EFs. Conversely, it is predicted that acquisition of better performance in EFs will presents when any approaches improve the condition in stress, sadness, loneliness, and poor health regardless the direct training or indirect support.

An review of systematic reviews and meta-analyses concerning PA and mental health in children and adolescents was conducted, and to judge the extent to which association can be considered causal[217]. Results support the PA is significant associated with reduction of depression in children and adolescents, the meta-analytic effect size (ES) ranged from -0.41 to -0.61. Moreover, this is slight difference of ES between the depressed population (ES=-0.43 to -0.61) and healthy or mixed participants (ES=-0.26 to -0.52). Hence, a summary of the evidence regarding the criteria for judging shows that the PA is partially, causally associated with depression in young people.

Self-esteem is defined as an evaluation of oneself and consist more specific sub-domains, such as physical and social self-perceptions. The evidence of review support self-esteem is related to PA, Effect sizes for self-esteem intervention varied from 0.12-0.78. Even the conclusion that association between PA and self-esteem in young people are causal cannot made, evidence of studies still partially support that PA is causally associated with self-esteem.

Furthermore, it is general agreement that PA induce numerous health benefits in children, such as cholesterol and blood lipids, high blood pressure, metabolic syndrome, overweight and obesity, bone mineral density. And the relation between PA and health confirmed, aerobic-based activities underly the cardiovascular and respiratory systems have the greatest health benefit[218].

There are anecdotal evidence and a commonsense belief that exercise can improve quality of sleep. A study with RCT design among 67 older adults with mild sleep impairment was conducted[219], results show that an 8-week aquatic exercise has greater improvement to sleep efficiency and less time for sleep onset latency. Moreover physical activity level likely predict the sleep patterns and quality in children [220], a study with children(9-16 years) with Autism Spectrum Disorders(ASD) aimed to determine the relationship between sleep and PA, results support that PA is significantly related to sleep pattern, furthermore, the more physically active children had overall higher sleep quality. A relationship between PA and sleep was objectively and subjectively assessed in average children (M_{age}=17.98, SD=1.36) with relevant questionnaire, accelerometers for PA and sleep-EEG devices for sleep, result asserted that PA lever among normal adolescents is significantly associated with higher sleep quality [221]. Hence, the PA from different model of exercise likely improve sleep quality of human in spite of the age and health condition.

It remains imprecise to explain the underlying mechanism how the PA induce the changes of mental health at present. A perspective stand for a number of interacting neuro-biological, psychological, and social mechanisms may play a role which lead to changes of structure and function of brain, feeling of competence and confidence, and opportunity for positive social interaction and growth [222].

2.6.3 Alternative aerobic exercise interventions to improve the core EFs in children and adolescents

According to duration of aerobic exercise interventional studies at present, the chronic PA interventions and acute PA interventions are applied to improve the core EFs in children and adolescent.

In this study, we reviewed those representative PA intervention studies with executive function outcomes in children or adolescent since 2000. Descriptive information about the subjects, modality of the intervention conditions, the study design, and the executive function outcomes and the results are presented in Table 2-1 and Table 2-2 according to the duration of intervention. The demographics for subjects included the total sample size and age or school grade, and the country in which the intervention was conducted.

The modalities of PA intervention were classified followed three conceptually qualitative characteristics that were included aerobic, motor skill, cognitively engaging[167].

2.6.3.1 Chronic exercise and executive function

There are different qualitative PA intervention of studies on EF in children or adolescent according to diversified modality of PA such as plain aerobic PA[26, 31, 33, 34, 223-228], motor skill[228-230], cognitively engaging PA[23, 27-29, 32, 35, 36, 155, 185, 231-233]

Table 1, Alternative chronic PA intervention on EF in children or adolescent since 1993.

Author	Sample	Intervention (modality, intensity, duration)	Study design	Outcomes	Results
Reed, Maslow, Long, & Hughey, 2013	N=470 Age (10.2 ± 2.3 y) USA	Motor skill (fundamental motor skills, 45 min/day, 6 months	Quasi-	Fluid intelligence*, perceptual speed*	+0-* +0-*
M. C. Gallotta et al., 2015	N=156 3rd - 5th grades Italy	Motor skill (sports games, rhythmic, gymnastics, fitness 120 min/week, 5 months	C RCT	Attention* concentration	-*0**
Fisher et al., 2011	N=60 Age (6.2 ± 0.3 Y) UK	Aerobic (aerobic activities, 120 min/week, 10 weeks	RCT	Attention RT& accuracy, spatial span, spatial WM errors	+ 0
Hinkle, Tuckman, & Sampson, 1993	N=85 8th grade USA	Aerobic (running, 5*30 min/ week, 8 weeks)	RCT	Creative fluency Creative flexibilty Creativity originality	+ + +
Koutsandreou, Wegner, Niemann, & Budde, 2016	N=71 Age (9.4 ± 0.6 Y) Germany	Aerobic (60-70% HR_{max} exercise vs 55-65% motor skill vs academic, 3*45 min/week, 10 weeks)	RCT	Working memory	+*
Aadland et al., 2019	N=28 I +29 C n=971-1123 5th grade (10 Y) Norwegian	Aerobic (PE+ PA breaks + PA homework, Plus 165-135 min/week, 7 months)	C RCT	Score of Executive function Cognitive flexibility Motor skill	+ + +
de Greeff et al., 2016	N=I 249 + C 250 Age (8.1±.7) Netherland	Aerobic (integrating PA program*20-30 min/week, 44 weeks	RCT	Cardiovascular fitness Muscular fitness Executive function	+ + 0

Table 2, Alternative chronic PA intervention on EF in children or adolescent since 1993 (continued)

Author	Sample	Intervention (modality, intensity, duration)	Study design	Outcomes	Results
Kvalø et al., 2017	N=I 5 + C 4 n=I 227+ C 231 Age (9-10 Y) Norway	Aerobic (Physically active academic lessons, 2*45 min/week + physically active homework, 5*10 min/week + physically activity during recess ,5*10 min/week 10 months)	CRCT	Executive function Aerobic fitness	+ 0
Moreau et al., 2017	N=318 Age (9.9±1.74 Y) New Zealand	Aerobic (high-intensity training*10 min /week, 6 weeks)	RCT	Cognitive control Working memory	+ +
Ludyga et al., 2018	N=36 Age (12-15 Y)	Aerobic (aerobic and coordinative exercise session, 5*20 min/week, 8 weeks)	RCT	P 300 amplitude Inhibition control	+ +
Manjunath & Telles, 2001	N=20 Age (10-13 Y) India	Cognitively engaging (yoga, 7*75 min /week, 1 month	RCT	Planning time Execution time	+* +
Chang et al., 2013	N=26 Age (6-7.5 Y) Taiwan, China	Cognitively engaging (60-70% HR_{max} exercise, 2*35 min/week, 8 weeks	Quasi-	Inhibition accuracy Inhibition RT	0 0
Hillman et al., 2014	N=221 Age (7-9 Y) USA	Cognitively engaging (FitKid program, 5*120 min /week, 9 months	RCT	Inhibition accuracy Inhibition RT Cognitive flexibility accuracy and RT	+ + 0

Crova et al., 2014	N=70 Age (9-10Y) Italy	Cognitively engaging (PE class tennis training, 120min /week, 21weeks	Quasi-	Inhibition Working memory	+ 0

Table 3, Alternative chronic PA intervention on EF in children or adolescent since 1993 (continued)

Author	Sample	Intervention (modality, intensity, duration)	Study design	Outcomes	Results
Lakes & Hoyt, 2004	N=193 5th grade USA	Cognitively engaging (Martial arts program, 2 or 3 of the 4*45 min PE/ week, 4 months	RCT	Cognitive self-regulation affective self-regulation physical self-regulation teacher-related strengths& difficulties	+ + + +*
Pesce et al.,2016	N=460 Age (5-10 Y) Italy	Cognitively engaging (PE with complex motor and cognitively challenging task, 60 min/week, 6 months	CRCT	Inhibition Working memory Executive attention	+ 0 0
Schmidt et al., 2015	N=181 Age (11.35±0.6 Y) Switzerland	Cognitively engaging (basketball with frequent changes of rules I_1VS running I_2VS traditional PE, 2*45 min /week, 6 weeks	CRCT	Inhibition Updating Shifting (noly I_1)	0 0 +*
van der Niet et al., 2016	N=105 Age (8-12 Y) Netherlands	Cognitively engaging (running games, circuit training, football, relay games with letters, sit-ups, rope skipping, 2*30 min/week, 22 weeks)	Quasi-	Inhibition Verbal working memory Cognitive flexibility planning	+ + 0 0
Tarp et al., 2016	N=16 n= 855 Age (12.9±.6 Y) Denmark	Aerobic (PA improvement program which including PA academic subjects + PA during recess+ PA homework+ active transportation 5*60 min/week, 20 weeks)	CRCT	Inhibition accuracy Inhibition RT Mathematics skills	0 0 0

Kamijo et al., 2011	N=43 Age (7-9 Y)	Cognitively engaging (endurance training, resistance training, motor skill, 5*120 min/week, 9 months)	RCT	Cardiorespiratory fitness Working memory	+ +

Notes: Y=years; m=months; I=intervention; C=comparison; HR= heart rate; BPM=beats per minute; RT=reaction time; 0= no difference; +=difference in favor of the intervention group; -= difference in favor of the comparison group

2.6.3.2 Acute exercise and executive function

Acute PA studied on effect of executive function targeted children and adolescent are included those [37, 44, 45, 52, 234-243]

Table 4, Alternative acute PA intervention on EF in children or adolescent since 1993

Author	Sample	Intervention (modality, intensity, duration)	Study design	Outcomes	Results
Budde et al., 2008	N=115 Age (13-16 Y) Germany	Cognitively engaging (coordinative exercise HR=122 BPM) + Circuit training HR=122 BPM 10 min)	RCT	Attention concentration	+ +
Stroth et al., 2009	N=35 Age (13-16 Y) Germany	Aerobic (stationary biking, 60% HR_{max} 20 min)	Quasi-	inhibition	+
Charles H Hillman et al., 2009	N=69 Age (9.6±.7 Y) USA	Aerobic (treadmill walking, 60% HR_{max} 20 min)	Cross-over	Inhibition accuracy Inhibition RT	+ 0
Ellemberg & St-Louis-Deschênes, 2010	N=72 Age (7-10 Y) Canada	Aerobic (stationary biking while watching TV, 60% HR_{max} 40 min)		P 300 amplitude Task accuracy Task RT	+ 0 +
Pirrie & Lodewyk, 2012	N=40 Age(9.8±.4 Y) Canada	Aerobic (PE lesson, moderate to vigorous intensity, 60 min)	Cross-over	Shifting Planning attention	0 + 0

Table 5, Alternative chronic PA intervention on EF in children or adolescent since 1993 (continued)

Author	Sample	Intervention (modality, intensity, duration)	Study design	Outcomes	Results
Howie, Schatz, & Pate; Jäger, Schmidt, Conzelmann, & Roebers, 2014	N=104 Age (7.9±.4 Y) Switzerland	Aerobic (running and jumping, 20 min)	RCT	Inhibition Shifting Working memory	+ 0 0
A.-G. Chen, Yan, Yin, Pan, & Chang, 2014	N=83 Age (10.2±.7 Y) China	Aerobic (running, 60-70% HR_{max}, 30 min)	RCT	Inhibition Working memory shifting	+ + 0
Hogan et al., 2015	N_1=13 N_2=15 Age (14.2±.5 Y) Germany	Aerobic (ergometer cycling, 70% HR_{max}, 20 min)	Cross-over	inhibition	+
Piepmeier et al., 2015	N=18 Age (11.2±2.4 Y) USA	Aerobic (ergometer cycling, 70% HR_{max}, 30 min)	Cross-over	Shifting Processing Inhibitory control planning	0 + + 0
Soga, Shishido, & Nagatomi, 2015	N=55 Age (15.7±.5 Y)	Aerobic (treadmill running, 60-70% HR_{max}, 10 min)	Cross-over	Inhibition Working memory	+

Note: Y=years; m=months; I=intervention; C=comparison; HR= heart rate; BPM=beats per minute; RT=reaction time; 0= no difference; +=difference in favor of the intervention group; -= difference in favor of the comparison group

2.7 The effect of archery exercise on health

Chinese archery art originated from hunting activities with bow and arrow in the Stone Age and developed from archery rituals, which has been regarded as one of the six essential skills required of pupils since the West Zhou Dynasty (1046 BC-771 BC)[244]. With the evolution of history, Chinese archery art has been described as a spiritual (expression of one' n inner self) and mental (emotion release) approach in the ritual setting[245]. Furthermore, the central themes of the indoctrination of archery rituals were educating the officials, timeliness in attending to the rulers, adherence to the doctrines, and not failing in duties in ancient times[245-247]. The education process aims to complete skills and cultivate virtuous conduct[248].

Participants must be taken up bow and arrow with a peaceful mind and posture erect and a fully concentrated shooting process[249]. Archery art is not principally concerned with scoring hits because participants are not matched in their strength. Hence, the performance during the archery ritual was regarded as a quality control test of the education system [247].

The shooter during Chinese archery art program has to shoot the feather arrow towards the target with a Chinese bow (traditional Chinese bow) follow specific procedures and actions. The Chinese archer arts always includes posture, etiquette, mental training and cultivation and the externally physical techniques training.

As one of the representatively traditional (sports) martial arts in China, Chinese archery art emphasizes mind-body unity and pursues simultaneous development of technique and Tao of the individual[244, 247]. According to the historical and expert experience. There is some benefit on health with regular Chinese archery art program. Firstly, it enhances physical health, such as muscle strength of the back and arm[250], control of respiration, heart[251], arousal system[252], motor execution, and imagery[253]. Secondly, due to simultaneous emphasis on skill training, self-reflection, self-control, concentration, discipline, and individual character development (e.g., humility, virtue, respect, morality, Tao philosophy), Chinese archery art program help to cultivate a calm and relaxed state, reduce stress, inspire personality development and individual self-confidence[246].

At present, relevant literature is very limited the effect of Chinese archery art program on practitioner's health outcomes in experimental studies, especially the children and adolescent subpopulation. However, it is supported to benefit on improvement of physical, mental, and social health outcomes in practitioners according to those existing literature about archery arts.

Muscle strength, especially upper body strength, is directly associated with archery performance [254]. H. Surendra Sharma ect al. [255] reported a significant improvement in the arm strength and back strength in intervention group than control group with a 6-week archery training in 30 subjects (age: 17-24 years). Using a randomized pretest-posttest design. In addition to upper body strength, upper body steadiness is usually associated with archery performance [256].

In spite of the performance level, respiratory system benefits from the archery exercise. Practitioners have higher lung volumes than non-practitioners, the results probably explained the proficient demand on respiratory system during archery practice. Indeed, archery is related to higher level of control of heart rate and breathing [255, 257]. Unless the respiratory benefit, the archery practitioners increase their ability to control the heart rate and arousal system [251].

It is fundamental to maintain balance of body when the practitioners are participating archery exercise. hence the individual who participate archery exercise required to improve the regulation of postural control and weight distribution for better performance [258]. A study result shown that the participants with an archery training program presented greater postural control than control group [258]. Archery exercise as a kind of techniques is involved motor function and coordination of neural process. The excellent archery practitioners indicates motor execution and motor imagery enhanced [259].

Similarly, archery exercise is associated with certain mental and cognitive benefits. Proficient archery practitioners reveal better emotional regulation, concentration, self-efficacy [260]. Moreover, archery exercise may a significantly positive effect on coping with stress [75]. Because the self-reflection is emphasized during the archery exercise, the practitioners indicate improvement of self-regulation [76].

CHAPTER 3: RESEARCH METHODOLOGY

The primary outcome of present study evaluated the effect on core executive functions with chronic Chinese archery art program in children of elementary school in Shanghai. This study developed our theory of knowledge on this PA program intervention strategy which might serve as the alternative exercise prescription to improve the core executive functions of children, especially those children who are impaired on EFs in real world. In present study, Core executive function would be assessed by those psychological paradigms: inhibition (Fish Flanker Task), working memory (N-Back Task) and cognitive flexibility (Border Version of DCCS) and physical activity and Sedentary behaviours level were measured with ActiGraph GT3X+ accelerometer; The aerobic fitness was evaluated 20-m Shuttle Run Test;, The Rosenberg Self-Esteem Scale was used to evaluate global self-esteem scores of individuals, Pittsburgh sleep quality index(PSQI) evaluated the global sleep quality scores of participants in recent study, Anxiety/depression (anxiety/depression scores) were assessed with Achenbach Child Behaviour Checklist (CBCL).

3.1 Research design

A quasi-experimental design was conducted in this study. According to the age as the significant covariable of outcomes, eligible participants recruited from total 328 participants of 4th grade elementary school. And then, all eligible participants were assigned to receive intervention trial or controlled trial.

3.2 Study Setting

In present study, Songjiang Experimental School Affiliated to SUIBE, a public primary school is in Songjiang District, Shanghai City, China. It is main primary school, and the grades are included from 1^{st} to 6^{th} grade. 328 registered in this school from 4^{th} grade. All intervention trials involved in school.

Figure 2, The map of study setting

3.3 Study Period

This study consisted of three steps. The first one was baseline data collection which was carried out within 2 weeks during September 2021 after ethical approval obtained. Collecting database conclude general information about socio-demographics data of respondent and core EF performance, level of PA, level of SB, level of aerobic fitness, anxiety/depression, global self-esteem and sleep quality scores of individuals; The second step continued by implementing a 12-week Chinese archery art program to intervention group and an extracurricular activity-based control group. One group completed the intervention with 12 weeks, from October 2021 to January 2022. During the treatment period at the baseline, 6^{th}, and 12^{th} week time-piont, the data of relevant primary and secondary outcomes collected from intervention group and control group according to study schedule. The third step, we conducted a 6-week follow-up end of treatment period to explore how do the benefit from Chinese archery art program last. Detail presented in Table 6.

Table 6, The study period and point of measurement

pre-test baseline repeated test 18th week test

1st -2nd week of Sep 2021	2nd week of Oct 2021	4th week of Nov 2021	2nd week of Jan 2022	6 weeks	4th week of Feb 2022

3.4 Study population

Because the match stench is necessary to pull the archery string during Chinese archery art program and according to the character of core EFs which develop early life during the whole life. We chose those students in 4th grade as our population. This population is a good balance between the age and necessity during real intervention. All samples recruited from total 328 students of 6 classes of 4th grade in the Songjiang Experimental School Affiliated to Shanghai University of International Business and Economic (SUIBE) which locate in Songjiang District, Shanghai City, China. All subjects screened according to inclusion and exclusion criteria in this study.

3.5 Sample Size and Sampling Technique

3.5.1 Sample size calculation

G*Power 3.1 was used to calculate sample size with effect size f=0.3 [167, 185]; α=0.05; ß=0.2 (Power=0.8) 1:1 in each group, 62 total participants met the requirement of this study. 31 Participants per group are required. With 15% inflation for loss in each group, there needed 36 participants in each group. Eventually, we recruited 68 eligible participants and relocated in intervention group (n=34) and control group (n=34), respectively.

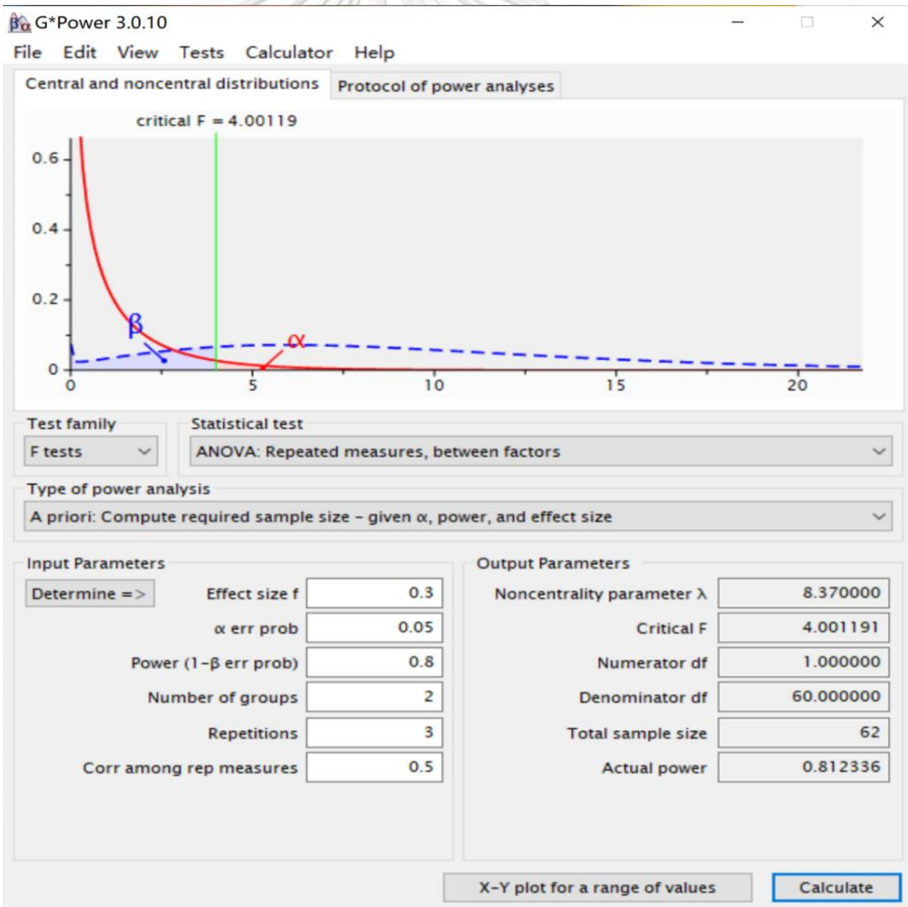


Figure 3, Sample size calculation using G-power3.0.10

3.5.2 Sampling Technique

Songjiang Experimental School Affiliated to SUIBE was purposively sampled as the target elementary school. Considering the balance core EFs characteristics of age and the physical requirements of Chinese archery art program, the 4th grade students was as sampling target. All samples recruited from total 328 students in 6 classes in Songjiang Experimental School Affiliated to SUIBE which locate in Songjiang District, Shanghai City, China. All 6 classes of 4th grade purposively allocated to intervention unit or control unit. All participants recruited through notice. The study plan and parent's consent form were taken to parents or guardian by the students and filled them out. The children whose parents have signed the consent are regarded as potential participants. Because coach is professional to screen the inclusive participants to Chinese Artery arts training and who was response for all interventional activities, so the students in the intervention group were inspected by the intervention coach to decide whether to participate and give the reasons. For the students in the control group, those head teachers known well and was responsible for the daily situation of students in school, therefore those head teacher finally decided whether to participate and give the reasons. The screening form followed this flow chart of figure 4.

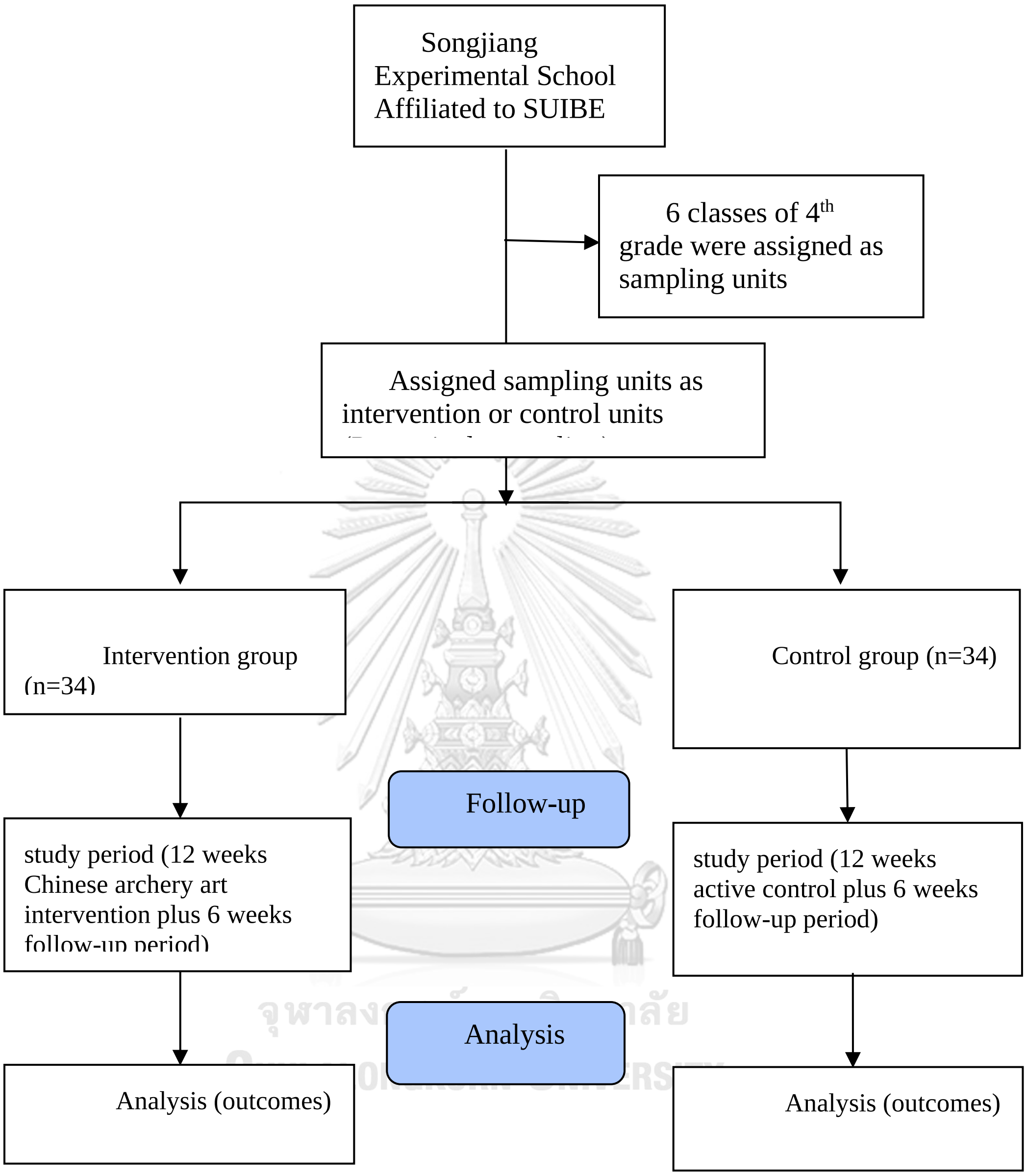


Figure 4, The flow chart of process of recruitment

3.5.3 Inclusion and Exclusion Criteria

Potential participants were initially recruited from a appointed public elementary school in Songjiang District, Shanghai, China.

All participants were then included only if they matched all of the inclusion criteria as follows：

1) Children are enrolled from 4th grades (10-11 years old).
2) Normal physical fitness and health condition
3) Parents can fill the CBCL questionnaire

There are also exclusion criteria that will be applied to screen those who qualify on the inclusive criteria. The exclusion criteria as follow：

1) Intellectual disability, brain injury and other serious disease (medical certificate).
2) Obesity (physical test from school).
3) Attendance rate less 80% (attendance record from coach or research assistants)
4) Decline to participate.

Those research assistants were responsible for screening process to recruit potential research participants with the suggestions and support of head teachers.

3.6 Measurement Tools/ Instruments

Demographic data were collected from the physical fitness assessment database in school for the current semester. The aerobic fitness data was measured during P.E class within the week by P.E teachers and researcher assistants before intervention. The executive function performance was assessed in the quiet computer classroom more than 30 minutes after lunch. All subjects were led to the designated computer classrooms and were instructed to complete three computer-based neuropsychological paradigms: Fish flanker task, N-Back task, and DCCS (Border version) in sequence.

3.6.1.1 Eriksen Flanker task for inhibition control

In cognitive psychology, the Eriksen Flanker task is a set of response inhibition tests that was first published since 1974 and most frequently use to assess the inhibition control that are inappropriate in a particular context. In a typical flanker task, participants are required to identify a centrally presented directional stimulus. These stimuli may be congruent stimuli (>>>>>), or incongruent stimuli (>><>>). Participants are required to ignore the distracters and respond only to the centrally targeted stimuli. Inhibitory ability is assessed by comparing performance on trials.

In this study, *Fish Flanker Task* was used to assess the inhibition control of participants. The stimuli and procedure are similar to those previously[261]. During the trial, participants had a seat in front a computer monitor and two response buttons ("A" and "L"). Participants were required to complete a series of trials in that they were shown a stimulus comprising a horizontal row of five fish. One each trial, they were required to give response as soon as possible when facing direction of the center fish will be made sure. If the center fish is facing left, the left button “A” pressed with left finger, or the right button “L” with right finger if the center fish is facing right.

Two trial types are presented: congruent and incongruent. On congruent trials, all five fish in the stimulus array pointed in the same direction (e.g., <<<<< or >>>>>). On incongruent trials, the four distracting fish pointed in the opposite direction of the central target fish (e.g., <<><< or >><>>). The target fish is presented on the display just like the picture illustrated in the lower Figure *5*.

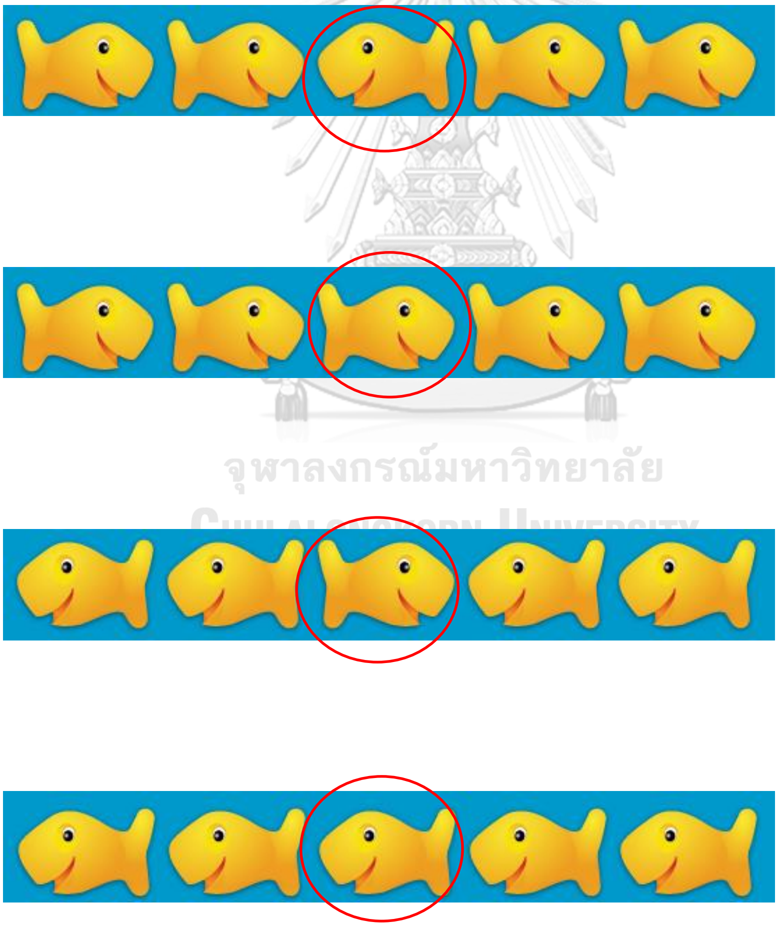


Figure 5, The congruent and incongruent during Fish Flanker Task

In terms of size, each individual fish stimulus will display 3 cm tall and is separate by 1 cm for visual angle of 1.72◦. the target fish was always located in the same location on every trial. The stimuli is presented until a response is made or more than 1500 ms elapsed for each trial. A new trial is presented after an interval ("+" with blue background) of 500 ms.

If a response is made less than 200 ms after appearance of the target (an anticipatory error), the message "Early response" displayed. If subject cannot make response within 1500 ms (an inattentive error), a message "Too slow" presented. If a response is made by pressing the incorrect button (an accuracy error), "Wrong response" presented.

Regarding the assessment of a single bout of Chinese archery art program, before each formal trial, each block of practice trials (12 congruent trials and 12 incongruent trials) was conducted to ensure sufficient accuracy for all participants. Formal trials consisted of 48 congruent trials and 48 incongruent trials, respectively, followed by 1-minute intervals between 2 block trials. All trial types were randomly presented with equal probability.

Considering the assessment of chronic Chinese archery art program, 20 practice trials were conducted to ensure that participants achieved a sufficient level of accuracy during chronic intervention assessment. After one practice trial block, one more practice trial block will be offered after pressing the "F" button if subjects feel unskilled enough. After practice, participants will be required to complete 2 experimental trial blocks with total 152 trials (76 congruent and 76 incongruent trials), those trial types will be randomly presented with equal probability. there is a one-minute interval between 2 blocks.

Analysis: The accuracy percentage and reaction times of correct responses on both congruent and incongruent trials were identified as main evaluation index of inhibitory control performance.

3.6.1.2 N-Back Task Paradigm for Working Memory

The variants of n-back procedure have been widely investigated the performance of human's working memory [134]. During the task, the participants would be required to control a serious of stimuli and correct respond with. Whenever a stimulus is presented which is the same as the one presented n trials as soon as possible, usually n can be 0,1,2 or 3. Monitoring, updating, and manipulation of remembered information are required during the on-line task, therefore it is assumed to place demands on a number of key processes within working memory. The many different types of stimuli have been put into practice with various input modalities because of demanding on different processing systems. Different loads also have been used from 0 to 3-back depending on the target population.

The N-Back task paradigm in this study is programmed in E-Prime Software (Psychology Software Tools, Pittsburgh, PA). The 1 and 2-Back task paradigms would be used because of the younger target population.

Procedure : subjects would be required to monitor the 1- and 2-back task while seat 1meter from a computer screen. Six different shapes of various color (i.e.

green circle, red lune, blue cross, purple star, brown square and orange triangle) would be presented focally in a appointed manner. Two different conditions (n back, n=1,2) would be performed, with each condition would be present in a fixed order for all subjects.

During the task, subjects would be demonstrated to make a response as soon and accurate as possible with a appointed button L when a correctly matching target appear same as 1 or 2 trials back. The subjects are required to press A button when any of the other remaining five shapes present. A button press would mean same matching target as 1 or 2 trials back, and a L button press means that shape presented is not same as 1 or 2 trials back. The targets would be presented on the display just like the picture illustrated in the lower Figure (*6*) and Figure (*7*).

Considering the assessment of a single bout Chinese archery art program, formal trials consisted of 2 condition block trials (24 1-back trials and 24 2-back trials), followed by a 1-minute interval between 2 block trials. Before each formal trial, each block of training trials (10 1-back trials and ten 2-back trials) was conducted to ensure sufficient accuracy for all participants during the formal experiment.

Compared with the assessment of a single bout Chinese archery art program, 30 practice trials conducted to confirm all subjects achieve a sufficient level of accuracy during chronic intervention assessment. Each trial was presented for 2900 ms, then a interval of 3000 ms with a fixed inter-stimulus would be presented on a black background. Figure of shapes would be height of 3 cm. Each condition was presented in one block containing 72 trials with 24 targets (25% probability) for the 1-

and 2-back conditions.

Analysis: The hit rate, reaction time, correct rejections, false alarm rate would be identified as main metrics of working memory performance. The hit rate is the probability of correctly identifying a target, correct rejections (CR) is the probability of correctly identifying a non-target, false alarm rate (FA) is the probability of incorrectly identifying a non-target as a target.

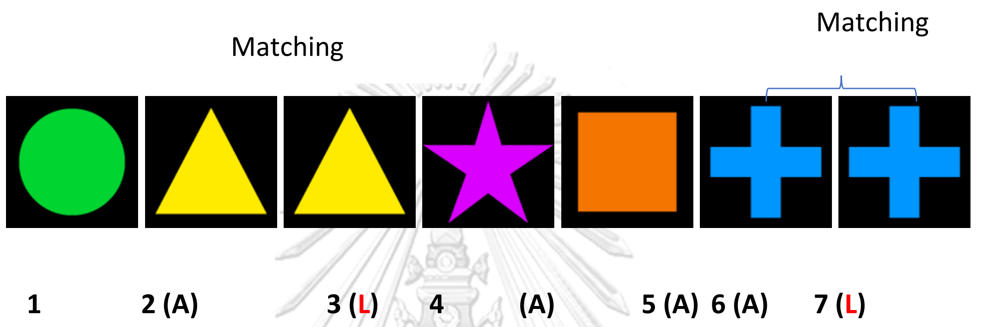


Figure 6, The illustration of 1-back of task

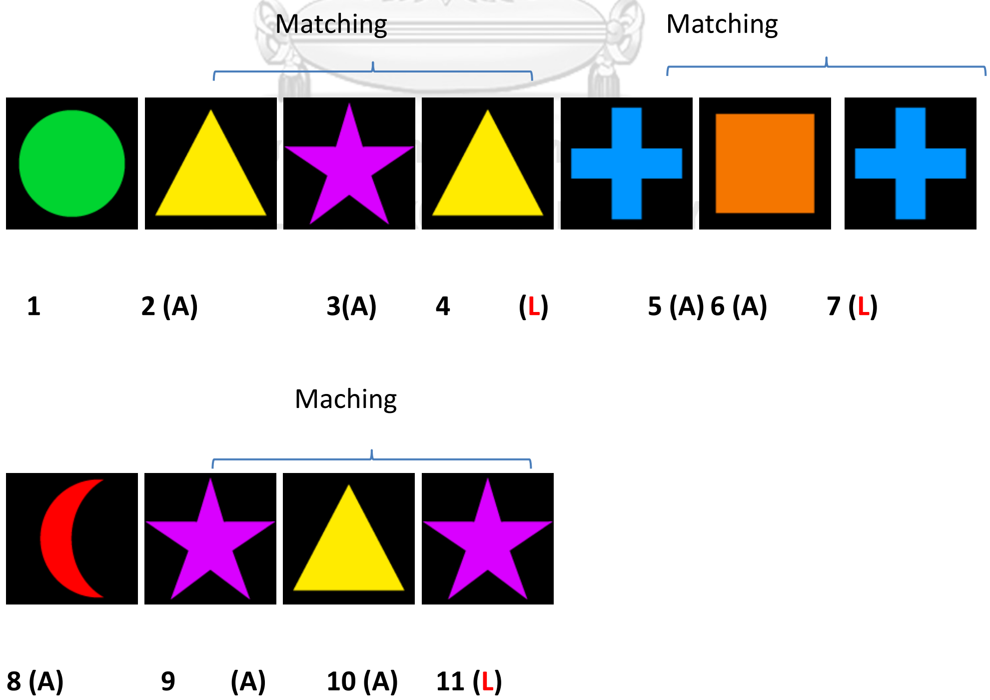


Figure 7, The illustration of 2-back of task

3.6.1.3 The Dimensional Change Card Sort (DCCS) Task for Cognitive Flexibility

The DCCS called also Shape and Color Task which is widely used to investigate the cognitive flexibility across the lifespan. It is advantageable to measure children with simplicity. In the standard version of this task, the participants would show usually two target card (e.g., a blue rabbit and a red boat) and would be required to sort a series of bivalent test cards (e.g., red rabbits and blue boats) according to one dimension (e.g., color).

This task includes pre-switch phase (e.g., color) (figure 3-8) and post-switch phase (e.g., shape) (figure 3-9). it is suitable to measure the executive function of healthy preschool children. The more challenging version of the DCCS have been used to measure the older children even adults across the lifespan successfully, such as the border version (figure 3-10). In this version, if the black border test card display, the participants have to play the color game, otherwise the shape game has to conduct. During the task, switches are presented randomly (e.g., on 25 % of trials) and ensure that the same test card cannot display on the screen sequentially. Response would be trigged via visual stimuli, and participants may be instructed to respond as soon as possible.

In this study, the border version of DCCS would be used to measure the cognitive flexibility of participants according to their age.

Materials: the task would include the Pre-switch Phase (colour game), Post-switch Phase (shape game) and Border Phase (mixed game with the direction of border). subjects would be required to pass the post-switch phase to the mixed phase in turn. In this task, subjects would be completed 2 blocks of homogeneous trials (either colour or shape) and heterogeneous trials (mixed colour and shape with the cue by direction of bordered test cards). The stimuli were 5 cm tall and 9 cm wide cards presented focally for 3000 milliseconds on a black background (or until a response was given) with a fixed intertrial interval of 2500 milliseconds.

Procedure: The whole task would include the standard version of the DCCS and the border version. The color game and shape game would be as the pre-switch and post-switch task dimension respectively, this border version would be chosen as mixed phase.

Considering the assessment of a single bout of Chinese archery art program, all subjects should try to give fast and accurate responses when visual stimuli are presented on the screen. For smooth operation during the trials, each phase of practice trials (eight shape trials, eight color trials, and 12 border trials) was given. In turn, participants completed three blocks of heterogeneous trials (16 color trials, 16 shape trials, and 32 border trials). Each block test followed a 1-minute interval. During the trials, stimuli switches were presented randomly, ensuring that the same target card could not be displayed on the screen sequentially.

Regarding the assessment of chronic Chinese archery art program period, the detail if the task should be demonstrated on all participants that and ensure all smooth operation during the trials. Each phase of 50 (15 colour trials, 15 shape trials and 20 border trials) practice trials would be given. Moreover, proceed immediately to the task. Participants would complete 3 blocks of 60 (60 colour trials, 60 shape trials and 72 border trials) heterogeneous trials in turn, 60 seconds interval would be given after 1 block test[27].

Analysis: The accuracy percentage and reaction times of correct responses on shape trails, colour trails and border trials would be identified as metrics of flexible cognitive performance.

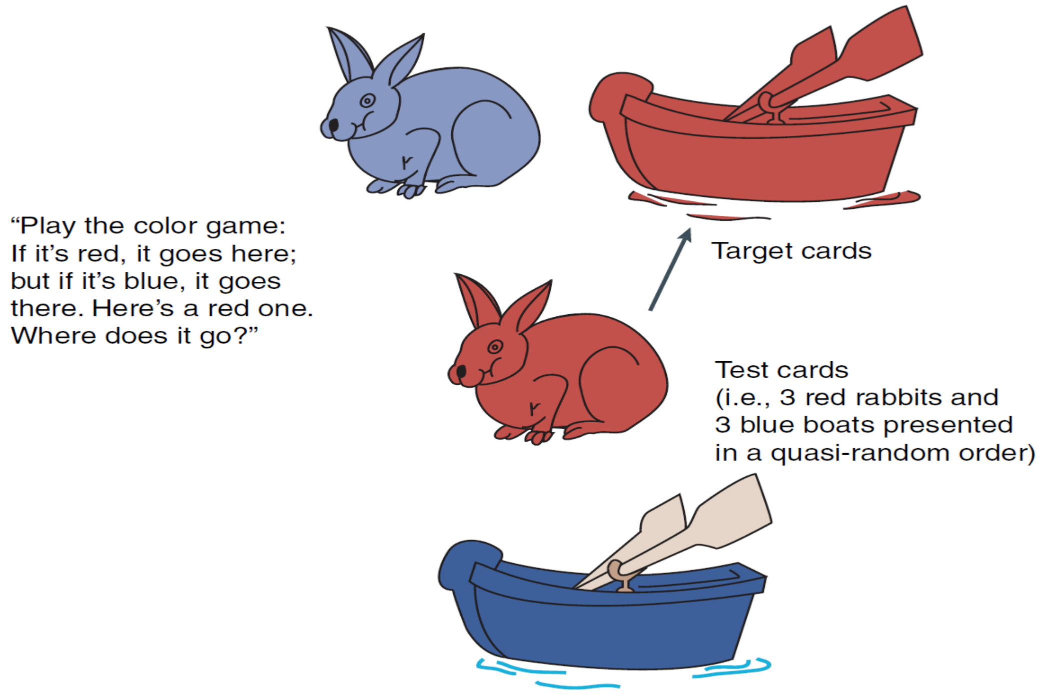


Figure 8, The illustration of sample target cards and test cards used during pre-switch phase (citation)

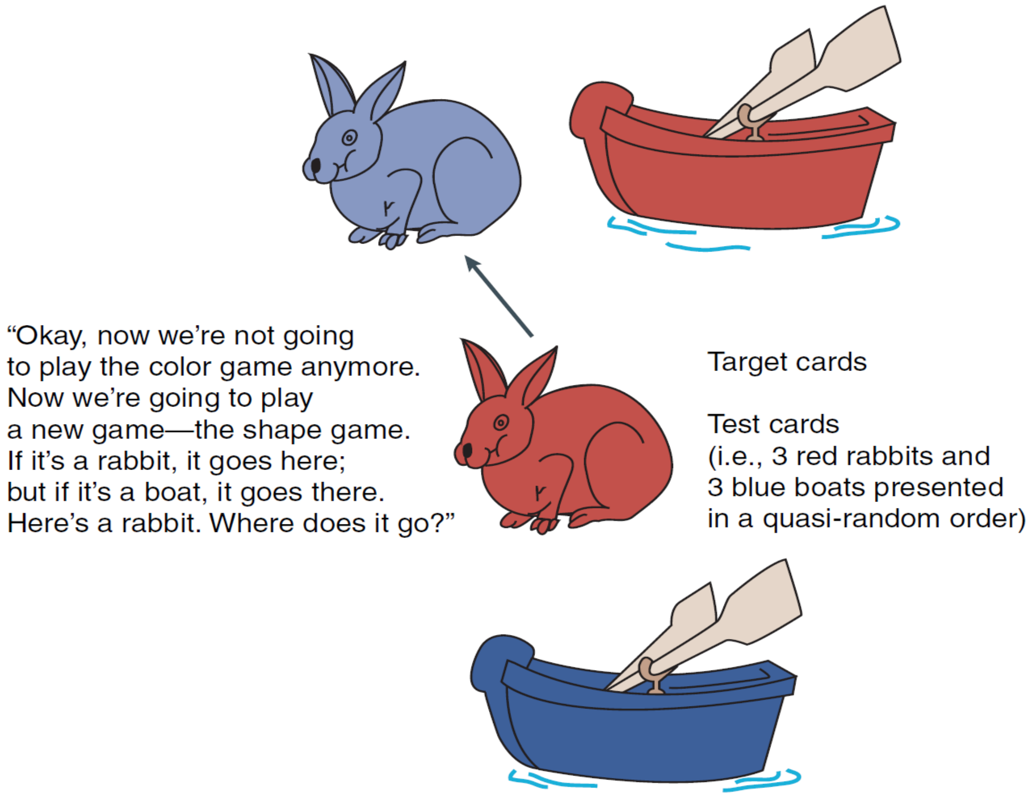


Figure 9, The illustration of sample target cards and test cards used during post-switch phase (citation)

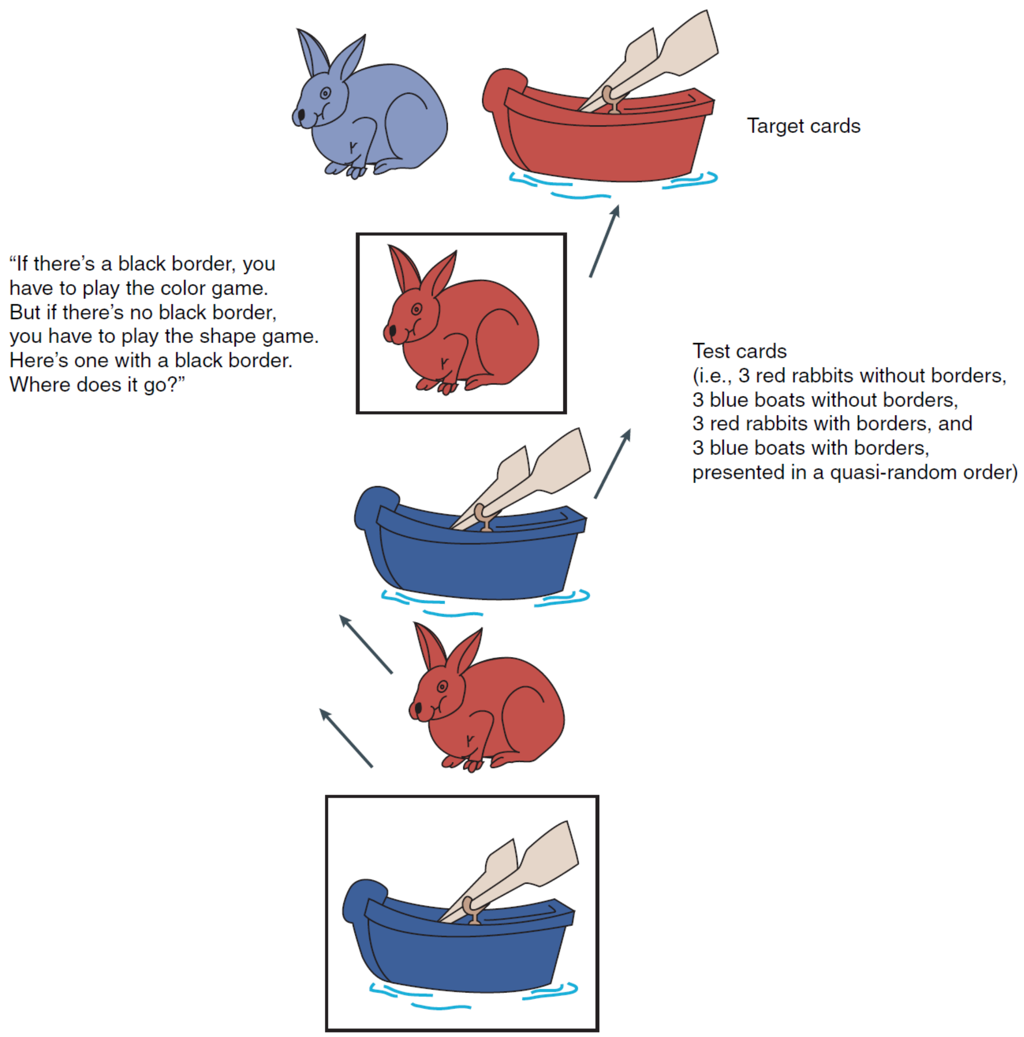


Figure 10, The illustration of sample target cards and test cards used during border-switch phase (citation)

3.6.2 ActiGraph GT3X+ Accelerometer for Physical Activity and Sedentary behaviour

ActiGraph GT3X+ Accelerometer is widely used to measure the children's physical activity and sedentary behaviour and the reliability and validity was reported. [262, 263]. Physical activity level and sedentary behaviour measurement using the three-axis ActiGraph GT3X (Actigraph LLC, Pensacola, FL), the tool measures the coronal axis (x-axis, anteroposterior), sagittal axis (y-axis, left-right direction) and vertical Acceleration in three directions of the axis (z axis, up and down direction). According to the selected intensity, the electrical signal is then converted into a Counts value by the electrical signal for output. The point classifies the Counts value to obtain the daily Sedentary behaviour (SB), light physical activity (LPA), moderate-vigogous intensity (Moderate physical activity, MPA), Vigorous physical activity (VPA) and other accumulation time of different intensity activities.

Total physical activity (TPA) equals to the sum of LPA, MVPA and VPA. In this study, the subjects would be objectively measured the level of daily sedentary behavior and physical activity with consecutive a 7-day GT3X+ accelerometer sensors. the period of 7 days must be included 5 working days and 2 weekend days. Acceleration sensor would be fixed to the belt on the top and placed on the upper part of the right ridge (see Figure *11*).

Figure 11, The illustration of GT3X+ accelerometer sensor wearing

The research assistants illustrated the procedure of the testing content to parents of the subjects in detail before formal measurement. And guide the parents how to wear and remove the sensors in case of emergency during of the course of testing, the instruments must be removed before for bathing and swimming. parents of subjects would be the supervisor and confirm the instruments operate correctly. All instruments would be taken back on the 8^{th} day after the 7-day testing. The data would be acquired with Actilife (Version 6.11.5). the survey was conducted with the consent of the parents if the data does not meet the inclusion criteria or is not incomplete.

Due to the age of subjects, the parameter settings in this study mainly include the following:

1) the decision of epoch time of sensor.

2) define a non-wear time period, daily

3) definition of a valid day

4) Minimum number of wear days to be met the analysis of inclusion criteria

5) the choice of different intensity division points.

The specific settings are shown in Table *7*.

Table 7, Parameter setting of ActiGraph GT3X^{+} for physical activity

Number	Content parameters	Parameter setting
1	Test instrument	ActiGraph GT3X^{+}
2	Epoch time	5 second
3	Define a non-wear time period	600 seconds
4	Definition of a valid day	>=600 min
5	Minimum number of wear days to be included in analyses	At least 3 days (includes 1 weekend and 2 study days)
6	VPA	Counts>=4012/min
	MVPA	4011/min=>Counts>=2296/min
	LPA	2295/min =>Counts>=101/min
	Sedentary behaviors	Counts=<100/min

Statistical inclusion criteria about sedentary behavior and physical activity levels:

1) Working day sedentary behavior and physical activity level: Monday to Friday, subjects with at least two days of valid data would be included in the statistical analysis of different levels of physical activity

2) Weekday sedentary behavior and physical activity levels: subjects with valid data at least one day on Saturday or Sunday would be included in the statistical analysis

3) A week sedentary behavior and physical activity level: at least 2 working days + 1 weekend day valid data would be included in the statistical analysis

4) the sedentary behavior and the level of physical activity presented in the form of specific values (%) of the mean daily accumulation time of SB, LPA, MVPA, VPA.

3.6.3 20-Meter Shuttle Run Test for Aerobic Fitness

Multistage 20-Meter Shuttle Run test would be used to assesses the Children's aerobic fitness [264]. The reliability and validity of test this has been proved [265, 266]

Subjects have to run back and forth on a 20-m course following the CD pace and touching the determinant lines is required very round. At the same time, a sound signal is emitted from a CD. Running speed would be increased by 0.5 km/h each minute according to frequency of the CD sound signals and starting speed would be settled at 8.5 km/h. The test would be stopped when the participants cannot reach the end lines concurrent with the audio signals on 2 consecutive occasions, or when the participants give up because of fatigue. The last announced stage number or the equivalent maximal aerobic fitness would be used as the VO_{2max} index. The last announced stage number or the equivalent maximal aerobic fitness would be used as the VO_{2max} index.

For children, VO_{2max} (Y,ml/kg min) was predicted from the maximal aerobic shuttle running speed (X_1, km/h) and age (X_2, year as the lower rounded integer), formula is: $Y=31.025+3.238 X_1-3.248 X_2 +0.1536 X_1 X_2$

3.6.4 Achenbach Child Behaviour Checklist (CBCL) for Anxiety/depression

CBCL (Achenbach, 2001) has been worked with a wide usage of research and clinic long history. The latest version of the CBCL has two separate forms, one is suitable to assess those children aged from 1.5 to 5 years old and another one is prefer children aged from 6 to 18 years old[267].

And there are different wide use of version CBCL in the world. The CBCL was introduced and adapted for Chinese children by Shanghai mental health center in 1992. The good reliability and validity were reported. For the cutoff of total problem, a score of 35 was used as a cutoff [268]. In this study would choose the anxiety/depression syndromes to assess the emotional problems. The cutoff of anxiety/depression syndrome in Chinese children is 8 for male and 7.3 for female respectively.

The parent's version would be used in this study considering the children's age and parents would complete the scale. Parents would rate their child true condition on each item has been of them in the recent 6 months. Responses are rated on Not True, Sometimes/Somewhat True; Very Often True. We selected anxiety/depression scales to evaluate the anxiety/depression of participants.

3.6.5 The Pittsburgh Sleep Quality Index (PSQI) for Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI) is one of the most widely used standardized measures to assess subjective sleep quality[269]. The PSQI is reliable and validated to assess the sleep quality of normal children and adolescents [269-271]. This tool was used to assess sleep quality in the Chinese normal children. Overall, the Chinese version of the PSQI had a considerable test-retest reliability over a 14- to 21-day interval with a coefficient of .85 for all subjects [272].It would cover subjective sleep quality, sleep latency, sleep duration, sleep efficiency, sleep disturbance, use of hypnotic medications and daytime dysfunction assessment in the recent week to month.

Scoring instructions: 19 self-rated questions are contained in this PSQI scale. seven “component” scores combine all 19 items, each of which has a range of 0-3 points. In all cases, a score of “0” means no difficulty, while a score of “3” means severe difficulty. The seven component scores are then added to one “global” score with range of 0-21 point. “0” means no difficulty and “21” means severe difficulty in all areas. A global PSQI score above 5 indicates poor sleep [270].

3.6.6 The Rosenberg self-esteem scale (RSES) for self-esteem

RSES is a self-report instrument for assessing individual self-esteem and it is regarded as a reliable and valid quantitative tool for self-esteem assessment [273]. RSES is widely used to assess the children subpopulation for self-esteem [274]. The Chinese version indicated a good reliability and validity in diverse children in Children after confirmatory factor analyses[274]. Compared with previous studies which includes separate self-confidence and self-depreciation factors, RSES components only single common factor. It is a 10-items scale. The pattern of functioning of the items was examined with respect to their content, and observations are offered with implications for validating and developing future personality instruments.

A 10-item scale includes both positive and negative feelings about the self. A 10 items scale measures global self-worth by self-report assessment. All 10 items would be answered with a 4-point Likert-type scale format (strongly agree, agree, disagree, strongly disagree). For items NO.1, 2, 4, 6, 7 the scores are calculated as follow that rule *(strongly agree=3, agree=2, disagree=1, strongly disagree=0);* For items NO.3, 5, 8, 9, 10 the scores are calculated as follow that rule *(strongly agree=0, agree=1, disagree=2, strongly disagree=3).* The global scores range from 0-30; the scores range from 15 to 25 is normal. Less 15 is low self-esteem. More than 25 is high self-esteem.

3.7 Data Collection

All physical testing of participants was carried out study setting area. Those relevant questionnaire and tools were offered to measure:

1) The demographics and population characteristics

2) Core Executive function performance

3) Physical activity

4) Aerobic fitness

5) Self-esteem

6) Sleep quality

7) Anxiety/depression

Data collection period in this study was processed 20 weeks which lasts from September 2021 to February 2022. The whole process was consisted of 3 steps as follows. researcher teacher and assistants were responsible for the whole data collection period. *Research assistants incorporates 7 students of SUIBE who are received standard training to conduct or support the relevant test.*

3.7.1 Preparation and database collection

All permission obtained from related government officer and caregivers of participants. All necessary tools and equipment were confirmed before formal database collection. The tools were same if those are repeated measurement. Database collection was conducted by researcher and assistants from the study setting area. The cooperation and support are vital to guarantee smooth progress because of the minor population in this study. We worked with the school to obtain the support and cooperation from parents during preparation period in written form which elaborate on the details and significance of this research to parents.

The socio-demographics scale collected with CBCL questionnaire by caregivers at baseline test; At the same period, the instructions of ActiGraph GT3X+ accelerometer was demonstrated to all caregivers. And all confirmations were required. All participants were requested to wear ActiGraph GT3X+ accelerometer for a consecutive 7-day duration, the PA level and SB level during this week were measured with this process; The aerobic fitness test was completed during P.E class within week by P.E teachers and researcher assistants at pre-test; The core EF performance were unified measured in the quiet computer classroom.

Data collection time-point include baseline, 6th week, 12th week, and 18th week. All participants were measured at each test. And this test spent about 50-60 minutes for chronic intervention each time; The PSQI scale was used to measure the sleep quality of participants by themselves before every core EF measurement during treatment period. This test spent about 5 minutes each time; The RSES scale was used to measure the self-esteem of participants by themselves before every core EF measurement during treatment period. This test spent about 3 minutes each time; CBCL was used to measure the anxiety/depression of participants by parents（either mother or father during the whole study period on baseline, 12th week, and 18th week). This test spent 10-20 minutes each time.

3.7.2 Implementation

3.7.2.1 Chinese archery art program vs extracurricular activities

1) Intervention group

All 34 participants in intervention group recruited from 4th Grade at Songjiang Experimental School Affiliated to SUIBE. And then assigned to Chinese archery art program after class. During the 2021-2022 academic year, Chinese archery art program substituted extracurricular activities curriculum as an extra sport project (4 classes per week except of Thursday, 45 minutes per class). This project contains different content over time. Interventional training program was instructed by same professional coaches who are experienced in instructing adult and children with diverse abilities and background. The material of training includes theory knowledge (origin, history, cultural feature etc,.), primary techniques (standing posture, set arrow, push bow, pull off the string, lift bow, draw a full bow, collimation, shot, closing form etc,.), and mind regulation training (deep-breathing techniques, introspection, relaxation). The pictures show the primary techniques (Figure 12). The training court isolated is settled to intervention group and nobody except interventional subjects permit entrance during training, to prevent contamination between group and control group.

Basic Etiquette

Primary Techniques

Figure 12, The illustration of the primary techniques of Chinese archery art program

The techniques of Chinese archery art program were instructed to children of another class including theory knowledge (origin, history, cultural feature etc,.), primary techniques (standing posture, set arrow, push bow, pull off the string, lift bow, draw a full bow, collimation, shot, closing form et al.), mind regulation training (mediation, deep-breathing techniques, introspection), and basic etiquette (pre-etiquette, post-etiquette, etiquette to target). All content was instructed and completed within 2 weeks, and students in the intervention group are required to master basic proficiency. The coach evaluated whether the student has mastered the technical movements that have been taught through his own experience and teaching requirements standards. If students cannot master it in time, the coach given special intensive training until reaching the standard. Then forms presented with a series of traditional etiquettes and techniques applied in an artistic arrangement of program. And the forms also be emphasized during instruction. In addition, more cognitively engaging was underlined during classes, such as deep-breathing relaxation techniques, self-regulation with internal dialogue skill, concentration, perseverance, keeping calm and patient, emphasis on the process of competition, introspection. Finally, all of these of techniques were instructed in an condition characterized by respect, discipline, and self-regulation. The content and time distribution will follow the syllabus (table-8).

Table 8, Syllabus of the Chinese archery art program during interventional group

Content	Activities	Intervention goals	Duration
theory knowledge	The instructor will be delivered content in the class	Understand the history and cultural feature of Chinese archery art program	40-45 min first session
basic etiquette	The instructor will be delivered content in the class; basic etiquette content includes pre-etiquette, post-etiquette, etiquette to target	Improve the cultural conception and self-regulation	20 min training with the first session, then it is required during practice.
primary techniques	primary techniques include all required content such as standing posture, set arrow, push bow, pull off the string, lift bow, draw a full bow, collimation, shot, closing form etc. will be instructed by coach	Improve the physical fitness and self-regulation, flexibility and mental health level	30-40 min/ session
mind regulation training	Those content includes mediation, deep-breathing techniques, introspection and will be instructed by coach	Improve the self-regulation, flexibility and	3-5 min/session
Resistance and aerobic exercise	Running, jump, resistance exercise which will be instructed by coach		5 min / session

At start of Chinese archery art program class, students would line up and have an etiquette ceremony. Later, few minutes meditation is necessary section of class. students were instructed to focus on correct breathing. And then, some techniques were imparted to students in a class. Generally, students should be followed the principle that the students should learn to ask himself/herself with internal dialogue and correct their position, behaviour or thoughts during the practice of all techniques. So, students should regulate mind behaviours by themselves in accordance with the expectation of the real situation. The preference of process than scores during competition was always emphasized by instructor during the class. at the conclusion of each class, students lined up and bowed to each other's and instructor as the class were dismissed.

The Chinese archery art program is a sport with potential danger, so the safety is first during practice. To prevent the injury to children, all children except of interventional participants was prohibited entry into the training court unless the permission from the coach. And the rule of safety should be obeyed all training time. Warm-up activities were conducted by coach before every formal training.

All 34 participants in control goup in this study recruited from 4th Grade at Songjiang Experimental School Affiliated to SUIBE. And then received to assign to control group. And this group received extracurricular activities (4 classes per week, 45 minutes per class) after allocation. Extracurricular activities were the scheduled curriculum at Songjiang Experimental School Affiliated to SUIBE. This curriculum was incorporated sedentary behaviours at classroom sometimes, or activities outside (stretching, running, physical games et al.) and sports (football, basketball et al.). The curriculum provided the children with a diverse experience of exercise or active study method.

3.7.3 Evaluation of relevant variables between control group and intervention group and time-point

Fish flanker task, N-Back test, and DCCS (Border version) were investigated the inhibitory control, working memory, and cognitive flexibility of core executive function respectively. The quietly designated computer room offered to conduct those tests. Those tasks were conducted during the baseline, 6th week, 12th week and 18th week in this study. Researcher teachers and assistants ensured the smooth measurement. The participants would spend 50-60 minutes to complete a series of three executive function performance tests. All outcomes of variables were saved in database automatically.

The Rosenberg self-esteem scale (RSES) was used to evaluate self-esteem, those scales will be conducted before every core EF measurement by participants during the baseline test, 6th week, 12th week, 18th week. Researcher teachers and assistants ensured the smooth test. This test was conducted before relevant executive function measurement and spent about 5 minutes.

PSQI evaluated the sleep quality of participants in recent from 1 week to 1 month. Those scales were conducted before every core EF measurement by participants during the baseline, 6th week, 12th week and 18th week. Researcher teachers and assistants will ensure the smooth test. This test will be conducted before relevant executive function measurement and spent about 5-10 minutes.

Anxiety/depression were assessed with CBCL completed by parents. The CBCL questionnaire was completed by either father or mother during the whole 3 times period. Assistants distributed CBCL questionnaires enveloped to parents through children after every core executive function measurement and collected that within 7 days. Those assessments were conducted during the baseline test, 12th week, and 18th week.

ActiGraph GT3X+ accelerometer was used to measure the PA level and SB of participants during the baseline test. ActiGraph GT3X+ accelerometer instruction clearly explained to all participants and their patents by research assistants, after completing the questionnaires. All participants wear an ActiGraph GT3X+ accelerometer to measure their physical activity during daily time for a consecutive 7-day duration. After 7 days, the ActiGraph GT3X+ accelerometer was collected from the participants by the researchers. A week sedentary behavior and physical activity level: at least 2 working days + 1 weekend day valid data were included in the statistical analysis. If the data did not meet the requirements, we re-testted after obtaining the consent of the parents and students. Head teachers and assistants ensured the smooth test. The distribution was conducted in the classroom after illustration. Head teachers was responded to remind parents of subjects to supervise and confirmed the instruments correctly operate every morning during test period through Wechat messages.

20-m shuttle run test was used to evaluate the aerobic fitness of participants during the baseline test. All participants would have to run between 2 lines 20 m apart following audio signal pace from designated CD. The starting speed is 8.5 km/h. the speed was increased by 0.5 km/h per minute. The test was stopped when the participants cannot reach the end lines concurrent with the audio signals on 2 consecutive occasions, or when the participants give up because of fatigue. The last announced stage number or the equivalent maximal aerobic fitness was used as the $VO_{2\,max}$ index. For children, $VO_{2\,max}$ (Y, ml/kg min) was predicted from the maximal aerobic shuttle running speed (X_1, km/h) and age (X_2, year as the lower rounded integer), formula is: $Y=31.025+3.238\ X_1-3.248\ X_2 + 0.1536\ X_1\ X_2$. This test was conducted in the same week of core executive function measure by P.E teachers and research assistants. P.E teachers would be responsible for this test with the support of research assistants. Each participant would spend about 5-10 minutes during this test.

The detail procedure of data collection shows according to the flow diagram blow Figure *13*.

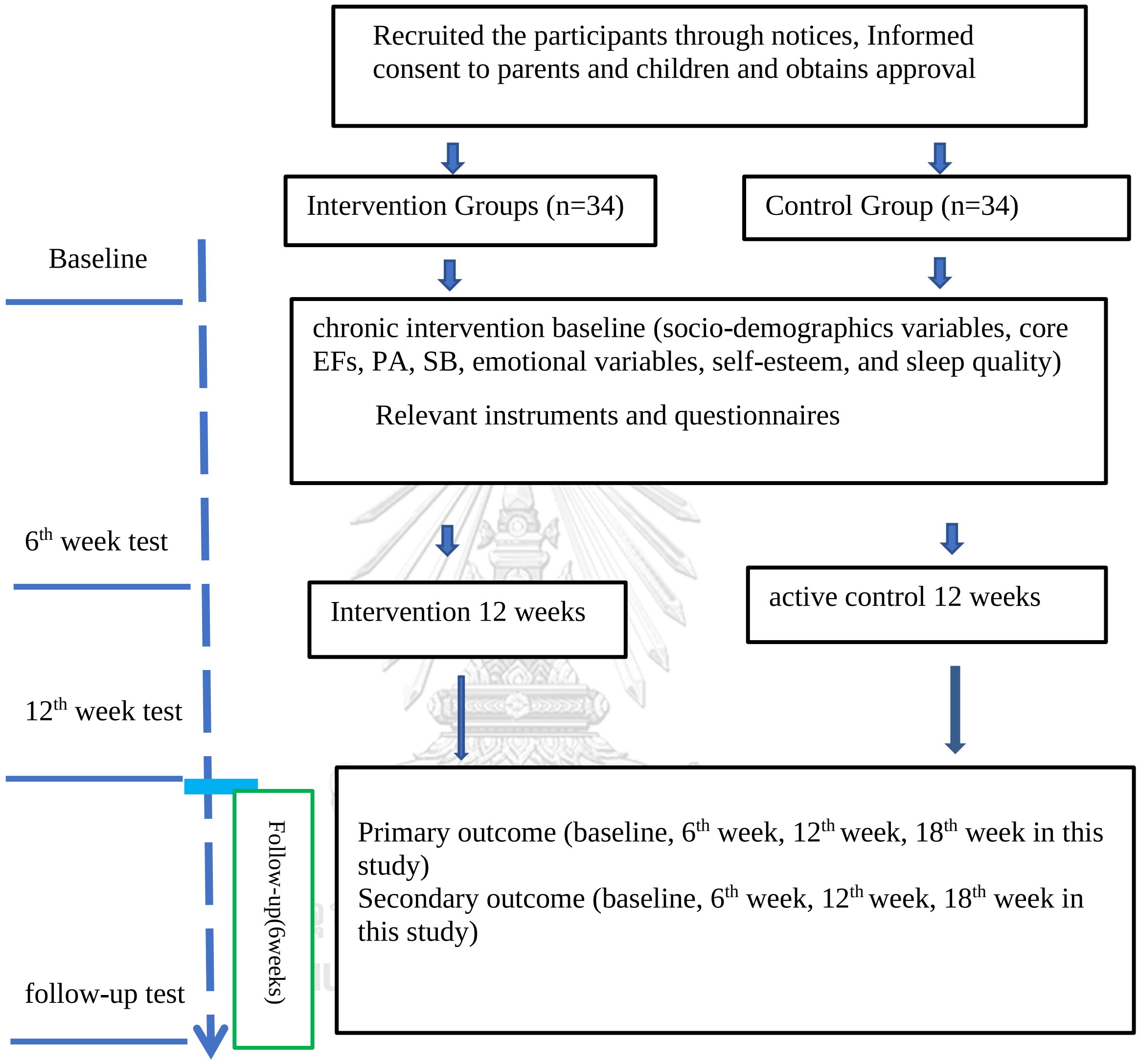


Figure 13, The procedure of data collection in this study

3.8 Data Analysis

Statistical significance was represented at a p value of 5%. All frequencies were expressed as total numbers (percentage). Averaged values were expressed as mean ± standard deviation (range).

Descriptive statistics was used to describe the socio-demographic characteristics between groups. Shapiro-Wilk test was used to assess normality distribution of core EFs, PA, aerobic fitness, sleep quality, and anxiety/depression at baseline data.

The independent-samples t-test was performed to examine the significant difference of mean of core EFs, self-esteem scores, sleep quality scores, and anxiety/depression scores at 18th week, respectively.

The paired-samples t-test was performed to determine the statically significant difference of mean of core EFs, self-esteem sleep quality scores, and anxiety/depression scores at 12th, 18th week, respectively.

A repeated measures ANOVA test was used to examine the statistically significant difference mean of core EFs, self-esteem scores, and sleep quality scores within and between group at baseline, 6th, 12th timepoint test.

The Friedman test was used to examine the statistically significant difference in median of sleep quality among the repeated test time points within and between group at baseline, 6th, 12th timepoint test.

Data collection and analysis with SPSS 22.0 version under licensed of Chulalongkorn university was used to analyze the descriptive and inferential statistics in the result of this study as describing in the following table below.

3.8.1 Descriptive statistics

The percentage (%), mean (x), standard deviation (SD), minimum, maximum, median was used to describe the socio-demographics data, PA, aerobic fitness, Core EF performance and the scores of self-esteem scores, anxiety/depression scores, and sleep quality scores. Detail presented in the following table 9.

Table 9, Descriptive Statistic Analysis

Variables	Measurement Scales	Statistical analysis
Socio-demographics: Gender Age,, Height, Weight, and BMI Family income, Education	Nominal Ratio Ordinal	Frequency and percentage mean, SD Frequency, percentage
Core EF performance	Interval	Descriptive statistics: mean, SD
PA	Interval	Descriptive statistics: mean, SD
Aerobic fitness	Interval	Descriptive statistics: mean, SD
Anxiety/depression score	Interval	Descriptive statistics: mean, SD
Score of self-esteem	Interval	Descriptive statistics: mean, SD
Score of sleep quality	Interval	Descriptive statistics: mean, SD

3.8.2 Inferential statistics

The inferential statistics was analyzed and assessed the effect of Chinese archery art program on the Core EF performance, anxiety/depression, self-esteem, sleep quality, PA, aerobic fitness in children of elementary school, in Shanghai. Detail presented in the following table 10.

Table 10, Inferential statistical analysis

Variables	Measurement scale	Statistical analysis	Objective
Socio-demographics: Gender, education family income Age, Height, weight, BMI, PA, and aerobic fitness	Nominal and ordinal Ratio	Chi-square test Independent -samples t-test	Tested homogeneity between two groups
core EFs, PA, aerobic fitness, anxiety/depression, self-esteem, and sleep quality at baseline	Interval	Shapiro-Wilk test	Assessed the normality of distribution between groups at baseline
Core EF performance at 18th week	Interval	Independent -samples t-test	Examined the statically significant difference in mean 18th week between groups
Core EF performance at 12th, 18th week	Interval	Paired samples T-test	Examined the statically significant difference in mean at 12th and 18th week each group, respectively
Depression/anxiety scores at baseline, 12th, and 18th week	Interval	Independent -samples t-test	Examined the statically significant mean difference at baseline, 12th week, and 18th week between groups, respectively
Depression/anxiety scores at baseline, 12th, and 18th week	Interval	Paired samples T-test	Examined the statically significant difference of median of baseline and 12th week, 12th and 18th week each group, respectively
Self-esteem scores 18th week	Interval	Independent -samples t-test	Examined the statically significant difference of mean at different test timepoint between groups
Self-esteem scores at 12th week and 18th week	Interval	Paired samples T-test	Examined the statically significant difference of mean at 12th and 18th week each group, respectively
Sleep quality scores at baseline, 6th week, 12th week and 18th week	Interval	Independent -samples t-test	Examined the statically significant difference of mean at different test timepoint between groups
Sleep quality scores at 12th week, and 18th week	Interval	Paired samples T-test	Examined the statically significant difference of mean at 12th and 18th week each group, respectively
Core EF performance at baseline, 6th, and 12th week	Interval	A repeated measures ANOVA test	Examined the statistically significant difference in mean within-between subjects.
Self-esteem scores at baseline, 6th, and 12th week	Interval	A repeated measures ANOVA test	Examined the statistically significant difference in mean within-between subjects.
Sleep quality scores at	Interval	A repeated	Examined the statistically significant

baseline, 6^{th}, 12^{th} week		measures ANOVA test	difference in mean within-between subjects.

3.9 Ethical Consideration

The Declaration of Helsinki conducted this study with the approval of the ethics review committee for research at Chulalongkorn University (Protocol NO. 073. 1/64). The purpose, benefits, data collection process, and ethical issues in this study confidentially informed to the ethical committee. The adequate obligatory information to all of participants and their caregivers also delivered by researcher directly. Written informed consent for data usage obtained from all caregivers of participants, informed consent for intervention also obtained from all caregivers of participants in the intervention. Permission of the study has obtained from the local school and educational authority.

CHAPTER 4: RESULTS

4.1 Baseline information on socio-demographic, aerobic fitness, and physical activity

All samples recruited from total 328 students of 6 classes of 4th grade in the Songjiang Experimental School Affiliated to Shanghai University of International Business and Economic (SUIBE) which locate in Songjiang District, Shanghai City, China. Eventually, 68 eligible subjects recruited according to inclusion and exclusion criteria in this study. 34 participants were allocated in Chinese archery art program group, the other 34 respondents in the control group. The data regarding sociodemographic variables, physical activity level in daily, aerobic fitness were shown in the table 11.

In this study, after the Shapiro-Wilk test, the data of age, weight, height, BMI, PA, and $Vo_{2\ max}$ in each group obeyed a normal distribution ($p_{int}>.05$, $p_{con}>.05$). Levene's Test for Equality of Variances ($p_{int}>.05$, $p_{con}>.05$). The independent sample T-test was used to analyze the difference in age, weight, height, BMI, PA, and $Vo_{2\ max}$ of subjects between the intervention group and the control group at baseline. Data detail displayed in the table 11.

Specifically, the results showed that the age in the intervention group (115.58±3.51) months was older than those of the control group (115.62±3.28) months, with a difference of .029 months (95% CI: -1.67-1.62). The independent sample t-test results suggest that there was no statistical difference (t=-.036, p=.97) in the age between groups. Data detail displayed in the table 11.

The results showed that the weight in the intervention group (41.26±11.53) kg were higher than those of the control group (42.53±9.93) kg, with a difference of -1.27 kg (95% CI: -6.48-3.94). The independent sample t-test results indicated that there was no statistical difference (t=-.48, p=.628) in the weight between groups. Data detail displayed in the table 11.

The results showed that the height in the intervention group (143.18±6.00) was higher than those of the control group (145.16±5.39) cm, with a difference of -1.98 cm, (95% CI: -4.74-.78). The independent sample t-test results suggest that there was no statistical difference (t=-1.694, p=.095) in the height between groups. Data detail displayed in the table 11.

The results showed that the BMI scores in the intervention group (19.93±4.53) were higher than those of the control group (19.36±3.20), with a difference of .57 (95% CI: -1.33-2.47). The independent sample t-test results suggest that there was no statistical difference (t=.60, p=.55) in the BMI scores between groups. Data detail displayed in the table 11.

The results showed that the sedentary behavior percentage in the intervention group (47.84±3.28) ml/min/kg was higher than those of the control group (47.09±2.93) ml/min/kg, with a difference of -.66 ml/min/kg, (95% CI: -1.90-.58). The independent sample t-test results indicated that there was no statistical difference (t=-1.06, p=.294) in $Vo_{2\ max}$ of subjects between groups. Data detail displayed in the table 11.

The results showed that the SB percentage in the intervention group (69.95±5.41) was higher than those of the control group (69.83±6.09), with a difference of .12 (95% CI: -3.47-3.70), but no statistical difference (t=.067, p=.947) in the sedentary behavior percentage between groups; The LPA percentage in the intervention group (24.45±4.60) was lower than those of the control group (24.91±4.93), with a difference of -.46 (95% CI: -3.43-2.51). The independent sample t-test results suggest that there was no statistical difference (t=-.314, p=.755) in the LPA percentage between groups; The MVPA percentage in the intervention group (3.60±.95) was higher than those of the control group (3.41±1.16), with a difference of .18 (95% CI: -.48-.84). The independent sample t-test results suggest that there was no statistical difference (t=.564, p=.576) in the MVPA percentage between groups; The VPA percentage in the intervention group (2.01±.43) was higher than those of the control group (1.85±.72), with a difference of .16 (95% CI: -.21-.52). The independent sample t-test results indicating that there was no statistical difference (t=.873, p=.388) in the VPA percentage between groups. Data detail displayed in the table 11.

In this study, Chi-Square Tests for gender was used to analyze the difference in gender, paternal education, maternal education, and monthly family incomes of subjects between the intervention group and the control group at baseline. Data detail displayed in the table 11.

Basically, the results showed that the gender in the intervention group with females 16 (47.1 %), and males 18 (52.9 %) was no statistical difference (χ^2=.06, p=.808) from those of the control group with females 17 (50.0 %), and males 17 (50.0 %). Data detail displayed in the table 11.

The paternal education in the intervention group, with 2 (5.9%) junior high schools, 7 (20.6 %) high schools, 11 (32.4%) college, 14 (41.2 %) undergraduate were no statistical difference (χ^2=1.15, p=.76) from those of the control group with 3 (8.8 %) junior high schools, 4 (11.8 %) high schools, 11 (32.4 %) college, 16 (47.1 %) undergraduate. Data detail displayed in the table 11.

The maternal education in the intervention group, with 2 (5.9 %) junior high schools, 6 (17.6 %) high schools, 15 (44.1 %) college, 10 (29.4 %) undergraduate, and 1(2.9%) postgraduate were no statistical difference (χ^2=1.42, p=.92) from those of the control group with 1 (2.9 %) elementary school, 2 (5.9 %) junior high schools, 5 (14.7%) high schools, 13 (38.2 %) college, 12 (35.3 %) undergraduate, and 1 (2.9 %) postgraduate. Data detail displayed in the table 11.

The family monthly income in the intervention group, with 2 subjects (5.9 %) less than 4000 RMB, 3 subjects (8.8 %) ranged from 4001 to 8000 RMB, 9 subjects (26.5 %) ranged from 8001 to 15000 RMB, and 20 subjects (58.8 %) more than 15000 RMB was no statistical difference (χ^2=2.10, p=.553) from those of the control group with 0 subjects (0%) less than 4000 RMB, 3 subjects (8.8 %) ranged from 4001 to 8000 RMB, 9 subjects (26.5 %) ranged from 8001 to 15000 RMB, and 22 subjects (64.7 %) more than 15000 RMB. Data detail displayed in the table 11.

Table 11, Participants' demographics variables, aerobic fitness, and physical activity

variables	Control group(n=34) M (SD)/n	Intervention group (n=34) M (SD)/n	p
N(male/female)	34(17 F/17 M)	34(16 F/18 M)	.81 [b]
Age (month)	115.62(3.28)	115.59(3.51)	.97 [a]
Height(cm)	145.16(5.39)	143.18(6.00)	.16 [a]
Weight(kg)	42.53(9.92)	41.26(11.53)	.63 [a]
BMI (kg/m^2)	19.36(3.20)	19.93(4.53)	.55 [a]
VO_{2Max} (ml/min/kg)	45.71(2.38)	45.06(2.74)	.29 [a]
PA(SB%)	69.83(6.09)	69.95(5.41)	.95 [a]
PA(LPA%)	24.91(4.93)	24.45(4.60)	.76 [a]
PA(MVPA%)	3.41(1.16)	3.60(.95)	.58 [a]
PA(VPA%)	1.85(.72)	2.01(.43)	.39 [a]
Family income/month	Less than 8000 RMB (3) More than 8000 RMB (31)	Less than 8000 RMB (5) More than 8000 RMB (29)	.55 [b]
Maternal education	Lower education (8) Higher education (26)	Lower education (8) Higher education (26)	.92 [b]
Paternal education	Lower education (7) Higher education (27)	Lower education (9) Higher education (25)	.76 [b]

Note. N present number of participants; BMI= Body mass index; Aerobic fitness is presented by assessment of VO_{2max}. PA=physical activity; SB=sedentary behaviors; LPA= light physical activity; MVPA= moderate-vigorous physical activity; VPA=vigorous physical activity. Lower education includes elementary and secondary education; higher education includes college, undergraduate, and postgraduate; a= Independent T-test, b= Chi square.

4.2 Core executive functions measures

4.2.1 Core executive functions performance measurement during treatment period

The accuracy percentage and reaction time of correct response on trials were identified as metrics of core executive functions performance. 68 participants were included intervention group (n=34) and control group (n=34), respectively. The data of core executive functions in each group obeyed a normal distribution with the Shapiro-Wilk test (P>0.05). A repeated measures ANOVA was used to determine the difference in the reaction time and accuracy percentage of relevant trials of in the study over time within and between groups.

4.2.1.1 The response reaction time of inhibition control in the congruent trials and incongruent trials

After Mauchly's Test of Sphericity, results in the congruent trials show that the interaction of group and time is not consistent with Mauchly's spherical assumption (p=.040). The interaction of group and time did not have a significant effect, $F_{(1.692,55.825)}=1.07$, p=.349, partial η^2=.031. Data detail presented in the table 12.

*Table 12, The effect of group, time, and group*time on reaction time of inhibition control performance over treatment period within and between subjects (n=68)*

Inhibition control	Source of Variance	F	p-value	Partial eta square(η^2)
	Time*group	$F_{(1.692,55.825)}=1.07$	.349	.031
Congruent trial	Group	$F_{(1, 33)}=2.09$	.157	.060
	Time	$F_{(1.641,54.141)}=5.678$	.005*	.147
	Time*group	$F_{(1.607,53.036)}=1.05$	.345	.031
Incongruent trial	Group	$F_{(1,33)}=2.052$	.161	.059
	Time	$F_{(1.706,56.300)}=2.46$	.102	.069

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

Considering the group, the main effect on the reaction time of congruent trials was not statistically significant, $F_{(1, 33)}$=2.09, p=.157, η^2=.060. The reaction time of congruent trials of the intervention group was -29.04 milliseconds, (95% CI: -59.60-1.51) faster than that of the control group. the difference was not statistically significant. The detail presented in the figure 14.

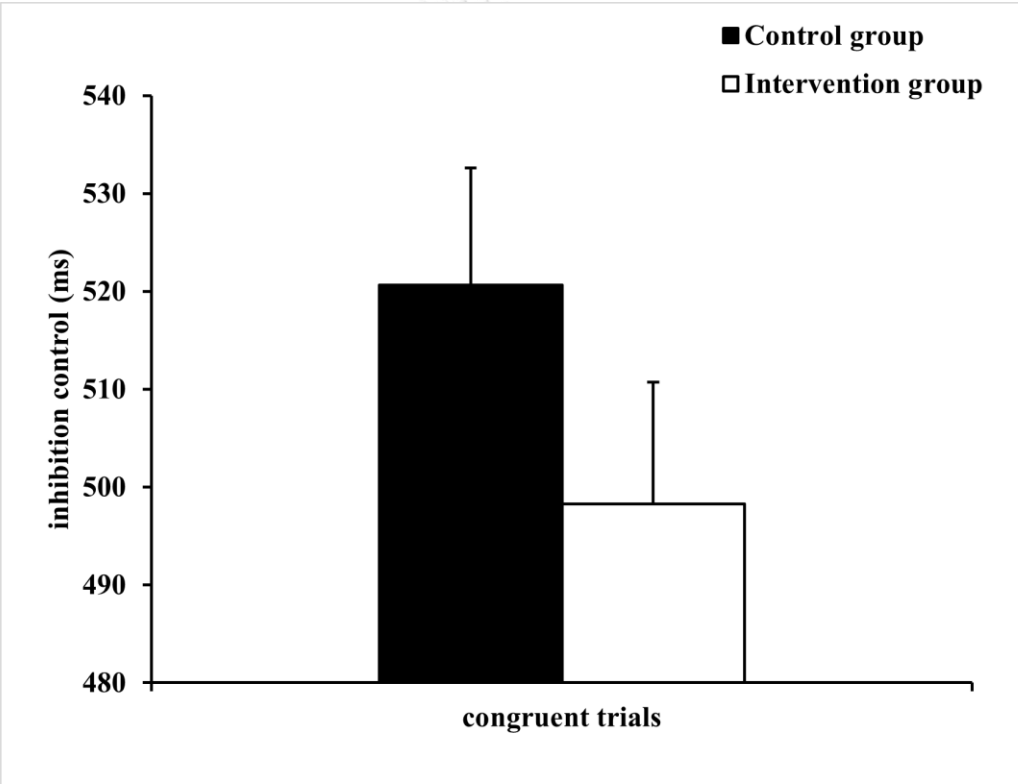


Figure 14, The pairwise comparisons in reaction time of congruent trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Compared with the time, the effect of time on the reaction time of congruent trials was statistically significant, $F_{(1.641,54.141)}$ =5.678, p=.005, partial η^2=.147. With a pairwise comparison, the mean difference in the reaction time of congruent trials was not statistically significant (p=.326) between the baseline and the 6^{th} week period, with a mean difference of 26.50 milliseconds, (95% CI: -14.05-67.04). The mean difference between at 6^{th} week and 12^{th} week period was not statistically significant (p=.133), and the mean difference was 21.96 milliseconds, (95% CI: -4.54-48.46). Simultaneously, the mean difference in the reaction time between the baseline of the test and the end of the test was statistically significant (p=.014), with a mean difference of 48.46* milliseconds, (95% CI: 8.31-88.61). The detail presented in the figure 15.

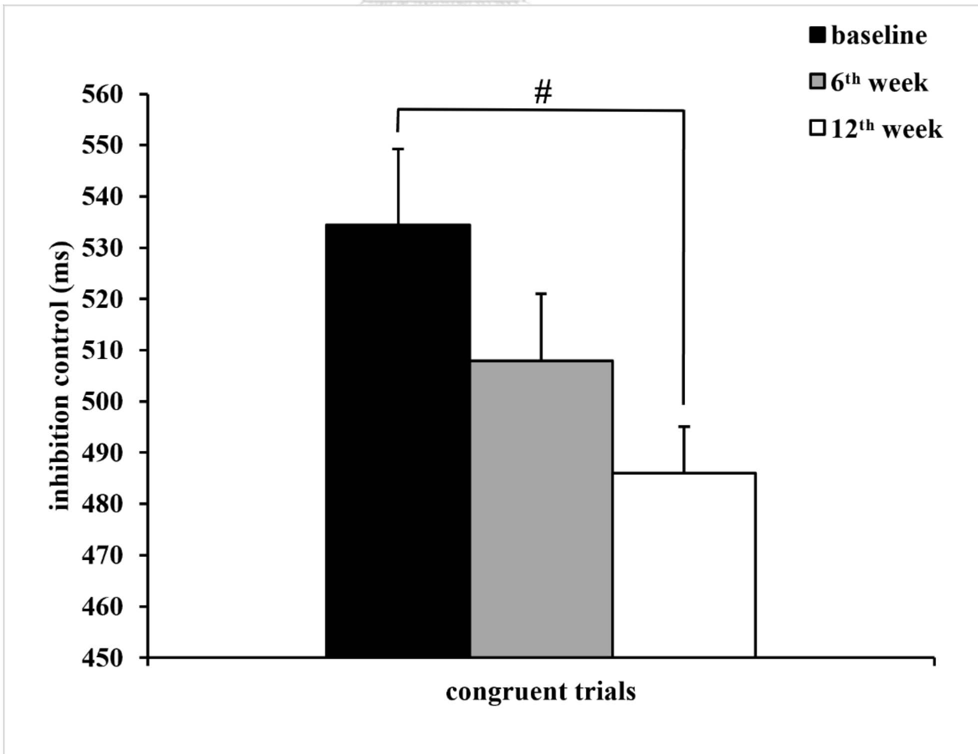


Figure 15, The pairwise comparisons in reaction time of congruent trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Similarly, the results in incongruent trials show that the interaction of group and time is not consistent with Mauchly's spherical assumption (p= .011). The interaction of group and time did not have a significant effect on the reaction time of incongruent trials, $F_{(1.607,53.036)}=1.05$, $p=.345$, partial $\eta^2=.031$.

The main effect of the group on the reaction time of incongruent trials was not statistically significant, $F_{(1,33)}=2.052$, $p=.161$, $\eta^2=.059$. The reaction time of incongruent trials of the intervention group was -24.04 milliseconds, (95% CI: -59.90-11.82) faster than that of the control group. the difference was not statistically significant. The detail presented in the figure 16.

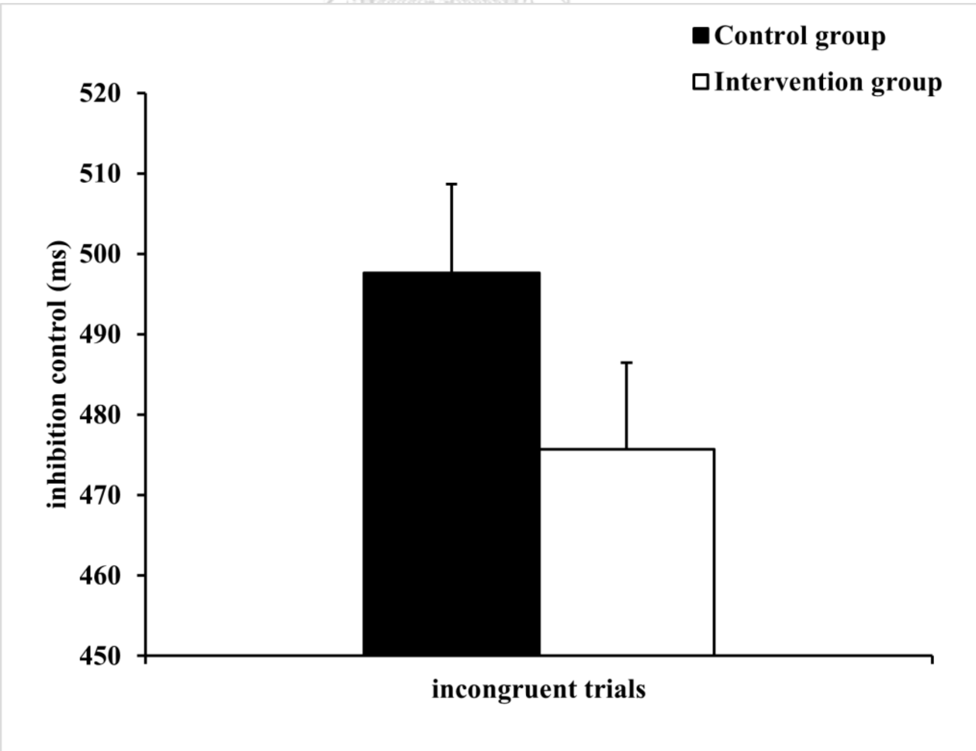


Figure 16, The pairwise comparisons in reaction time of incongruent trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Considering time, the effect on the reaction time was not significant, $F_{(1.706,56.300)}$ =2.46, p= .102, partial η^2= .069. With a pairwise comparison, the difference in the reaction time of incongruent trials was not statistically significant (p= .446) between the baseline and the 6^{th} week period with a difference of 15.40 milliseconds, (95% CI: -10.86-41.66). the difference of reaction time between the 6^{th} week period of the research and the 12^{th} week period of the research was also not statistically significant (p=1.00), and the difference was 8.03 milliseconds, (95% CI: -14.17-30.23). Simultaneously, the difference in the reaction time of incongruent trials between the baseline of the test and the end of the test was not significant (p= .217), with a difference of 23.43 milliseconds, (95% CI: -8.42-55.28). The detail presented in the figure 17.

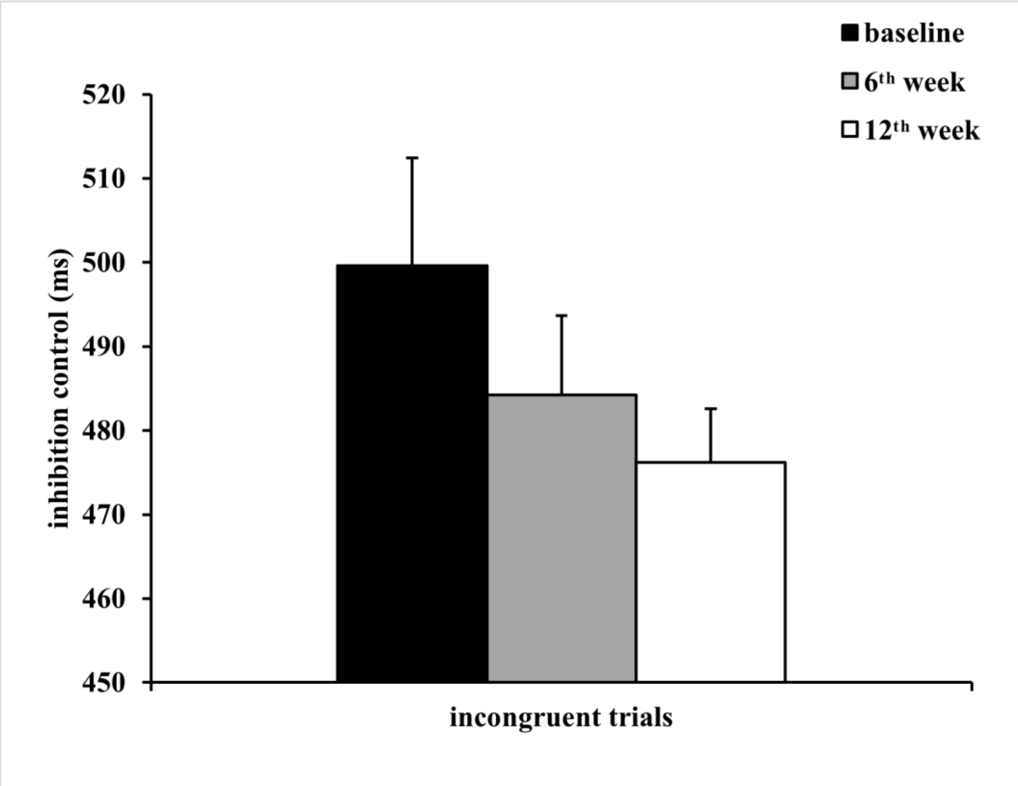


Figure 17, The pairwise comparisons in reaction time of incongruent trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The data detail presented on the table 13.

Table 13 performance results for reaction time of inhibition control over treatment period within and between subjects(n=68)

variables	Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
	M ± SD	M ± SD				
Inhibition control						
Incongruent trials			2.05	-24.04 (95% CI: -59.90-11.82)	.161	.059
baseline	506.80±114.91	492.42±94.28				
6th week	489.62±67.95	478.80±81.96				
12th week	496.48±58.46	455.88±61.58				
F_{time}		2.46				
p-value		.102				
η^2		.069				
		A 15.40 (95% CI: -10.86-41.66)				
Bonferroni post-hoc		B 8.03 (95% CI: -14.17-30.23)				
analysis						
Mean difference (95% CI:)		C 23.43 (95% CI: -8.42-55.28)				
Congruent trials			2.09	-29.04 (95% CI: -59.60-1.51)	.157	.06
baseline	553.85±111.99	535.03±112.96				
6th week	527.07±100.76	488.81±98.52				
12th week	500.93±78.61	471.03±82.41				
F_{time}		5.68				
p-value		.005				
η^2		.147				
		A 26.50 (95% CI: -14.05-67.04)				
Bonferroni post-hoc		B 21.96 (95% CI: -4.54-48.46)				
analysis						
Mean difference (95% CI:)		C 48.46*(95% CI: 8.31-88.61)				

Note. With main effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; * present p<.05, ** present p<.001

The Figure 18 and 19 displayed the data detail of the reaction time in inhibition control over treatment period within and between subjects

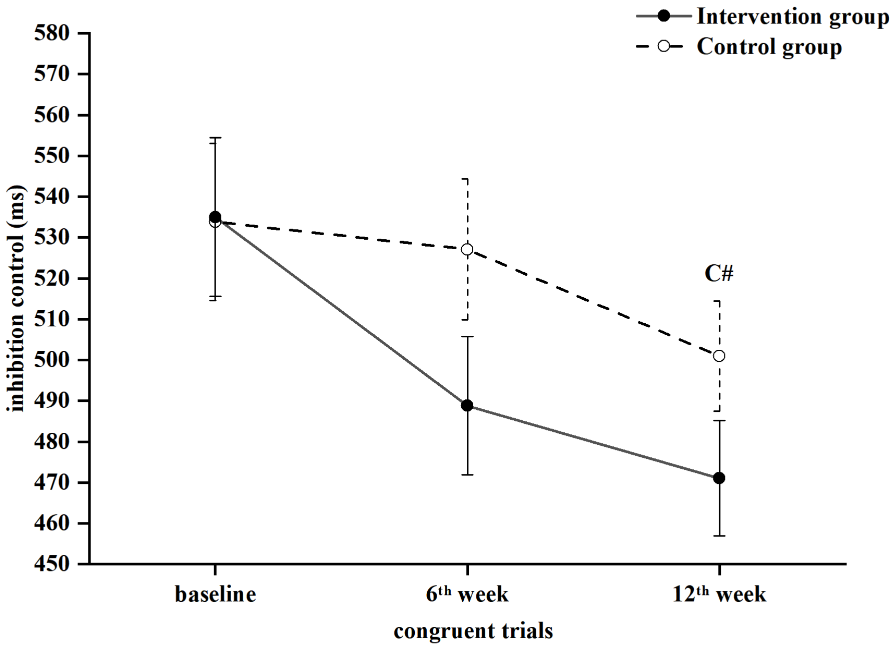


Figure 18, The performance in reaction time of congruent trials over treatment period within and between subjects(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively, data presented as the mean and SEM.

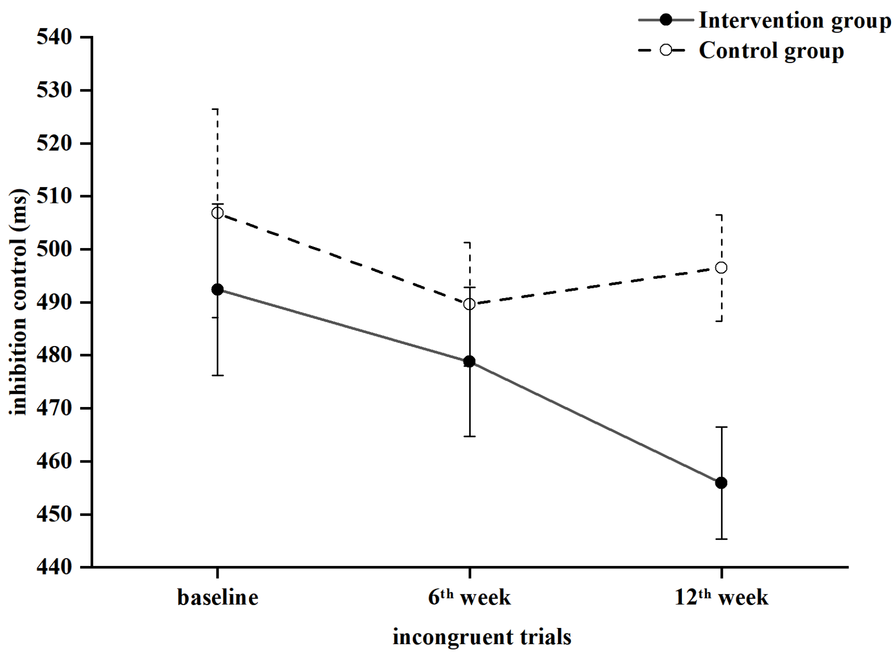


Figure 19, The performance in reaction time of incongruent trials over treatment period within and between subjects(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively, data presented as the mean and SEM.

4.2.1.2 The response reaction time of working memory in 1-back trials and 2-back trials

With Mauchly's Test of Sphericity, results in 1-back trials and 2-back trials show that the interaction of group and time is consistent with Mauchly's spherical assumption (p>.05). The interaction of group and time did not have a significant effect on the reaction time of both 1-back trials, $F_{(2,66)}$= .152, p= .859, partial η^2=.005 and 2-back trials, $F_{(2,66)}$ = .535, p= .588, partial η^2=.016. Therefore, the main effects tests of the two within-subject factors (group and time) were required. And pairwise comparisons are required. Data detail presented in the table 14.

*Table 14 The effect of group, time, and group*time on reaction time of working memory performance over treatment period within and between subjects (n=68)*

Working memory	Source of Variance	F	p-value	Partial eta square(η^2)
	Time*group	$F_{(2,66)}$= .152	.859	.005
1-back trial	Group	$F_{(1,33)}$=5.30	.028	.138
	Time	$F_{(1.515,49.985)}$ =13.67	.000	.293
	Time*group	$F_{(2,66)}$ = .535	.588	.016
2-back trial	Group	$F_{(1, 33)}$=2.126	.154	.061
	Time	$F_{(2,66)}$=15.54	.000	.320

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

The main effect of the group on the reaction time of 1-back trials was statistically significant, $F_{(1,33)}=5.30$, $p=.028$, $\eta^2=.138$. The reaction time of 1-back trials of the intervention group was faster than that of the control group. the difference of -89.87* milliseconds, (95% CI: -169.30- -10.44) was statistically significant. The detail presented in the figure 20.

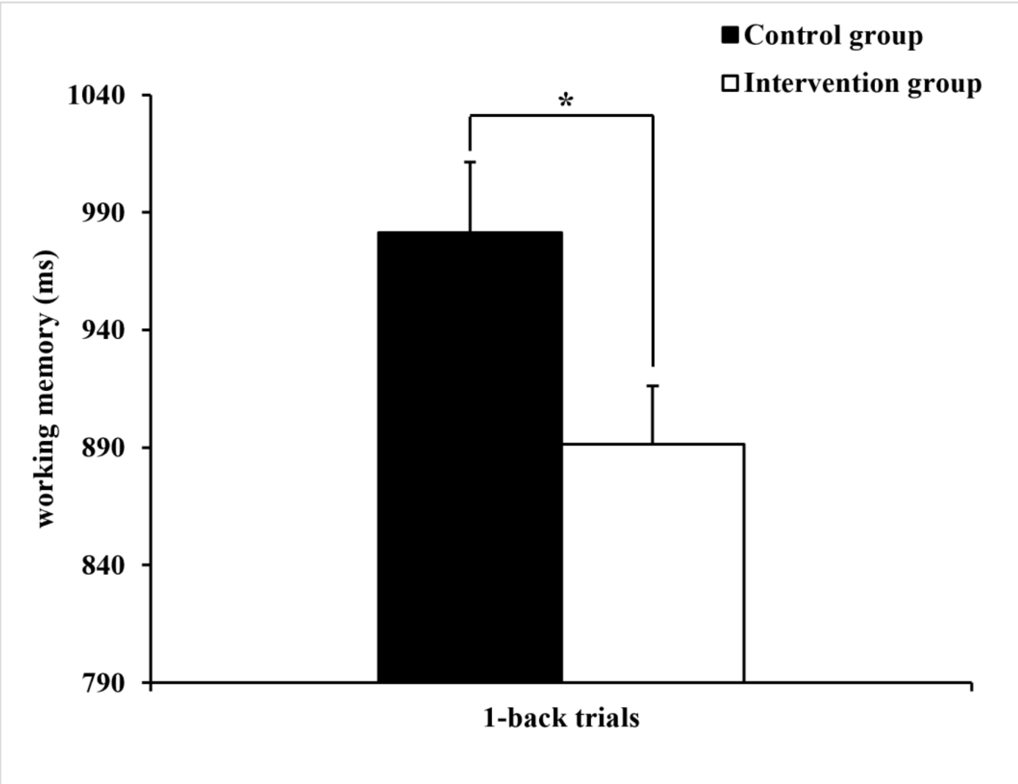


Figure 20, The pairwise comparisons in reaction time of 1-back trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Regarding the time in the 1-back trials, the effect on the reaction time was statistically significant, $F_{(1.515,49.985)}$ =13.67, p=.000, partial η^2=.293. With a pairwise comparison, the difference in the reaction time of 1-back trials was statistically significant (p=.014) between the baseline and the 6th week period with a difference of 162.03* milliseconds, (95% CI: 26.87-297.20). the difference of reaction time between the 6th week and the 12th week timepoint of the research was not statistically significant (p=.066), and the difference was 73.52 milliseconds, (95% CI: -3.61-150.65). Simultaneously, the difference in the reaction time of 1-back trials between the baseline of the test and the end of the test was statistically significant (p=.000), with a difference of 235.55** milliseconds, (95% CI: 107.71-363.39). The detail presented in the figure 21.

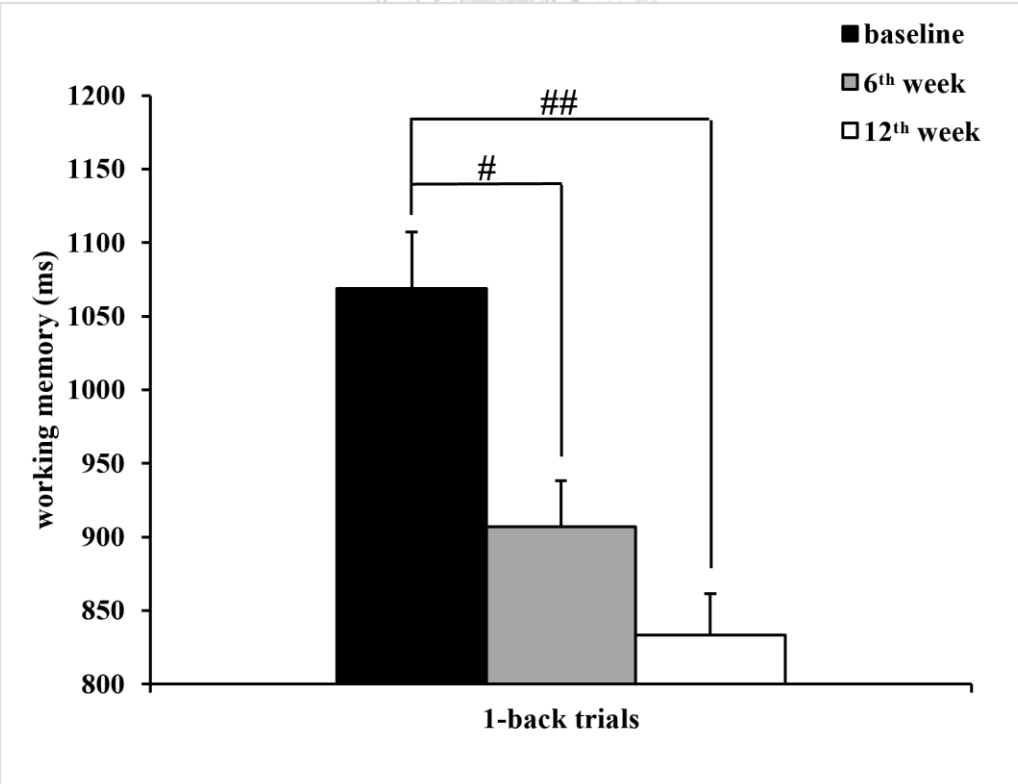


Figure 21, The pairwise comparisons in reaction time of 1-back trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The main effect of the group on the reaction time of 2-back trials was not statistically significant, $F_{(1, 33)}=2.126$, p=.154, $\eta^2=.061$. The reaction time of 2-back trials of the intervention group was faster than that of the control group. the difference of -71.69 milliseconds, (95% CI: -149.04-5.66) was not statistically significant. The detail presented in the figure 22

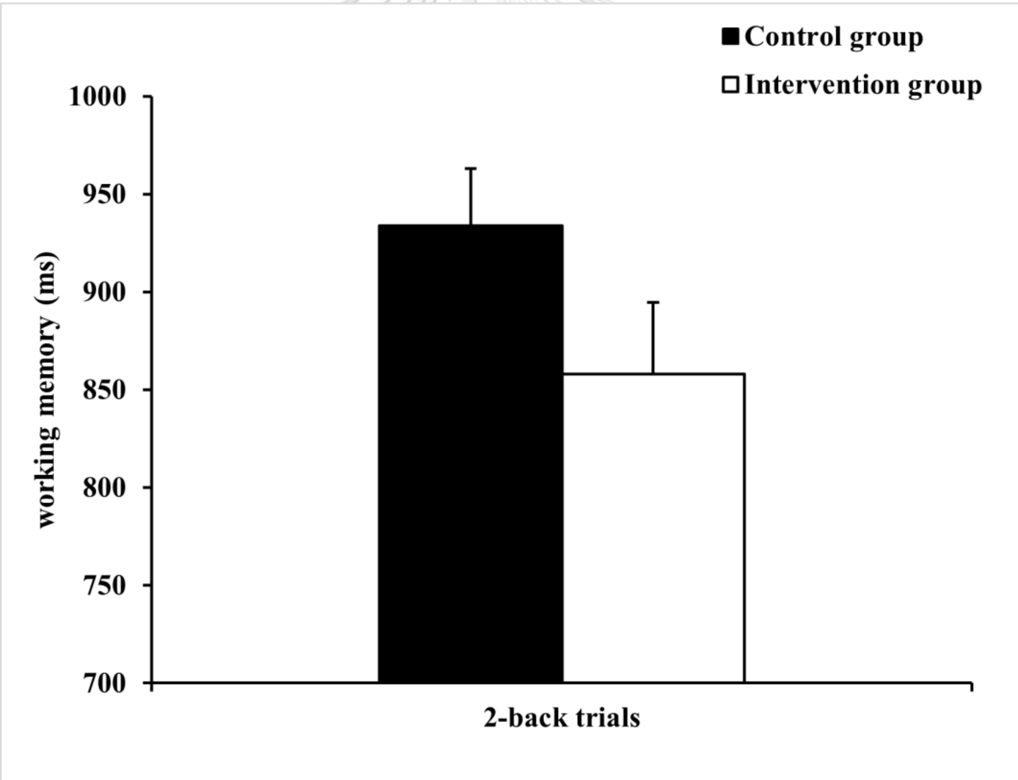


Figure 22, The pairwise comparisons in reaction time of 2-back trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The effect of time on the reaction time of 2-back trials was statistically significant, $F_{(2,66)}$=15.54, p=.000, partial η^2=.320. With a pairwise comparison, the difference in the reaction time of 2-back trials was statistically significant (p=.003) between the baseline and the 6th week period with a difference of 127.30* milliseconds, (95% CI: 37.43-217.17). The difference was 101.47 milliseconds, (95% CI: -1.19-204.13) at the 6th week period of the research and the 12th week period of the research, result indicated that there was not significant (p=.054). Simultaneously, the difference in the reaction time between the baseline of the test and the end of the test was statistically significant (p=.000), with a difference of 228.77** milliseconds, (95% CI: 111.93-345.61). The detail presented in the figure 23.

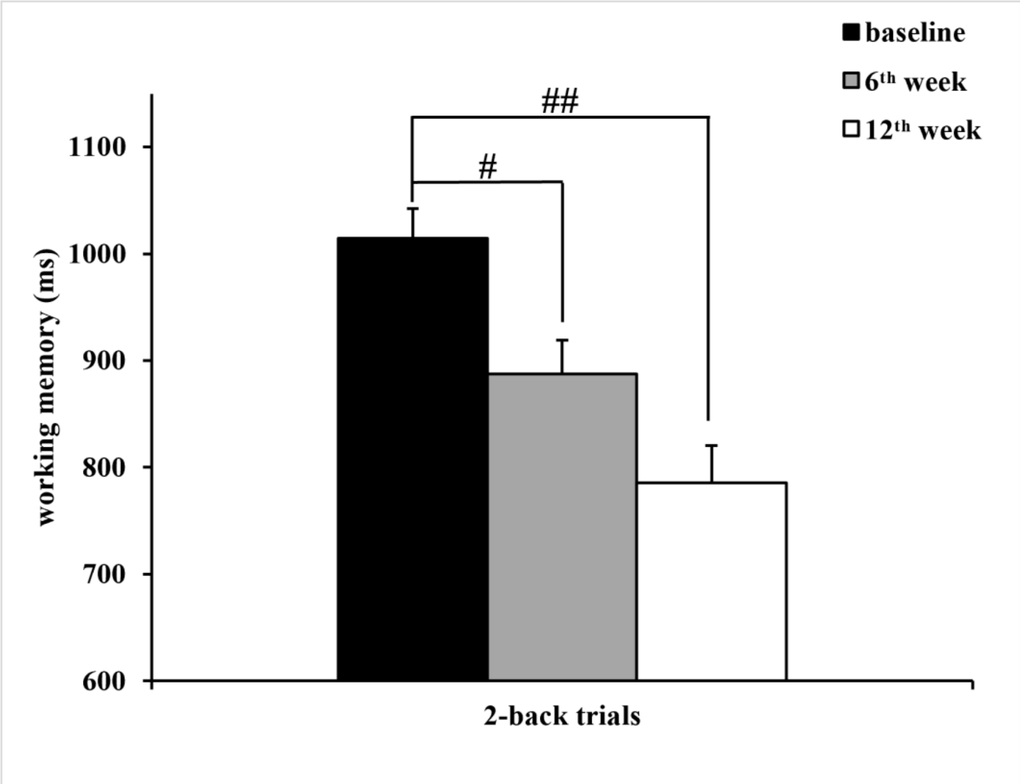


Figure 23, The pairwise comparisons in reaction time of 2-back trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Data detail of working memory performance presented on table 15.

Table 15 the performance results for reaction time of working memory over treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
	M ± SD	M ± SD				
Working memory						
1-back trials			5.30	-89.87* (95% CI: -169.30- -10.44)	.028	.13
baseline	1127.47±292.36	1010.31±312.61				
6th week	939.76±276.59	873.96±291.69				
12th week	876.67±216.43	790.01±237.18				
F_{time}		13.67				
p-value		.000				
η^2		.293				
		A 162.03* (95% CI: 26.87-297.20)				
Bonferroni post-hoc analysis		B 73.52 (95% CI: -3.61-150.65)				
Mean difference (95% CI:)		C 235.55** (95% CI: 107.71-363.39)				
2-back trials			2.13	-71.69 (95% CI: -149.04-5.66)	.154	.06
baseline	1029.67±301.29	999.41±305.48				
6th week	935.72±245.26	838.77±291.51				
12th week	835.91±226.79	735.63±240.83				
F_{time}		15.54				
p-value		.000				
η^2		.320				
		A 127.30* (95% CI: 37.43-217.17)				
Bonferroni post-hoc analysis		B 101.47 (95% CI: -1.19-204.13)				
Mean difference (95% CI:)		C 228.77** (95% CI: 111.93-345.61)				

Note. With main effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week; * present p<.05, ** present p<.001

The Figure 24 and 25 displayed the data detail of the reaction time in working memory over treatment period within and between groups

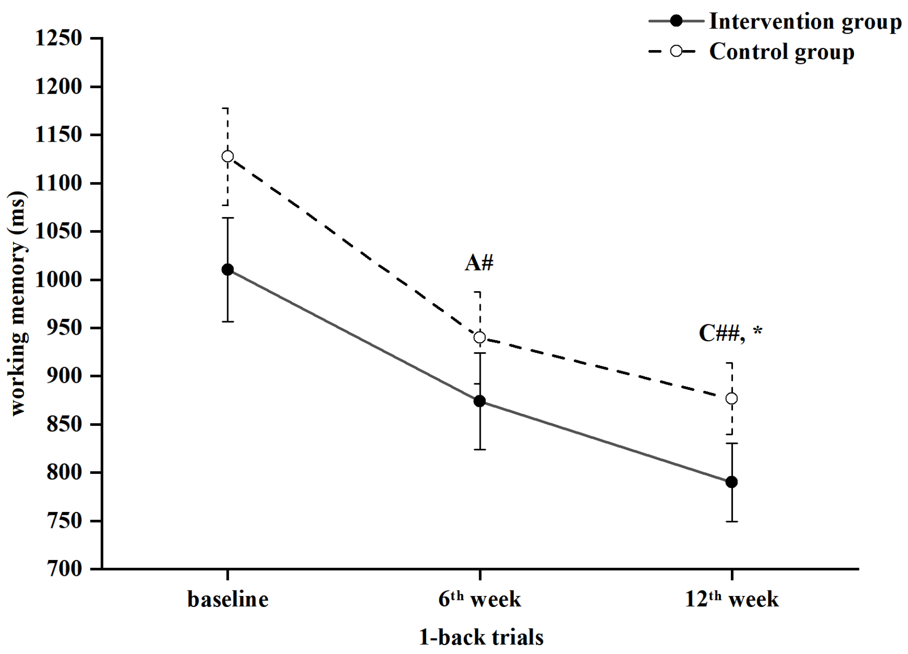


Figure 24, The performance in reaction time of 1-back trials over treatment period within and between subjects(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, data presented as the mean and SEM

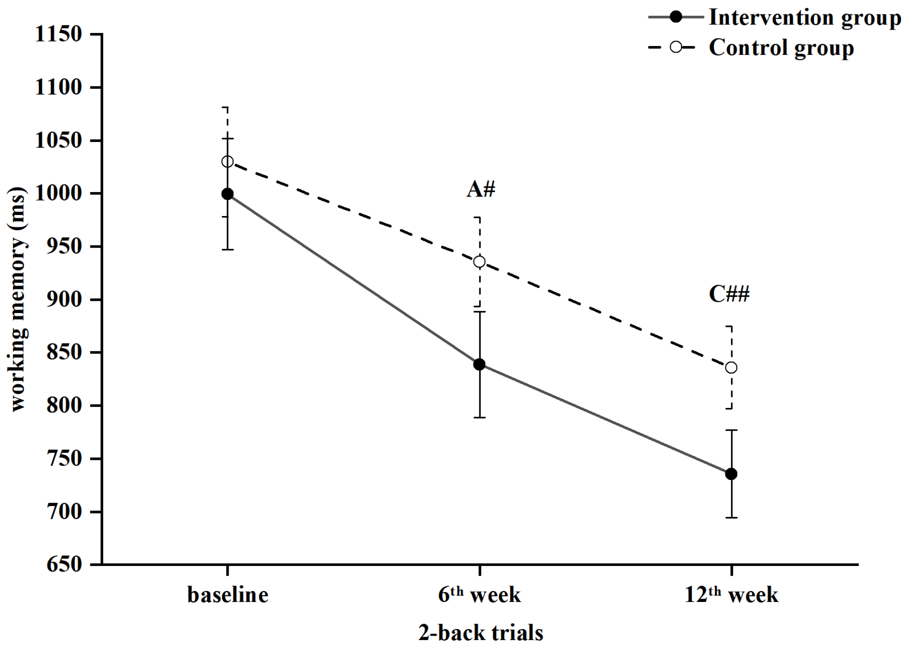


Figure 25, The performance in reaction time of 2-back trials over treatment period within and between subjects(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, data presented as the mean and SEM

4.2.1.3 The response reaction time of cognitive flexibility in color trials, shape trials and border trials

With Mauchly's Test of Sphericity, the results from the color trials, shape trials, and border trials show that the interaction of group and time is consistent with Mauchly's spherical assumption (p> .05). The interaction of group and time did not have a significant effect on the reaction time among color trials, $F_{(2,66)}$=2.10, p=.131, partial η^2=.060, shape trials, $F_{(1.598,52.741)}$ =.417, p=.616, partial η^2=.012, and border trials, $F_{(2,66)}$ =2.70, p=.075, partial η^2=.076. Therefore, the main effects tests of the two within-subject factors (group and time) were required. And pairwise comparisons are required. Data detail presented in the table 16.

*Table 16 The effect of group, time, and group*time on performance of reaction time of cognitive flexibility performance over treatment period within and between groups (n=68)*

cognitive flexibility	Source of Variance	F	p-value	Partial eta square(η^2)
	Time*group	$F_{(2,66)}$=2.10	.131	.060
Color trial	Group	$F_{(1, 33)}$=5.23	.027	.139
	Time	$F_{(2,66)}$=3.90	.025	.106
	Time*group	$F_{(1.598,52.741)}$ =.417	.616	.012
Shape trial	Group	$F_{(1, 33)}$=4.36	.045	.117
	Time	$F_{(2,66)}$=9.28	.000	.220
	Time*group	$F_{(2,66)}$ =2.70	.075	.076
Border trial	Group	$F_{(1,33)}$=6.25	.018	.159
	Time	$F_{(2,66)}$=25.17	.000	.433

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

The main effect of the group on the reaction time of color trials was statistically significant, $F_{(1, 33)}$=5.23, p=.027, η^2=.139. The mean difference was 189.38^* milliseconds, (95% CI: -168.19- -10.56) it was faster intervention group than e control group. The detail presented in the figure 26.

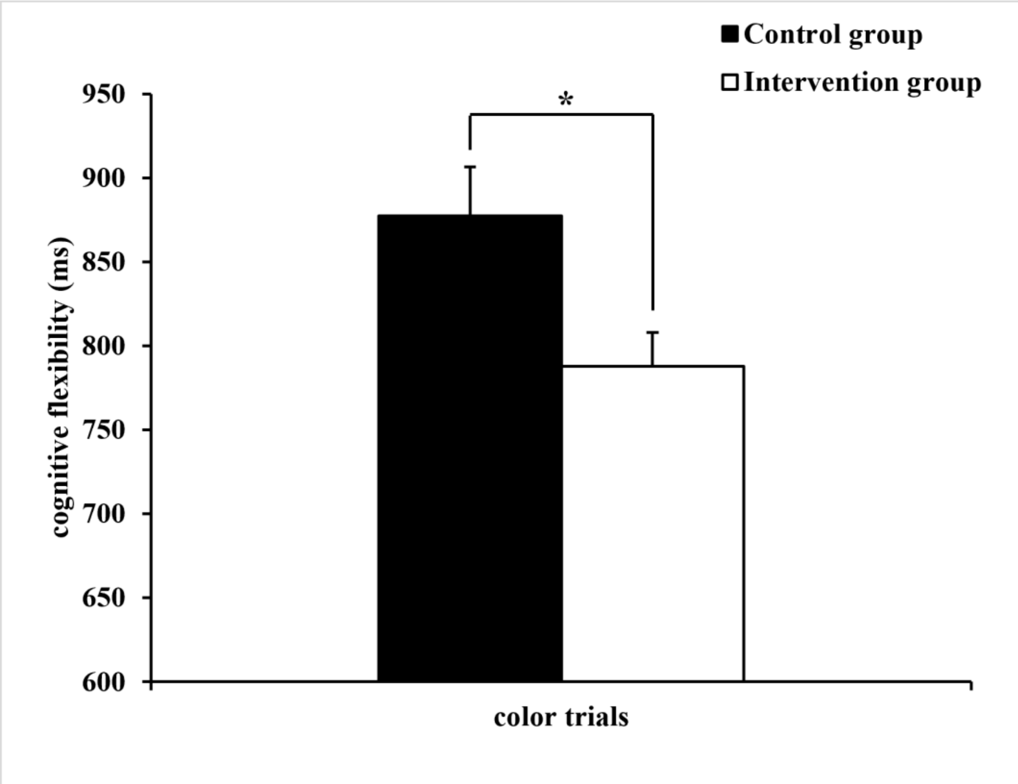


Figure 26, The pairwise comparisons in reaction time of color trials over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The effect of time on the reaction time of color trials was statistically significant, $F_{(2,66)}$=3.90, p=.025, partial η^2=.106. With a pairwise comparison, the difference in the reaction time of color trials was not statistically significant (p=.542) between the baseline and the 6th week period with a difference of 57.56 milliseconds, (95% CI: -48.60-163.73). The difference of 51.04 milliseconds, (95% CI: -46.28-148.36) also not was statistically significant (p=.585) between the 6th week period of the research and the 12th week period of the research. Simultaneously, the difference in the reaction time of color trials between the baseline of the test and the end of the test was statistically significant (p=.014), with a difference of 108.60* milliseconds, (95% CI: 18.29-198.92). The detail presented in the figure 27.

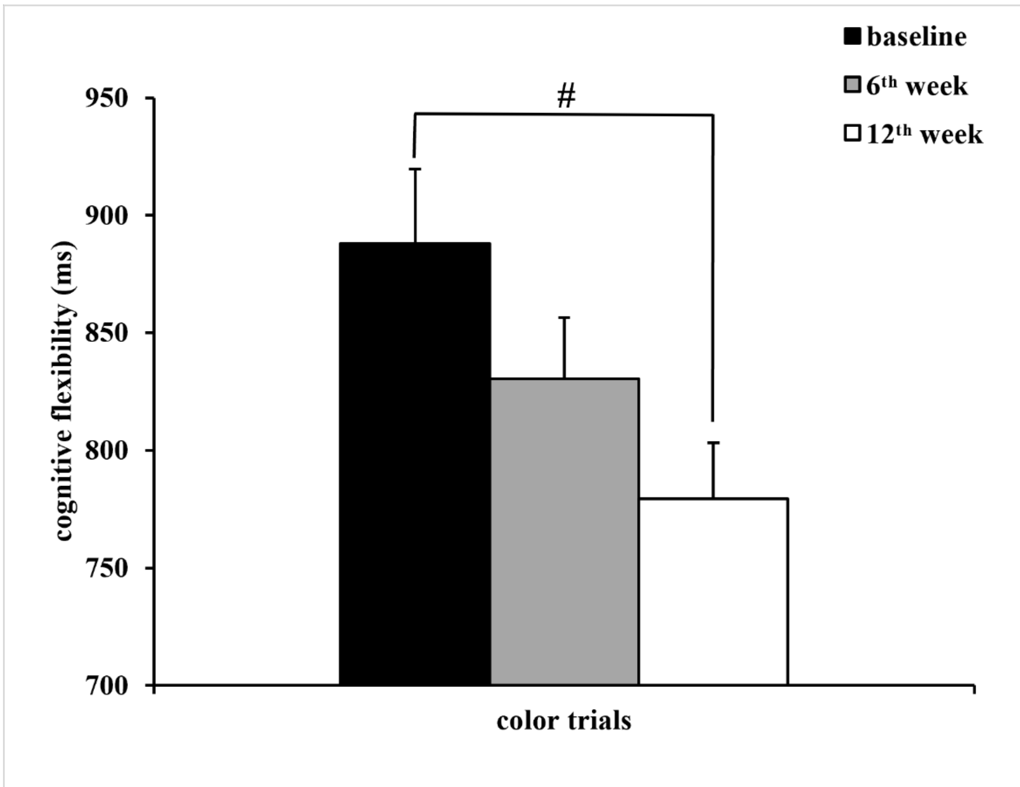


Figure 27, The pairwise comparisons in reaction time of color trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The main effect of the group on the reaction time was statistically significant, $F_{(1, 33)}$=4.36, p=.045, η^2=.117. The reaction time of shape trials of the intervention group was faster than that of the control group. the difference of -60.84* milliseconds, (95% CI: -120.12--1.56) was statistically significant. The detail presented in the figure 28.

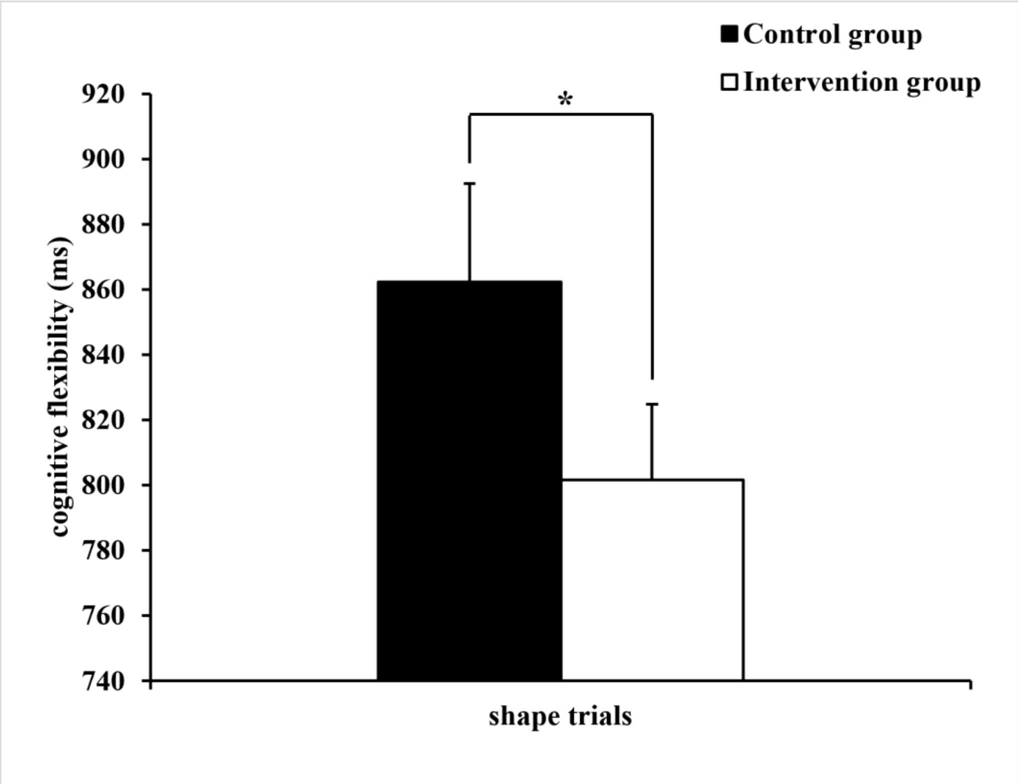


Figure 28, The pairwise comparisons in reaction time of shape trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The effect of time on the reaction time was statistically significant, $F_{(2,66)}=9.28$, p=.000, partial $\eta^2=.220$. With a pairwise comparison, the difference in the reaction time was not statistically significant (p=.284) between the baseline and the 6th week period, with a difference of 51.57 milliseconds, (95% CI: -24.04-127.17). The difference was 80.79 milliseconds, (95% CI: -2.97-164.55) was not statistically significant (p=.062) between the 6th week period and the 12th week period. Simultaneously, the difference in the reaction time between the baseline of the test and the end of the test was statistically significant (p=.000), with a difference of 132.36** milliseconds, (95% CI: 57.72-206.99). The detail presented in the figure 29.

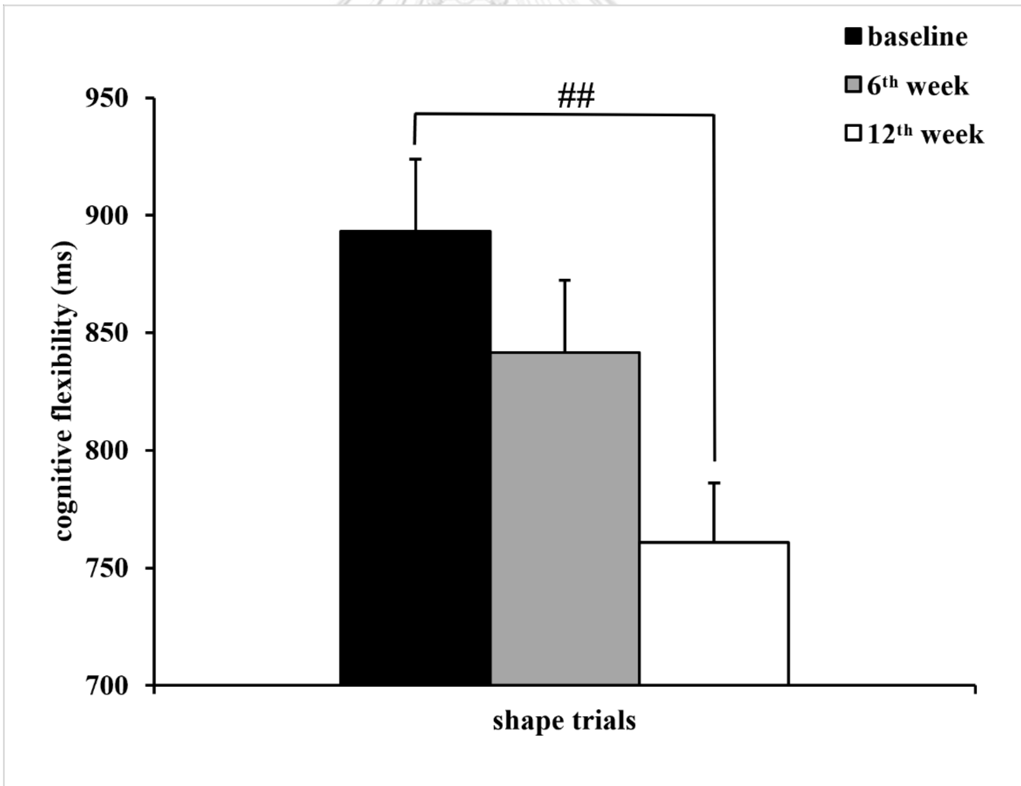


Figure 29, The pairwise comparisons in reaction time of shape trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The main effect of the group on the reaction time was statistically significant, $F_{(1,33)}$=6.25, p=.018, η^2=.159. The reaction time of the intervention group was faster than that of the control group. And the difference of -127.41* milliseconds, (95% CI: -231.06- -23.75) was statistically significant. The detail presented in the figure 30.

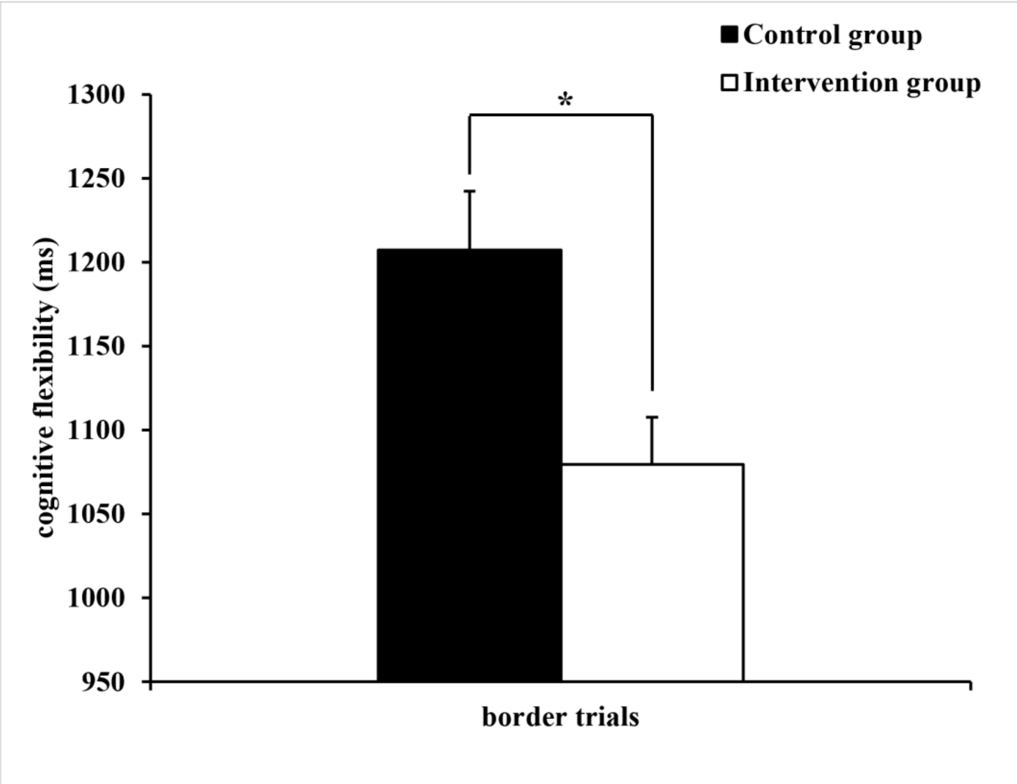


Figure 30, The pairwise comparisons in reaction time of border trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The effect of time on the reaction time was statistically significant, $F_{(2,66)}$=25.17, p=.000, partial η^2=.433. With a pairwise comparison, the outcome was statistically significant (p=.012) between the baseline and the 6th week period with a difference of 216.63* milliseconds, (95% CI: 84.71-348.55). Meanwhile, the difference was 161.52* milliseconds, (95% CI: 24.48-298.56) was statistically significant (p=.016) between the 6th week period and the 12th week period. Similarly, a statistical significance (p=.000) reached between baseline and 12th week, with a difference of 378.15** milliseconds, (95% CI: 242.42-513.88). The detail presented in the figure 31.

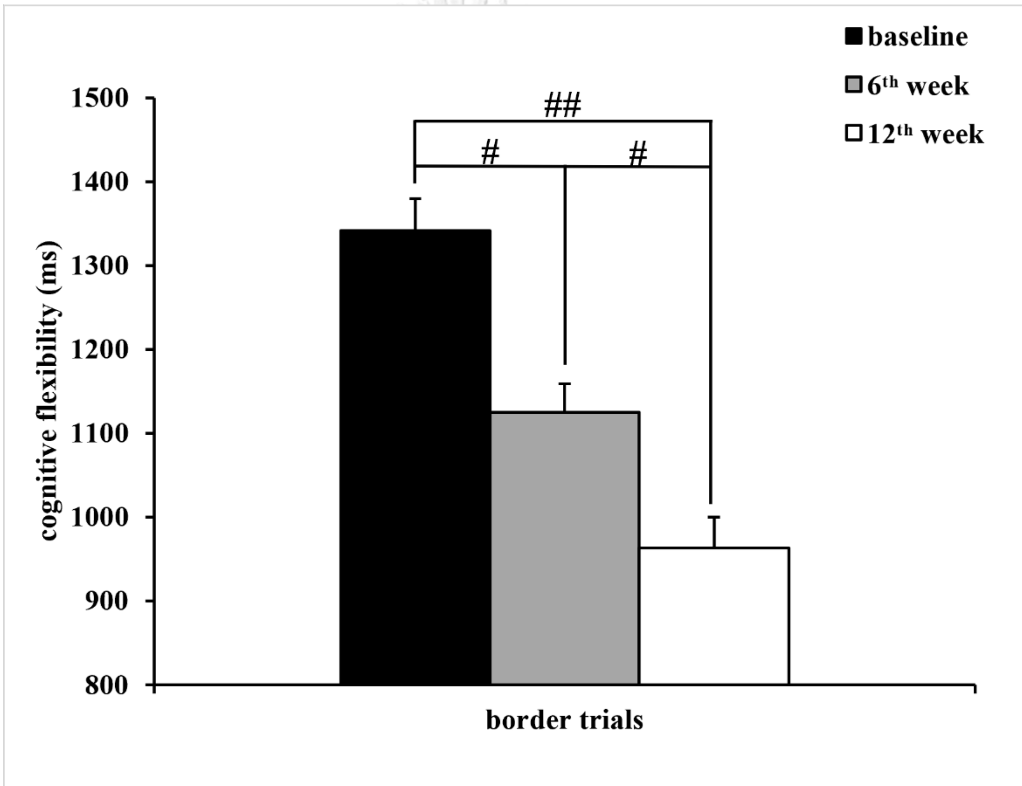


Figure 31, The pairwise comparisons in reaction time of border trials performance over treatment period within subjects (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Data detail of cognitive flexibility performance presented on table 17, and table 18

Table 17 The performance results for reaction time of cognitive flexibility over treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
	M±SD	M±SD				
Cognitive flexibility						
color trials			5.23	189.38* (95% CI: -168.19- -10.56)	.027	. 139
baseline	886.58±304.07	889.16±247.63				
6^{th} week	885.06±238.50	775.56±237.60				
12^{th} week	859.88±212.62	698.66±180.65				
F_{time}		3.90				
p-value		.025				
η^2		.11				
		A 57.56 (95% CI: -48.60-163.73)				
Bonferroni post-hoc analysis		B 51.04 (95% CI: -46.28-148.36)				
Mean difference (95% CI:)		C 108.60* (95% CI: 18.29-198.92)				
Shape trials			4.36	-60.84* (95% CI: -120.12—1.56)	.045	.117
baseline	899.92±191.2	886.58±304.07				
6^{th} week	878.80±292.12	804.56±203.11				
12^{th} week	808.36±262.24	713.42±188.11				
F_{time}		15.54				
p-value		.000				
η^2		.320				
		A 51.57 (95% CI: -24.04-127.17)				
Bonferroni post-hoc analysis		B 80.79 (95% CI: -2.97-164.55)				
Mean difference (95% CI:)		C 132.36** (95% CI: 57.72-206.99)				

Note. With main effect, A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, respectively; * present p<.05, ** present p<.001

Table 18 The performance results for reaction time of cognitive flexibility over treatment period within and between groups(n=68) (continued)

variables		Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
		M±SD	M±SD				
Border trials				6.25	-127.41* (95% CI: -231.06- -23.75)	.018	.159
baseline		1360.61±337.03	1322.57±322.34				
6th week		1165.38±297.47	1084.53±269.95				
12th week		1095.10±359.59	831.77±269.18				
F_{time}			25.17				
p-value			.000				
η^2			.433				
	A		216.63* (95% CI: 84.71-348.55)				
Bonferroni post-hoc analysis	B		161.52* (95% CI: 24.48-298.56)				
Mean difference (95% CI:)	C		378.15** (95% CI: 242.42-513.88)				

Note. With main effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; * present p<.05, ** present p<.001

The Figure 32, 33, and 34 displayed the data detail of the reaction time in cognitive flexibility over treatment period within and between groups

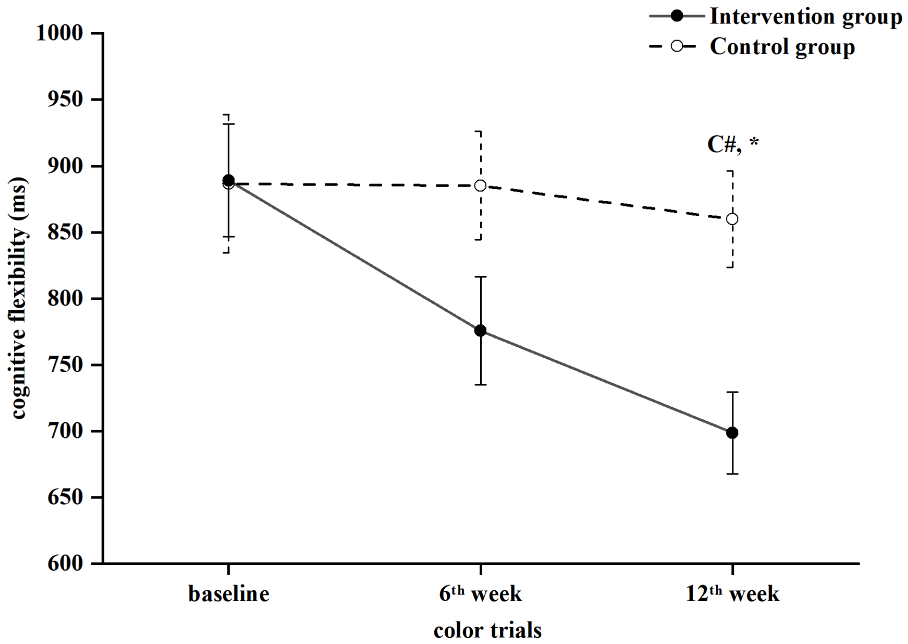


Figure 32, The performance in reaction time of color trials over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, respectively, data presented as the mean and SEM

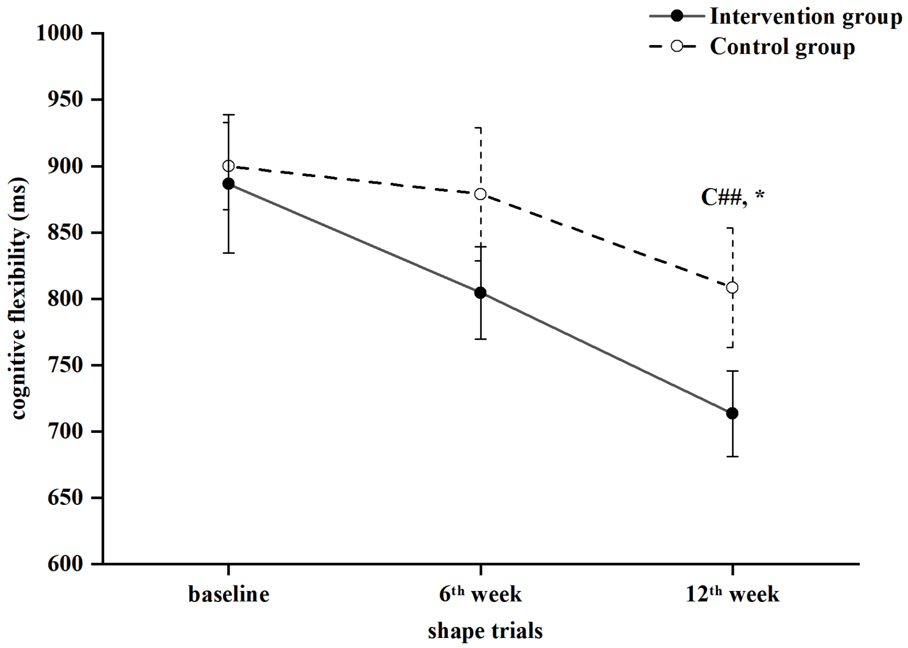


Figure 33, The performance in reaction time of shape trials over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively, data presented as the mean and SEM

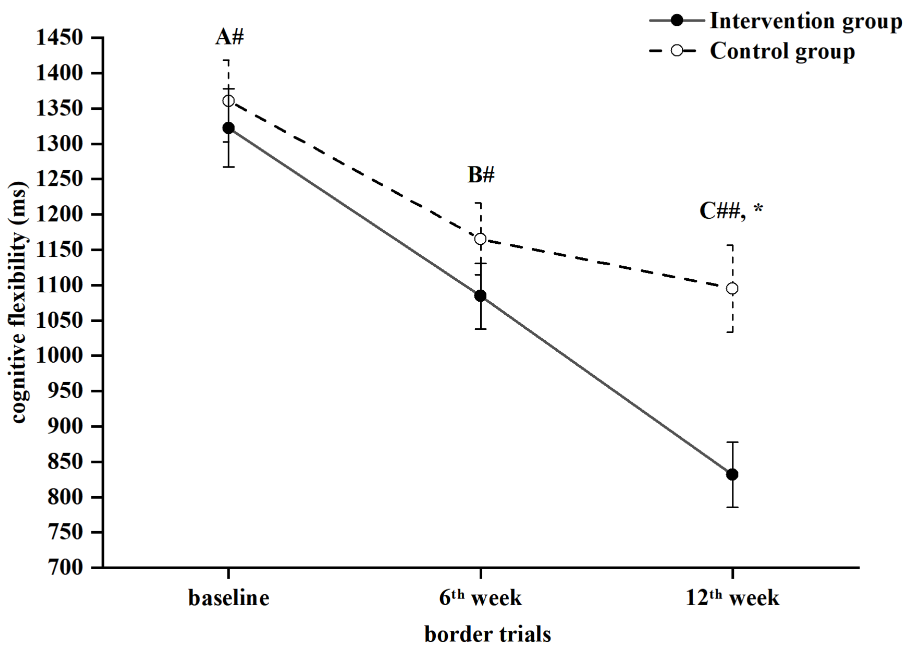


Figure 34, The performance in reaction time of border trials over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001; with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively, data presented as the mean and SEM

4.2.1.4 The accuracy of inhibition control in the congruent trials and incongruent trials

With Mauchly's Test of Sphericity, results in the congruent trials show that the interaction of group and time is consistent with Mauchly's spherical assumption(p>.05). The interaction of group and time had a statistically significant effect on the accuracy of congruent trials, $F_{(2,66)}$= 6.38, p=.003, partial η^2=.162. Therefore, the independent simple effect test was performed on the two within-subject factors group and time.

About the incongruent trials, results show that the interaction of group and time is not consistent with Mauchly's spherical assumption($p<.05$). The interaction of group and time did not have significant effect on the accuracy of incongruent trials, $F_{(1.50,49.46)}= 2.25$, $p=.129$, partial $\eta^2=.064$. Therefore, the main effects tests of the two within-subject factors (group and time) and pairwise comparisons were required. Data detail presented in the table 19.

*Table 19, The effect of group, time, and group*time on performance of accuracy percentage of inhibition control over treatment period within and between groups (n=68)*

Inhibition control	Source of Variance	F	p-value	Partial eta square(η^2)
	Time*group	$F_{(2,66)}= 6.38$	.003	.162
Congruent trial	Group $_{baseline}$	$F_{(1,33)}= .003$	.960	.000
	Group $_{6th\ week}$	$F_{(1,33)}= 5.27$	.028	.138
	Group $_{12th\ week}$	$F_{(1,33)}= 15.60$	.000	.321
	Time $_{intervention}$	$F_{(1.385,\ 45.692)}= 1.25$	.283	.037
	Time $_{control}$	$F_{(2,66)}= 6.49$	.003	.164
	Time*group	$F_{(1.50,49.46)}= 2.25$	.129	.064
Incongruent trial	Group	$F_{(1,33)}=4.88$	.034	.129
	Time	$F_{(1.554,51.287)} =.823$	.418	.024

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present $p<.05$, ** present $p<.001$

Regarding the group, there was no significant difference in the accuracy of congruent trials between the intervention group (88.52±15.90)% and the control group (88.36±13.84)%, $F_{(1,33)}= .003$, $p=.960.$, $\eta^2=.000$ at the baseline of the study, with the difference of -.156%, (95% CI: -6.09-6.40). In the 6th week period of the study, the difference in accuracy between the intervention group (89.17±11.10)% and the control group (80.70±16.97)% was a statistically significance, $F_{(1,33)}$= 5.27, p=.028, η^2=.138, with the difference of 8.47^{*}%, (95% CI: .96-15.98). During the 12^{th} week period of the study, there was a statistically significant difference between the intervention group (92.54±7.20)% and the control group (79.29±19.00)%, with a difference of 13.24^{**} (95% CI: 6.42-20.06), $F_{(1,33)}$= 15.60, p=.000, η^2=.321. The detail presented in the figure 35.

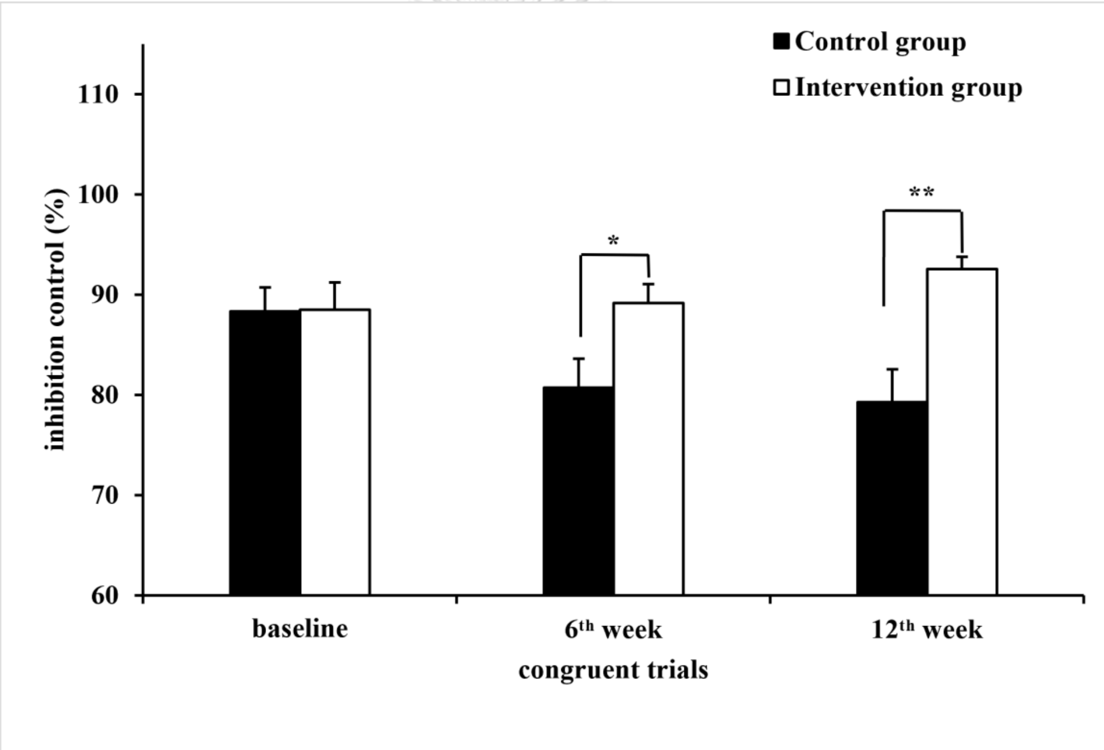


Figure 35, The pairwise comparisons in accuracy of congruent trials performance over treatment period within groups (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Considering time in the intervention group, the dependent variable was not consistent with Mauchly's spherical assumption (p=.000). Greenhouse-Geisser adjustment in result presented. Furthermore, the simple effect of time on the accuracy was not statistically significant, $F_{(1.385, 45.692)}$= 1.25, p=.283, η^2=.037. Specifically, the difference in the accuracy of congruent trials between the baseline of the study (88.52±15.90)% and the 6th week period of the study (89.17±11.10)% was not statistically significant (p=1.00) with the difference of -.66%, (95% CI: -9.26-7.95). The difference in the accuracy of congruent trials between the 6th week period of the study (89.17±11.10) and the 12th week period of study (92.54±7.20)% was not statistically significant (p=.191), and the difference was -3.36%, (95 %CI: -7.79-1.06). Meanwhile, the difference in the accuracy of congruent trials between the baseline of the study (88.52±15.90)% and the 12th week period of study (92.54±7.20)% was also not statistically significant (p=.458), and the difference was -4.02%, (95% CI: -10.94-2.91). The detail presented in the figure 36.

Regarding time in the control group, the dependent variable was consistent with Mauchly's spherical assumption (p=.301). Moreover, the simple effect of time on the accuracy of congruent trials was statistically significant, $F_{(2,66)}$= 6.49, p=.003, η^2=.164. Particularly, there was a significant difference (p=.029) in the accuracy between the baseline of the study (88.36±13.84)% and the 6th week period of the study (80.70±16.97)%, with the difference 7.66*, (95% CI: .612-14.71). The difference between the 6th week period of the study (79.29±19.00)% and the 12th week period of the study (80.15±18.49)% was not significant (p=1.00), with the difference 1.41%, (95% CI: -4.48-7.29). The difference in the accuracy of congruent trials between the baseline of the study ((88.36±13.84)% and the 12th week period of the study (79.29±19.00)% was statistically significant (p=.013), with the difference 9.07*%, (95% CI: 1.60-16.53). The detail presented in the figure 36.

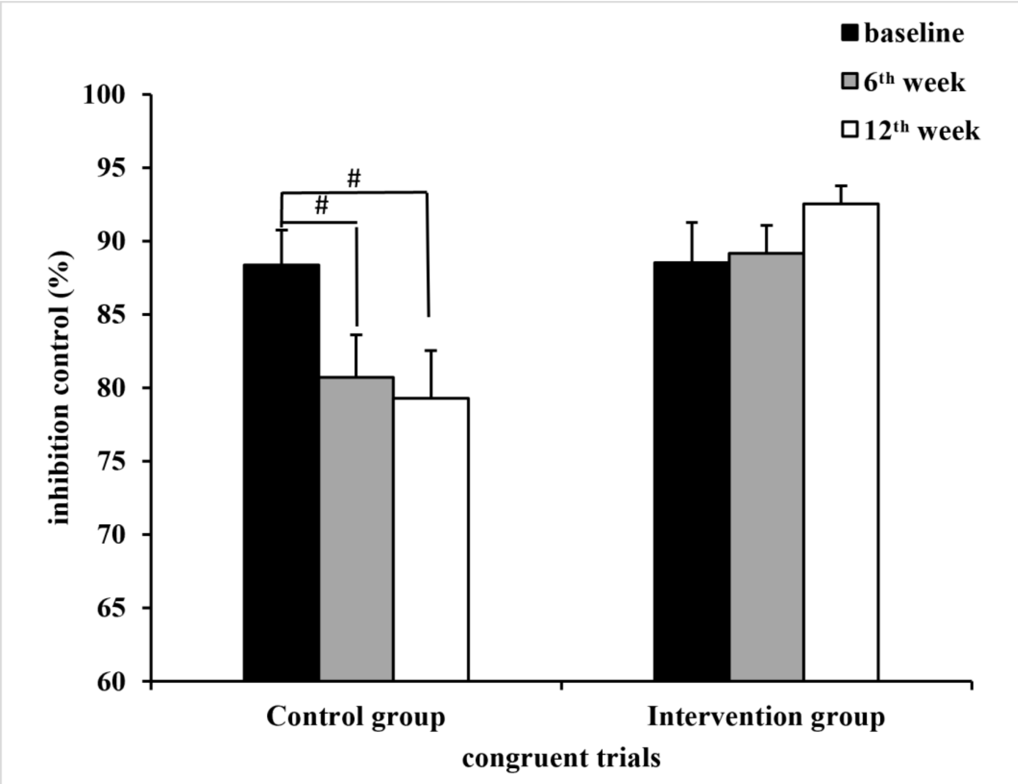


Figure 36, The pairwise comparisons in accuracy of congruent trials performance over treatment period within time (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

The main effect of the group on the accuracy of incongruent trials was statistically significant, $F_{(1,33)}$=4.88, p=.034, η^2=.129. The accuracy of incongruent trials of the intervention group was higher than that of the control group. the difference of 6.00%, (95% CI: .48-11.53) was statistically significant. The detail presented in the figure 37.

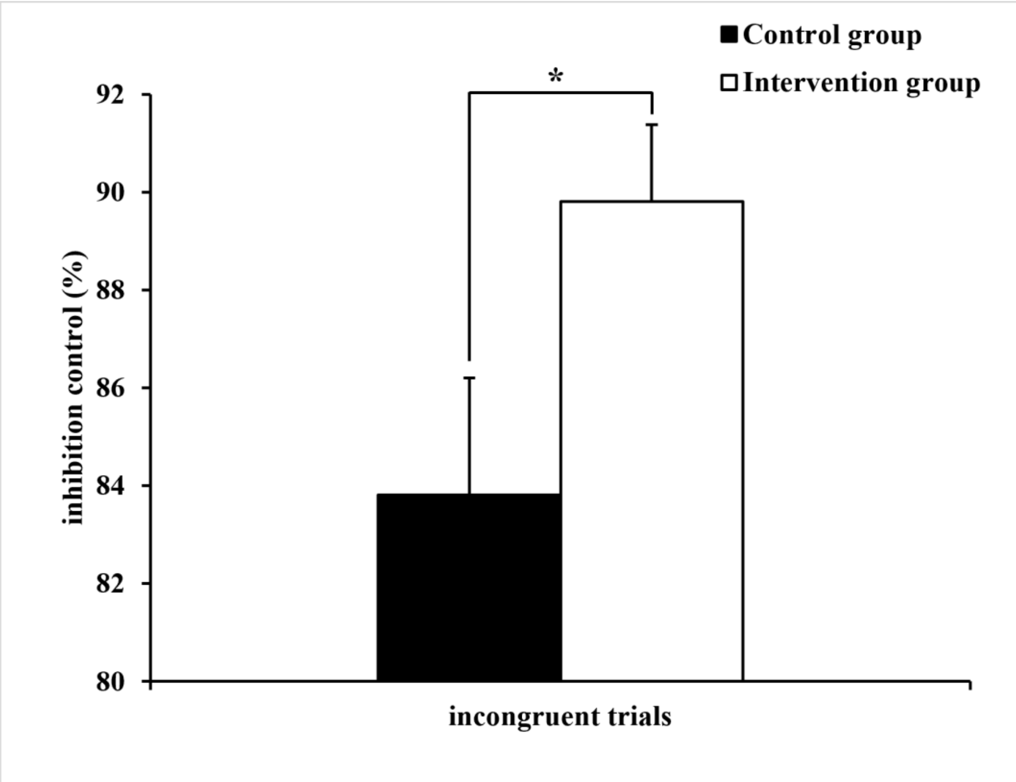


Figure 37, The pairwise comparisons in accuracy of incongruent trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Regarding the time, the effect on the accuracy of incongruent trials was not statistically significant, $F_{(1.554,51.287)}$ =.823, p=.418, partial η^2=.024. With a pairwise comparison, there was no statistical difference with the comparation of baseline vs the 6th week period (p=1.00), the 6th week VS the 12th week (p=.996), and baseline VS the 12th week (p=.460), with the difference of -.80%, (95% CI: -7.09-5.49), -1.73%, (95%

CI: -6.06-2.60), and -2.53%, (95% CI: -6.88-1.83), respectively. The detail presented in the figure 38.

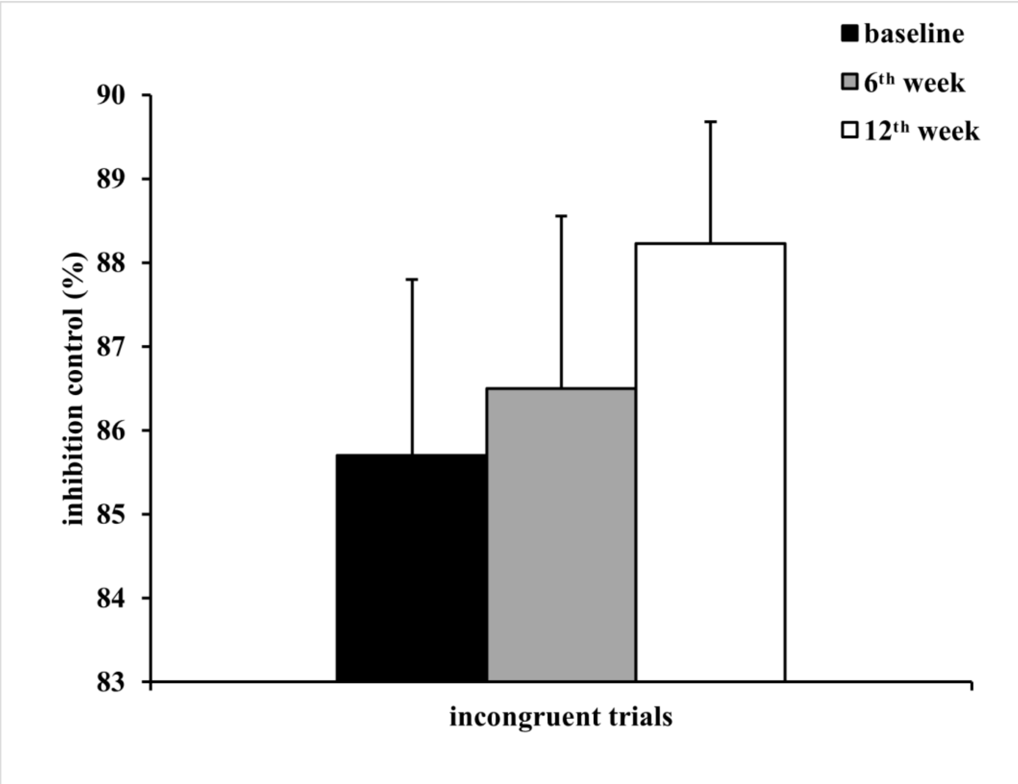


Figure 38, The pairwise comparisons in accuracy of incongruent trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The data detail of inhibition control performance presented on table 20.

Table 20 The performance in accuracy of inhibition control over treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)				
	M ± SD	M ± SD	F_{group}	Mean difference (95% CI:)	p-value	η^2
Inhibition control						
Congruent trials (%)						
baseline	88.36±13.84	88.52±15.90	.003	-.156 (95% CI: -6.09-6.40)	.960	000
6th week	80.70±16.97	89.17±11.10	5.27	8.47* (95% CI: .96-15.98)	.028	.138
12th week	79.29±19.00	92.54±7.20	15.60	13.24** (95% CI: 6.42-20.06)	.000	.321
	a 7.66* (95% CI: .612-14.71)	a -.66 (95% CI: -9.26-7.95)				
Bonferroni post-hoc analysis	b 1.41 (95% CI: -4.48-7.29)	b -3.36 (95 %CI: -7.79-1.06)				
Mean difference (95% CI:)	c 9.07* (95% CI: 1.60-16.53)	c -4.02 (95% CI: -10.94-2.91)				
Incongruent trials (%)			4.88	6.00* (95% CI: .48-11.53)	.034	.129
baseline	84.48±16.02	86.91±15.86				
6th week	84.38±17.28	88.61±18.87				
12th week	82.55±15.33	93.90±6.63				
F_{time}		.823				
p-value		.418				
η^2		.024				
		A -.800 (95% CI: -7.09-5.49)				
Bonferroni post-hoc analysis		B -1.73 (95% CI: -6.06-2.60)				
Mean difference (95% CI:)		C -2.53 (95% CI: -6.88-1.83)				

Note. With main effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; With simple effect, a: baseline VS 6th week, b: 6th week VS 12th week, c: baseline VS 12th week, respectively; * present p<.05, ** present p<.001

The Figure 39 and 40 displayed the data detail of the accuracy in inhibition control over treatment period within and between groups

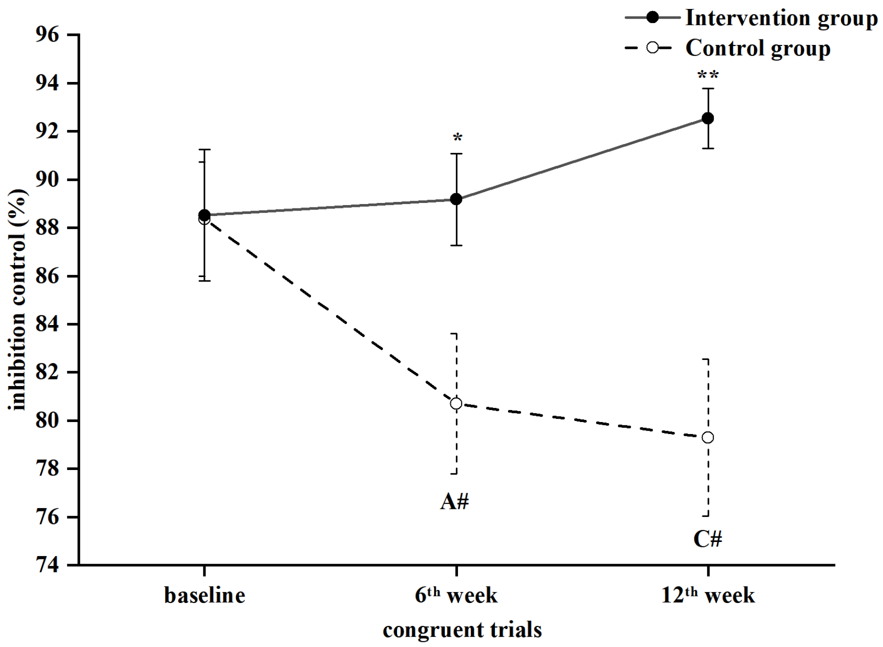


Figure 39, The performance in accuracy of congruent trials over treatment period within and between groups(n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001; pairwise comparisons within times in control group: A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; data presented with mean and SEM.

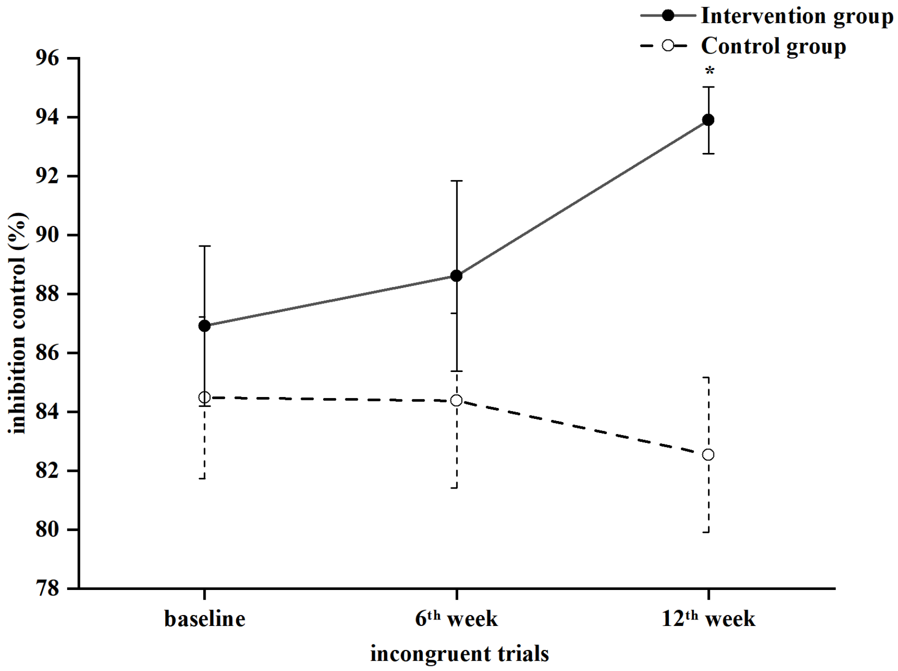


Figure 40, The performance in accuracy of incongruent trials over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001, data presented with mean and SEM.

4.2.1.5 The accuracy of working memory in 1-back trials and 2-back trials

With Mauchly's Test of Sphericity, results in the 1-back trials show that the interaction of group and time is consistent with Mauchly's spherical assumption(p>.05). The interaction of group and time did not have a significant effect on the accuracy of 1-back trials, $F_{(2,66)}$ =.272, p=.763, partial η^2=.008. Therefore, the main effects tests of the two within-subject factors (group and time) were required. And pairwise comparisons also are required.

During the 2-back trials, results show that the interaction of group and time is not consistent with Mauchly's spherical assumption(p>.05). The interaction of group and time had a statistically significant effect on the accuracy of 2-back trials, $F_{(2,66)}$=

17.31, p=.000, partial η^2=.344. Therefore, the independent simple effect test was performed on the two within-subject factors group and time. Data detail presented in the table 21.

*Table 21, The effect of group, time, and group*time on accuracy of working memory performance over treatment period within and between groups (n=68)*

Working memory	Source of Variance	F	p-value	Partial eta square(η^2)
1-back trial	Time*group	$F_{(2,66)}$ =.272	.763	.008
	Group	$F_{(1, 33)}$=.568	.456	.017
	Time	$F_{(2,66)}$ =19.53	.000	.372
2-back trial	Time*group	$F_{(2,66)}$= 17.31	.000	.344
	Group $_{baseline}$	$F_{(1,33)}$= .229	.635	.007
	Group $_{6th\ week}$	$F_{(1,33)}$= 4.05	.052	.109
	Group $_{12th\ week}$	$F_{(1,33)}$= 24.39	.000	.425
	Time $_{intervention}$	$F_{(2,66)}$= 3.33	.042	.092
	Time $_{control}$	$F_{(1.675,55.265)}$= 12.42	.000	.273

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

Considering the group, there was not statistically significant on the accuracy of 1-back trials, $F_{(1, 33)}$=.568, p=.456, partial η^2=.017. The accuracy of 1-back trials of the intervention group was higher than that of the control group. the difference of 1.89%, (95% CI: --3.21-6.98) was not statistically significant. The detail presented in the figure 41.

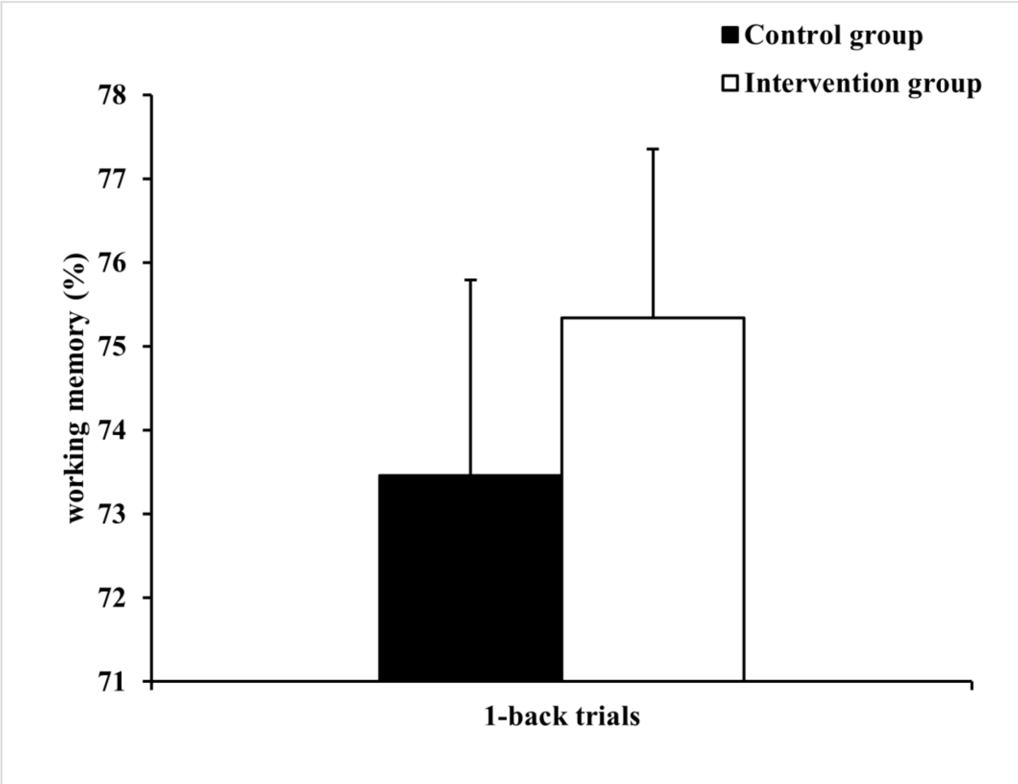


Figure 41, The pairwise comparisons in accuracy of 1-back trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Considering the time, the effect on the accuracy of 1-back trials was statistically significant, $F_{(2,66)}$ =19.53, p=.000, partial η^2=.372. With a pairwise comparison, the difference in the accuracy of 1-back trials was statistically significant (p=.000) between the baseline and the 6th week period with the difference of 12.65**%, (95% CI: 6.38-18.92). The difference in the accuracy between the 6th week period of the research and the 12th week period of the research was not statistically significant (p=.288), and the difference was -2.20%, (95% CI: -5.42-1.04). Simultaneously, the difference 10.45**%, (95% CI: 4.16-16.74) in the accuracy between the baseline of the test and the end of the test was statistically significant (p=.001). The detail presented in the figure 42.

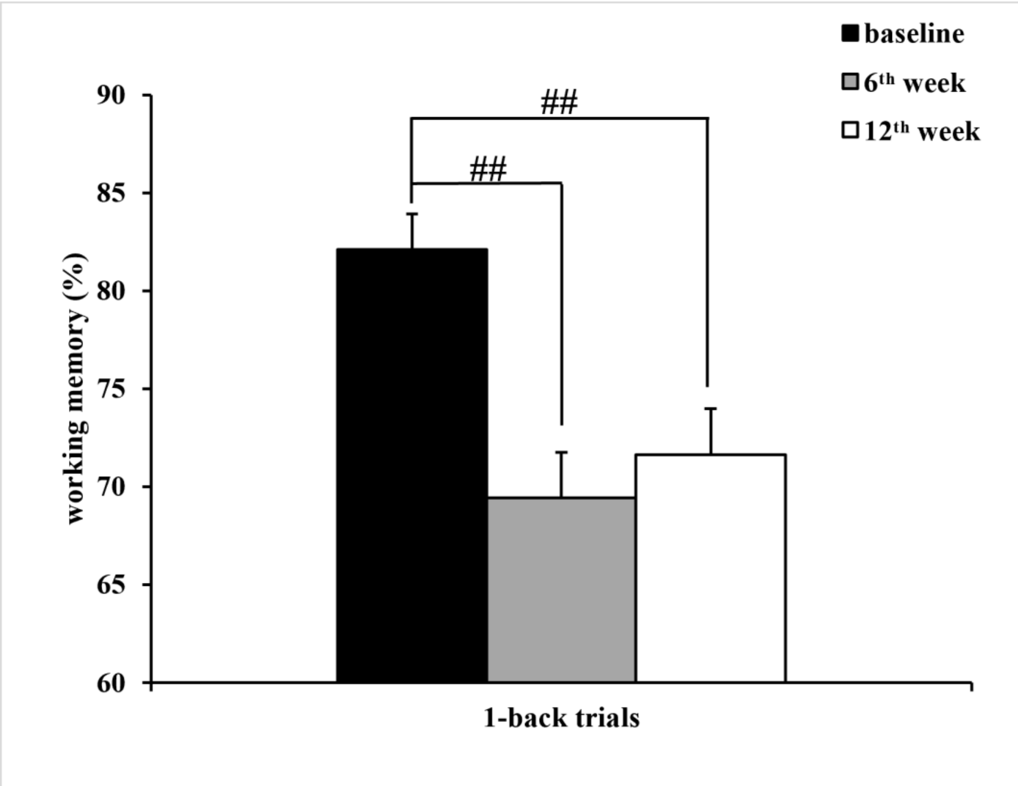


Figure 42, The pairwise comparisons in accuracy of 1-back trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Regarding 2-back, there was no significant difference between the intervention group (71.71±10.28)% and the control group (73.00±12.75)%, $F_{(1,33)}$= .229, p=.635, partial η^2=.007 at the baseline of the study, with the difference of -.1.29% (95% CI: -6.79-4.20). In the 6th week period of the study, the difference in accuracy of 2-back trials between the intervention group (68.93±15.81)% and the control group (61.90±16.28)% was not statistically significant, $F_{(1,33)}$= 4.05, p=.052, η^2=.109, with the difference of 7.02%, (95% CI: -.076-14.11). During the 12th week period of the study, there was a statistically significant difference in the accuracy of 2-back trials between the intervention group (75.62±17.74) % and the control group (58.04±16.30)%, with a difference of 17.59** (95% CI: 10.34-24.83), $F_{(1,33)}$= 24.39, p=.000, η^2=.425. The detail presented in the figure 43.

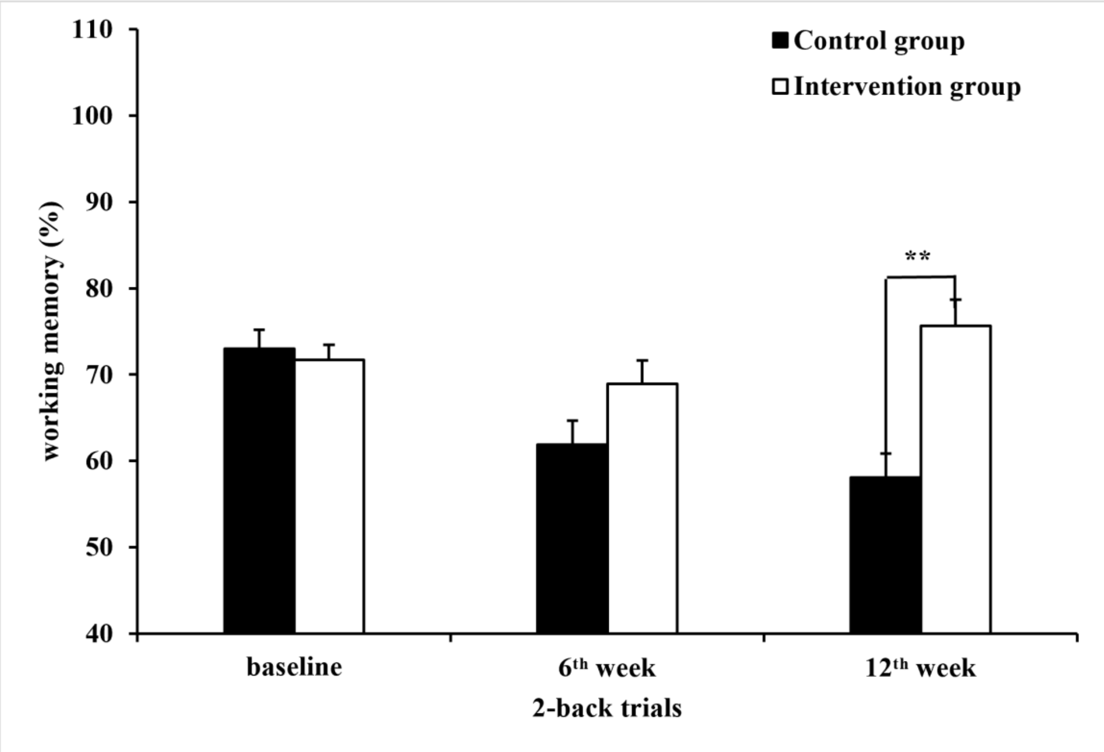


Figure 43, The pairwise comparisons in accuracy of 2-back trials performance over treatment period within groups (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Considering the within-subject factor time in the intervention group, the dependent variable was consistent with Mauchly's spherical assumption (p=.955). Furthermore, the simple effect of time on the accuracy of 2-back trials was statistically significant, $F_{(2,66)}$= 3.33, p=.042, η^2=.092. Specifically, the difference in the accuracy of 2-back trials between the baseline of the study (71.71±10.28)% and the 6^{th} week period of the study (68.93±15.81)% was not statistically significant (p=.901) with the difference of 2.78%, (95% CI: -3.88-9.44). The difference in the accuracy of 2-back trials between the 6th week period of the study (68.93±15.81)% and the 12th week period of study (75.62±17.74)% was statistically significant (p=.038), and the difference was -6.70*%, (95 %CI: -13.09--.30). Meanwhile, the difference in the accuracy of 2-back trials between the baseline of the study (71.71±10.28)% and the 12th week period of study (75.62±17.74)% was also not statistically significant (p=.441), and the difference was -3.92%, (95% CI: -10.57-2.74). The detail presented in the figure 44.

Regarding the within-subject factor time in the control group, the dependent variable was not consistent with Mauchly's spherical assumption (p=.032). Greenhouse-Geisser adjustment in result presented. Moreover, the simple effect of time on the accuracy of 2-back trials was statistically significant, $F_{(1.675,55.265)}$= 12.42, p=.000, η^2=.273 Particularly, there was a significant difference in the accuracy of 2-back trials between the baseline of the study (73.00±12.75)% and the 6th week period of the study (61.90±16.28)% (p=.004), with the difference 11.09**%, (95% CI: 3.09-19.17). The difference between the 6th week period of the study (61.90±16.28)% and the 12th week period of the study (58.04±16.30)% was not significant (p=.350), with the difference 3.87%, (95% CI: -2.19-9.93). The difference in the accuracy of 2-back trials between the baseline of the study (73.00±12.75)% and the 12th week period of the study (58.04±16.30)% was statistically significant (p=.001), with the difference 14.96** %(95% CI: 5.83-24.10). The detail presented in the figure 44.

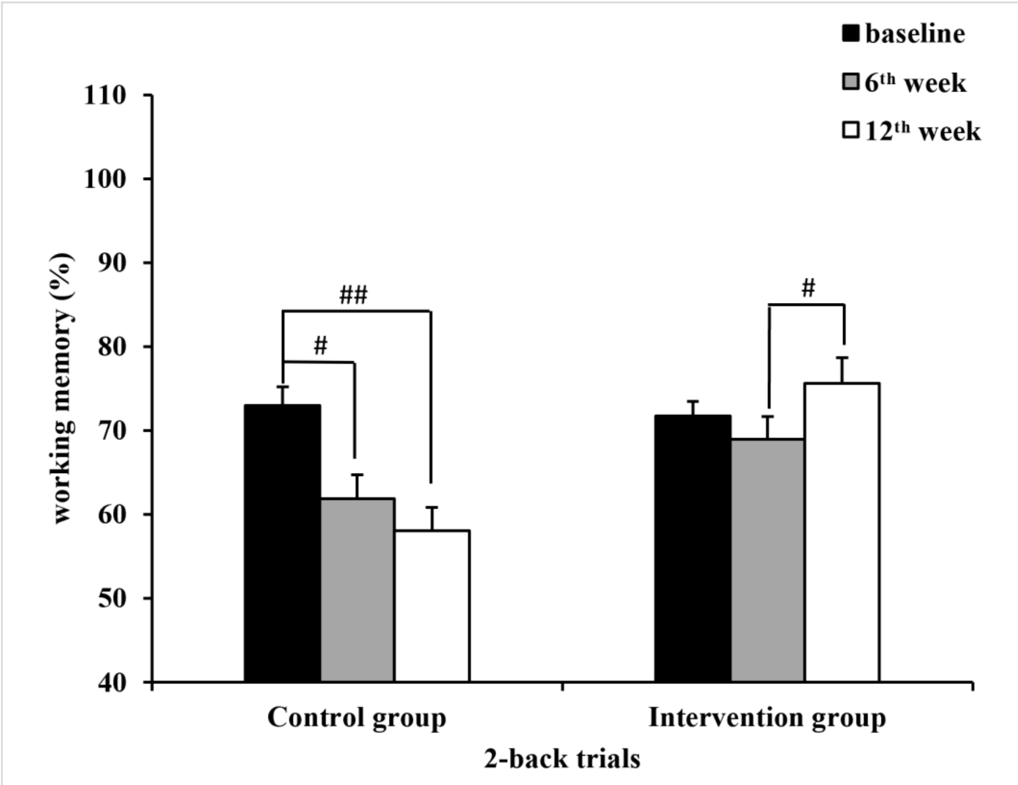


Figure 44, The pairwise comparisons in accuracy of 2-back trials performance over treatment period within times (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

The data detail of working memory performance presented on the table 22.

Table 22 The performance in accuracy of working memory over treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)				
	M ± SD	M ± SD	F_{group}	Mean difference (95% CI:)	p-value	η^2
Working memory						
1-back trials (%)			.568	1.89 (95% CI: --3.21-6.98)	.456	.017
baseline	80.79±14.90	83.40±13.74				
6^{th} week	69.61±20.49	69.30±16.19				
12^{th} week	69.96±17.44	73.33±18.83				
F_{time}		19.53				
p-value		.000				
η^2		.372				
Bonferroni post-hoc analysis Mean difference (95% CI:)		A 12.65** (95% CI: 6.38-18.92) B -2.20 (95% CI: -5.42-1.04) C 10.45** (95% CI: 4.16-16.74)				
2-back trials (%)						
baseline	73.00±12.75	71.71±10.28	.229	-.1.29 (95% CI: -6.79-4.20)	.635	.007
6^{th} week	61.90±16.28	68.93±15.81	33.00	7.02 (95% CI: -.076-14.11)	.052	.109
12^{th} week	58.04±16.30	75.62±17.74	53.08	17.59** (95% CI: 10.34-24.83)	.000	.425
Bonferroni post-hoc analysis Mean difference (95% CI:)	a 11.09* (95% CI: 3.09-19.17) b 3.87 (95% CI: -2.19-9.93) c 14.96** (95% CI: 5.83-24.10)	a 2.78 (95% CI: -3.88-9.44) b -6.70* (95 % CI: -13.09--.30) c -3.92 (95% CI: -10.57-2.74)				

Note. With main effect, A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, respectively; With simple effect, a: baseline VS 6^{th} week, b: 6^{th} week VS 12^{th} week, c: baseline VS 12^{th} week, respectively; * present p<.05, ** present p<.001

The Figure 45 and 46 displayed the data detail of the accuracy in inhibition control over treatment period within and between groups

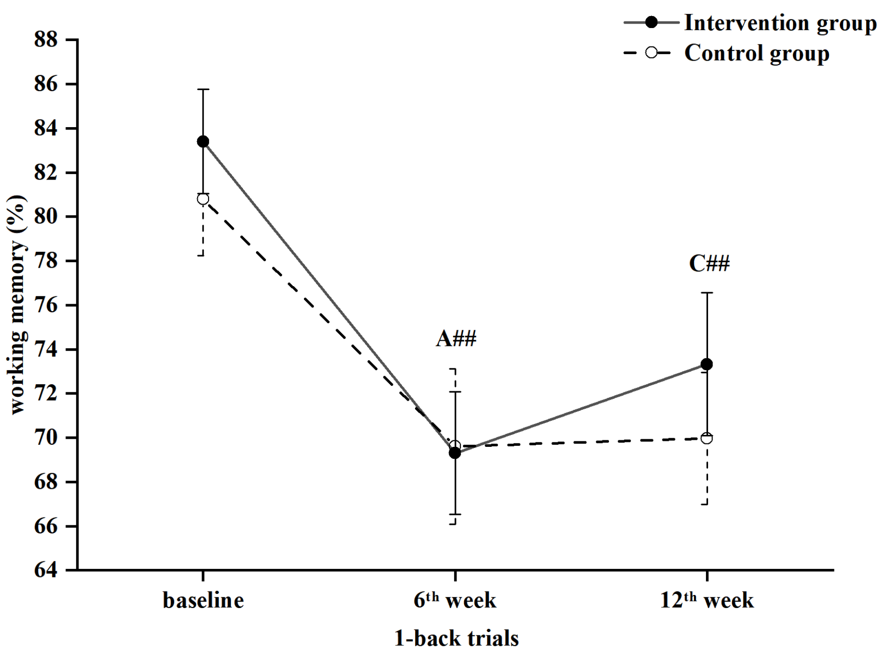


Figure 45, The performance in accuracy of 1-back trials performance over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001; A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively, data presented with mean and SEM.

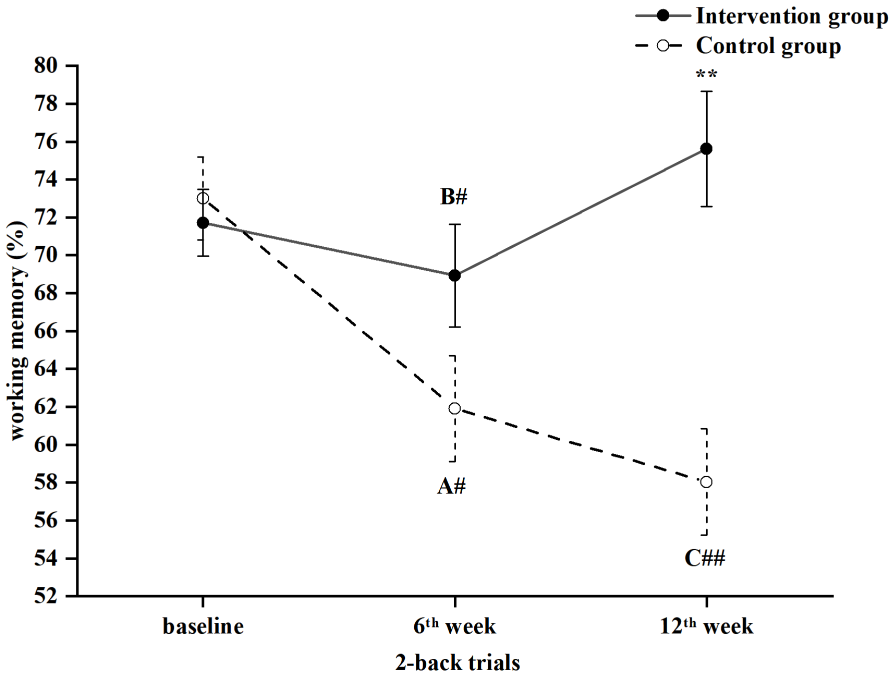


Figure 46, The performance in accuracy of 2-back trials performance over treatment period within and between groups(n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001; the pairwise comparisons within time in control group: A: baseline VS 6th week, C: baseline VS 12th week, respectively; the pairwise comparisons within time in intervention group: B: 6th week VS 12th week; data presented with mean and SEM

4.2.1.6 The accuracy of cognitive flexibility in color trials, shape trials and border trials

With Mauchly's Test of Sphericity, results in the color trials, shape trials, and border trials show that the interaction of group and time is not consistent with Mauchly's spherical assumption($p>.05$). The interaction of group and time did not have a significant effect on the accuracy of color trial, $F_{(2,66)}=1.94$, $p=.152$, partial $\eta^2=.055$. Therefore, the main effects tests of the two within-subject factors (group and time) were required.

However, there were statistically significant interaction effect of group* time on the accuracy both shape trials $F_{(2,66)}= 34.41$, $p=.000$, partial $\eta^2=.51$ and the border trials $F_{(2,66)}= 9.98$, $p=.001$, partial $\eta^2=.232$. Therefore, the independent simple effect test was performed on the two within-subject factors group and time. Data detail presented in the table 23.

*Table 23 The effect of group, time, and group*time on accuracy of cognitive flexibility performance over treatment period within and between groups (n=68)*

Cognitive flexibility	Source of Variance	F	p-value	Partial eta square(η^2)
Color trial	Time*group	$F_{(2,66)}$=1.94	.152	.055
	Group	$F_{(1, 33)}$=3.72	.062	.101
	Time	$F_{(2,66)}$ =1.58	.213	.046
Shape trial	Time*group	$F_{(2,66)}$= 34.41	.000	.51
	Group $_{baseline}$	$F_{(1,33)}$=.000	.986	.000
	Group $_{6th\ week}$	$F_{(1,33)}$= 33.00	.000	.613
	Group $_{12th\ week}$	$F_{(1,33)}$= 53.08	.000	.617
	Time $_{intervention}$	$F_{(1.50, 49.50)}$=.003	.997	.000
	Time $_{control}$	$F_{(2,66)}$= 45.24	.000	.578
Border trial	Time*group	$F_{(2,66)}$= 9.98	.001	.232
	Group $_{baseline}$	$F_{(1,33)}$=.178	.676	.005
	Group $_{6th\ week}$	$F_{(1,33)}$=10.40	.003	.240
	Group $_{12th\ week}$	$F_{(1,33)}$= 53.08	.000	.595
	Time $_{intervention}$	$F_{(1.683,55.549)}$=14.269	.000	.302
	Time $_{control}$	$F_{(1.473, 48.612)}$= .907	.409	.027

Note: $p_{Time*group}$ >.05 present the main effect of group and time conducted, $p_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

The main effect of the group on the accuracy of color trials was not statistically significant, $F_{(1, 33)}$=3.72, p=.062, partial η^2=.101. The accuracy of color trials in the intervention group was 4.15%, (95% CI: -.225-8.51) higher than that of the control group. the difference was not statistically significant. The detail presented in the Figure 47.

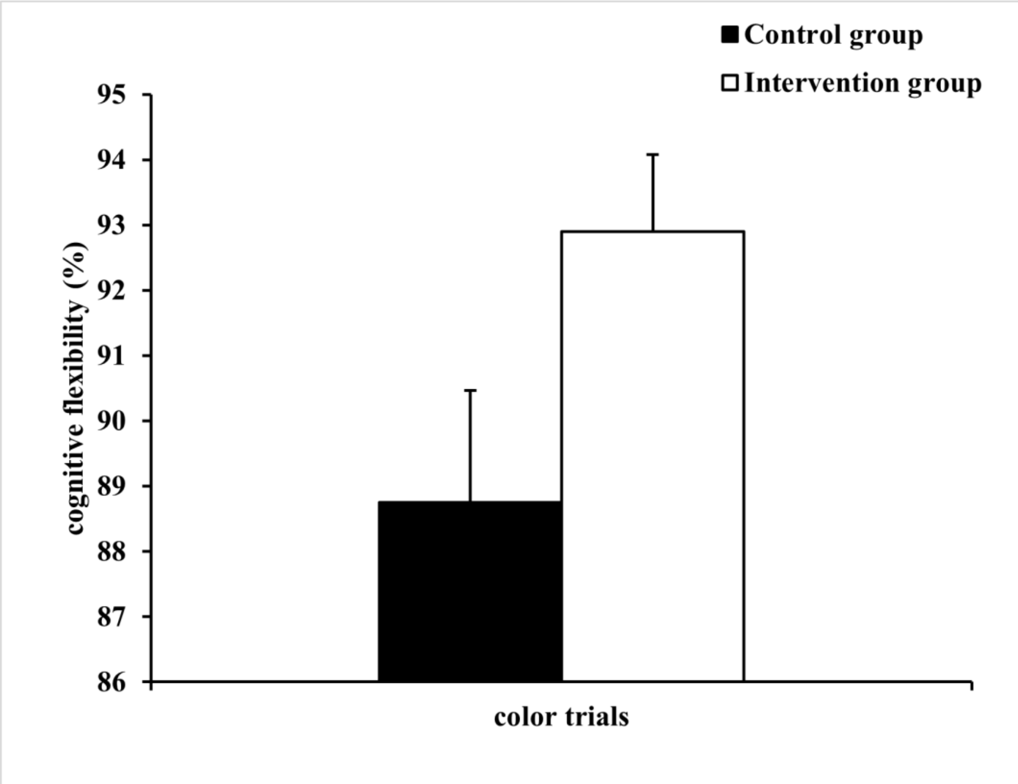


Figure 47, The pairwise comparisons in accuracy of color trials performance over treatment period within groups (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

The effect of time on the accuracy of color trials was not statistically significant, $F_{(2,66)}$ =1.58, p=.213, partial η^2=.046. With a pairwise comparison, the difference in the accuracy of color trials was not statistically significant (p=.670) between the baseline and the 6th week period with a difference of 2.51%, (95% CI: -2.59-7.60). in the accuracy of color trials between 6th week period and the 12th week period were not statistically significant (p=.747), and the difference was .75% (95% CI: -3.00-4.50). Simultaneously, the difference in the accuracy of color trials between the baseline of the test and the end of the test was statistically significant (p=.433), with the difference of 3.25%, (95% CI: -2.23-8.74). The detail presented in the figure 48.

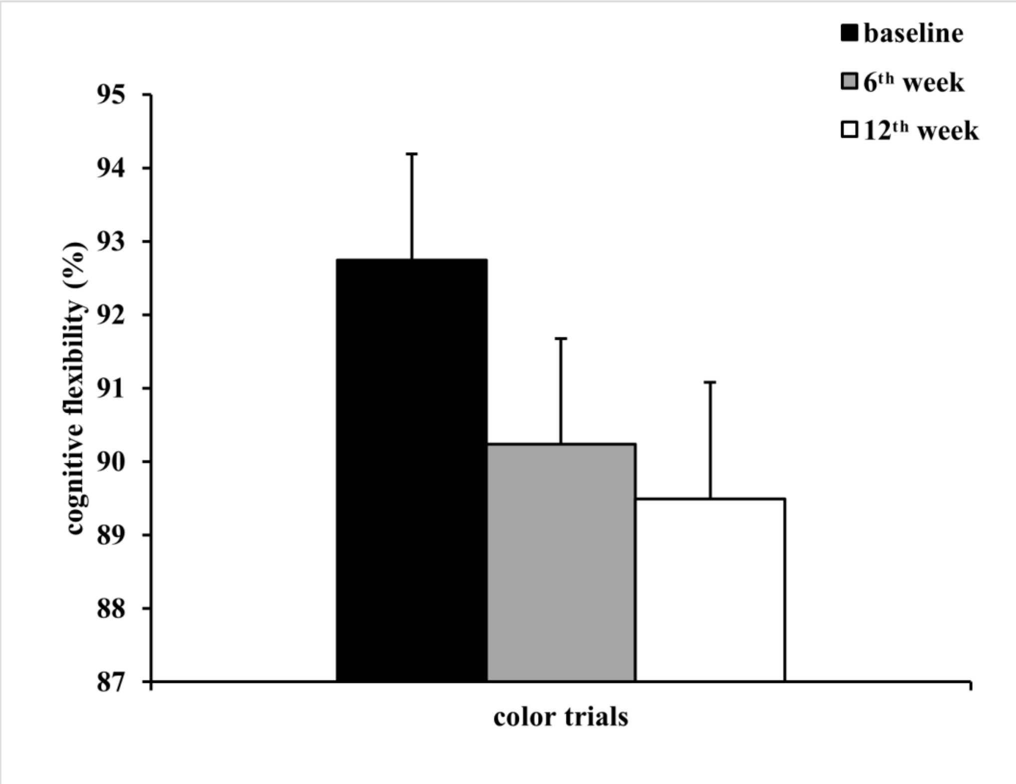


Figure 48, The pairwise comparison in accuracy of color trials performance over treatment period within times (n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001

Considering the group in the accuracy of shape trials, there was no significant difference between the intervention group (93.07±8.67)% and the control group (93.11±8.59)%, $F_{(1,33)}$=.000, p=.986, η^2=.000 at the baseline of the study, with the difference -.038%, (95% CI: -4.28, 4.21). In the 6th week of the study, the difference in the accuracy of shape trials between the intervention group (93.17±7.81)% and the control group (68.59±22.36)% was statistically significant $F_{(1,33)}$= 33.00, p=.000, η^2=.613. the difference was 24.59**%, (95% CI: 17.66-31.51). During the 12th week of the study, there was also a statistically significant difference in the accuracy of color trials (post trials) between the intervention group (93.00±11.64)% and the control group (65.89±18.39)%, with a difference of 27.12**%, (95% CI: 19.54-34.69), $F_{(1,33)}$= 53.08, p=.000, η^2=.617. The detail presented in the figure 49.

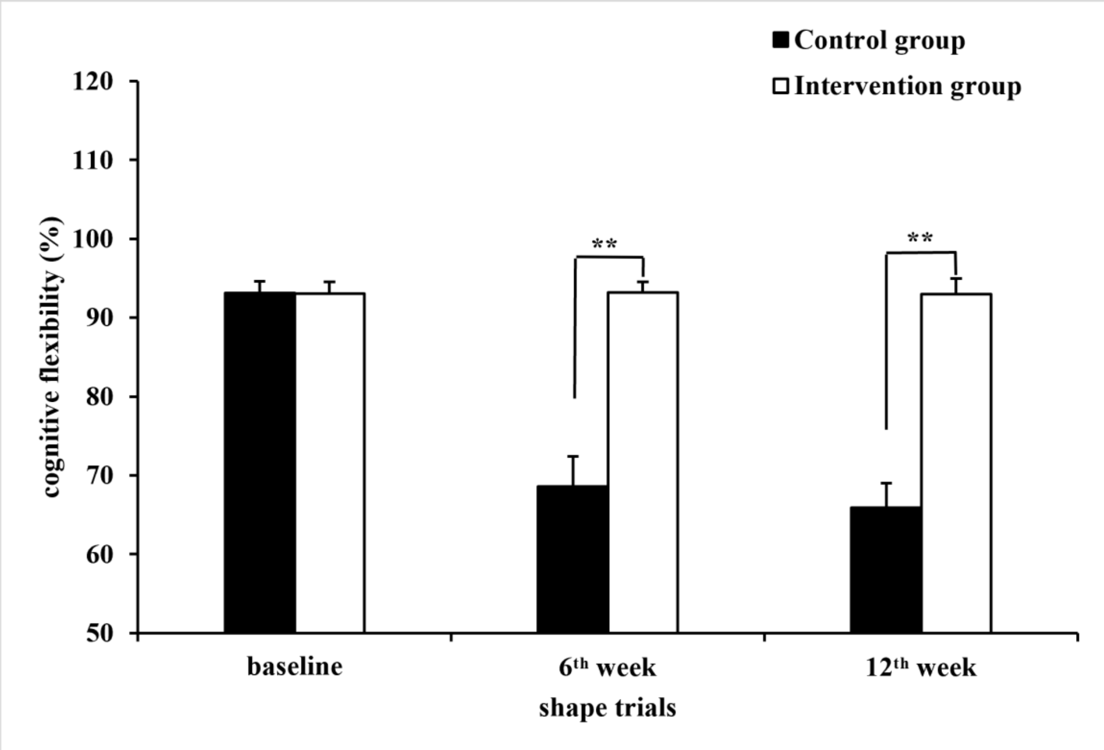


Figure 49, The pairwise comparison in accuracy of shape trials performance over treatment period within groups (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Considering the within-subject factor time in the intervention group, the dependent variable was not consistent with Mauchly's spherical assumption (p=.001). Greenhouse-Geisser adjustment in result presented. Furthermore, the simple effect of time on the accuracy of shape trials was not statistically significant, $F_{(1.50, 49.50)}$=.003, p=.997, η^2=.000. Specifically, the difference in the accuracy of shape trials between the baseline of the study (93.07±8.67)% and the 6th week period of the study

(93.17±7.81)% was not statistically significant (p=1.00) with the difference -.098% (95% CI: -5.47-5.27). The difference in the accuracy of shape trials between the 6th week period of the study (93.17±7.81)% and the 12th week period of study (93.00±11.64)% was not statistically significant (p=1.00), and the difference was .166%, (95 %CI: -3.62-3.96). Meanwhile, the difference in the accuracy of shape trials between the baseline of the study (93.07±8.67)% and the 12th week period of study (93.00±11.64)% was also not statistically significant (p=1.00), and the difference was .069% (95% CI: -6.51-6.65). The detail presented in the figure 50.

Considering the within-subject factor time in the control group, the dependent variable met Mauchly's spherical assumption (p=.190). Moreover, the simple effect of time on the accuracy of shape trials was statistically significant, $F_{(2,66)}$= 45.24, p=.000, η^2=.578. Particularly, there was a significant decline (p=.000) in the accuracy of shape trials between the baseline of the study (93.11±8.59)% and the 6th week period of the study (68.59±22.36)%, with a difference 24.53** (95% CI: 15.53-33.52); the difference between the 6th week period of the study (68.59±22.36)% and the 12th week period of the study (65.89±18.39)% was no significant (p=.978), with the difference 2.70% (95% CI: -4.12-9.51). The difference in the accuracy of shape trials between the baseline of the study (93.11±8.59) and the 12th week period of the study (65.89±18.39)% was statistically significant (p=.000) decline, with the difference of 27.22** (95% CI: 19.32-35.13). The detail presented in the figure 50.

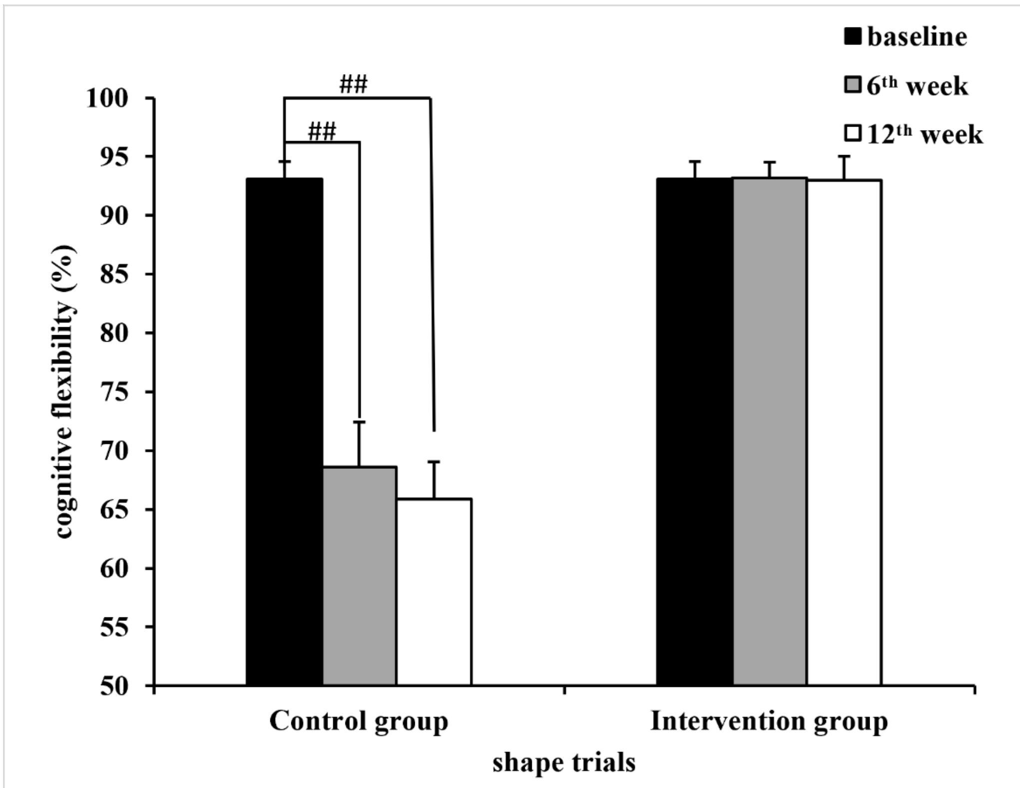


Figure 50, The pairwise comparison in accuracy of shape trials performance over treatment period within times (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Regarding the group in the accuracy of border trials, there was no significant difference between the intervention group (60.17±4.78)% and the control group (59.32±10.11)%, $F_{(1,33)}$=.178, p=.676, η^2=.005 at the baseline of the study, with the difference -.850% (95% CI: -3.25-4.95). In the 6th week period of the study, the difference was statistically significant $F_{(1,33)}$=10.40, p=.003, η^2=.240, with a difference of 5.03* (95% CI: 1.86-8.20) between the intervention group (63.31±7.05)% and the control group (58.28±4.51)%. During the 12 week period of the study, there was also a statistically significant difference in the accuracy of border trials between the intervention group (67.25±7.20)% and the control group (57.23±3.62)%, with a difference of 10.02** (95% CI: 7.10-12.95), $F_{(1,33)}$= 53.08, p=.000, η^2=.595. The detail presented in the figure 51.

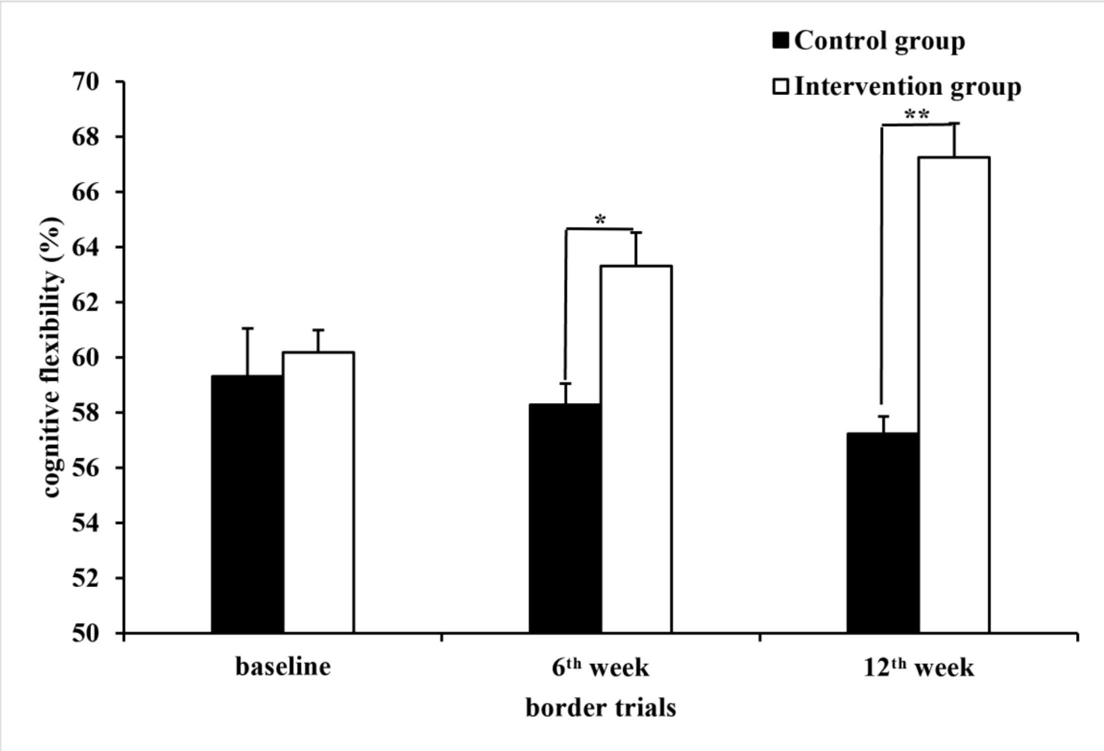


Figure 51, The pairwise comparison in accuracy of border trials performance over treatment period within groups (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Considering the within-subject factor time in the intervention group, the dependent variable was not consistent with Mauchly's spherical assumption (p=.036). Greenhouse-Geisser adjustment in result presented. Furthermore, the simple effect of time on the accuracy of border trials was not statistically significant, $F_{(1.683,55.549)}$=14.269, p=.000, η^2=.302. Specifically, the difference in the accuracy of border trials between the baseline of the study (60.17±4.78)% and the 6th week period of the study (63.31±7.05)% was not statistically significant (p=.103) with the difference of -.3.14%, (95% CI: -6.73-.45). The difference in the accuracy of border trials between the 6th week period of the study (63.31±7.05) and the 12th week period of study (67.25±7.20)% was statistically significant (p=.001), and the difference was -3.95** (95 %CI: -6.49--1.41). Meanwhile, the difference in the accuracy of border trials between the baseline of the study (60.17±4.78)% and the 12th week period of study (67.25±7.20)% was also statistically significant (p=.000), and the difference was -7.09** (95% CI: -10.89—3.29).

Regarding the within-subject factor time in the control group, the dependent variable met Mauchly's spherical assumption (p=.001). Moreover, the simple effect of time on the accuracy of border trials was not statistically significant, $F_{(1.473, 48.612)}$= .907, p= .409, η^2= .027. Particularly, there was no significant difference (p=1.000) in the accuracy of border trials between the baseline of the study (59.32±10.11)% and the 6th week period of the study (58.28±4.51)%, with a difference of 1.04 (95% CI:-3.50 -5.58); the difference between the 12th week period of the study (58.28±4.51)% and the three-month period of the study (57.23±3.62)% was no significant (p=.888), with the difference 1.05%, (95% CI: -1.44-3.53). The difference in the accuracy of border trials between the baseline of the study (59.32±10.11)% and the 12th week period of the study (57.23±3.62)% was not significant (p=.707), with a difference of 2.09%, (95% CI: -2.27-6.44). The detail presented in the Figure 52.

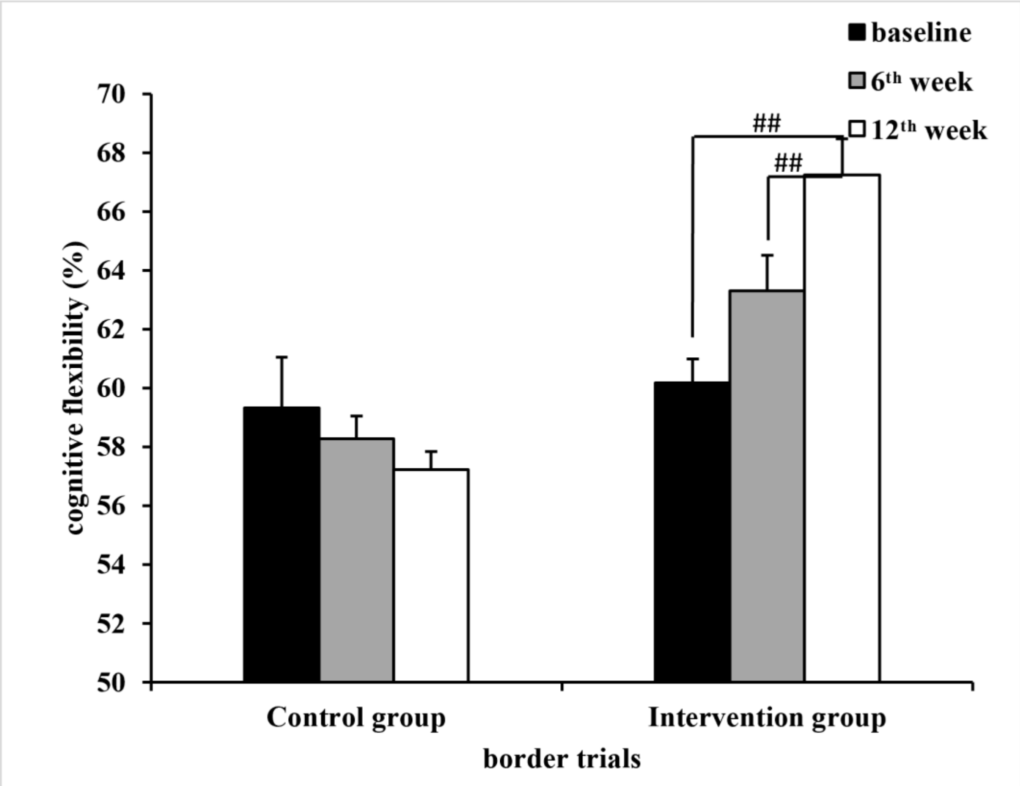


Figure 52, The pairwise comparison in accuracy of border trials performance over treatment period within times (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

The data detail of cognitive flexibility performance presented on the table 24 and table 25.

Table 24 The performance results for accuracy of cognitive flexibility over treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)				
	M ± SD	M ± SD	F_{group}	Mean difference (95% CI:)	p-value	η^2
Cognitive flexibility						
color trials (%)			3.72	4.15 (95% CI: -.225-8.51)	.062	. 101
baseline	92.83±10.77	92.66±13.11				
6^{th} week	85.98±16.54	94.50±8.64				
12^{th} week	87.45±15.53	91.53±11.86				
F_{time}		1.58				
p-value		.213				
η^2		.046				
		A 2.51 (95% CI: -2.59-7.60)				
Bonferroni post-hoc analysis		B .747(95% CI: -3.00-4.50)				
Mean difference (95% CI:)		C 3.25 (95% CI: -2.23-8.74)				
Shape trials (%)						.117
baseline	93.11±8.59	93.07±8.67	.000	-.038 (95% CI: -4.28, 4.21)	.986	.000
6^{th} week	68.59±22.36	93.17±7.81	33.00	24.59** (95% CI: 17.66-31.51)	.000	.613
12^{th} week	65.89±18.39	93.00±11.64	53.08	27.12** (95% CI: 19.54-34.69)	.000	.617
F_{time}	45.24	.003				
p-value	.000	.997				
η^2	.578	.000				
	a 24.53**(95% CI: 15.53-33.52)	a -.098 (95% CI: -5.47-5.27)				
Bonferroni post-hoc analysis	b 2.70 (95% CI: -4.12-9.51)	b .166 (95% CI: -3.62-3.96)				
Mean difference (95% CI:)	c 27.22** (95% CI: 19.32-35.13)	c .069 (95% CI: -6.51-6.65)				

Note. With main effect, A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, respectively; With simple effect, a: baseline VS 6^{th} week, b: 6^{th} week VS 12^{th} week, c: baseline VS 12^{th} week, respectively; * present p<.05, ** present p<.001

Table 25 the performance results for accuracy of cognitive flexibility over treatment period within and between groups(n=68) (continued)

variables	Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
	M±SD	M±SD				
Border trials (%)						
baseline	59.32±10.11	60.17±4.78	.178	-.850 (95% CI: -3.25-4.95)	.676	.005
6^{th} week	58.28±4.51	63.31±7.05	10.40	5.03* (95% CI: 1.86-8.20)	.003	.240
12^{th} week	57.23±3.62	67.25±7.20	53.08	10.02** (95% CI: 7.10-12.95)	.000	.595
F_{time}	.907	14.269				
p-value	.409	.000				
η^2	.027	.302				
	a 1.04 (95% CI:-3.50 -5.58)	a -.3.14 (95% CI: -6.73-.45)				
Bonferroni post-hoc analysis	b 1.05 (95% CI: -1.44-3.53)	b -3.95** (95 %CI: -6.49—1.41)				
Mean difference (95% CI:)	c 2.09 (95% CI: -2.27-6.44)	c -7.09** (95% CI: -10.89—3.29)				

Note. With main effect, A: baseline VS 6^{th} week, B: 6^{th} week VS 12^{th} week, C: baseline VS 12^{th} week, respectively; With simple effect, a: baseline VS 6^{th} week, b: 6^{th} week VS 12^{th} week, c: baseline VS 12^{th} week, respectively; * present p<.05, ** present p<.001

The Figure 53, 54, and 55 displayed the data detail of the accuracy in cognitive flexibility over treatment period within and between groups

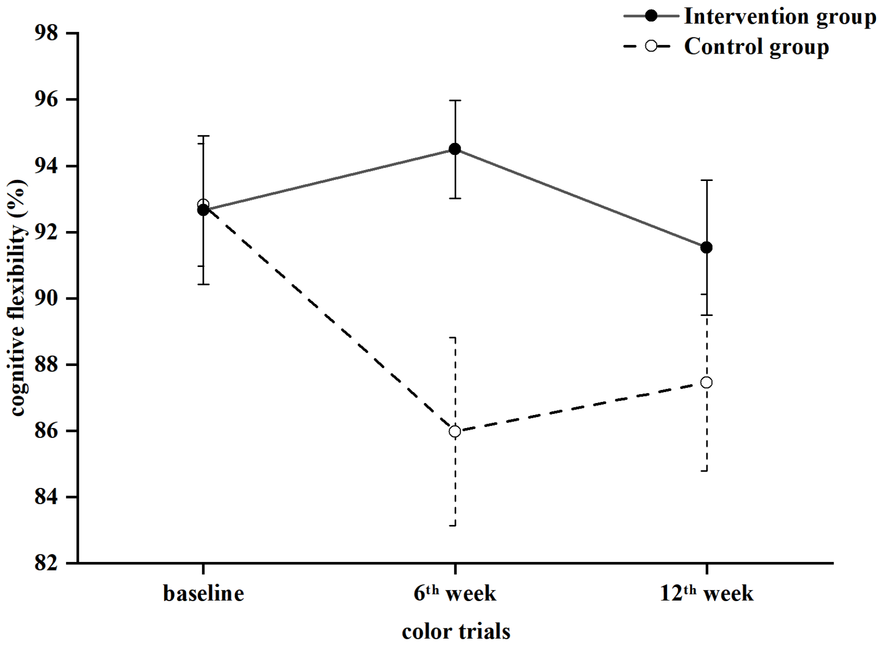


Figure 53, The performance in accuracy of color trials over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with main effect of group, * present p<.05, ** present p<.001; data presented with mean and SEM.

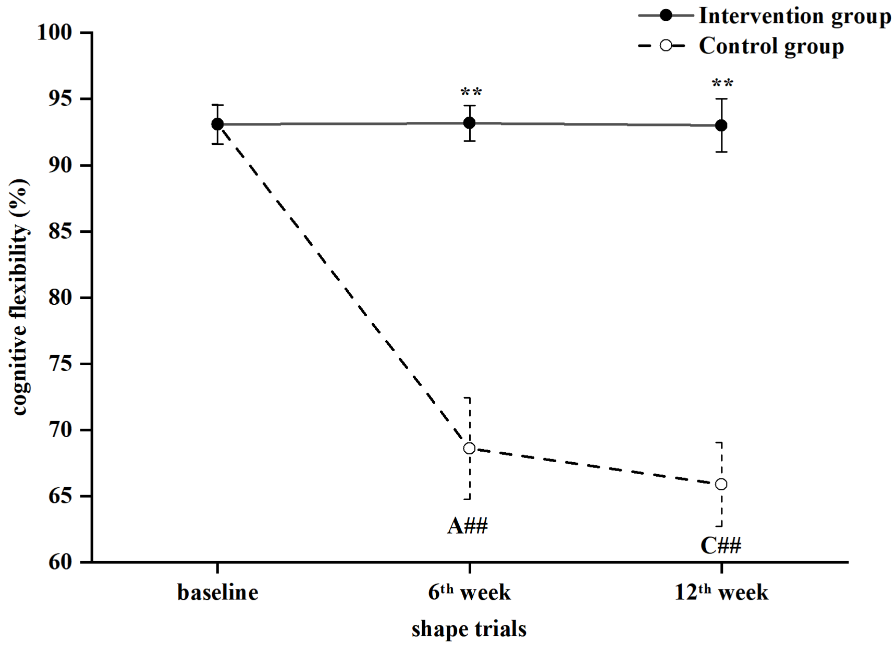


Figure 54, The performance in accuracy of shape trials over treatment period within and between groups(n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001; with simple effect of group, * present p<.05, ** present p<.001; the pairwise comparisons within time in control group: A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; data presented with mean and SEM.

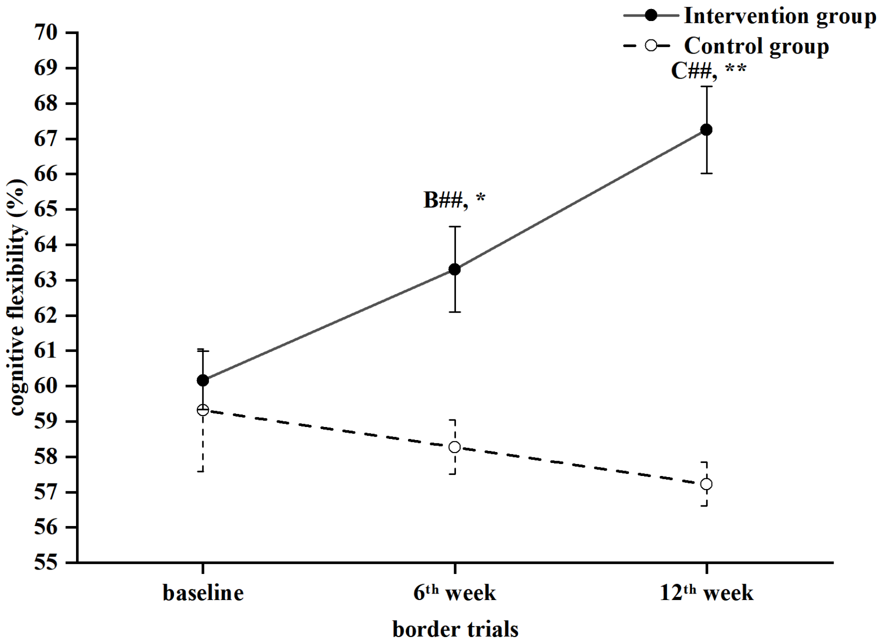


Figure 55, The performance in accuracy of border trials over treatment period within and between groups(n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001; the pairwise comparisons within time in intervention group: A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; data presented with mean and SEM.

4.2.2 core executive functions performance measurement at 18th week in the study.

The data of core executive functions performance during follow-up period included 68 participants (n_{int}=34, n_{con}=34, respectively) in this study. There were no outliers in the data by the boxplot; The data in each group obeyed a normal distribution with the Shapiro-Wilk test (p>0.05).

4.2.2.1 The response reaction time of inhibition control in the congruent trials and incongruent trials

Regarding congruent trials, A paired-sample t-test displayed that there was a significant difference of (26.40±59.68)* milliseconds, (95% CI: 5.58-47.23) (t=2.58, p=.015) in the intervention group, with the mean of 12th week (471.03±82.41) milliseconds and 18th week (444.63±62.20) milliseconds, respectively. Similarly, the difference (1.21±90.58) milliseconds, (95% CI: 30.40-32.81) in control group did not reach significant (t=.078, p=.939), with the mean of 12th week (500.93±78.60) milliseconds and 18th week (499.73±75.22) milliseconds, respectively. The detail presented in the figure 56.

With an independent sample t-test, there was a statistical difference (t=3.29, p=.002) between the intervention group (444.63±62.20) milliseconds and those of control group (499.73±75.22) milliseconds, with a difference of 55.10* milliseconds, (95% CI: 21.68-88.52) at 18th week timepoint. The detail presented in the figure 56.

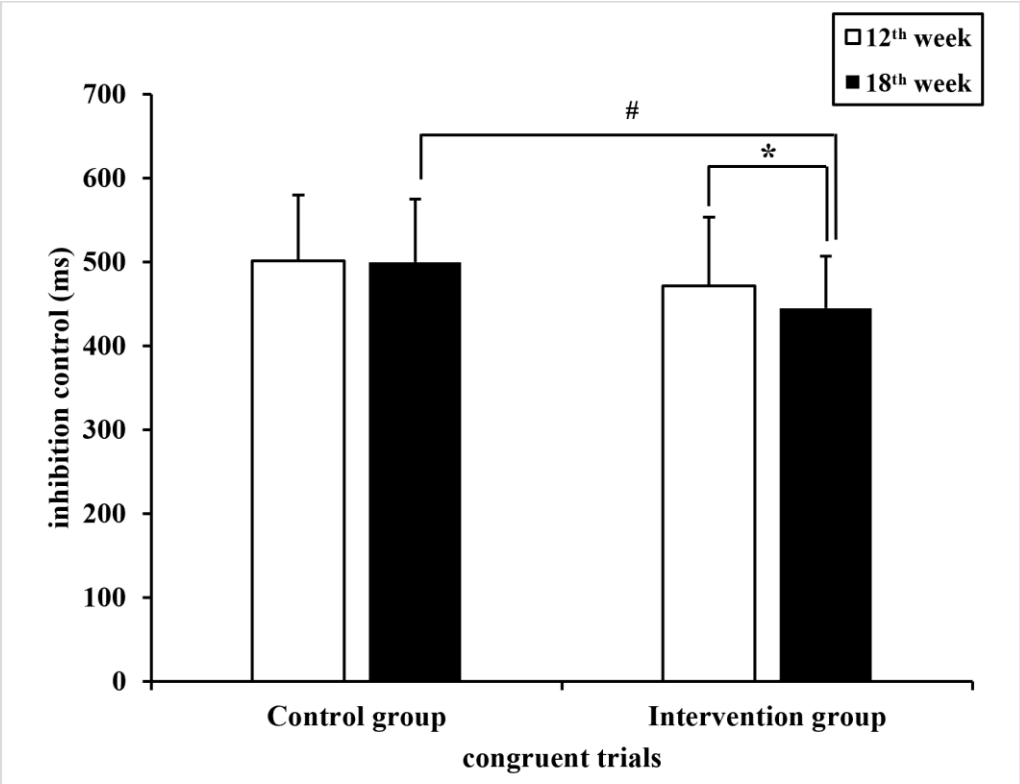


Figure 56, The pairwise comparison in reaction time of inhibition control within times and between groups during follow-up period.

Note, * present p<.05, ** present p<.001 within time, # present p<.05, ## present p<.001 between groups

Regarding incongruent trials, a paired-sample t-test displayed that there was no significant difference of (11.31±39.80) milliseconds, (95% CI: -2.58-25.19) (t=1.66, p=.107) in the intervention group, with the mean of 12th week (496.48±58.46) milliseconds and 18th week (486.78±66.79) milliseconds, respectively. Otherwise, the difference (9.70±86.03) milliseconds, (95% CI: -20.32-39.72) in control group did not reach significant (t=.657, p=.516), with the mean of 12th week (500.93±78.60) milliseconds and 18th week (499.73±75.22) milliseconds, respectively.

The results showed that the independent sample t-test demonstrated that the reaction time of 1-back trials in the intervention group (444.57±56.78) milliseconds were faster than those of control group (486.78±66.79) milliseconds, with a difference of 42.21*milliseconds, (95% CI: 12.19-72.22). Moreover, there was a statistical difference (t=2.81, p=.007) between groups. The detail presented in the figure 57.

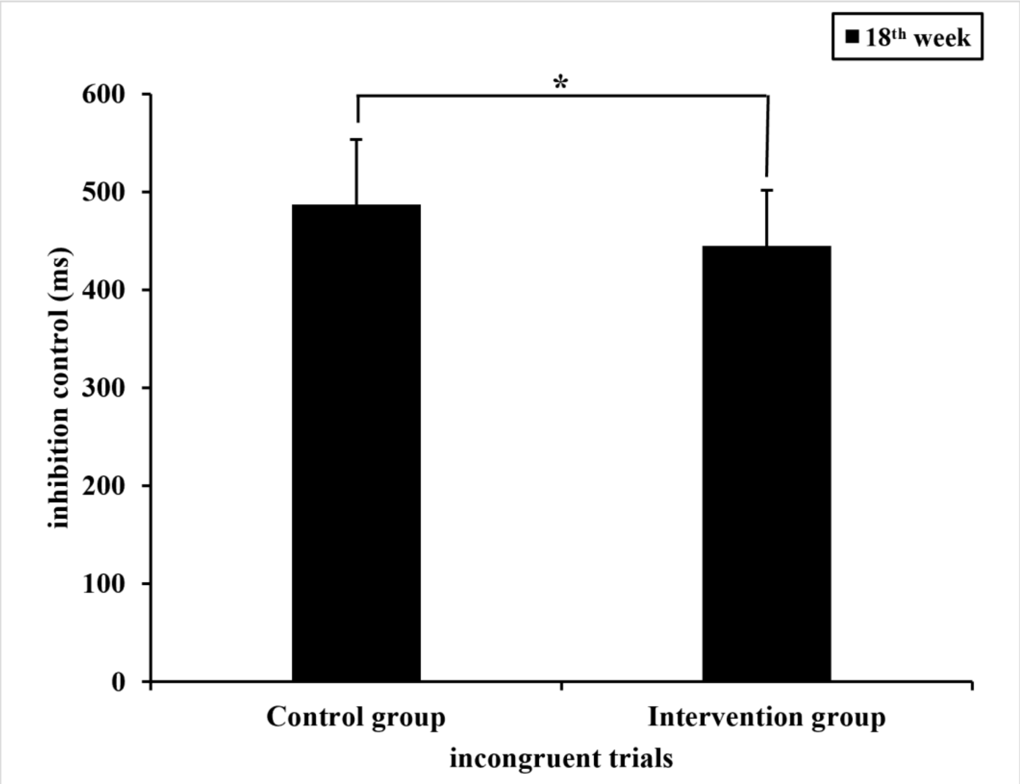


Figure 57, The pairwise comparison of inhibition control reaction time between groups on 18th week.

Note, * present p<.05, ** present p<.001

The data detail of inhibition control during follow-up period presented on table 26.

Table 26 The performance in reaction time of inhibition control in the follow-up period within and between subjects(n=68)

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
Inhibition control					
Congruent trials					
12^{th} week	500.93±78.6	471.03±82.41			
18^{th} week	499.73±75.22	444.63±62.20	3.29	.002	55.10* (95% CI: 21.68-88.52)
t	.078	2.58			
p-value	.939	.015			
Mean difference (95% CI:)	1.21±90.58 (95% CI: 30.40-32.81)	26.40*±59.68 (95% CI: 5.58-47.23)			
Incongruent trials					
12^{th} week	496.48±58.46	455.88±61.58			
18^{th} week	486.78±66.79	444.57±56.78	2.81	.007	42.21*(95% CI: 12.19-72.22)
t	.657	1.66			
p-value	.516	.107			
Mean difference (95% CI:)	9.70±86.03 (95% CI:-20.32-39.72)	11.31±39.80(95% CI:-2.58-25.19)			

Note: * present p<.05, ** present p<.001

4.2.2.2 The response reaction time of working memory in the 1-back trials and 2-back trials

With a paired-sample t-test, there was no significant difference of (55.41±234.69) milliseconds, (95% CI: -26.48-137.30) (t=1.38, p=.178) in the intervention group, with the mean of 12th week (790.01±237.18) milliseconds and 18th week (734.60±234.34) milliseconds, respectively. Similarly, there was no significance (t=1.62, p=.115) with the mean of 12th week (876.67±216.43) milliseconds than 18th week (824.37±201.94) milliseconds with the difference (52.30±188.59) milliseconds, (95% CI: -13.50-118.11)

With an independent sample t-test, there was no statistical difference (t=1.69, p=.095) between intervention group (734.60±234.34) milliseconds and control group (824.37±201.94) milliseconds in 1-back trials, with a difference of 89.76 milliseconds, (95% CI: -16.16- 195.68). The data detail presented in the table 27.

About the results of reaction time in 2-back trials, A paired-sample t-test displayed that there was no significant difference of (-.800±264.82) milliseconds, (95% CI: -.22-11.10) (t=-.018, p=.986) in the intervention group, with the mean of 12th week (735.63±240.83) milliseconds and 18th week (736.43±238.82) milliseconds, respectively. Otherwise, the difference (32.63±210.63) milliseconds, (95% CI: -40.86-106.13) in control group did not reach significant (t=.903, p=.373) (t=.903, p=.373), with the mean of 12th week (835.91±226.79) milliseconds and 18th week (803.27±208.39) milliseconds, respectively.

With an independent sample t-test, there was no statistical difference (t=1.23, p=.223) between intervention group (736.43±238.82) milliseconds and control group

(803.27±208.39) milliseconds in 2-back trials, with a difference of 66.84 milliseconds, (95% CI: -41.69- 175.37). The data detail presented in the table 27.

Table 27 The performance results for working memory reaction time in the follow-up period within and between subjects (n=68)

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
Working memory					
1-back trials					
12th week	876.67±216.43	790.01±237.18			
18th week	824.37±201.94	734.60±234.34	1.69	.095	89.76 (95% CI: -16.16-195.68)
t	1.62	1.38			
p-value	.115	.178			
Mean difference (95% CI:)	52.30±188.59 (95% CI: -13.50-118.11)	55.41±234.69 (95% CI: -26.48-137.30)			
2-back trials					
12th week	835.91±226.79	735.63±240.83			
18th week	803.27±208.39	736.43±238.82	1.23	.223	66.84(95% CI: -41.69-175.37)
t	.903	-.018			
p-value	.373	.986			
Mean difference (95% CI:)	32.63±210.63 (95% CI: -40.86-106.13)	-.800±264.82 (95% CI: -.22-11.10)			

Note: * present p<.05, ** present p<.001

4.2.2.3 The response reaction time of cognitive flexibility in the color trials, shape trial and border trials.

About the results of reaction time in the color trials, shape trials, and border trials, Boxplots found no outliers. After the Shapiro-Wilk test, the data in each group obeyed a normal distribution (p>.05). A paired-sample t-test displayed that there was a significant difference of -98.74±298.78 milliseconds (95% CI: -202.99- 5.50) (t=-1.93, p=.063) in the intervention group, with the mean of 12th week (698.66±180.65) milliseconds and 18th week (797.41±259.35) milliseconds, respectively. Otherwise, the difference 26.93±298.85 milliseconds, (95% CI: -77.34-131.20) in control group did not reach significant (t=.525, p=.603), with the mean of 12th week (859.88±212.62) milliseconds and 18th week (832.95±247.36) milliseconds, respectively.

With an independent sample t-test, the reaction time of color trials in the intervention group (797.41±259.35) milliseconds were faster than those of control group (832.95±247.36) milliseconds (t=-.578, p=. 565) between groups, with a difference of -35.545 milliseconds (95% CI: -158.26- 87.17).

Regarding shape trials, A paired-sample t-test displayed that there was a significant difference of -83.99±318.02 milliseconds, (95% CI: -194.95-26.97) (t=-1.54, p=.133) in the intervention group, 12th week (713.42±188.11) milliseconds than 18th week (797.41±259.35) milliseconds. Otherwise, the difference -66.28±291.12 milliseconds, (95% CI: -167.85-35.30) in control group did not reach significant (t=-1.33, p=.193), with the mean of 12th week (808.37±262.24) milliseconds and 18th week (874.64±216.98) milliseconds, respectively.

With an independent sample t-test, there was no statistical difference (t=-1.33, p=.187) between groups. Even if, it was faster intervention group (797.41±259.35) milliseconds those of control group (874.64±216.98) milliseconds, with a difference of -77.23 milliseconds, (95% CI: -193.02- 38.55).

About the results of reaction time in the border trials, A paired-sample t-test displayed that there was a significant difference of (-122.12*±333.51) milliseconds (95% CI: -238.49-5.75) (t=2.14, p=.04) in the intervention group, with the mean of 12th week (831.77±269.18) milliseconds and 18th week (953.89±187.64) milliseconds, respectively. Otherwise, the difference (67.28±283.07) milliseconds, (95% CI: -31.49-166.05) in control group did not reach significant (t=.139, p=.175), with the mean of 12th week (1095.10±359.59) milliseconds and 18th week (1027.83±355.66) milliseconds, respectively. The detail displayed in the figure 58

With an independent sample t-test, there was no statistical difference (t=1.07, p=.288) in reaction time in the intervention group (953.89±187.64) milliseconds than those of control group (1027.83±355.66) milliseconds, with a difference of 79.94 milliseconds (95% CI: -63.75-211.63).

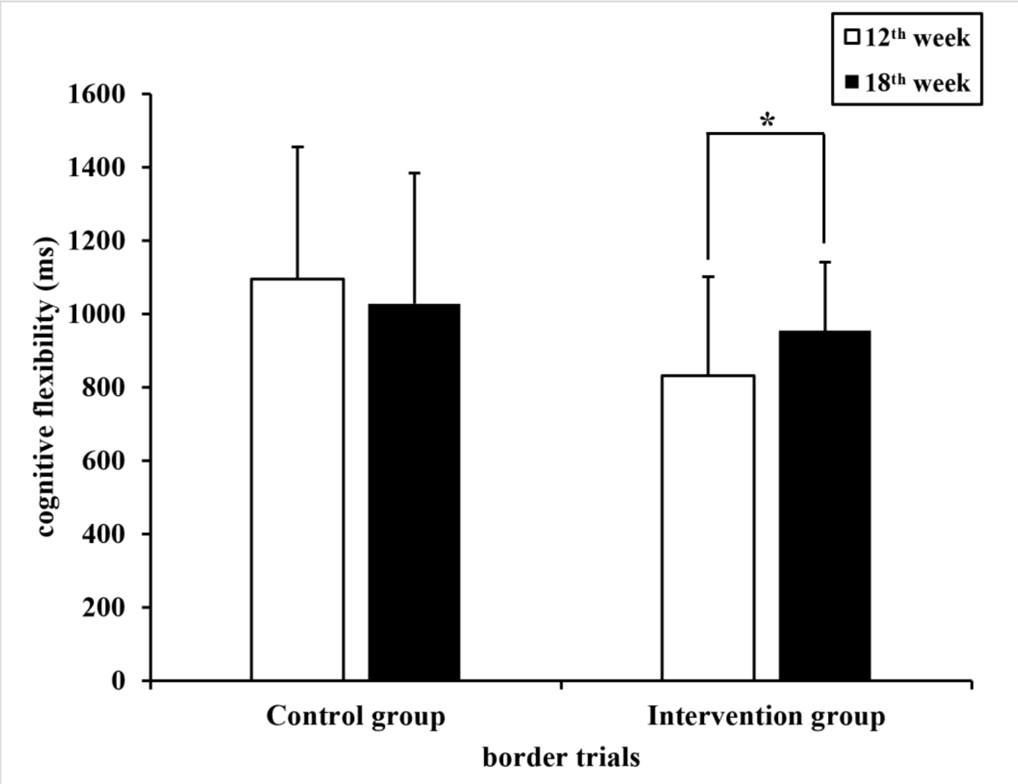


Figure 58, The pairwise comparison in reaction time of border trials within times and between groups during follow-up period.

Note, * present p<.05, ** present p<.001

The data detail of cognitive flexibility presented in the table 28

Table 28 the performance of cognitive flexibility reaction time in the follow-up period within and between subjects

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
cognitive flexibility					
Color trials					
12th week	859.88±212.62	698.66±180.65			
18th week	832.95±247.36	797.41±259.35	-.578	. 565	-35.545 (95% CI: -158.26- 87.17)
t	.53	-1.93			
p-value	.603	. 063			
lean difference (95% CI:)	26.93±298.85 (95% CI: -77.34-131.20)	-98.74±298.78 (95% CI: -202.99- 5.50)			
shape trials					
12th week	808.37±262.24	713.42±188.11			
18th week	874.64±216.98	797.41±259.35	-1.33	.187	-77.23 (95% CI: -193.02- 38.55)
t	-1.33	-1.54			
p-value	.193	.133			
lean difference (95% CI:)	-66.28±291.12 (95% CI: -167.85-35.30)	-83.99±318.02 (95% CI: -194.95-26.97)			
Border trials					
12th week	1095.10±359.59	831.77±269.18			
18th week	1027.83±355.66	953.89±187.64	1.07	.288	79.94 (95% CI: -63.75-211.63)
t	.139	2.14			
p-value	.175	.04			
lean difference (95% CI:)	67.28±283.07 (95% CI:-31.49-166.05)	-122.12*±333.51 (95% CI:-238.49-5.75)			

Note: * present p<.05, ** present p<.001

4.2.2.4 The accuracy of inhibition control in the congruent trials and incongruent trials

With a paired-sample t-test, the mean of the accuracy percentage in congruent trials of intervention group were (92.54±7.20) at 12th week and (92.56±9.00) at 18th week in this study, with a difference (.03±8.77), (95% CI: -3.09-3.03). The difference was not statistically significant (t=-.02, p=.986). Additionally, the mean of the accuracy percentage in congruent trials of control group were (79.29±19.00) at 12th week and (81.84±16.01) at 18th week in this study, with a difference (2.55±17.73), (95% CI: -8.74-3.64). The difference was not statistically significant (t=-.84, p=.408).

With independent sample t-test, the results showed that the accuracy percentage in the intervention group (92.56±9.00) were higher than those of control group (81.84±16.01), with a difference of 10.72**, (95% CI: 4.43-17.01), with a statistical difference (t=3.40, p=.001).

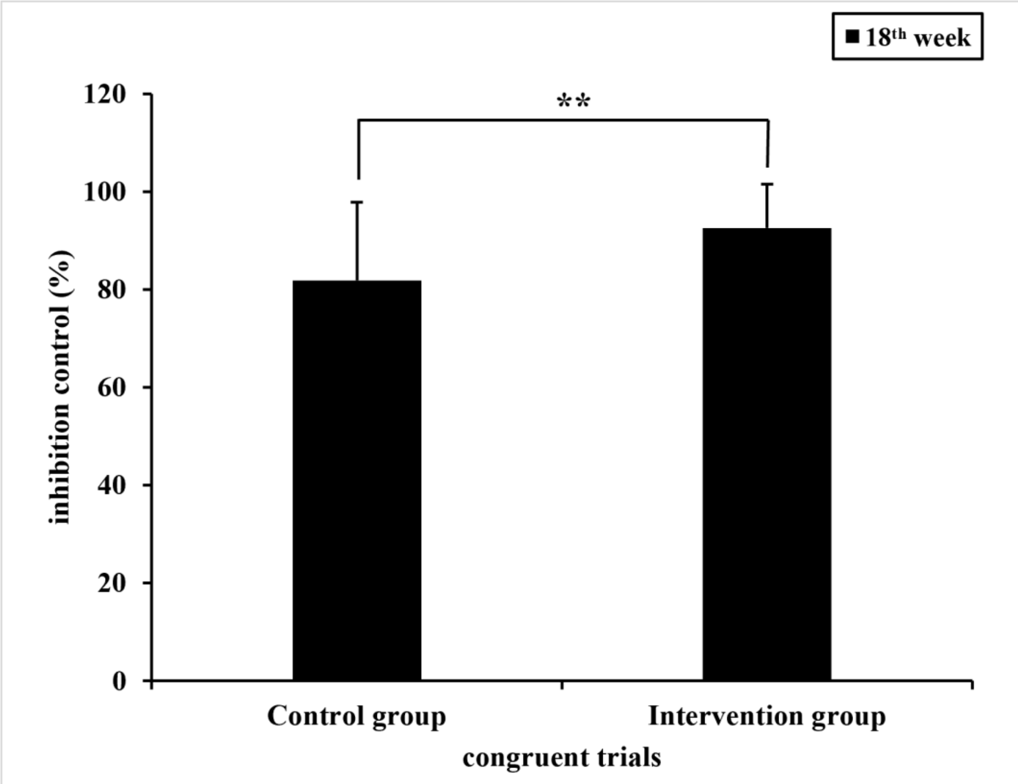


Figure 59, The comparison of accuracy in congruent trials between groups on 18th week.

Note, * present p<.05, ** present p<.001

Regarding incongruent trials, the mean of the accuracy percentage in intervention group were (93.90±6.63) at 12th week and (93.10±7.87) at 18th week in this study, with a difference (.80±9.12), (95% CI: -2.38-3.98). And the difference was not statistically significant (t=-.51, p=.614).

The mean of the accuracy percentage in control group were (82.55±15.33) at 12th week and (85.75±15.53) at 18th week in this study, With a difference of (-3.19±17.03), (95% CI: -9.14-2.75). And the difference was not statistically significant (t=-1.09, p=.282).

Using independent sample t-test, the results showed that the accuracy percentage in the intervention group (93.10±7.87) were higher than those of control group (85.75±15.53), with a difference of 7.36*, (95% CI: 1.40-13.32). Meanwhile, there was a statistical difference ($t=2.46$, $p=.016$) between groups at 18th week in this study.

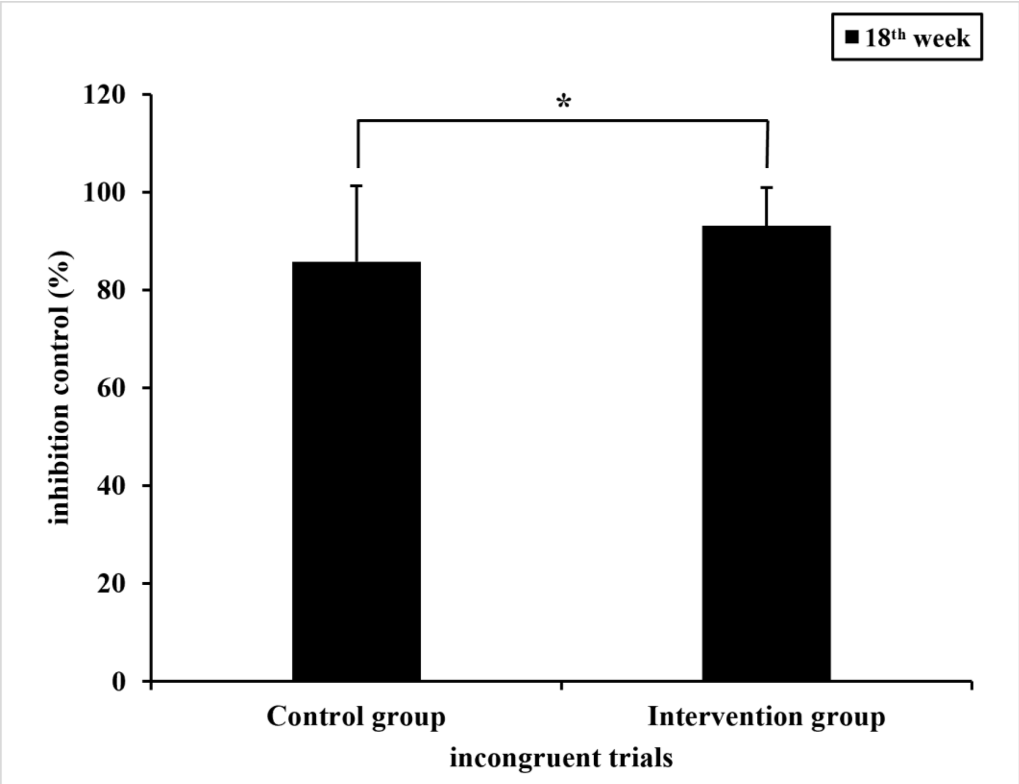


Figure 60, The comparison of accuracy in incongruent trials between groups on 18th week.

Note, * present $p<.05$, ** present $p<.001$

The data detail presented in the table 29.

Table 29 The performance result of inhibition control accuracy in the follow-up period within and between groups(n=68)

variables	Control group(n=34) M ± SD	Intervention group (n=34) M ± SD	t	p-value	Mean difference (95% CI:)
Inhibition control congruent trials (%)					
12^{th} week	79.29±19.00	92.54±7.20			
18^{th} week	81.84±16.01	92.56±9.00	3.40	. 001	10.72^{**}, (95% CI: 4.43-17.01)
t	-.84	-.02			
p-value	.408	.986			
Mean difference (95% CI:)	(2.55±17.73), (95% CI: -8.74-3.64)	(.03±8.77), (95% CI: -3.09-3.03)			
incongruent trials (%)					
12^{th} week	82.55±15.33	93.90±6.63			
18^{th} week	85.75±15.53	93.10±7.87	2.46	$.016^{*}$	7.36^{*}, (95% CI: 1.40-13.32)
t	-1.09	-.51			
p-value	.282	.614			
Mean difference (95% CI:)	(-3.19±17.03), (95% CI: -9.14-2.75)	(.80±9.12), (95% CI: -2.38-3.98)			

Note: * present p<.05, ** present p<.001

4.2.2.5 The accuracy of working memory in the 1-back trials and 2-back trials

A paired-sample t-test displayed that there was no significant difference of (1.39±16.25), (95% CI: -4.28-7.06) (t=.498, p=.621) in the intervention group, with the mean of 12th week (73.33±18.84) and 18th week (71.94±14.35), respectively. Otherwise, the difference (6.79±13.84)*, (95% CI: 1.96-11.62) in control group was significant (t=2.859, p=.007), with the mean of 12th week (69.97±17.44) and 18th week (63.18±20.02), respectively.

The independent sample t-test demonstrated that the accuracy percentage in the intervention group (71.94±14.35) were faster than those of control group (63.18±20.02), with a difference of -8.76* (95% CI: -17.19-.33). Moreover, there was a statistical difference (t=-2.07, p=.042) between groups. The detail presented in the figure 61.

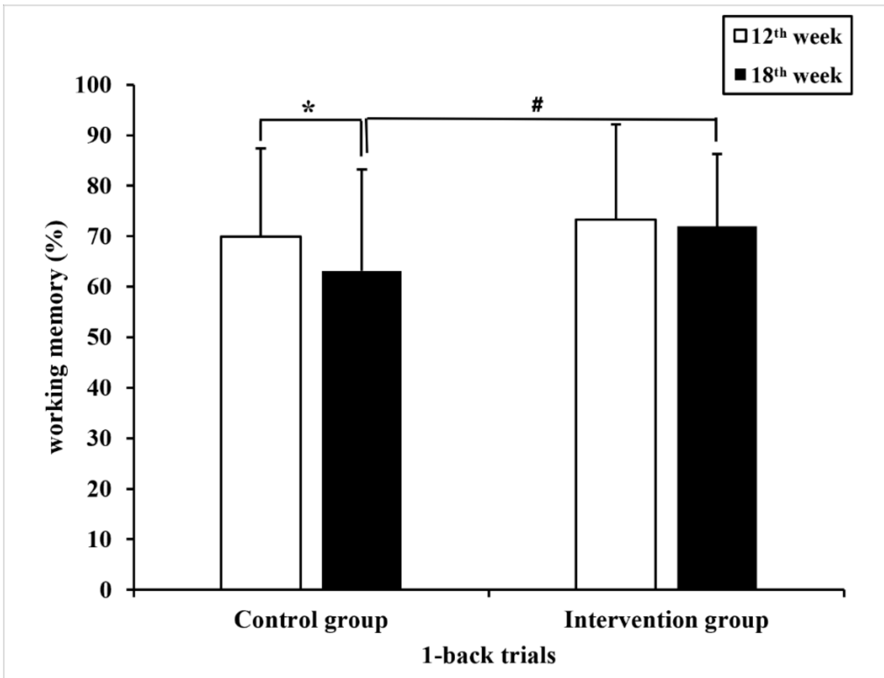


Figure 61, The pairwise comparison of accuracy in 1-back trials within time and between groups during follow-up period

Note, * present p<.05, ** present p<.001 with group, # present p<.05, ## present p<.001 between groups

Regarding the 2-back trials, a paired-sample t-test displayed that there was no significant difference of (5.44±16.22), (95% CI: -.22-11.10) (t=1.95, p=.06) in the intervention group, with the mean of 12th week (75.62±17.74) and 18th week (70.19±14.63), respectively. Otherwise, the difference (-3.77±11.30), (95% CI: -7.71-.174) in control group was significant (t=-1.94, p=.06), with the mean of 12th week (58.04±16.30) and 18th week (61.80±15.25), respectively.

The results showed that the independent sample t-test demonstrated that the accuracy percentage of 2-back trials in the intervention group (70.19±14.63) were faster than those of control group (61.80±15.25), with a difference of -8.38* (95%CI: -

15.62- -1.15). Moreover, there was a statistical difference (t=-2.31, p=.024) between groups. The detail presented in the figure 62.

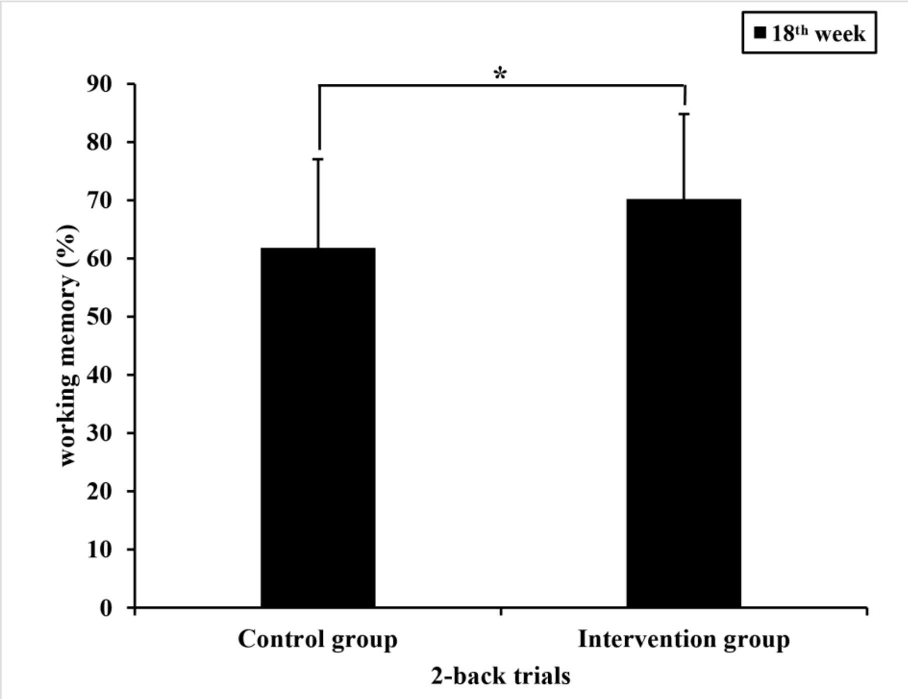


Figure 62, The comparison of accuracy in 2-back trials between groups on 18^{th} week.
Note, * present p<.05, ** present p<.001

The data detail presented in the table 30

Table 30 The performance results for working memory accuracy in the follow-up period within and between groups

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
Working memory					
1-back trials (%)					
12th week	69.97±17.44	73.33±18.84			
18th week	63.18±20.02	71.94±14.35	-2.07	.042	-8.76* (95% CI: -17.19-.33)
t	2.86	.498			
p-value	.007	.621			
Mean difference (95% CI:)	6.79±13.84 (95% CI: 1.96-11.62)	1.39±16.25 (95% CI: -4.28-7.06)			
2-back trials (%)					
12th week	58.04±16.30	75.62±17.74			
18th week	61.80±15.25	70.19±14.63	-2.31	.024	-8.38* (95% CI: -15.62- -1.15)
t	-1.94	1.95			
p-value	.06	.06			
Mean difference (95% CI:)	-3.77±11.30 (95% CI: -7.71-.174)	5.44±16.22 (95% CI: -.22-11.10)	-1.97	.53	-

Note: * present p<.05, ** present p<.001

4.2.2.6 The accuracy of cognitive flexibility in color trials, shape trials and border trials

A paired-sample t-test displayed that there was no significant difference of -.57 ±11.57 (95% CI: -4.61-3.47) (t=-.071, p=.943) in the intervention group on 12th week (91.53±11.86) than 18th week (92.10±13.01). Similarly, the difference -.23 ±11.15 (95% CI: -4.12-3.66) in control group did not reach significant (t=-.12, p=.905) on 12th week (65.89±18.39) and 18th week (66.11±18.10).

With a independent sample t-test, the outcome demonstrated that the accuracy percentage of color trials in the intervention group (92.10±13.01) were faster than those of control group (66.11±18.10), with a difference of 25.98**(95% CI: 18.35-33.61. Moreover, there was a statistical difference (t=5.46, p=.000) between groups. The data detail presented in the figure 63.

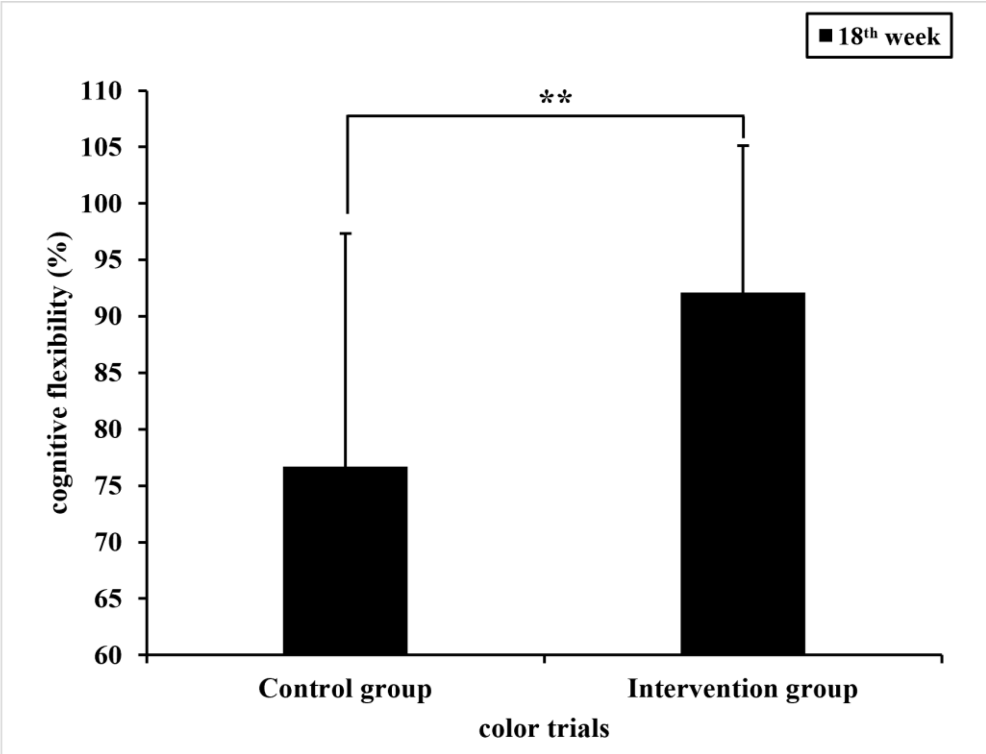


Figure 63, The pairwise comparison of accuracy in color trials between groups on 18th week

Note, * present p<.05, ** present p<.001

A paired-sample t-test displayed that there was no significant difference of 1.52±13.02 (95% CI: -3.02-6.06) (t=.681, p=.501) in the intervention group, with the mean of 12th week (93.00±11.64) and 18th week (91.49±14.56), respectively. Otherwise, the difference 10.78* ±18.44 (95% CI: 4.35-17.22) in control group did not reach significant (t=3.41, p=.002), with the mean of 12th week (87.45±15.53) and 18th week (76.67±20.69), respectively.

The results showed that the independent sample t-test demonstrated that the accuracy percentage of shape trials in the intervention group (91.49±14.56) were faster than those of control group (76.67±20.69), with a difference of 14.82**(95% CI: 6.15-23.48). Moreover, there was a statistical difference ($t=3.41$, $p=.001$) between groups. The data detail presented in the table 64.

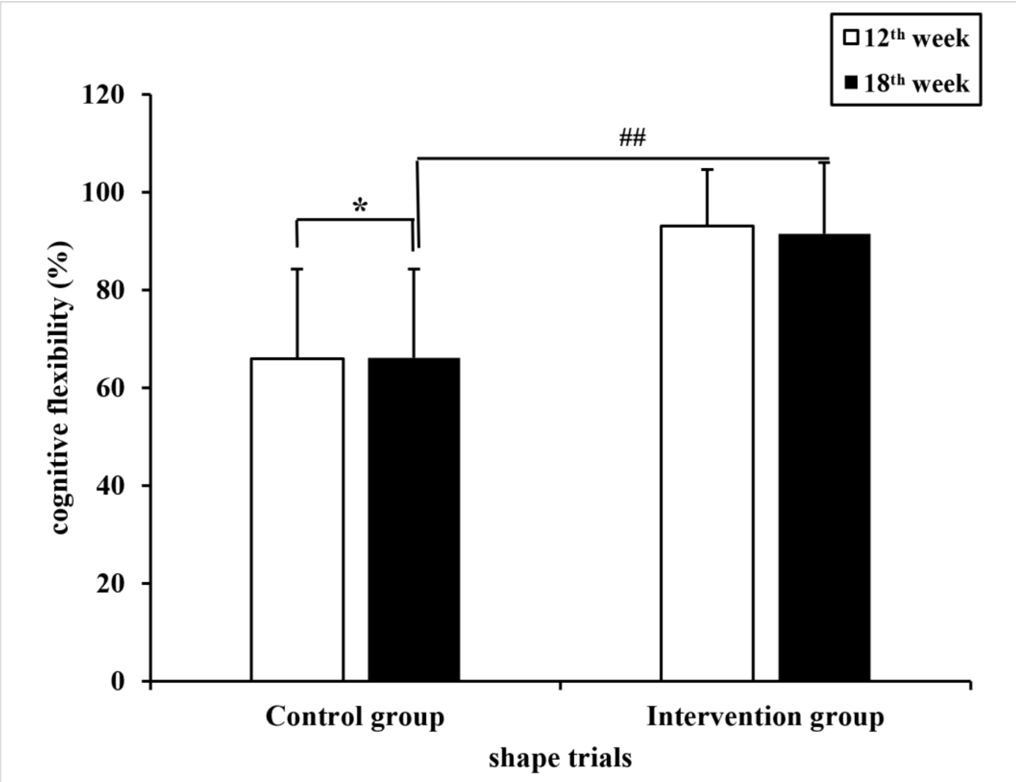


Figure 64, The pairwise comparison of accuracy in shape trials within subjects during follow-up period within time and between groups

Note, * present $p<.05$, ** present $p<.001$ within group, # present $p<.05$, ## present $p<.001$ between groups

A paired-sample t-test displayed that there was no significant difference of (2.60±8.52) (95% CI: -.37-5.57) ($t=1.78$, $p=.084$) in the intervention group, with the mean of 12th week (67.25±7.20) and 18th week (64.65±5.28), respectively. Otherwise, the difference (.119±6.58), (95% CI:-2.18-2.41) in control group did not reach significant (t=.105, p=.917), with the mean of 12th week (57.23±3.62) and 18th week (57.11±6.08), respectively.

The results showed that the independent sample t-test demonstrated that the accuracy percentage of border trials in the intervention group (64.65±5.28) were faster than those of control group (57.11±6.08), with a difference of 7.54**(95% CI: 4.78-10.30). Moreover, there was a statistical difference (t=5.46, p=.000) between groups. The data detail presented in the figure 65.

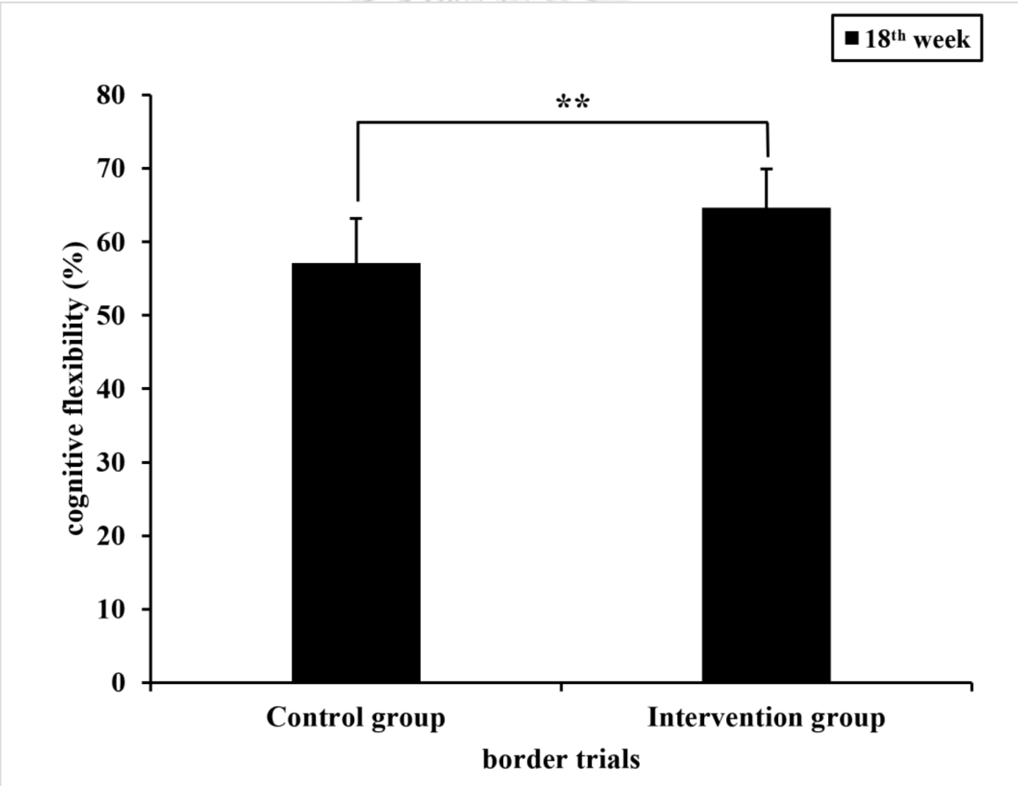


Figure 65, The comparison of accuracy in border trials between groups on 18th week
Note, * present p<.05, ** present p<.001

The data detail presented in the table 31

Table 31 performance results for cognitive flexibility accuracy in the follow-up period within and between groups

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
cognitive flexibility					
Color trials (%)					
12^{th} week	65.89±18.39	91.53±11.86			
18^{th} week	66.11±18.10	92.10±13.01	6.80	.000	25.98^{**}(95% CI: 18.35-33.61)
t	-.12	-.071			
p-value	.905	.943			
	-.23 ±11.15 (95% CI: -4.12-3.66)	-.57 ±11.57 (95% CI: -4.61-3.47)			
shape trials (%)					
12^{th} week	87.45±15.53	93.00±11.64			
18^{th} week	76.67±20.69	91.49±14.56	3.41	.001	14.82^{**}(95% CI: 6.15-23.48)
t	3.41	.681			
p-value	.002	.501			
	10.78^{*} ±18.44 (95% CI: 4.35-17.22)	1.52±13.02 (95% CI: -3.02-6.06)			
Border trials (%)					
12^{th} week	57.23±3.63	67.25±7.20			
18^{th} week	57.11±6.08	64.65±5.28	5.46	.000	7.54^{**}(95% CI: 4.78-10.30)
t	.105	1.78			
p-value	.917	.084			
Mean difference (95% CI:)	.119±6.58 (95% CI: -2.18-2.41)	(2.60±8.52) % (95% CI: -.37-5.57)			

Note: * present p<.05, ** present p<.001

4.3 Self-esteem measurement

The data of self-esteem included 68 participants (n_{int}=34, n_{con}=34, respectively) in this study. There were no outliers in the data by the boxplot; The data in each group obeyed a normal distribution with the Shapiro-Wilk test (p>0.05).

4.3.1 Self-esteem scores during treatment period

A repeated ANOVA was used to determine the effect on the self-esteem scores of the subjects in this study over time within-between group.

There were significant interaction effect of time*group ($F_{(2,66)}$=4.734, p=.012, η^2=.125) on self-esteem scores during the treatment period. Therefore, the independent simple effect test was performed on the two within-subject factors group and time. data detail presented table 32.

*Table 32 The effect of group, time, and group*time on scores of self-esteem over treatment period within and between groups (n=68)*

Outcomes	Source of Variance	F	p-value	Partial eta square(η^2)
Self-esteem	Time*group	$F_{(2,66)}$=4.734	.012	.125
	Group $_{baseline}$	$F_{(1,33)}$=.979	.330	.029
	Group $_{6th\ week}$	$F_{(1,33)}$= 8.14	.007	.198
	Group $_{12th\ week}$	$F_{(1,33)}$= 5.148	.030	.135
	Time $_{intervention}$	$F_{(1.46,\ 48.09)}$=26.76	.000	.448
	Time $_{control}$	$F_{(2,66)}$= 3.31	.043	.091

Note: p $_{Time*group}$ >.05 present the main effect of group and time conducted, p $_{Time*group}$ <.05 present the simple effect of group and time conducted in each group, * present p<.05, ** present p<.001

Regarding the group, there was no significant difference in the self-esteem scores between the intervention group (22.21±4.97) and the control group (21.82±4.77), $F_{(1,33)}$=.979, p=.330, η^2=.029 at the baseline, with the difference 1.176, (95% CI: -1.24-3.60). In the 6th week period of the study, the difference in self-esteem scores between the intervention group (25.03±4.17) and the control group (22.15±5.46) was statistically significant $F_{(1,33)}$= 8.14, p=.007, η^2=.198. the difference was 3.50*, (95% CI: 1.00-6.00). During the 12th week period of the study, there was a statistically significant difference in the self-esteem scores between the intervention group (25.26±3.83) and the control group (23.03±5.23), with a difference of 2.735*, (95% CI: .28-5.19), $F_{(1,33)}$= 5.148, p=.030, η^2=.135. The data detail presented in figure 66.

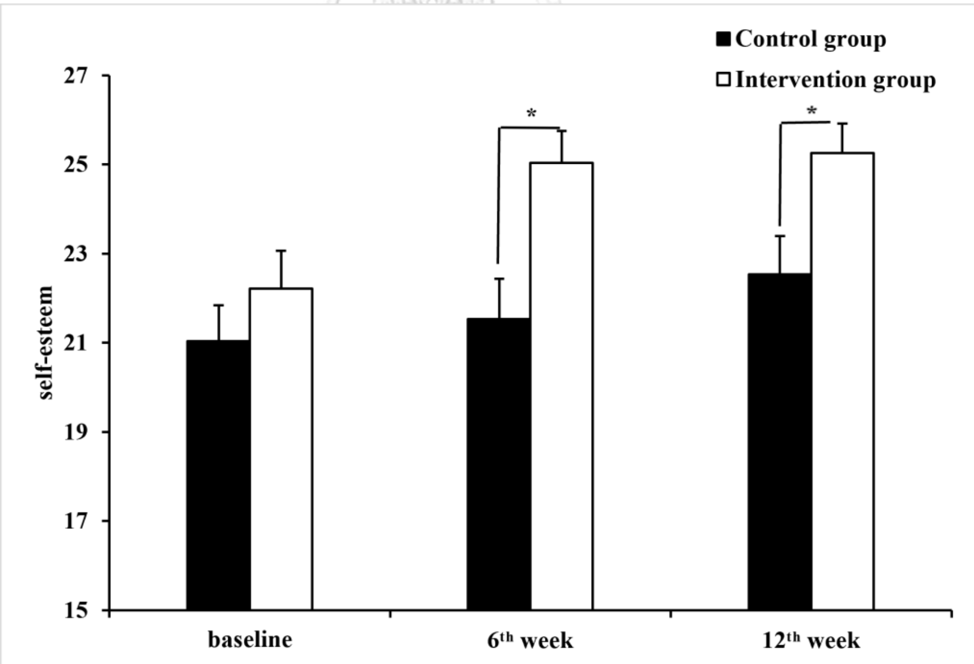


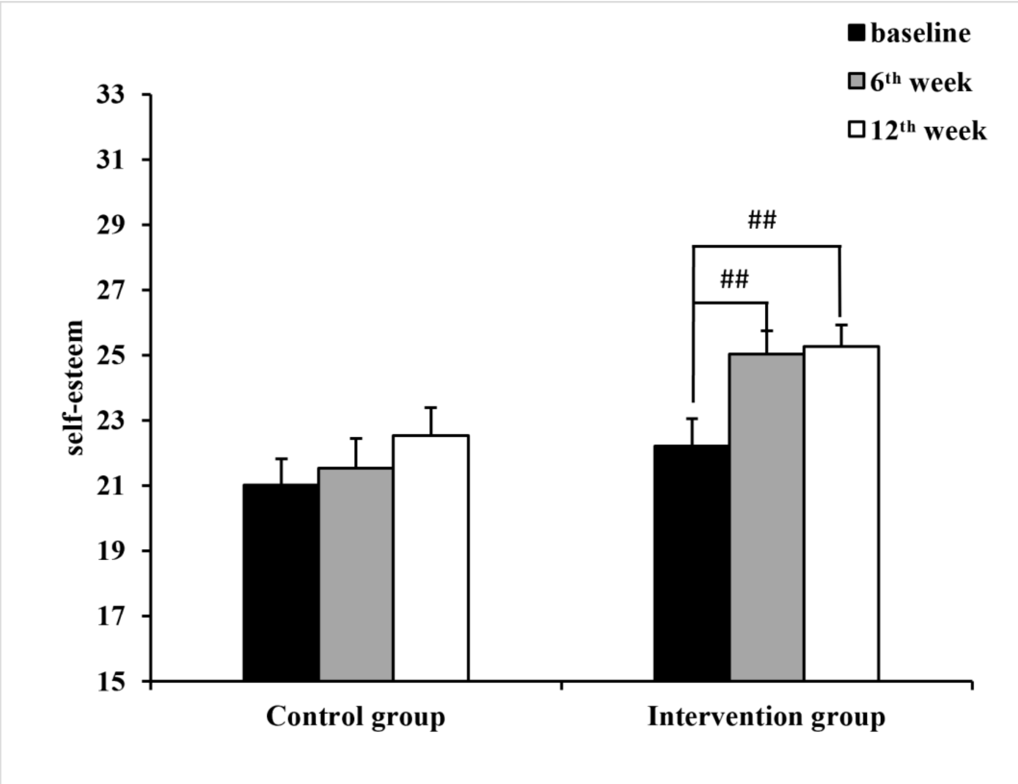
Figure 66, The pairwise comparisons in scores of self-esteem over treatment period within groups (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

Considering the within-subject factor time in the intervention group, the dependent variable was not consistent with Mauchly's spherical assumption (p=.001). Greenhouse-Geisser adjustment in result presented. Furthermore, the simple effect of time on the self-esteem scores was statistically significant, $F_{(1.46, 48.09)}$=26.76, p=.000, η^2=.448. Specifically, the difference in the self-esteem scores between the baseline of the study (22.21±4.97) and the 6th week period of the study (25.03±4.17) was statistically significant (p=.000) with the difference -2.82**, (95% CI: -4.22-1.43). The difference in the self-esteem scores between the 6th week period of the study (25.03±4.17) and the 12th week period of study (25.26±3.83) was not statistically significant (p=1.00), and the difference was -.235 (95% CI: -.98-.51). Meanwhile, the difference in the self-esteem scores between the baseline of the study (22.21±4.97) and the 12th week period of study (25.26±3.83) was statistically significant (p=.000), and the difference was -3.06**, (95% CI: -4.34--1.78).

Regarding the within-subject factor time in the control group, the dependent variable met Mauchly's spherical assumption (p=.324). Moreover, the simple effect of time on the self-esteem scores was statistically significant, $F_{(2,66)}$= 3.31, p=.043, η^2=.091. Particularly, there was no significant difference in the self-esteem scores between the baseline of the study (21.03±4.70) and the 6th week period of the study (21.53±5.32) (p=1.00), with the difference -.50, (95% CI: -1.79-.79); the difference between the 6th week period of the study (21.53±5.32) and the 12th week period of the study (22.53±5.00) was no significant (p=.369), with the difference -1.00, (95% CI: -

2.59-.59). The difference in the self-esteem scores between the baseline of the study (21.03±4.70) and the 12th week period of the study (22.53±5.00) was not statistically



significant (p=.070), with the difference -1.50, (95% CI: -3.09-.09). The detail displayed on figure 67 and figure 68.

Figure 67, The pairwise comparisons in scores of self-esteem over treatment period within times (n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001

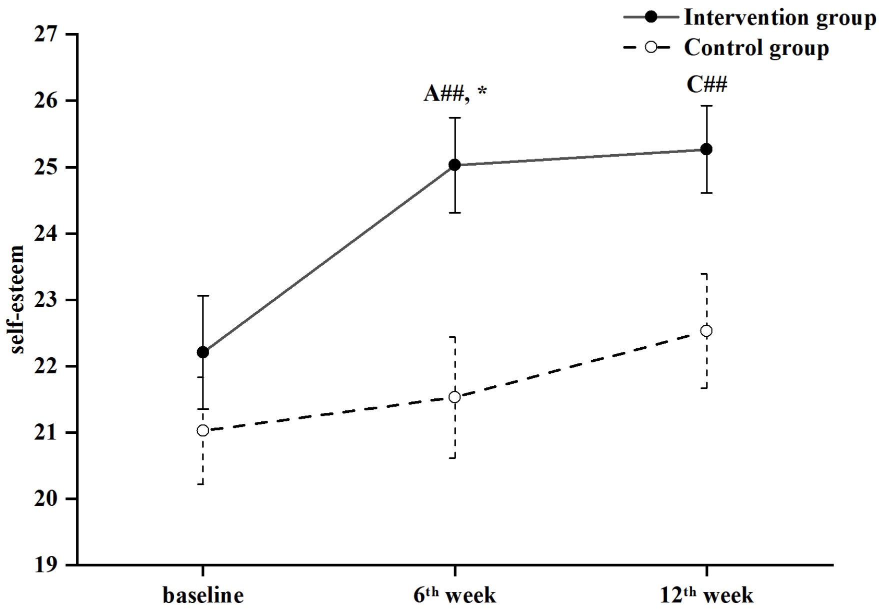


Figure 68, The results for scores of self-esteem over treatment period within and between groups(n=68)

Note, with simple effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001; the pairwise comparisons within times in the intervention group: A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; data presented with mean and SEM.

4.3.2 Self-esteem scores at 18th week in the study

A paired-sample t-test was used to determine whether the self-esteem scores differed after a follow-up period in each group.

The mean of the self-esteem scores of intervention group (25.26±3.83) at 12th week and at 18th week (25.12±4.01), with a mean difference of (.15±2.98), (95% CI: -.89-1.19) and (t=.29, p=.775). Similarly, the difference was (.38±4.09), (95% CI: -

1.04-1.81) in control group at 12th week (22.53±5.00) than 18th week (22.15±4.76), (t=.55, p=.589).

With the independent sample t-test, the results showed that the self-esteem scores in the intervention group (25.12±4.01) were higher than those of control group (22.15±4.76), with a difference of 2.97* (95% CI: .84-5.10), a statistical difference (t=2.78, p=.007) detected between groups at 18th week in this study. The detail presented in the figure 69.

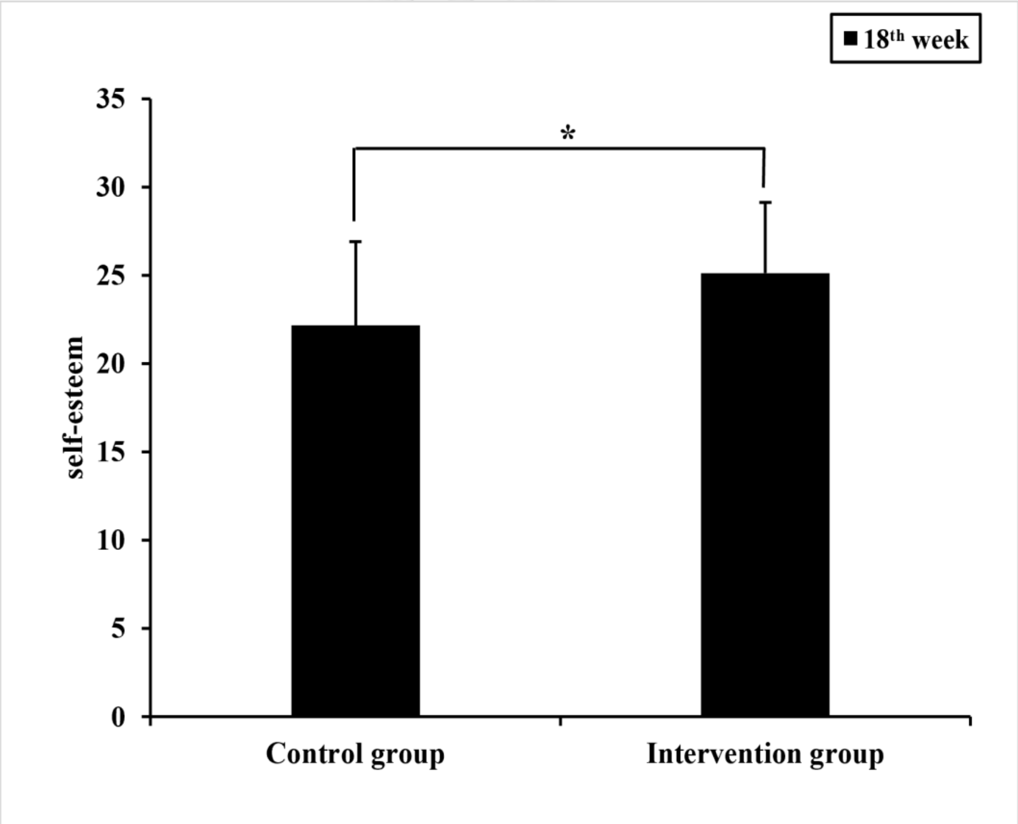


Figure 69, The pairwise comparison of self-esteem scores between groups on 18th week

Note, present p<.05, ** present p<.001, between subjects

The data detail presented in the table 33 and table 34

Table 33 the results for scores of self-esteem over the treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)	F_{group}	Mean difference (95% CI:)	p-value	η^2
	M ± SD	M ± SD				
baseline	21.03±4.70	22.21±4.97	.979	1.18 (95% CI: -1.24-3.60)	.330	.029
6th week	21.53±5.32	25.03±4.17	8.14	3.50* (95% CI: 1.00-6.00)	.007	.198
12th week	22.53±5.00	25.26±3.83	5.15	2.74* (95% CI: .28-5.19)	.030	.135
F_{time}	3.31	26.76				
p-value	.043	000				
η^2	.091	.448				
	A -.50, (95% CI: -1.79-.79)	A -2.82** (95% CI: -4.22-1.43)				
Bonferroni post-hoc analysis	B -1.00, (95% CI: -2.59-.59)	B -.235 (95 %CI: -.98-.51)				
Mean difference (95% CI:)	C -1.50, (95% CI: -3.09-.09)	C -3.06** (95% CI: -4.34--1.78)				

Note. With simple effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week; * present p<.05, ** present p<.001

Table 34 pairwise comparisons of scores self-esteem in the follow-up period within and between groups

variables	Control group(n=34)	Intervention group (n=34)	t	p-value	Mean difference (95% CI:)
	M ± SD	M ± SD			
12th week	22.53±5.00	25.26±3.83			
18th week	22.15±4.76	25.12±4.01	2.78	.007	2.97* (95% CI: .84-5.10)
t	.55	.29			
p-value	.589	.775			
Mean difference (95% CI:)	.71±4.01(95% CI: -.61-2.03)	.15±2.98(95% CI: -.89-1.19)			

Note: * present p<.05, ** present p<.001

4.4 Sleep quality assessment

The database of sleep quality included 34 participants from intervention group and 34 participants from control group, respectively. After the Shapiro-Wilk test, the data each group did not obey the normality distribution ($p<.05$).

4.4.1 The sleep quality scores during treatment period

A repeated ANOVA was used to determine the effect on the sleep quality scores of the subjects in this study over time within-between group.

There was no significant interaction effect of time*group ($F_{(2,66)}=1.79$, $p=.18$, $\eta^2=.05$) on sleep quality scores during the treatment period. Therefore, the independent main effect test was performed on the two within-subject factors group and time. Data detail presented table 35

*Table 35 The effect of group, time, and group*time on scores of sleep quality over treatment period within and between groups (n=68)*

outcomes	Source of Variance	F	p-value	Partial eta square(η^2)
Sleep quality	Time*group	$F_{(2,66)}=1.79$	.175	.051
	Group	$F_{(1,33)}= 15.57$	.146	.063
	Time	$F_{(2,66)}= 3.31$	.000	.321

The effect of time on the sleep quality scores was statistically significant, $F_{(2,66)}=15.67$, $p=.000$, partial $\eta^2=.32$. With a pairwise comparison, the difference in scores was statistically significant ($p=.001$) between the baseline and the 6th week period, with a difference of 1.40**, (95% CI: .57- 2.23). The mean difference was .62, (95% CI: -.33- 1.56) was not statistically significant ($p=.33$) between the 6th week period and the 12th week period. Simultaneously, the difference in the reaction time between the baseline of the test and the end of the test was statistically significant (p=.000), with a mean difference of 2.02**, (95% CI: 1.00- 3.03). The detail presented in the figure 70.

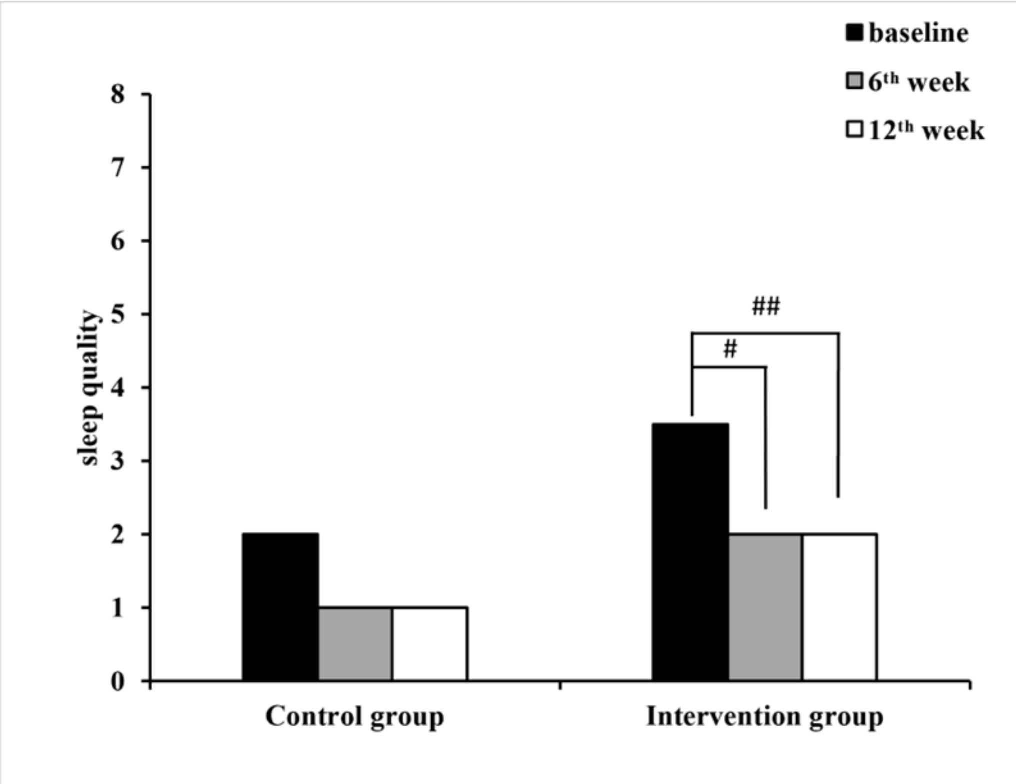


Figure 70 The pairwise comparisons in scores of sleep quality over treatment period within times (n=68)

Note, # present p<.05, ## present p<.001, within subjects. * Present p<.05, ** present p<.001 between subjects.

The main effect of the group on the sleep quality scores was not statistically significant, $F_{(1, 33)}$=15.57, p=.146, η^2=.063. The mean difference was 1.56, (95% CI: -.57- 3.69). The detail presented in the figure 71

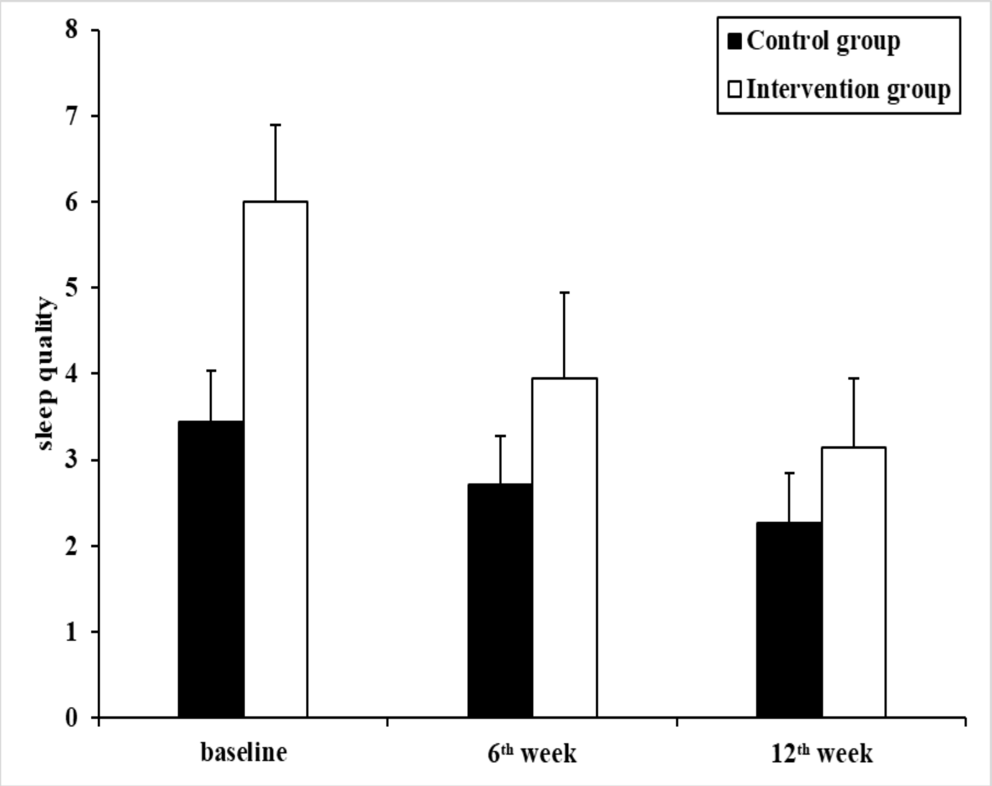


Figure 71 The pairwise comparisons in scores of sleep quality over treatment period between groups (n=68)

Note, # present p<.05, ## present p<.001, within subjects. * Present p<.05, ** present p<.001 between subjects.

The data detail of scores of sleep quality over treatment is displayed in figure 72.

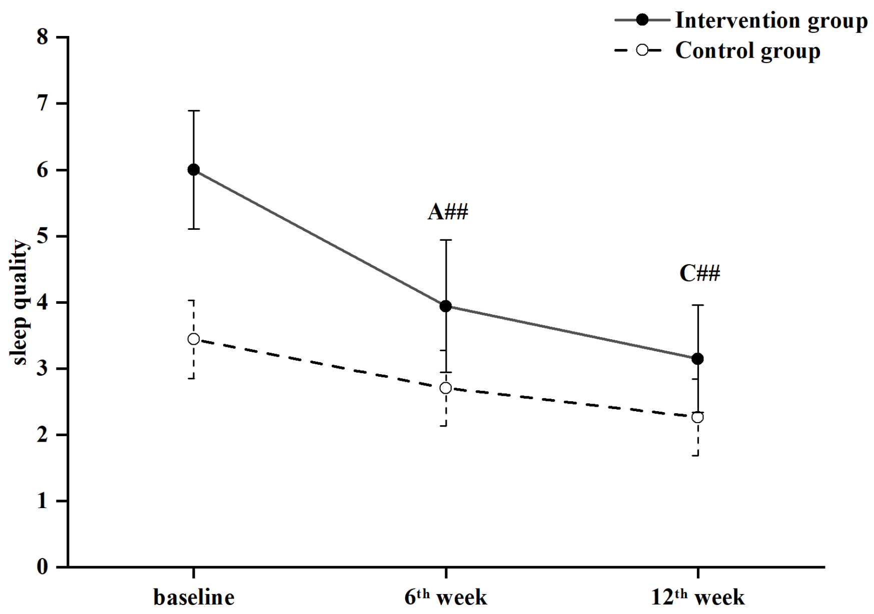


Figure 72 The comparison of scores of sleep quality over treatment period within and between groups(n=68)

Note, with main effect of time, # present p<.05, ## present p<.001. with simple effect of group, * present p<.05, ** present p<.001; the pairwise comparisons within times in the intervention group: A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week, respectively; data presented with mean and SEM.

4.4.2 The sleep quality scores at 18th week in this study

After the Shapiro-Wilk test, the data in each group was not obeyed a normal distribution (p<.001).

A paired-sample t-test was used to determine whether the sleep quality scores differed after a follow-up period in each group. The mean of the sleep quality scores of intervention group (3.15 ± 4.71) at 12th week and at 18th week (3.21 ± 4.50), with a mean difference of -.06 (95% CI: -.80- .69) and (t= .16, p=.87). Similarly, the difference was .94 (95% CI: -.14 - .2.02) in control group at 12th week (2.27 ± 3.36) than 18th week (1.32 ± 1.75), (t= 1.77, p=.09).

With the independent sample t-test, the results showed that the sleep quality scores in the intervention group (3.21 ± 4.50) were higher than those of control group (1.32 ± 1.75), with a difference of 1.88* (95% CI: .23-3.54), a statistical difference (t=2.27, p=.03) detected between groups at 18th week in this study. The detail presented in the figure 73

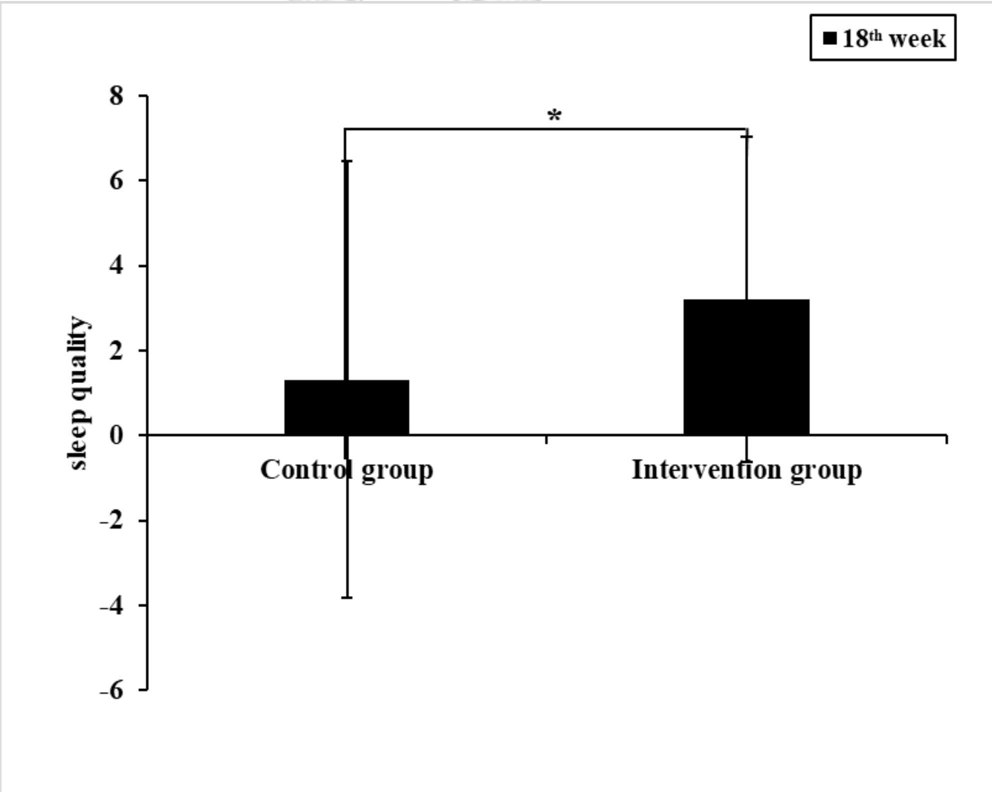


Figure 73 he pairwise comparison of sleep quality scores between groups on 18th week

Note, present p<.05, ** present p<.001, between subjects

The data detail presented in the table 36 and 37.

Table 36 pairwise comparisons of sleep quality scores over the treatment period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)				
	M ± SD	M ± SD	F_{time}	Bonferroni post-hoc analysis Mean difference (95% CI:)	p-value	η^2
baseline	3.44 ± 3.43	6.00 ± 5.22	15.57		.000	.321
6th week	2.71 ± 3.32	3.94 ± 5.82		A: 1.40** (95% CI: .57- 2.23)	.001	
12th week	2.26 ± 3.36	3.15 ± 4.71		B: .62 (95% CI: -.33- 1.56)	.326	
F_{group}	2.23			C: -2.02** (95% CI: 1.00- 3.03)	.000	
p-value	.146					
η^2	.063					

Note. With main effect, A: baseline VS 6th week, B: 6th week VS 12th week, C: baseline VS 12th week; * present p<.05, ** present p<.001

Table 37 comparisons of sleep quality scores during follow-up period within and between groups(n=68)

variables	Control group(n=34)	Intervention group (n=34)			
	M ± SD	M ± SD	t	p-value	mean difference (95% CI:)
12th week	2.27 ± 3.36	3.15 ± 4.71	.89	.38	.88 (95% CI: -1.10-2.86)
18th week	1.32 ± 1.75	3.21 ± 4.50	2.27	.03*	1.88 (95% CI: .23-3.54)
t	1.77	-.16			
p-value	.09	.87			
mean difference (95% CI:)	.94 (95% CI: -.14 - .2.02)	-.06 (95% CI: -.80- .69)			

Note. * present p<.05, ** present p<.001

4.5 Anxiety/depression

The data of anxiety/depression scores included 67 participants (n_{int}=33, n_{con}=34, respectively), 1 participant in intervention withdrew this test.

4.5.1 Anxiety/depression scores assessment during treatment period

A paired-sample t-test was used to determine whether the anxiety/depression scores differed during treatment in each group. The mean of the anxiety/depression scores of intervention group (1.21 ± 2.07) at baseline and at 12th week (.55 ± 1.25), with a mean difference of .67* (95% CI: .14 – 1.19 and (t= 2.6, p=.01). Similarly, the difference was .50 (95% CI: -1.27 – 1.13) in control group at baseline (1.38 ± 2.34) than 12th week (.88 ± 1.53), (t= .60, p=.55). The data detail presented in the figure 74.

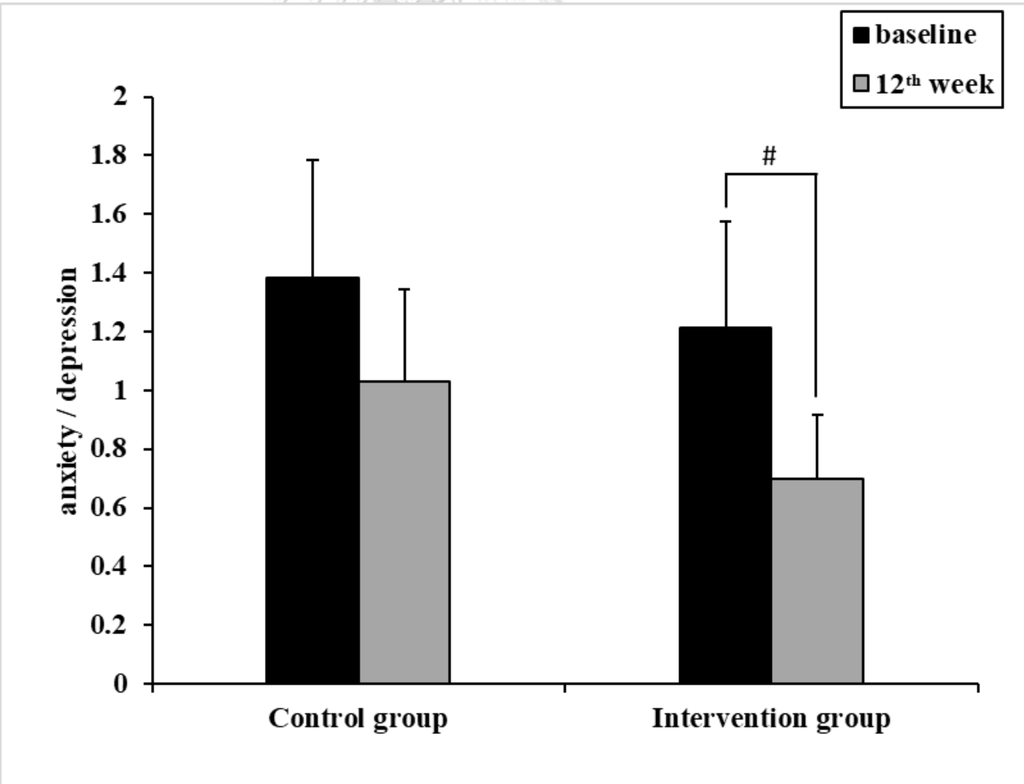


Figure 74 The pairwise comparison of sleep quality scores within subjects from baseline to 12th week.

Note, present p<.05, ** present p<.001, between subjects

With the independent sample t-test, the results showed that there was not significant difference between intervention group and control group, with a difference of -.17 (95% CI: -1.24 - .91, (t=-.32, p=.28) at baseline and a difference of -.37 (95% CI: -1.02 - .35), (t=-.98, p=.34) at 12^{th} week, respectively. The data detail presented in the table 38.

4.5.2 Anxiety/depression scores assessment at 18^{th} week in this study

A paired-sample t-test was used to determine whether the anxiety/depression scores differed after a follow-up period in each group. The mean of the anxiety/depression scores of intervention group (.55 ± 1.25) at 12^{th} week and at 18^{th} week (.70 ± 1.26), with a difference of mean -.15 (95% CI: -.39 - .09) and (t= -1.31, p= .20). Similarly, the difference was -.15 (95% CI: -.53 - .24) in control group at 12^{th} week (.88 ± 1.53) than 18^{th} week (1.03 ± 1.83), (t= -.78, p=.44).

With the independent sample t-test, the results showed that there was no significant difference -.34 (95% CI: -1.10 - .44), (t=-.87, p=.051) of the anxiety/depression scores between the intervention group (.70 ± 1.26) and control group (1.03 ± 1.83) at 18^{th} week in this study.

The data detail presented in the figure 38.

Table 38 comparisons of mean anxiety/depression scores over time within and between groups(n=67)

variables	Control group(n=34)	Intervention group (n=33)			
	M ± SD	M ± SD	t	p-value	mean difference (95% CI:)
baseline	1.38 ± 2.33	1.21 ± 2.07	-.32	.28	-.17 (95% CI: -1.24 - .91)
12^{th} week	.88 ± 1.53	.55 ± 1.25	-.98	.34	-.33 (95% CI: -1.10 - .44)
18^{th} week	1.03 ± 1.83	.70 ± 1.26	-.86	.05	-.34 (95% CI: -1.01 - .35)
t	1.62 [a], -.78 [b]	2.60 [a], -1.31 [b]			
p-value	.11 [a], .44 [b]	.014 [a*], .20 [b]			
mean difference (95% CI:)	.50 [a] (95% CI: -.13– 1.13)	.67 [a*] (95% CI: 1.45 – 1.19)			
	.15 [b] (95% CI: -.53 – .24)	-.15 [b] (95% CI: -.39 - .09)			

Note. M=Mean, SD= Std. Deviation; a: baseline VS 12^{th} week, b: 12^{th} week VS 18^{th} week; * present p<.05, ** present p<.001

CHAPTER 5: DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1 Discussion

Currently, this study intended to explore the effect of multiple components of core executive functions performance, self-esteem, sleep quality, and anxiety/depression after a 12-weeks Chinese archery art program in preadolescent children. Furthermore, a follow-up study with 6 weeks after end of intervention was also conducted to provide the evidence how long do the relevant effect last? Subsequently, the impressive evidence in this study support that the Chinese archery art program is benefit preadolescent children's core executive function, self-esteem, sleep quality, and anxiety/depression and the effect still revealed after a 6-week follow-up.

5.1.1 Chinese archery art program and core executive functions

The outcomes in present study showed an impressive improvement in subcomponents of core executive functions with 12-week Chinese archery art program. Specifically, the considerably reduction in response reaction time was confirmed in incongruent trials and 2-back trials within group, 1-back, color trials, shape trials, and border trials within and between groups. In addition, taking response accuracy into account, although the stable accuracy in intervention group and declined accuracy in the control group were observed during , the significant difference between groups were consistently detected with a 12-week treatment in preadolescent children.

Our results from this study are consistent with those literature previous. L Flook and SL Smalley et al. examined a considerable interaction effect on EF scores between groups with a school-based program of mindful awareness practices (MAPs) in 64 3rd-grade children (age= 8.23 ±.66 Y). Using a randomized control study design, the EF scores was assessed with Behavior Rating Inventory of Executive Function (BRIEF) which completed by teachers and parents after 8-week MAPs intervention with twice/week session, respectively [161]. Meanwhile, P Janz, S Dawe , M Wyllie [275] demonstrated an improvement in EF and attention with the mindfulness program, CalmSpace in 55 young children (M_{age} = 76.4 ± 8.62 months) after a 2-terms intervention. Using a randomized control study design, the EF was assessed with Flanker Task for inhibition control and attention, DCCS for cognitive flexibility, respectively. More recently, accumulating evidence from empirical outcomes declared the subdomains of core executive functions are sensitive to mind exercise [179] (such as yoga [180, 181], t'ai chi [182-184], Chinese mind-body practices [185], and Quadrato motor training [186])

Meanwhile, the stable even declined accuracy in intervention group were observed in the 1-back trials, 2-back trials, and shape trials during the treatment period. This probably explanation is that the subjects were bored during those trials, especially the working memory demanding trials. the similar result as Kamijo et al [29]who demonstrate the pre- and post- treatment response accuracy on working memory with the Sternberg test with a 1-year 5 days/week Aerobic Activity program. Eventually, the negative outcomes in the 3-and 5-Letter condition perhaps resulted from the bored subjects [48]. In present study, the greater decrease in accuracy during the trials in the control group supports our explanation. meanwhile, significant differences between groups perhaps indirectly demonstrated the effect of Chinese archery program on improvement of working memory in young children.

As a mindfulness activity, Chinese archery art program emphasizes mind-body unity and pursues simultaneous development of technique and Tao of the individual. Given mental, cognitive engagement, and morality addressed, there appear to be at least three advantages to enhancing executive functions in the present study with Chinese archery art intervention. Firstly, it aims to reduce stress and foster mind-body unity to benefit positive mood and relaxed brain states. Executive functions rely on the prefrontal cortex and other neural regions, which behave the most vulnerable with excess dopamine when suffering from negative emotion (e.g., stress, sadness, loneliness)[207, 276]. Conversely, reduction of stress [277, 278] and positive mood [279] benefit more enhancement of executive functions. Bigelow et al.[280] even illustrated that a 10-minute session of mindfulness meditation display a premium improvement(d=.55-.86) of all executive function tasks (Stroop Task, TMT-B, and Leiter-3) than a 10-minute exercise with a within-subjects pretest-posttest design in children (n=16, $Mean_{age}$ =11.38 (±1.5)) with ADHD. During the practice of Chinese archery art, participants must fully concentrate on motor coordination and breathing rhythm in a calm and relaxed mood. The state facilitates the arousal of the mind-body unity state as soon as possible. It produces a simultaneous concentrated, relaxed state of the brain, which enable to promote executive function performance[70]. Secondly, over the competition in sports can destruct self-esteem and character development. Chinese archery art practice highlight comparison of one's own past and peer interaction instead of scoring hits[247]. This process produces less aggression and anxiety, and more self-esteem and facilitates the cultivation of introspection, self-control, and character development of individuals than competitive sport[247]. Thirdly, the key to physical activity-induced benefits of executive functions is that the diverse and continuous challenges of executive functions are addressed in the real world[281]. Indeed, the exercise-induced transfer of executive functions might be determined by the complex, controlled, and adaptive cognition and movement of the degree addressed in exercise [174]. During the Chinese archery art performance, participants would be confronted with diverse real-world situation. The condition pushes participants to continuously challenge various executive skills[249] that are conducive to the improvement of executive function. For instance, participants must bear complex motor sequences and discipline in mind, inhibit attending to distractions, and concentrate on every motor action during the process. Meanwhile, cognitive flexibility is also challenged. Participants would constantly adjust their targeting actions and timing of shooting arrows based on their experience and prediction of unexpected changes in a natural setting.

As mentioned above, an emerging body of evidence has verified the positive association with the core executive functions and brain function induced by physical activity program in preadolescents, recently. However, all evidence obtained almost derived from the comparison between pretest and posttest intervention. Few relevant follow-up studies were conducted to investigate how long the benefit will last end of the intervention[70, 179]. Currently, a 6-week follow-up research was performed in this study. The outcomes demostrated a overall particular difference between groups in core executive function performance, regarding response raction time and accuracy. Meanwhile, the decline trend from 18^{th} week to 12^{th} week also was detected in intervention group. This finding in this study is consistant with those investigation previous regarding the EFs performance with a follow-up period after the intervention was ended [184, 282].

Taylor Piliae et al. [184] oberserved a greater improvement in working memory ($F = 7.75$, $p < .001$) in Taiji group (n=37) than western exercise (n=39) and attention-control group (n=56) with a 6-month treatment in healthy adults (Age : 69 ± 5.8 Y), moreover, an differential cognitive-function improvements were maintaned with a 6-month follow-up period. Using a randomized between-subjects pretest-posttest design, a 60s animal-naming test, forward and backward digit-span tests were used to assess the semantic fluency and attention, contration, and mental tracking, respectively. possible underlying mechanisms is still at a early stage which may involve the changes in brain physiological structure and biochemical indicators, as well as changes in mental health.

5.1.2 Chinese archery art program and self-esteem

The positive effect of physical activity on self-esteem outcomes was consistently reported in children and youth[283]. For instance, Hasanpour M et al.[284] revealed a significant improvement ($p = .001$) and in one month follow-up scores ($p = .03$) in the self-esteem scores in intervention group with a 3-week aerobic exercise (60 min/session, 3 sessions/week) than control group in 66 orphan female adolescent (Age: 13-19 years). The self-esteem was assessed with The Rosenberg Self-Esteem Scale (RSES). As the increasing of literature, the types of physical activity programs and settings are regarded as the considerable moderators to benefit the self-esteem with physical activity intervention. Specifically, Spruit et al.[285]

shown that there are larger effects in the aerobic exercise than sport. School /gymnasium setting achieve more benefit on self-esteem in preadolescents opposite to clinic, family, or detention facility-based settings[286]. Eventually, the research on the association between physical activity intervention and self-esteem in preadolescents is still in its infancy, the optimal type and intensity of physical activity, particularly. However, supervised, aerobic-based program is still declared as a perspective future [287]. More recently, mindful activity program was highlighted to examine the effect on the self-esteem in the adolescents[288-290]. Specifically, Yook YS, Kang SJ, Park IK [291] demonstrated an impressive enhancement in the self-esteem (F=3.47, p=.49), resilience (F=9.72, p=.003), and happiness (F=31.61, p=.001) in the intervention group with 8-week new sport and mindful yoga than control group in the 46 preadolescents (M_{age}=10.98±.39 years; Male=25, Female=21). The outcomes were evaluated with RSES for self-esteem, The Ego-Resiliency Scale for resilience, and The Psychological Well-being Scale for happiness, respectively.

Archery practice consists of the following physiological and psychological process, such as techniques (standing posture, setting arrow, pushing and pulling off the string, lifting the bow, drawing a full bow, collimation, shot, closing form, etc,), mind regulation (concentration, deep-breathing techniques, self-reflection). Given the process addressed physiological and mind challenge, archery inherit potential advantages in improving mental health. Indeed, Zolkafi et al. [292] currently represented a significant enhancement (p=.006) in self-esteem scores on the 12 week timepoint than on the baseline timepoint within group with a 12-week archery intervention (42 shots/session, 3 session/week) in 34 male sedentary youth (Age=18-30 years). Using a randomized study design, the main outcome was evaluated RSES.

Although, with a follow-up after 12 weeks of end of the intervention, the scores at 24th week was decrease than at 12th week. Similarly, the outcomes in present study also showed a significant difference in self-esteem scores within and between group with 12-week Chinese archery art program.

The reasonable explanations are that, on the one hand, Chinese archery art program emphasizes mind-body unity and pursues simultaneous development of technique and Tao of the individual, which benefit the reduction of stress and anxiety [75, 76, 244] and enhancement self-emotional regulation. The depression and anxiety condition erodes self-esteem[293]. On the other hand, over the competition in sports can destruct self-esteem and character development. Chinese archery art practice highlight comparison of one's own past and peer interaction instead of scoring hits[247]. This process produces less aggression and anxiety, more self-confidence, fun and facilitates the cultivation of introspection, and character development of individuals than competitive sport[247].

Furthermore, the significant difference in self-esteem scores still revealed between group after 6 weeks of end of the intervention program. The outcomes are consistent with the literature previous. JJ Noordstar et al. [294]reported a stability of global self-esteem on the timepoint of cohort II than cohort I with a 2-year follow-up period in children from kindergarten to grade 2 (n=292, 148 boys). Using a prospective longitudinal cohort-sequential design, the self-esteem was measured with self-perception profile for children. The self-perception probably mediated the results according to the exercise and self-esteem model.

5.1.3 Chinese archery art program and sleep quality

Currently, the outcomes in this study supported a positive benefit on the sleep quality within the intervention group with a 12-week Chinese archery art program. Specifically, we detected the significant reduction in global scores of sleep quality when compared baseline with the 6th week test and the 12th week test, respectively. the outcomes in this study are supported with previous studies.

Last decades, numerous studies have examined the association between physical activity and sleep in children and adolescents [295]. Generally, evidence support that physical activity is positively related to sleep. Wang [296] revealed more effectively benefit in sleep quality when moderate intensity physical activity compared with vigorous intensity activity in both young and old population through a systematic review. Mendelson et al. [297] revealed the beneficial effect on sleep duration and variables of sleep quality in the adolescents in intervention group with a 12-week exercise training than in control group. Specially, the outcomes in this study reported a reduction in NERM stage N1 and improvement of REM sleep, sleep continuity, and sleep efficiency measured with polysomnography. Greever et al.[298] explored the negative correlations ($r=-.45$, $p=.04$) physical activity and the number of awakenings per night in 55 girls (age=7-12 years). Physical activity was measured with accelerometer, sleep quality was assessed with the Children's sleep habits questionnaire and accelerometer. Conversely, Williams [299] found a negative association between the intensity of daily physical activity and sleep duration in children. The possible explanations include the methodology of the study and exercise occupied the time of sleep available.

Now a trend in relevant research is the modality and intensity of the exercise performed [296, 300]. Commonly, moderate-intensity aerobic exercise as an intervention is considerate as the most popular alternative [300, 301]. Regarding the advantages of a blend of aerobic and resistance movement at a moderate intensity while simultaneously emphasize relaxation and the release of tension, mind-body exercise (such as Taiji, Qigong, Yoga) were utilized as intervention to improve the sleep quality. For instance, Siddarth [302] found a better sleep quality in 42 participants (Mean $_{age}$=64.6±13.6 years) in mind-body exercise group (Yoga n=8, Taiji n=12) than aerobic exercise (n=22). Moreover, Wang [303] identified a beneficial effect on a range of sleep measures in the intervention group with mind-body exercise through a systematic review with 17 RCTs from English and Chinese database. Although, it is scarcely relevant research on preadolescent population at present. Complexity of perception and construction on the mind-body activity program are possible explanation.

The reasonable explanations are that Chinese archery art program emphasizes mind-body unity and pursues simultaneous development of technique and Tao of the individual, which benefit the reduction of stress, increase of concentration, and enhancement self-emotional regulation[75, 76, 244]. Moreover, Chinese archery art practice as sport involve mind skill and physical skill and highlight comparison of one's own past and peer interaction instead of scoring hits[247]. This process produces less aggression and anxiety than competitive sport[247]. Chinese archery art as feasible mind-body sports facilitate the cultivation of self-esteem and character development of individuals. The self-esteem inversely predict the depression and anxiety[293]. The potentially psychosocial, behavioral mechanisms were involved that the enhancement of self-esteem and the decline of depression/anxiety [304]. Indeed, the outcomes in the current study demonstrated the positive effect on self-esteem and depression/anxiety scores.

Eventually, we originally explored a significant decrease on the global sleep quality scores in preadolescents between intervention group and control group with a 6-week follow-up period. The result is supported with the previous study. Eva R. Hedlund et al. [305] examined a significant decline in sleep time ($p < .001$) and sleep efficiency ($p < .005$) with a 1-year follow-up period after a 12-week endurance training program in children (n_{in}= 27, n_{con}=22). Using a within-between subjects' pretest-posttest design, the Actigraph GT3X accelerometer was used to measure sleep–wake scoring for seven consecutive days and nights during a regular school week. The probability explanation is a worsening sleep pattern in the intervention group over time.

5.1.4 Chinese archery art program and depression/anxiety

Nowadays, it is a concerned public health issue about mental health in children around the world. More than 10% prevalence rate for chronic depression in Europe for the adolescents. 19.7% of people the UK adolescents displayed symptoms of anxiety or depression. The inclining tender is keeping from the previous year[306]. Mental health always involves the depression, anxiety which charactered low mood, dysphoria, cognitive impairments and psychomotor impairments, even the health comorbidities such as cardiovascular disease, adiposity, premature mortality and heavy financial cost[307].

The treatment and prevention of mental illness remains a public health priority [308]. Compared with several adverse side-effects from the pharmacotherapy and psychotherapy, physical activity intervention is regarded as alternative method to improve the mental health in children and preadolescents. Indeed, physical activity is consistently examined the significant association with psychological benefits including depression and anxiety [309]. Carter et al. [310] documented a positive benefit (SMD=-.54, 95% CI: -0.796, -0.28) between physical activity and anxiety in intervention group with physical activity program compared with control group in 3590 children and young people (more than 25 years) from eligible 22 randomized controlled trials through systematic review and meta-analysis. Meanwhile, Elaine et al. [311]reported a positive relationship between frequency of activity and wellbeing and negative relationship with both anxiety and depression symptoms with a school-based survey in 11110 adolescents from Europe. Moreover, more frequent physical activity and participation in sport were independently contribute to more wellbeing and less symptoms of anxiety and depression in male and female with a muti-level mixed effects model. Meanwhile, Xin Hong et al [312] reported an overall 15.7% (95% CI: 14.3%, 17.1%) prevalence rate of depression in mainland China. Importantly, this research detected the negative relationship between physical activity and depression in 72 classes of randomly selected from 24 urban junior high schools in Nanjing with a population-based cross-sectional study. Furthermore, the significant difference in gender ad grade were also confirmed on the inverse association between physical activity time and depression.

As the literature updating, there is still a inconclusion on the exact modality, frequency, duration, and intensity effect of physical activity on depression and anxiety.

Wegner et al [313]presented a meta-analyses which documented a small to medium (d=-.48--.50) consistently positive effect in children and adolescents with clinical and nonclinical depression in 2110 participants (Age: 5-20 years) from 30 inclusive studies. Moreover, aerobic exercise was the most implemented intervention type (normally 11.5 weeks duration, 41 minutes/session, 3 sessions/week). Additionally, Bailey et al. [314] found a large effect size (SMD = −0.82, 95% CI: −1.02, −0.61, $p < 0.05$, $I^2 = 38\%$) in intervention group with a physical activity program than control group in 771 participants (Age: 12-25 years) with clinical or non-clinical symptoms of depression from 16 eligible randomized controlled trials through meta-analysis. Regarding the specific physical activity intervention characteristics, the best candidates of PA program is a more than 8-week, supervised, aerobic-based activity with moderate-to-vigorous intensity, engaged in multiple times per week.

Recently, considering the advantage of mind-body activity in regulating stress, anxiety, and depression through self-care. it is highlighted that increasing mind-body activity programs were used as complementary and alternative therapies to release the anxiety and depression symptoms. Wang et al. [315]shown a considerable benefit on reduction of anxiety (SMD=-.75, 95% CI: -1.11, -.40) and stress (SMD=-.88, 95% CI: -1.22, -.55) in intervention group with 1-3 months QiGong exercise than control group in healthy subjects with 7 randomized controlled trials. Concurrently, Wang et al. [316] evaluated the beneficial effects on depression, anxiety, general stress management, and exercise self-efficacy in various populations through meta-analysis, significant improvement (ES=-5.97, 95% CI: -7.06, -4.87) of depression outcome measure on 3 RCTs, especially. Despite the impressive effect of mind-body activity programs on the reduction of depression or anxiety, it is still rare in the relevant field in children and adolescents. Complexity of perception and construction on the mind-body activity program are possible explanation. Until currently, Aysan [317] determined the significant improvement ($p<.01$) of coping with stress in adolescents with a single bout of archery practice with a comparison between pre-test ($Mean_{female}=7.52\pm4.02$, $Mean_{male}= 10.27\pm3.50$) and post-test ($Mean_{female}= 10.31\pm4.52$, $Mean_{male}= 13.11\pm3.48$).

Eventually, we originally explored a significant decrease ($t=-2.60$, $p=.014$) on the depression/anxiety scores within intervention group, compared pre-test with post-test with 12-week Chinese archery training in 33 preadolescents ($Mean_{age}=115.71\pm3.54$ months). Using a quasi-experimental study design, the depression/anxiety scores were assessed using Achenbach Child Behavior Checklist (CBCL). The reasonable explanations are that Chinese archery art program emphasizes mind-body unity and pursues simultaneous development of technique and Tao of the individual, which benefit the reduction of stress, increase of concentration, and enhancement self-emotional regulation[75, 76, 244]. Moreover, Chinese archery art practice highlight comparison of one’s own past and peer interaction instead of scoring hits[247]. This process produces less aggression and anxiety than competitive sport[247]. Chinese archery art as feasible mind-body activity facilitates the cultivation of self-esteem and character development of individuals. The self-esteem inversely predict the depression and anxiety[293]. The potentially psychosocial, behavioral mechanisms were involved that the enhancement of self-esteem and self-regulation probably mediated the decline of depression/anxiety scores [304].

5.2 Conclusion

Chinese archery art program as one of mind-body exercise are beneficial effect on the performance of core executive functions, self-esteem, sleep quality, anxiety/depression in healthy preadolescents. Specifically, some points can be concluded in this present study as follows:

5.2.1 there were significant improvements in core EFs which include inhibition control, working memory, and cognitive flexibility after a 12-week Chinese archery art program in preadolescent children. Specifically,

(1) About the inhibition control performance, there was a considerably reduction in reaction time in congruent trials within group on the 12^{th} week timepoint after a 12-week Chinese archery art program in preadolescent children; Regarding the accuracy, there were significant difference in congruent trials on the 6^{th} and the 12^{th} week timepoint, and a significant difference in incongruent trials on the 12^{th} week timepoint between groups. The intervention group was higher than control group.

(2) About the working memory performance, there were statistical reduction in reaction time in 1-back and 2-back trials within group on the 6^{th} and the 12^{th} week timepoint with a 12-week Chinese archery art program in preadolescent children. Moreover, the significant difference between groups were detected on the 12^{th} week timepoint, intervention group is faster than control group; Regarding the accuracy, there were significant decrease in 1-back within group on the 6^{th} and the 12^{th} week timepoint, and a significant difference in 2-back trials on the 12^{th} week timepoint between groups. The intervention group was higher than control group.

(3) About the cognitive flexibility performance, there were statistical reduction in reaction time in color trial, and shape trial within group on the 12th week timepoint, and the border trial on the 6th and 12th week timepoint, with a 12-week Chinese archery art program in preadolescent children. Moreover, the significant difference in color trial, shape trial and border trial between groups were detected on the 12th week timepoint, intervention group is faster than control group; Regarding the accuracy, there were significant decrease in shape trials in control group on the 6th and the 12th week timepoint. Otherwise, the impressive improvement in border trial in intervention group were revealed on the 6th and the 12th week timepoint. Furthermore, the significant difference in shape trials and border trials were displayed on the 6th and 12th week timepoint between groups. The intervention group was better than control group.

5.2.2 the significant benefit in core executive functions on the 18th week timepoint between groups still was displayed with a 6-week follow-up period. Althougth, the decline trend was detected in itervention grouop at 18th week. Specifically,

(1) About the inhibition control performance, there was a considerably reduction in reaction time in congruent trials and incongruent trials between groups on the 18th week timepoint after a 6-week follow-up period in preadolescent children. The intervention group was higher than control group.

(2) About the working memory performance, there were significant difference of response accuracy in 1-back trials and 2-back trials between groups on the 18th week

timepoint in preadolescent children. The intervention group was higher than control group.

(3) About the cognitive flexibility performance, there were statistical difference in response accuracy in color trials, shape trials, and border trials between groups on the 18^{th} week timepoint with a 6-week follow-up period in preadolescent children.

5.2.3 there was a impressive increase of self-esteem scores within intervention group at the 6^{th} and 12^{th} week timepoint with a 12-week Chinese archery art program in preadolescent children, respectively.

5.2.4 there was a significant improvement of self-esteem scores between group at the 6^{th} and 12^{th} week timepoint with a 12-week Chinese archery art program in preadolescent children, respectively. Furthermore, the trend in self-esteem scores still revealed between group with a 6-week follow-up.

5.2.5 there were considerable benefit on the global sleep quality scores in both group when baseline test compared with 6^{th} week test and 12^{th} week test with a 12-week Chinese archery art program in preadolescent children. there was no statistical difference on the 18^{th} week timepoint after a 6-week follow-up.

5.2.6 there were significant decline of the global anxiety/depression scores in intervention group on 12^{th} week timepoint with a 12-week Chinese archery art program in preadolescent children. meanwhile, there was not a significant increase of the global anxiety/depression scores on the 18^{th} week timepoint with a 6-week follow-up period.

5.3 Strengths, limitations, and recommendations

5.3.1 Strengths

The exercise protocol in the present study utilized the real world with ecological validity, which is based on extracurricular activities in school, rather than most of the investigations being conducted in the laboratory with treadmills or cycle ergometers [318]. The real-world condition probably benefits participants' executive functions more than the experimental or decontextualized physical activity programs[319]. Additionally. group extracurricular activity in school provides children with more opportunities for social interaction and a better motivational climate; emotional investment is probably the considerable mediator to whether that activity determines enhancement of executive functions[70]. Simultaneously, with growing concerns about the younger generation's health, school-based interventional programs have several critical advantages (e.g., economy, convenience, breadth, diversity, and accessibility). Importantly, this study not only objectively proves that Chinese archery art program has a significant effect on improving executive function in adolescent children but also further supports Diamond and Ling's prediction[179] of how the physical activities will be the most effective enhance executive function. The encouraging finding provides an alternative application for improving core executive functions in normal preadolescent children in large-scale educational settings.

5.3.2 Limitation

There are several limitations to this study. First, the randomized trial was not conducted in the present study but was a quasi-experimental design. It is possible to produce more bias in to result of this study. Therefore, it is necessary to consider future research involving a randomized controlled study design to reduce bias. Second, an objective measure of physical activity during intervention is missed. Regarding the role of intensity as moderator[177], it is acceptable to monitor the heart rate range in real-time during the intervention and collect data as a subjective index for all participants in the future. Third, although the real-world interventional setting is regarded as a strength in this study, it also inevitably increased other confounders.

5.3.3 Recommendations

This study detected an impressive result in the benefit of inhibitory control, working memory and cognitive flexibility performance and self-esteem, sleep quality, anxiety/depression, however further investigations about the mechanism will be merited. the long-term effects of this physical activity program and the sustainability of its advantage remain unknown. Further investigations are valuable. Meanwhile, those children with ADHD are characterized by deficits in core executive functions. It is worth conducting relevant research of the benefit with Chinese archery art program to these clinical populations in the future. Importantly, this is a great opportunity to make relevant policies to promote the Chinese archery in preadolescent children in large-scale educational settings

REFERENCES

[320]

1. Diamond, A., *Executive functions.* Annu Rev Psychol, 2013. **64**: p. 135-68.

2. Best, J.R. and P.H. Miller, *A developmental perspective on executive function.* Child development, 2010. **81**(6): p. 1641-1660.

3. Miyake, A., et al., *The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis.* Cognitive psychology, 2000. **41**(1): p. 49-100.

4. Collins, A. and E. Koechlin, *Reasoning, learning, and creativity: frontal lobe function and human decision-making.* PLoS biology, 2012. **10**(3): p. e1001293.

5. Lunt, L., et al., *Prefrontal cortex dysfunction and 'jumping to conclusions': bias or deficit?* Journal of Neuropsychology, 2012. **6**(1): p. 65-78.

6. Baler, R.D. and N.D. Volkow, *Drug addiction: the neurobiology of disrupted self-control.* Trends in molecular medicine, 2006. **12**(12): p. 559-566.

7. Diamond, A. and N. Kirkham, *Not quite as grown-up as we like to think: Parallels between cognition in childhood and adulthood.* Psychological Science, 2005. **16**(4): p. 291-297.

8. Lui, M. and R. Tannock, *Working memory and inattentive behaviour in a community sample of children.* Behavioral and Brain Functions, 2007. **3**(1): p. 12.

9. Fairchild, G., et al., *Deficits in facial expression recognition in male adolescents with early-onset or adolescence-onset conduct disorder.* Journal of Child Psychology and Psychiatry, 2009. **50**(5): p. 627-636.

10. Tavares, J.V.T., et al., *Distinct profiles of neurocognitive function in unmedicated unipolar depression and bipolar II depression.* Biological psychiatry, 2007. **62**(8): p. 917-924.

11. Barch, D.M., *The cognitive neuroscience of schizophrenia.* Annu. Rev. Clin. Psychol., 2005. **1**: p. 321-353.

12. Will Crescioni, A., et al., *High trait self-control predicts positive health behaviors and success in weight loss.* Journal of health psychology, 2011. **16**(5): p. 750-759.

13. Miller, G.E., E. Chen, and K.J. Parker, *Psychological stress in childhood and susceptibility to the chronic diseases of aging: moving toward a model of behavioral and biological mechanisms.* Psychological bulletin, 2011. **137**(6): p. 959.

14. Goldstein, S. and J.A. Naglieri, *Executive functioning.* A Goldstein, Sam, 2014.

15. Berlin, L., et al., *How well do measures of inhibition and other executive functions discriminate between children with ADHD and controls?* Child Neuropsychology, 2004. **10**(1): p. 1-13.

16. Klingberg, T., et al., *Computerized training of working memory in children with ADHD-a randomized, controlled trial.* Journal of the American Academy of Child & Adolescent Psychiatry, 2005. **44**(2): p. 177-186.

17. Thorell, L.B., et al., *Training and transfer effects of executive functions in preschool children.* Developmental science, 2009. **12**(1): p. 106-113.

18. Holmes, J., et al., *Working memory deficits can be overcome: Impacts of training and medication on working memory in children with ADHD.* Applied Cognitive Psychology, 2010. **24**(6): p. 827-836.

19. Holmes, J., S.E. Gathercole, and D.L. Dunning, *Adaptive training leads to sustained enhancement of poor working memory in children.* Developmental science, 2009. **12**(4): p. F9-F15.

20. Diamond, A., et al., *Preschool program improves cognitive control.* Science, 2007. **318**(5855): p. 1387-1388.

21. Diamond, A. and K. Lee, *Interventions shown to aid executive function development in children 4 to 12 years old.* Science, 2011. **333**(6045): p. 959-964.

22. Diamond, A., *Activities and programs that improve children's executive functions.* Current directions in psychological science, 2012. **21**(5): p. 335-341.

23. Manjunath, N. and S. Telles, *Improved performance in the Tower of London test following yoga.* Indian journal of physiology and pharmacology, 2001. **45**(3): p. 351-354.

24. Lebowitz, A., et al., *Exercise habit could modulate cognitive benefits from physical and cognitive intervention.* Psychiatry and clinical neurosciences, 2018. **72**(3): p. 189-190.

25. Drollette, E.S., et al., *Effects of the FITKids physical activity randomized controlled trial on conflict monitoring in youth.* Psychophysiology, 2018. **55**(3): p. e13017.

26. Fisher, A., et al., *Effects of a physical education intervention on cognitive function in young children: randomized controlled pilot study.* BMC pediatrics, 2011. **11**(1): p. 97.

27. Hillman, C.H., et al., *Effects of the FITKids randomized controlled trial on executive control and brain function.* Pediatrics, 2014. **134**(4): p. e1063-e1071.

28. Huang, T., et al., *Effects of an obesity intervention program on cognitive function in children: A randomized controlled trial.* Obesity, 2015. **23**(10): p. 2101-2108.

29. Kamijo, K., et al., *The effects of an afterschool physical activity program on working memory in preadolescent children.* Developmental science, 2011. **14**(5): p. 1046-1058.

30. Krafft, C.E., et al., *An 8-month randomized controlled exercise trial alters brain activation during cognitive tasks in overweight children.* Obesity, 2014. **22**(1): p. 232-242.

31. Moreau, D., I.J. Kirk, and K.E. Waldie, *High-intensity training enhances executive function in children in a randomized, placebo-controlled trial.* Elife, 2017. **6**: p. e25062.

32. Crova, C., et al., *Cognitively challenging physical activity benefits executive function in overweight children.* Journal of sports sciences, 2014. **32**(3): p. 201-211.

33. Kvalø, S., et al., *Does increased physical activity in school affect children's executive function and aerobic fitness?* Scandinavian journal of medicine & science in sports, 2017. **27**(12): p. 1833-1841.

34. Ludyga, S., et al., *Chronic effects of exercise implemented during school-break time on neurophysiological indices of inhibitory control in adolescents.* Trends in Neuroscience and Education, 2018. **10**: p. 1-7.

35. Schmidt, M., et al., *Cognitively engaging chronic physical activity, but not aerobic exercise, affects executive functions in primary school children: a group-randomized controlled trial.* Journal of Sport and Exercise Psychology, 2015. **37**(6): p. 575-591.

36. Tarp, J., et al., *Effectiveness of a school-based physical activity intervention on cognitive performance in Danish adolescents: lcomotion—learning, cognition and motion–a cluster randomized controlled trial.* PLoS One, 2016. **11**(6): p. e0158087.

37. Budde, H., et al., *Acute coordinative exercise improves attentional performance in adolescents.* Neuroscience letters, 2008. **441**(2): p. 219-223.

38. Pesce, C., et al., *Physical activity and mental performance in preadolescents: Effects of acute exercise on free-recall memory.* Mental Health and Physical Activity, 2009. **2**(1): p. 16-22.

39. Diamond, A., *Close interrelation of motor development and cognitive development and of the cerebellum and prefrontal cortex.* Child development, 2000. **71**(1): p. 44-56.

40. Audiffren, M., P.D. Tomporowski, and J. Zagrodnik, *Acute aerobic exercise and information processing: modulation of executive control in a Random Number Generation task.* Acta psychologica, 2009. **132**(1): p. 85-95.

41. Labban, J.D. and J.L. Etnier, *Effects of acute exercise on long-term memory.* Research quarterly for exercise and sport, 2011. **82**(4): p. 712-721.

42. Chang, Y.-K., et al., *Effects of acute exercise on executive function: a study with a Tower of London Task.* Journal of Sport and Exercise Psychology, 2011. **33**(6): p. 847-865.

43. McMorris, T., et al., *Acute incremental exercise, performance of a central executive task, and sympathoadrenal system and hypothalamic-pituitary-adrenal axis activity.* International Journal of Psychophysiology, 2009. **73**(3): p. 334-340.

44. Stroth, S., et al., *Physical fitness, but not acute exercise modulates event-related potential indices for executive control in healthy adolescents.* Brain research, 2009. **1269**: p. 114-124.

45. Hillman, C.H., et al., *The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children.* Neuroscience, 2009. **159**(3): p. 1044-1054.

46. Karbach, J. and J. Kray, *How useful is executive control training? Age differences in near and far transfer of task-switching training.* Developmental science, 2009. **12**(6): p. 978-990.

47. Persson, J. and P.A. Reuter-Lorenz, *Gaining control: Training executive function and far transfer of the ability to resolve interference [retracted].* Psychological Science, 2008. **19**(9): p. 881-888.

48. Diamond, A. and D.S. Ling, *Conclusions about interventions, programs, and approaches for improving executive functions that appear justified and those that, despite much hype, do not.* Dev Cogn Neurosci, 2016. **18**: p. 34-48.

49. Etnier, J.L., et al., *The influence of physical fitness and exercise upon cognitive functioning: A meta-analysis.* Journal of sport and Exercise Psychology, 1997. **19**(3): p. 249-277.

50. Colcombe, S. and A.F. Kramer, *Fitness effects on the cognitive function of older adults: a meta-analytic study.* Psychological science, 2003. **14**(2): p. 125-130.

51. Pesce, C. and T.D. Ben-Soussan, *"Cogito ergo sum" or "ambulo ergo sum"? New perspectives in developmental exercise and cognition research.* 2016.

52. Ellemberg, D. and M. St-Louis-Deschênes, *The effect of acute physical exercise on cognitive function during development.* Psychology of Sport and Exercise, 2010. **11**(2): p. 122-126.

53. Hillman, C.H., et al., *On mindful and mindless physical activity and executive function: A response to Diamond and Ling (2016).* Dev Cogn Neurosci, 2019. **37**: p. 100529.

54. Diamond, A., *Effects of physical exercise on executive functions: going beyond simply moving to moving with thought.* Annals of sports medicine and research, 2015. **2**(1): p. 1011.

55. Audiffren, M. and N. André, *The strength model of self-control revisited: Linking acute and chronic effects of exercise on executive functions.* Journal of Sport and Health Science, 2015. **4**(1): p. 30-46.

56. Barenberg, J., T. Berse, and S. Dutke, *Executive functions in learning processes: do they benefit from physical activity?* Educational Research Review, 2011. **6**(3): p. 208-222.

57. Best, J.R., *Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise.* Developmental review, 2010. **30**(4): p. 331-351.

58. Chaddock, L., et al., *Aerobic fitness and executive control of relational memory in preadolescent children.* Med Sci Sports Exerc, 2011. **43**(2): p. 344-9.

59. Etnier, J.L., et al., *A meta-regression to examine the relationship between aerobic fitness and cognitive performance.* Brain research reviews, 2006. **52**(1): p. 119-130.

60. Fedewa, A.L. and S. Ahn, *The effects of physical activity and physical fitness on children's achievement and cognitive outcomes: a meta-analysis.* Research quarterly for exercise and sport, 2011. **82**(3): p. 521-535.

61. Hillman, C.H., K.I. Erickson, and A.F. Kramer, *Be smart, exercise your heart: exercise effects on brain and cognition.* Nature reviews neuroscience, 2008. **9**(1): p. 58-65.

62. Hindin, S.B. and E.M. Zelinski, *Extended practice and aerobic exercise interventions benefit untrained cognitive outcomes in older adults: A meta-analysis.* Journal of the American Geriatrics Society, 2012. **60**(1): p. 136-141.

63. Kramer, A.F. and K.I. Erickson, *Capitalizing on cortical plasticity: influence of physical activity on cognition and brain function.* Trends in cognitive sciences, 2007. **11**(8): p. 342-348.

64. Moreau, D. and A.R. Conway, *Cognitive enhancement: a comparative review of computerized and athletic training programs.* International Review of Sport and Exercise Psychology, 2013. **6**(1): p. 155-183.

65. Tomporowski, P.D., et al., *Exercise and children's cognition: the role of exercise characteristics and a place for metacognition.* Journal of Sport and Health Science, 2015. **4**(1): p. 47-55.

66. Voss, M.W., et al., *Exercise, brain, and cognition across the life span.* Journal of applied physiology, 2011. **111**(5): p. 1505-1513.

67. Erickson, K.I., et al., *Exercise training increases size of hippocampus and improves memory.* Proceedings of the National Academy of Sciences, 2011. **108**(7): p. 3017-3022.

68. Etnier, J.L. and Y.-K. Chang, *The effect of physical activity on executive function: a brief commentary on definitions, measurement issues, and the current state of the literature.* Journal of Sport and Exercise Psychology, 2009. **31**(4): p. 469-483.

69. Prakash, R.S., et al., *Physical activity and cognitive vitality.* Annual review of psychology, 2015. **66**: p. 769-797.

70. Diamond, A. and D.S. Ling, *Aerobic-Exercise and resistance-training interventions have been among the least effective ways to improve executive functions of any method tried thus far.* Dev Cogn Neurosci, 2019. **37**: p. 100572.

71. Pesce, C., *Shifting the focus from quantitative to qualitative exercise characteristics in exercise and cognition research.* Journal of Sport and Exercise Psychology, 2012. **34**(6): p. 766-786.

72. Xue, Y., Y. Yang, and T. Huang, *Effects of chronic exercise interventions on executive function among children and adolescents: a systematic review with meta-analysis.* British journal of sports medicine, 2019. **53**(22): p. 1397-1404.

73. Gallotta, M.C., et al., *Effects of varying type of exertion on children's attention capacity.* Medicine and science in sports and exercise, 2012. **44**(3): p. 550-555.

74. Gallotta, M., et al., *Acute physical activity and delayed attention in primary school students.* Scandinavian journal of medicine & science in sports, 2015. **25**(3): p. e331-e338.

75. Aysan, H.A., *The Effects of Archery as a Sports Branch on Coping with Stress.* Studies on Ethno-Medicine, 2017. **10**(1): p. 39-43.

76. Tan, S.L., K.T. Koh, and M. Kokkonen, *The perception of elite athletes' guided self-reflection and performance in archery.* Reflective Practice, 2016. **17**(2): p. 207-220.

77. Hoagland, D.Q., *Archery exercise to promote successful aging through physical activity among baby boomers*. 2017, Capella University.

78. Coulacoglou, C. and D.H. Saklofske, *Executive Function, Theory of Mind, and Adaptive Behavior*, in *Psychometrics and Psychological Assessment*. 2017. p. 91-130.

79. Hughes, C., *Executive function in preschoolers: Links with theory of mind and verbal ability.* British Journal of Developmental Psychology, 1998.

80. Welsh, M.C., B.F. Pennington, and D.B. Groisser, *A normative‐developmental study of executive function: A window on prefrontal function in children.* Developmental neuropsychology, 1991. **7**(2): p. 131-149.

81. Senn, T.E., K.A. Espy, and P.M. Kaufmann, *Using path analysis to understand executive function organization in preschool children.* Developmental neuropsychology, 2004. **26**(1): p. 445-464.

82. Huizinga, M., C.V. Dolan, and M.W. Van der Molen, *Age-related change in executive function: Developmental trends and a latent variable analysis.* Neuropsychologia, 2006. **44**(11): p. 2017-2036.

83. Brown, W.H., et al., *Assessing preschool children's physical activity: the Observational System for Recording Physical Activity in children-preschool version.* Res Q Exerc Sport, 2006. **77**(2): p. 167-76.

84. Blair, C. and R.P. Razza, *Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten.* Child development, 2007. **78**(2): p. 647-663.

85. Borella, E., et al., *Working memory training in older adults: evidence of transfer and maintenance effects.* Psychology and aging, 2010. **25**(4): p. 767.

86. Duncan, G.J., et al., *School readiness and later achievement.* Developmental psychology, 2007. **43**(6): p. 1428.

87. Gathercole, S.E., et al., *The structure of working memory from 4 to 15 years of age.* Developmental psychology, 2004. **40**(2): p. 177.

88. Bailey, C.E., *Cognitive accuracy and intelligent executive function in the brain and in business.* Annals of the New York Academy of Sciences, 2007. **1118**(1): p. 122-141.

89. Eakin, L., et al., *The marital and family functioning of adults with ADHD and their spouses.* Journal of Attention Disorders, 2004. **8**(1): p. 1-10.

90. Broidy, L.M., et al., *Developmental trajectories of childhood disruptive behaviors and adolescent delinquency: a six-site, cross-national study.* Developmental psychology, 2003. **39**(2): p. 222.

91. Denson, T.F., et al., *Understanding impulsive aggression: Angry rumination and reduced self-control capacity are mechanisms underlying the provocation-aggression relationship.* Personality and Social Psychology Bulletin, 2011. **37**(6): p. 850-862.

92. Baler, R.D. and N.D. Volkow, *Drug addiction: the neurobiology of disrupted self-control.* Trends Mol Med, 2006. **12**(12): p. 559-66.

93. Lui, M. and R. Tannock, *Working memory and inattentive behaviour in a community sample of children.* Behav Brain Funct, 2007. **3**: p. 12.

94. Syngelaki, E.M., et al., *Executive functioning and risky decision making in young male offenders.* Criminal Justice and Behavior, 2009. **36**(11): p. 1213-1227.

95. Barch, D.M., *The cognitive neuroscience of schizophrenia.* Annu Rev Clin Psychol, 2005. **1**: p. 321-53.

96. Penades, R., et al., *Impaired response inhibition in obsessive compulsive disorder.* Eur Psychiatry, 2007. **22**(6): p. 404-10.

97. Riggs, N.R., et al., *Relationships between executive cognitive function and lifetime substance use and obesity-related behaviors in fourth grade youth.* Child Neuropsychology, 2012. **18**(1): p. 1-11.

98. Will Crescioni, A., et al., *High trait self-control predicts positive health behaviors and success in weight loss.* J Health Psychol, 2011. **16**(5): p. 750-9.

99. Brown, T.E. and J.M. Landgraf, *Improvements in executive function correlate with enhanced performance and functioning and health-related quality of life: evidence from 2 large, double-blind, randomized, placebo-controlled trials in ADHD.* Postgraduate medicine, 2010. **122**(5): p. 42-51.

100. Blair, C. and R.P. Razza, *Relating effortful control, executive function, and false belief understanding to emerging math and literacy ability in kindergarten.* Child Dev, 2007. **78**(2): p. 647-63.

101. Morrison, F.J., C.C. Ponitz, and M.M. McClelland, *Self-regulation and academic achievement in the transition to school*, in *Child development at the intersection of emotion and cognition.* 2010. p. 203-224.

102. Borella, E., B. Carretti, and S. Pelegrina, *The specific role of inhibition in reading comprehension in good and poor comprehenders.* J Learn Disabil, 2010. **43**(6): p. 541-52.

103. Gathercole, S.E., et al., *Working memory in children with reading disabilities.* J Exp Child Psychol, 2006. **93**(3): p. 265-81.

104. Denson, T.F., et al., *Understanding impulsive aggression: Angry rumination and reduced self-control capacity are mechanisms underlying the provocation-aggression relationship.* Pers Soc Psychol Bull, 2011. **37**(6): p. 850-62.

105. Theeuwes, J., *Top–down and bottom–up control of visual selection.* Acta psychologica, 2010. **135**(2): p. 77-99.

106. Anderson, M.C. and B.J. Levy, *Suppressing unwanted memories.* Current Directions in Psychological Science, 2009. **18**(4): p. 189-194.

107. Postle, B.R., L.N. Brush, and A.M. Nick, *Prefrontal cortex and the mediation of proactive interference in working memory.* Cognitive, Affective, & Behavioral Neuroscience, 2004. **4**(4): p. 600-608.

108. Louie, K. and P.W. Glimcher, *Separating value from choice: delay discounting activity in the lateral intraparietal area.* Journal of Neuroscience, 2010. **30**(16): p. 5498-5507.

109. Rachlin, H., A. Raineri, and D. Cross, *Subjective probability and delay*. Journal of the experimental analysis of behavior, 1991. **55**(2): p. 233-244.

110. MacLeod, C.M., et al., *In opposition to inhibition.* Psychology of learning and motivation, 2003. **43**: p. 163-215.

111. Pennington, B.F., et al., *Executive functions and working memory: Theoretical and measurement issues.* 1996.

112. Hommel, B., *The Simon effect as tool and heuristic.* Acta psychologica, 2011. **136**(2): p. 189-202.

113. Ridderinkhof, K.R., et al., *The arrow of time: Advancing insights into action control from the arrow version of the Eriksen flanker task.* Attention, Perception, & Psychophysics, 2021. **83**(2): p. 700-721.

114. Johnson, K.A., F.C. Lewis, and K.M. Cornish, *A child-focused version of the Attention Network Task designed to investigate interactions between the attention networks, including the endogenous orienting network.* Child Neuropsychology, 2020. **26**(5): p. 666-690.

115. Voelker, P., M.K. Rothbart, and M.I. Posner, *A polymorphism related to methylation influences attention during performance of speeded skills.* AIMS Neuroscience, 2016. **3**(1): p. 40-55.

116. Shapiro, Z. and C. Huang-Pollock, *A diffusion-model analysis of timing deficits among children with ADHD.* Neuropsychology, 2019. **33**(6): p. 883.

117. van Wouwe, N.C., et al., *Dissociable effects of dopamine on the initial capture and the reactive inhibition of impulsive actions in Parkinson's disease.* Journal of cognitive neuroscience, 2016. **28**(5): p. 710-723.

118. Eriksen, B.A. and C.W. Eriksen, *Effects of noise letters upon the identification of a target letter in a nonsearch task.* Perception & psychophysics, 1974. **16**(1): p. 143-149.

119. McDermott, J.M., K. Perez-Edgar, and N.A. Fox, *Variations of the flanker paradigm: Assessing selective attention in young children.* Behavior research methods, 2007. **39**(1): p. 62-70.

120. Alloway, T.P., et al., *Working memory and phonological awareness as predictors of progress towards early learning goals at school entry*. British Journal of Developmental Psychology, 2005. **23**(3): p. 417-426.

121. Alloway, T.P., et al., *A structural analysis of working memory and related cognitive skills in young children.* J Exp Child Psychol, 2004. **87**(2): p. 85-106.

122. Bell, M.A. and K. Cuevas, *Using EEG to study cognitive development: Issues and practices.* Journal of cognition and development, 2012. **13**(3): p. 281-294.

123. Cowan, N., *The focus of attention as observed in visual working memory tasks: Making sense of competing claims.* Neuropsychologia, 2011. **49**(6): p. 1401-1406.

124. Crone, E.A., et al., *Neurocognitive development of the ability to manipulate information in working memory.* Proceedings of the National Academy of Sciences, 2006. **103**(24): p. 9315-9320.

125. Luciana, M., et al., *The development of nonverbal working memory and executive control processes in adolescents.* Child development, 2005. **76**(3): p. 697-712.

126. Rutman, A.M., et al., *Early top–down control of visual processing predicts working memory performance.* Journal of cognitive neuroscience, 2010. **22**(6): p. 1224-1234.

127. Solesio-Jofre, E., et al., *Age-related effects in working memory recognition modulated by retroactive interference.* Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences, 2012. **67**(6): p. 565-572.

128. Hedden, T. and D. Park, *Aging and interference in verbal working memory.* Psychology and aging, 2001. **16**(4): p. 666.

129. Kurtz, T., et al., *Individual differences in task-specific paired associates learning in older adults: the role of processing speed and working memory.* Experimental aging research, 2013. **39**(5): p. 493-514.

130. Fry, A.F. and S. Hale, *Relationships among processing speed, working memory, and fluid intelligence in children.* Biological psychology, 2000. **54**(1-3): p. 1-34.

131. Diamond, A., N. Kirkham, and D. Amso, *Conditions under which young children can hold two rules in mind and inhibit a prepotent response.* Developmental psychology, 2002. **38**(3): p. 352.

132. Alloway, T.P., et al., *The cognitive and behavioral characteristics of children with low working memory.* Child development, 2009. **80**(2): p. 606-621.

133. Luciana, M. and C.A. Nelson, *Assessment of neuropsychological function through use of the Cambridge Neuropsychological Testing Automated Battery: performance in 4-to 12-year-old children.* Developmental neuropsychology, 2002. **22**(3): p. 595-624.

134. Owen, A.M., et al., *N-back working memory paradigm: a meta-analysis of normative functional neuroimaging studies.* Hum Brain Mapp, 2005. **25**(1): p. 46-59.

135. Pelegrina, S., et al., *Normative data on the n-back task for children and young adolescents.* Frontiers in psychology, 2015. **6**: p. 1544.

136. Friedman, N.P., et al., *Individual differences in executive functions are almost entirely genetic in origin.* Journal of experimental psychology: General, 2008. **137**(2): p. 201.

137. Jaeggi, S.M., et al., *The concurrent validity of the N-back task as a working memory measure.* Memory, 2010. **18**(4): p. 394-412.

138. Cepeda, N.J., A.F. Kramer, and J. Gonzalez de Sather, *Changes in executive control across the life span: examination of task-switching performance.* Developmental psychology, 2001. **37**(5): p. 715.

139. Kray, L.J., A.D. Galinsky, and E.M. Wong, *Thinking within the box: The relational processing style elicited by counterfactual mind-sets.* Journal of personality and social psychology, 2006. **91**(1): p. 33.

140. Perner, J. and B. Lang, *What causes 3-year-olds' difficulty on the dimensional change card sorting task?* Infant and Child Development: An International Journal of Research and Practice, 2002. **11**(2): p. 93-105.

141. Rennie, D.A., R. Bull, and A. Diamond, *Executive functioning in preschoolers: Reducing the inhibitory demands of the dimensional change card sort task.* Developmental neuropsychology, 2004. **26**(1): p. 423-443.

142. Davidson, M.C., et al., *Development of cognitive control and executive functions from 4 to 13 years: Evidence from manipulations of memory, inhibition, and task switching.* Neuropsychologia, 2006. **44**(11): p. 2037-2078.

143. Kray, J. and U. Lindenberger, *Adult age differences in task switching.* Psychology and aging, 2000. **15**(1): p. 126.

144. Kray, J., K.Z. Li, and U. Lindenberger, *Age-related changes in task-switching components: The role of task uncertainty.* Brain and cognition, 2002. **49**(3): p. 363-381.

145. Zelazo, P.D., D. Frye, and T. Rapus, *An age-related dissociation between knowing rules and using them.* Cognitive development, 1996. **11**(1): p. 37-63.

146. Zelazo, P.D., et al., *The development of executive function in early childhood.* Monographs of the society for research in child development, 2003: p. i-151.

147. Hongwanishkul, D., et al., *Assessment of hot and cool executive function in young children: Age-related changes and individual differences.* Developmental neuropsychology, 2005. **28**(2): p. 617-644.

148. Mackey, A.P., et al., *Differential effects of reasoning and speed training in children.* Developmental science, 2011. **14**(3): p. 582-590.

149. Bergman Nutley, S., et al., *Gains in fluid intelligence after training non‐verbal reasoning in 4‐year‐old children: A controlled, randomized study.* Developmental science, 2011. **14**(3): p. 591-601.

150. Tuckman, B.W. and J.S. Hinkle, *An experimental study of the physical and psychological effects of aerobic exercise on schoolchildren.* Health psychology, 1986. **5**(3): p. 197.

151. Ishihara, T., et al., *Improved executive functions in 6-12-year-old children following cognitively engaging tennis lessons.* J Sports Sci, 2017. **35**(20): p. 2014-2020.

152. Davis, C.L., et al., *Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial.* Health Psychol, 2011. **30**(1): p. 91-8.

153. Hillman, C.H., et al., *The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children.* Neuroscience, 2009. **159**(3): p. 1044-54.

154. Flook, L., et al., *Effects of Mindful Awareness Practices on Executive Functions in Elementary School Children.* Journal of Applied School Psychology, 2010. **26**(1): p. 70-95.

155. Lakes, K.D. and W.T. Hoyt, *Promoting self-regulation through school-based martial arts training.* Journal of Applied Developmental Psychology, 2004. **25**(3): p. 283-302.

156. Diamond, A., et al., *Preschool program improves cognitive control.* Science (New York, NY), 2007. **318**(5855): p. 1387.

157. Lillard, A. and N. Else-Quest, *The early years: Evaluating Montessori education.* Science, 2006. **313**(5795): p. 1893-1894.

158. Riggs, N.R., et al., *The mediational role of neurocognition in the behavioral outcomes of a social-emotional prevention program in elementary school students: Effects of the PATHS curriculum.* Prevention Science, 2006. **7**(1): p. 91-102.

159. Raver, C.C., et al., *CSRP's impact on low-income preschoolers' preacademic skills: self-regulation as a mediating mechanism.* Child development, 2011. **82**(1): p. 362-378.

160. Raver, C.C., et al., *Improving preschool classroom processes: Preliminary findings from a randomized trial implemented in Head Start settings.* Early childhood research quarterly, 2008. **23**(1): p. 10-26.

161. Flook, L., et al., *Effects of mindful awareness practices on executive functions in elementary school children.* Journal of applied school psychology, 2010.

162. Ericsson, K.A., K. Nandagopal, and R.W. Roring, *Toward a science of exceptional achievement.* Annals of the New York Academy of Sciences, 2009. **1172**(1): p. 199.

163. Trulson, M.E., *Martial arts training: A novel "cure" for juvenile delinquency.* Human Relations, 1986. **39**(12): p. 1131-1140.

164. Corbin, C.B., R.P. Pangrazi, and B.D. Franks, *Definitions: Health, fitness, and physical activity.* President's Council on Physical Fitness and Sports Research Digest, 2000.

165. Sibley, B.A. and J.L. Etnier, *The relationship between physical activity and cognition in children: a meta-analysis.* Pediatric exercise science, 2003. **15**(3): p. 243-256.

166. Davis, C.L., et al., *Effects of aerobic exercise on overweight children's cognitive functioning: a randomized controlled trial.* Research quarterly for exercise and sport, 2007. **78**(5): p. 510-519.

167. Vazou, S., et al., *More than one road leads to Rome: A narrative review and meta-analysis of physical activity intervention effects on cognition in youth.* Int J Sport Exerc Psychol, 2019. **17**(2): p. 153-178.

168. Singh, A.S., et al., *Effects of physical activity interventions on cognitive and academic performance in children and adolescents: a novel combination of a systematic review and recommendations from an expert panel.* Br J Sports Med, 2019. **53**(10): p. 640-647.

169. de Greeff, J.W., et al., *Effects of physical activity on executive functions, attention and academic performance in preadolescent children: a meta-analysis.* J Sci Med Sport, 2018. **21**(5): p. 501-507.

170. Donnelly, J.E., et al., *Physical Activity, Fitness, Cognitive Function, and Academic Achievement in Children: A Systematic Review.* Med Sci Sports Exerc, 2016. **48**(6): p. 1197-222.

171. Verburgh, L., et al., *Physical exercise and executive functions in preadolescent children, adolescents and young adults: a meta-analysis.* Br J Sports Med, 2014. **48**(12): p. 973-9.

172. Song, W., et al., *Play Smart, Be Smart? Effect of Cognitively Engaging Physical Activity Interventions on Executive Function among*

Children 4~12 Years Old: A Systematic Review and Meta-Analysis. Brain Sci, 2022. **12**(6).

173. *effect of physical activity and fitness on executive functions and academic performance in children of elementary school. A systematic review.* Cultura, Ciencia y Deporte, 2022.

174. Best, J.R., *Effects of Physical Activity on Children's Executive Function: Contributions of Experimental Research on Aerobic Exercise.* Dev Rev, 2010. **30**(4): p. 331-551.

175. Contreras-Osorio, F., et al., *Effects of Sport-Based Interventions on Children's Executive Function: A Systematic Review and Meta-Analysis.* Brain Sci, 2021. **11**(6).

176. Ishihara, T., et al., *The effects of acute aerobic exercise on executive function: A systematic review and meta-analysis of individual participant data.* Neurosci Biobehav Rev, 2021. **128**: p. 258-269.

177. Chang, Y.K., et al., *The effects of acute exercise on cognitive performance: a meta-analysis.* Brain Res, 2012. **1453**: p. 87-101.

178. Chang, Y.K., et al., *Dose-response relation between exercise duration and cognition.* Med. Sci. Sports Exerc, 2015. **47**: p. 159-165.

179. Diamond, A. and D.S. Ling, *Review of the evidence on, and fundamental questions about, efforts to improve executive functions, including working memory.* 2020.

180. *<046The Acute Effects of Yoga on Executive Function.pdf>.*

181. Luu, K. and P.A. Hall, *Examining the Acute Effects of Hatha Yoga and Mindfulness Meditation on Executive Function and Mood.* Mindfulness, 2016. **8**(4): p. 873-880.

182. Menglu, S., et al., *Effects of Tai Chi on the Executive Function and Physical Fitness of Female Methamphetamine Dependents: A Randomized Controlled Trial.* Front Psychiatry, 2021. **12**: p. 653229.

183. Wayne, P.M., et al., *Effect of Tai Chi on cognitive performance in older adults: Systematic review and meta‐Analysis.* Journal of the American Geriatrics Society, 2014. **62**(1): p. 25-39.

184. Taylor-Piliae, R.E., et al., *Effects of Tai Chi and Western exercise on physical and cognitive functioning in healthy community-dwelling older adults.* Journal of aging and physical activity, 2010. **18**(3): p. 261-279.

185. Fatemi, H., et al., *A Chinese Mind-Body Exercise Improves Self-Control of Children with Autism: A Randomized Controlled Trial.* PLoS ONE, 2013. **8**(7).

186. Lakes, K.D., et al., *The Healthy for Life Taekwondo Pilot Study: A Preliminary Evaluation of Effects on Executive Function and BMI, Feasibility, and Acceptability.* Ment Health Phys Act, 2013. **6**(3): p. 181-188.

187. Novick, J.M., et al., *Cognitive and Working Memory Training.* 2019.

188. Tomporowski, P.D., et al., *Exercise and Children's Intelligence, Cognition, and Academic Achievement.* Educational Psychology Review, 2008. **20**(2).

189. Banich, M.T., *Executive function: The search for an integrated account.* Current directions in psychological science, 2009. **18**(2): p. 89-94.

190. Tomporowski, P. and B. McCullick, *The effects of physical activity and direct instruction on children's executive functions: Pre-requisites and considerations.* Unpublished manuscript, 2009.

191. Diamond, A., *All or none hypothesis: A global-default mode that characterizes the brain and mind.* Developmental psychology, 2009. **45**(1): p. 130.

192. Carey, J.R., E. Bhatt, and A. Nagpal, *Neuroplasticity promoted by task complexity.* Exercise and sport sciences reviews, 2005. **33**(1): p. 24-31.

193. Holmes, P., *Current findings in neurobiological systems' response to exercise.* Active living, cognitive functioning, and aging, 2006. **1**.

194. Cotman, C.W., N.C. Berchtold, and L.-A. Christie, *Exercise builds brain health: key roles of growth factor cascades and inflammation.* Trends in neurosciences, 2007. **30**(9): p. 464-472.

195. Churchill, J.D., et al., *Exercise, experience and the aging brain.* Neurobiology of aging, 2002. **23**(5): p. 941-955.

196. Van Praag, H., *Exercise, neurogenesis, and learning in rodents.* Psychobiology of physical activity, 2006: p. 61-73.

197. da Silva, S.G., et al., *Physical exercise during the adolescent period of life increases hippocampal parvalbumin expression.* Brain and Development, 2010. **32**(2): p. 137-142.

198. Lou, S.-j., et al., *Hippocampal neurogenesis and gene expression depend on exercise intensity in juvenile rats.* Brain research, 2008. **1210**: p. 48-55.

199. Fabel, K. and G. Kempermann, *Physical activity and the regulation of neurogenesis in the adult and aging brain.* Neuromolecular medicine, 2008. **10**(2): p. 59-66.

200. Stranahan, A.M., D. Khalil, and E. Gould, *Social isolation delays the positive effects of running on adult neurogenesis.* Nature neuroscience, 2006. **9**(4): p. 526-533.

201. Ekstrand, J., J. Hellsten, and A. Tingström, *Environmental enrichment, exercise and corticosterone affect endothelial cell proliferation in adult rat hippocampus and prefrontal cortex.* Neuroscience letters, 2008. **442**(3): p. 203-207.

202. Pereira, A.C., et al., *An in vivo correlate of exercise-induced neurogenesis in the adult dentate gyrus.* Proceedings of the National Academy of Sciences, 2007. **104**(13): p. 5638-5643.

203. Meeusen, R., M.F. Piacentini, and K. De Meirleir, *Brain microdialysis in exercise research.* Sports Medicine, 2001. **31**(14): p. 965-983.

204. Ploughman, M., et al., *Endurance exercise facilitates relearning of forelimb motor skill after focal ischemia.* European Journal of Neuroscience, 2007. **25**(11): p. 3453-3460.

205. Winter, B., et al., *High impact running improves learning.* Neurobiology of learning and memory, 2007. **87**(4): p. 597-609.

206. McMorris, T., et al., *A test of the catecholamines hypothesis for an acute exercise–cognition interaction.* Pharmacology Biochemistry and Behavior, 2008. **89**(1): p. 106-115.

207. Arnsten, A.F. and P.S. Goldman-Rakic, *Noise stress impairs prefrontal cortical cognitive function in monkeys: evidence for a hyperdopaminergic mechanism.* Archives of general psychiatry, 1998. **55**(4): p. 362-368.

208. Liston, C., B.S. McEwen, and B. Casey, *Psychosocial stress reversibly disrupts prefrontal processing and attentional control.* Proceedings of the National Academy of Sciences, 2009. **106**(3): p. 912-917.

209. Desseilles, M., et al., *Abnormal neural filtering of irrelevant visual information in depression.* Journal of Neuroscience, 2009. **29**(5): p. 1395-1403.

210. Hirt, E.R., E.E. Devers, and S.M. McCrea, *I want to be creative: Exploring the role of hedonic contingency theory in the positive mood-cognitive flexibility link.* Journal of personality and social psychology, 2008. **94**(2): p. 214.

211. Cacioppo, J.T. and W. Patrick, *Loneliness: Human nature and the need for social connection*. 2008: WW Norton & Company.

212. Campbell, W.K., et al., *A magnetoencephalography investigation of neural correlates for social exclusion and self-control.* Social Neuroscience, 2006. **1**(2): p. 124-134.

213. Baumeister, R.F., J.M. Twenge, and C.K. Nuss, *Effects of social exclusion on cognitive processes: anticipated aloneness reduces intelligent thought.* Journal of personality and social psychology, 2002. **83**(4): p. 817.

214. Bernier, A., et al., *Sleep and cognition in preschool years: Specific links to executive functioning.* Child development, 2013. **84**(5): p. 1542-1553.

215. Saunamäki, T. and M. Jehkonen, *A review of executive functions in obstructive sleep apnea syndrome.* Acta Neurologica Scandinavica, 2007. **115**(1): p. 1-11.

216. Blanco‐Gómez, A., et al., *Being overweight or obese is associated with inhibition control in children from six to ten years of age.* Acta paediatrica, 2015. **104**(6): p. 619-625.

217. Biddle, S.J.H., et al., *Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality.* Psychology of Sport and Exercise, 2019. **42**: p. 146-155.

218. Janssen, I. and A.G. LeBlanc, *Systematic review of the health benefits of physical activity and fitness in school-aged children and youth.* International journal of behavioral nutrition and physical activity, 2010. **7**(1): p. 40.

219. Chen, L.-J., et al., *Effects of aquatic exercise on sleep in older adults with mild sleep impairment: a randomized controlled trial.* International journal of behavioral medicine, 2016. **23**(4): p. 501-506.

220. Wachob, D. and D.G. Lorenzi, *Brief report: influence of physical activity on sleep quality in children with autism.* Journal of autism and developmental disorders, 2015. **45**(8): p. 2641-2646.

221. Lang, C., et al., *Increased self-reported and objectively assessed physical activity predict sleep quality among adolescents.* Physiology & behavior, 2013. **120**: p. 46-53.

222. Biddle, S.J., N. Mutrie, and T. Gorely, *Psychology of Physical Activity: Determinants, Well-Being and Interventions.* 2015.

223. Koutsandreou, F., et al., *Effects of motor versus cardiovascular exercise training on children's working memory.* Medicine & Science in Sports & Exercise, 2016. **48**(6): p. 1144-1152.

224. Hinkle, J.S., B.W. Tuckman, and J.P. Sampson, *The psychology, physiology, and creativity of middle school aerobic exercisers.* Elementary School Guidance & Counseling, 1993. **28**(2): p. 133-145.

225. Chen, S.-R., et al., *Effects of a physical activity intervention on autonomic and executive functions in obese young adolescents: A randomized controlled trial.* Health Psychology, 2016. **35**(10): p. 1120.

226. Aadland, K.N., et al., *Effects of the Active Smarter Kids (ASK) physical activity school-based intervention on executive functions: a cluster-randomized controlled trial.* Scandinavian Journal of Educational Research, 2019. **63**(2): p. 214-228.

227. de Greeff, J.W., et al., *Long-term effects of physically active academic lessons on physical fitness and executive functions in primary school children.* Health education research, 2016. **31**(2): p. 185-194.

228. Gallotta, M.C., et al., *Impacts of coordinative training on normal weight and overweight/obese children's attentional performance.* Frontiers in Human Neuroscience, 2015. **9**: p. 577.

229. Goodwin, J.R., L.M. Hafner, and P.M. Fredericks, *Raman spectroscopic study of the heterogeneity of microcolonies of a pigmented bacterium.* Journal of Raman Spectroscopy: An International Journal for Original Work in all Aspects of Raman Spectroscopy, Including Higher Order Processes, and also Brillouin and Rayleigh Scattering, 2006. **37**(9): p. 932-936.

230. Reed, J.A., et al., *Examining the impact of 45 minutes of daily physical education on cognitive ability, fitness performance, and body composition of African American youth.* Journal of Physical Activity and Health, 2013. **10**(2): p. 185-197.

231. TELLES, S., *Spatial and verbal memory test scores following yoga and fine arts camps for school children.* Indian J Physiol Pharmacol, 2004. **48**(3): p. 353-356.

232. Pesce, C., et al., *Deliberate play and preparation jointly benefit motor and cognitive development: mediated and moderated effects.* Frontiers in Psychology, 2016. **7**: p. 349.

233. van der Niet, A.G., et al., *Effects of a cognitively demanding aerobic intervention during recess on children's physical fitness and executive functioning.* Pediatric Exercise Science, 2016. **28**(1): p. 64-70.

234. Davis, C.L., et al., *Exercise improves executive function and achievement and alters brain activation in overweight children: a randomized, controlled trial.* Health psychology, 2011. **30**(1): p. 91.

235. Coles, K. and P.D. Tomporowski, *Effects of acute exercise on executive processing, short-term and long-term memory.* Journal of sports sciences, 2008. **26**(3): p. 333-344.

236. Caterino, M.C. and E.D. Polak, *Effects of two types of activity on the performance of second-, third-, and fourth-grade students on a test of concentration.* Perceptual and motor skills, 1999. **89**(1): p. 245-248.

237. Soga, K., T. Shishido, and R. Nagatomi, *Executive function during and after acute moderate aerobic exercise in adolescents.* Psychology of Sport and Exercise, 2015. **16**: p. 7-17.

238. Pirrie, A.M. and K.R. Lodewyk, *Investigating links between moderate-to-vigorous physical activity and cognitive performance in elementary school students.* Mental Health and Physical Activity, 2012. **1**(5): p. 93-98.

239. Piepmeier, A.T., et al., *The effect of acute exercise on cognitive performance in children with and without ADHD.* Journal of Sport and Health Science, 2015. **4**: p. 97e104.

240. Howie, E.K., J. Schatz, and R.R. Pate, *Acute Effects of Classroom Exercise Breaks on Executive Function and Math Performance: A Dose–Response Study.*

241. Hogan, M.J., et al., *The effects of cardiorespiratory fitness and acute aerobic exercise on executive functioning and EEG entropy in adolescents.* 2015.

242. Jäger, K., et al., *Cognitive and physiological effects of an acute physical activity intervention in elementary school children.* Frontiers in psychology, 2014. **5**: p. 1473.

243. Chen, A.-G., et al., *Effects of acute aerobic exercise on multiple aspects of executive function in preadolescent children.* Psychology of Sport and Exercise, 2014. **15**(6): p. 627-636.

244. Lianzhen, M., *An introduction to Chinese archery*. Citeseer.

245. Bo, Z. and Y. Songping, *Cultural Comparison between Chinese and Western Sports Competition-Based on the Chinese Ritual Archery and Ancient Olympic Games.* 上海体育学院学报, 2018. **42**(5): p. 87-92, 98.

246. Lee, T.H., *Archery Ranges in the Educational Tradition of Confucian Academies in China*, in *Confucian Academies in East Asia*. 2020, Brill. p. 226-251.

247. Selby, S., *Chinese archery*. Vol. 1. 2000: Hong Kong University Press.

248. Bianchi, E., *Philosophies of Archery.* Popular Inquiry. The Journal of Kitsch, Camp and Mass Culture, 2021. **2**.

249. Henning, S.E., *Chinese Martial Arts Training Manuals: A Historical Survey.* China Review International, 2008. **15**(2): p. 247-249.

250. Baifa, Z., Z. Xinglong, and L. Dongmei, *Muscle coordination during archery shooting: A comparison of archers with different skill levels.* European Journal of Sport Science, 2021: p. 1-8.

251. Clemente, F., et al., *Study of the heart rate and accuracy performance of archers.* Journal of Physical Education and Sport, 2011. **11**(4): p. 434.

252. Lu, Q., et al., *Efficiency and Enhancement in Attention Networks of Elite Shooting and Archery Athletes.* Front Psychol, 2021. **12**: p. 638822.

253. Wang, D., et al., *Effect of Cognitive Reappraisal on Archery Performance of Elite Athletes: The Mediating Effects of Sport-Confidence and Attention.* Front Psychol, 2022. **13**: p. 860817.

254. Humaid, H., *Influence of arm muscle strength, draw length and archery technique on archery achievement.* Asian Social Science, 2014. **10**(5): p. 28.

255. Sharma, H.S., N.S. Singh, and T.B. Singh, *Effectiveness of six weeks training on static strength of archery players.* group, 2015. **12**: p. 2.13809.

256. Kim, H.-B., S.-H. Kim, and W.-Y. So, *The relative importance of performance factors in Korean archery.* The Journal of Strength & Conditioning Research, 2015. **29**(5): p. 1211-1219.

257. McArdle, W.D., F.I. Katch, and V.L. Katch, *Exercise physiology: nutrition, energy, and human performance*. 2010: Lippincott Williams & Wilkins.

258. Hrysomallis, C., *Balance ability and athletic performance.* Sports medicine, 2011. **41**(3): p. 221-232.

259. Tursi, D. and S. Napolitano, *Technical movements in archery.* 2014.

260. Bebetsos, E., *Psychological skills of elite archery athletes.* 2015.

261. Christ, S.E., et al., *Evidence for selective inhibitory impairment in individuals with autism spectrum disorder.* Neuropsychology, 2011. **25**(6): p. 690.

262. Hänggi, J.M., L.R. Phillips, and A.V. Rowlands, *Validation of the GT3X ActiGraph in children and comparison with the GT1M ActiGraph.* Journal of science and Medicine in Sport, 2013. **16**(1): p. 40-44.

263. Migueles, J.H., et al., *Accelerometer data collection and processing criteria to assess physical activity and other outcomes: a systematic review and practical considerations.* Sports medicine, 2017. **47**(9): p. 1821-1845.

264. Leger, L.A., et al., *The multistage 20 metre shuttle run test for aerobic fitness.* J Sports Sci, 1988. **6**(2): p. 93-101.

265. Liu, N.Y.-S., S.A. Plowman, and M.A. Looney, *The reliability and validity of the 20-meter shuttle test in American students 12 to 15 years old.* Research quarterly for exercise and sport, 1992. **63**(4): p. 360-365.

266. McVeigh, S.K., A.C. Payne, and S. Scott, *The reliability and validity of the 20-meter shuttle test as a predictor of peak oxygen uptake in Edinburgh school children, age 13 to 14 years.* Pediatric Exercise Science, 1995. **7**(1): p. 69-79.

267. Coulacoglou, C. and D.H. Saklofske, *Psychometrics and psychological assessment: Principles and applications*. 2017: Academic Press.

268. Cui, Y., et al., *The prevalence of behavioral and emotional problems among Chinese school children and adolescents aged 6–16: a national survey.* European child & adolescent psychiatry, 2020: p. 1-9.

269. Mollayeva, T., et al., *The Pittsburgh sleep quality index as a screening tool for sleep dysfunction in clinical and non-clinical samples: A systematic review and meta-analysis.* Sleep medicine reviews, 2016. **25**: p. 52-73.

270. Ertan, P., et al., *Relationship of sleep quality and quality of life in children with monosymptomatic enuresis.* Child: care, health and development, 2009. **35**(4): p. 469-474.

271. Tan, L.P., *The effects of background music on quality of sleep in elementary school children.* Journal of Music therapy, 2004. **41**(2): p. 128-150.

272. Zhou, H.Q., et al., *An epidemiological study of sleep quality in adolescents in South China: a school-based study.* Child: care, health and development, 2012. **38**(4): p. 581-587.

273. Gray-Little, B., V.S. Williams, and T.D. Hancock, *An item response theory analysis of the Rosenberg Self-Esteem Scale.* Personality and social psychology bulletin, 1997. **23**(5): p. 443-451.

274. Wu, Y., et al., *Rosenberg Self-Esteem Scale: Method effects, factorial structure and scale invariance across migrant child and urban child populations in China.* Journal of Personality Assessment, 2017. **99**(1): p. 83-93.

275. Janz, P., S. Dawe, and M. Wyllie, *Mindfulness-based program embedded within the existing curriculum improves executive functioning and behavior in young children: A waitlist controlled trial.* Frontiers in Psychology, 2019. **10**: p. 2052.

276. Cerqueira, J.J., et al., *The prefrontal cortex as a key target of the maladaptive response to stress.* Journal of Neuroscience, 2007. **27**(11): p. 2781-2787.

277. Gothe, N.P., R.K. Keswani, and E. McAuley, *Yoga practice improves executive function by attenuating stress levels.* Biological psychology, 2016. **121**: p. 109-116.

278. Purohit, S.P. and B. Pradhan, *Effect of yoga program on executive functions of adolescents dwelling in an orphan home: A randomized controlled study.* Journal of traditional and complementary medicine, 2017. **7**(1): p. 99-105.

279. Suwabe, K., et al., *Positive Mood while Exercising Influences Beneficial Effects of Exercise with Music on Prefrontal Executive Function: A Functional NIRS Study.* Neuroscience, 2021. **454**: p. 61-71.

280. Bigelow, H., et al., *The Differential Impact of Acute Exercise and Mindfulness Meditation on Executive Functioning and Psycho-Emotional Well-Being in Children and Youth With ADHD.* Front Psychol, 2021. **12**: p. 660845.

281. Ishihara, T., et al., *The beneficial effects of game-based exercise using age-appropriate tennis lessons on the executive functions of 6-12-year-old children.* Neurosci Lett, 2017. **642**: p. 97-101.

282. Oswald, W.D., et al., *Differential effects of single versus combined cognitive and physical training with older adults: the SimA study in a 5-year perspective.* European journal of ageing, 2006. **3**: p. 179-192.

283. Biddle, S.J. and M. Asare, *Physical activity and mental health in children and adolescents: a review of reviews.* Br J Sports Med, 2011. **45**(11): p. 886-95.

284. Hasanpour, M., et al., *Effect of aerobics exercise on self-esteem in Iranian female adolescents covered by welfare organization.* The Scientific World Journal, 2014. **2014**.

285. Spruit, A., et al., *The effects of physical activity interventions on psychosocial outcomes in adolescents: A meta-analytic review.* Clinical psychology review, 2016. **45**: p. 56-71.

286. Liu, M., L. Wu, and Q. Ming, *How does physical activity intervention improve self-esteem and self-concept in children and adolescents? Evidence from a meta-analysis.* PloS one, 2015. **10**(8): p. e0134804.

287. Dale, L.P., et al., *Physical activity and depression, anxiety, and self-esteem in children and youth: An umbrella systematic review.* Mental Health and Physical Activity, 2019. **16**: p. 66-79.

288. Janjhua, Y., et al., *A study on effect of yoga on emotional regulation, self-esteem, and feelings of adolescents.* Journal of Family Medicine and Primary Care, 2020. **9**(7): p. 3381.

289. Telles, S., et al., *Effect of yoga or physical exercise on physical, cognitive and emotional measures in children: a randomized controlled trial.* Child and adolescent psychiatry and mental health, 2013. **7**(1): p. 1-16.

290. Bhardwaj, A.K. and G. Agrawal, *Yoga practice enhances the level of self-esteem in pre-adolescent school children.* International Journal of Physical and Social Sciences, 2013. **3**(10): p. 189.

291. Yook, Y.-S., S.-J. Kang, and I. Park, *Effects of physical activity intervention combining a new sport and mindfulness yoga on psychological characteristics in adolescents.* International Journal of Sport and Exercise Psychology, 2017. **15**(2): p. 109-117.

292. Zolkafi, M.A.A., et al., *Changes Of Perceived Self Esteem Dimension Using Archery As A Weekly Exercise Regime In Sedentary Youth.* European Journal of Molecular & Clinical Medicine, 2020.

293. Sowislo, J.F. and U. Orth, *Does low self-esteem predict depression and anxiety? A meta-analysis of longitudinal studies.* Psychological bulletin, 2013. **139**(1): p. 213.

294. Noordstar, J.J., et al., *Global self-esteem, perceived athletic competence, and physical activity in children: A longitudinal cohort study.* Self-perceptions and physical activity in children with and without motor problems, 2016. **22**: p. 83-90.

295. Tremblay, M.S., et al., *Canadian 24-Hour Movement Guidelines for Children and Youth: An Integration of Physical Activity, Sedentary Behaviour, and Sleep1.* Applied Physiology, Nutrition, and Metabolism, 2016. **41**(6 (Suppl. 3)): p. S311.

296. Wang, F. and S. Boros, *The effect of physical activity on sleep quality: a systematic review.* 2019.

297. Mendelson, M., et al., *Sleep quality, sleep duration and physical activity in obese adolescents: effects of exercise training.* Pediatric obesity, 2016. **11**(1): p. 26-32.

298. Greever, C.J., et al., *Associations among physical activity, screen time, and sleep in low socioeconomic status urban girls.* Preventive medicine reports, 2017. **5**: p. 275-278.

299. Williams, S.M., et al., *Do more active children sleep more? A repeated cross-sectional analysis using accelerometry.* PloS one, 2014. **9**(4): p. e93117.

300. Kredlow, M.A., et al., *The effects of physical activity on sleep: a meta-analytic review.* Journal of behavioral medicine, 2015. **38**(3): p. 427-449.

301. Antczak, D., et al., *Physical activity and sleep are inconsistently related in healthy children: A systematic review and meta-analysis.* Sleep Medicine Reviews, 2020. **51**: p. 101278.

302. Siddarth, D., P. Siddarth, and H. Lavretsky, *An observational study of the health benefits of yoga or tai chi compared with aerobic exercise in community-dwelling middle-aged and older adults.* The American journal of geriatric psychiatry, 2014. **22**(3): p. 272-273.

303. Wang, F., et al., *The effect of meditative movement on sleep quality: A systematic review.* Sleep Medicine Reviews, 2016. **100**(30): p. 43-52.

304. Lubans, D., et al., *Physical activity for cognitive and mental health in youth: a systematic review of mechanisms.* Pediatrics, 2016. **138**(3).

305. Hedlund, E.R., et al., *Physical exercise may improve sleep quality in children and adolescents with Fontan circulation.* Cardiology in the Young, 2019. **29**(7): p. 922-929.

306. Zeanah, C.H., *Handbook of infant mental health*. 2018: Guilford Publications.

307. Kandola, A., et al., *Physical activity and depression: Towards understanding the antidepressant mechanisms of physical activity.* Neuroscience and Biobehavioral Reviews, 2019. **107**: p. 525-539.

308. Jorm, A.F., et al., *Has increased provision of treatment reduced the prevalence of common mental disorders? Review of the evidence from four countries.* World Psychiatry, 2017. **16**(1): p. 90-99.

309. Biddle, S.J. and M. Asare, *Physical activity and mental health in children and adolescents: a review of reviews.* British journal of sports medicine, 2011. **45**(11): p. 886-895.

310. Carter, T., et al., *The effect of physical activity on anxiety in children and young people: a systematic review and meta-analysis.* Journal of Affective Disorders, 2021. **285**: p. 10-21.

311. McMahon, E.M., et al., *Physical activity in European adolescents and associations with anxiety, depression and wellbeing.* 2016.

312. Hong, X., et al., *Physical activity inversely associated with the presence of depression among urban adolescents in regional China.* BMC Public Health, 2009. **9**: p. 148.

313. Wegner, M., et al., *Effects of exercise on anxiety and depression disorders: review of meta-analyses and neurobiological mechanisms.* CNS & Neurological Disorders-Drug Targets (Formerly Current Drug Targets-CNS & Neurological Disorders), 2014. **13**(6): p. 1002-1014.

314. Bailey, A., et al., *Treating depression with physical activity in adolescents and young adults: a systematic review and meta-analysis of randomised controlled trials.* Psychological Medicine, 2018. **48**(7): p. 1068-1083.

315. Wang, C.-W., et al., *Managing stress and anxiety through qigong exercise in healthy adults: a systematic review and meta-analysis of randomized controlled trials.* BMC complementary and alternative medicine, 2014. **14**(1): p. 1-9.

316. Wang, F., et al., *The effects of tai chi on depression, anxiety, and psychological well-being: a systematic review and meta-analysis.* International Journal of Behavioral Medicine, 2014. **21**(4): p. 605-617.

317. Aysan, H.A., *The effects of archery as a sports branch on coping with stress.* Studies on Ethno-Medicine, 2016. **10**(1): p. 39-43.

318. Pontifex, M.B., et al., *A primer on investigating the after effects of acute bouts of physical activity on cognition.* Psychology of Sport and Exercise, 2019. **40**: p. 1-22.

319. Taylor, A.F. and F.E. Kuo, *Children with attention deficits concentrate better after walk in the park.* J Atten Disord, 2009. **12**(5): p. 402-9.

320. Hillman, C.H., et al., *The effect of acute treadmill walking on cognitive control and academic achievement in preadolescent children.* Neuroscience, 2009. **159**(3): p. 1044-1054.

VITA

NAME	Jianjun Liu
DATE OF BIRTH	10 August 1978
PLACE OF BIRTH	JiangXi Province, China
INSTITUTIONS ATTENDED	Shanghai University of International Business and Economics
PUBLICATION	Int. J. Environ. Res. Public Health 2023, 20(2), 1415; https://doi.org/10.3390/ijerph20021415

Appendix A Consent form (Chinese version and English version)

CONSENT FORM

Dear Parent or Guardian:

I am a faculty *Jianjiu Liu* in the *P.E department* at Shanghai University of International Business and Economics. I am conducting a research project on *The effects of Chinese archery art program on core executive functions in children, This study aimed to explore the effect on core executive function after Chinese archery art intervention in primary school children in Shanghai* . I request permission for your child to participate.

The study consists of *describe what you will ask the child do to. If you will look at school or other records, mention this here.* The project will be explained in terms that your child can understand, and your child will participate only if he or she is willing to do so. Only I and members of the research staff, if any will have access to information from your child. At the conclusion of the study, children's responses will be reported as group results only. *If study results will be made available to parents, include a statement similar to the following: At the conclusion of the study a summary of group results will be made available to all interested parents." Then explain what the parent needs to do to obtain a copy of the results.*

Participation in this study is voluntary. Your decision whether or not to allow your child to participate will not affect the services normally provided to your child by the *entity where research is being conducted in school*. Your child's participation in this study will not lead to the loss of any benefits to which he or she is otherwise entitled. Even if you give your permission for your child to participate, your child is free to refuse to participate. If your child agrees to participate, he or she is free to end participation at any time. You and your child are not waiving any legal claims, rights, or remedies because of your child's participation in this research study.

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of *anonumity*

If information will be released to any other party for any reason, state the person or agency to whom the information will be furnished, the nature of the information, the purpose of the disclosure, and the conditions under which it will be released

If activities are to be audio- or videotaped or digitally recorded, describe who will have access, if the tapes/files will be used for educational purposes, and when they will be erased or destroyed.

If there is an expectation of a student completing an assignment, mention it will not affect any grade received for completing the assignment by not participating in the study.

Should you have any questions or desire further information, please call me or email me at *18101899661 and liujianjun362427@gmail.com*.

Sincerely,

Jianjun Liu

-

Please indicate whether or not you wish to allow your child to participate in this project by checking one of the statements below, signing your name and let your kid(s) *deliver this letter your signature to her(his) head tearcher*. Sign both copies and keep one for your records.

_____ I grant permission for my child to participate in *Jianjun Liu*'s study on *the effect of Chinese archery art program on core executive functions in primary school children in Shanghai*.

_____ I do not grant permission for my child to participate in *Jianjun Liu*'s study on *the effect of Chinese archery art program on core executive functions in primary school children in Shanghai*.

________________________________ ________________________________

Signature of Parent/Guardian Printed Parent/Guardian Name

________________________________ ________________________________

Printed Name of Child Date

知情同意书

<u>研究项目：</u>中华传统射艺对学龄儿童核心执行功能影响

尊敬的家长：

您好！

儿童的健康成长是所有家长及教育机构最关心的事情。**执行功能**属于高级认知的范畴，对孩子的学习以及今后的发展重要性甚至超过智商。国外研究表明一些特定的运动形式干预对提升孩子的核心执行功能作用明显。目前，在寻找和确定最佳运动模式方面我们还需要做很多的工作。为了探讨我国传统体育项目-中华射艺练习对普通学龄儿童执行功能表现水平的影响，你的孩子及您被邀请参加了“中华传统射艺对学龄儿童核心执行功能影响”研究课题的测试。如果你同意参加本研究，请仔细阅读下列内容，如有任何疑问，请询问联系您的相关科研人员，你可以保留此份“知情同意书”的复印本，以作参考。

<u>研究目的：</u>您的孩子将被邀请参加的是一项科学研究。本研究由上海对外经贸大学体育部刘建军副教授领衔开展。该研究试图了解中华传统射艺项目对学龄儿童核心执行功能、睡眠状况、心理健康等健康指标的影响。

<u>研究内容：</u>本次研究的内容主要探究中华射艺项目干预对普通学龄儿童群体的核心执行功能水平影响。需要涉及的变量测试主要包括：家庭基本情况，体力活动水平，有氧适能水平，身体形态特征，情绪、社会适应和睡眠状况，核心执行功能表现水平。

以上各项测试均免费进行，大部分测试结果将在试验结束后尽快反馈给参与儿童及家长，其余少部分结果要在课题结束后才能提供。我们将依法保护您及您的孩子在这项研究中的隐私，所有实验结果都将采用匿名进行报告。您的子女和您的所有信息将不会泄露给第三方。

参加这项研究完全是自愿的。在参加研究过程中，您有权作出让您或您的子女不继续参加该项研究或退出研究的决定。这项研究不会对您的子女及您带来任何不良影响。研究结果将有利于您了解您的孩子的健康状况，促进其健康成长。同时研究的新发现可作为今后改善生活方式、促进认知水平及体质健康的指导，为促进我国儿童青少年健康促进的发展作出贡献。科学研究需要严谨的科学态度，同时，此项研究需要投入大量的人力、物力和财力，因此，我们需要得到您的支持，配合我们完成该项研究任务，谢谢！

知情同意书
签署页

我已熟悉本研究内容，我理解测试的意义，我知道我的权利和义务，我本人及我的子女自愿参与此项研究，研究结果可以用于科学报导。

研究名称：中华传统射艺对学龄儿童核心执行功能影响
研究者：刘建军等
研究单位：上海对外经贸大学

本陈述证实已阅读了上述知情同意书内容，并理解了该研究的性质，我及我的子女志愿参加此科学研究。

父/母姓名：　　　　　　　　　　与子女的关系：□　父亲　□　母亲
儿童姓名：　　　　　　性别：　　　　　　所在班级：

出生日期：　　　　年　　　月　　　日

父母联系方式（移动电话）：
（邮　箱）：

日　期：

Appendix B **Child behavior checklist (Chinese version and English version)**

儿童行为量表（CBCL）Achenbach

（家长用）

说明：1.各项目后有横线者请用文字填写；有小方框者，请在相应的方框后打╳。2.本表内容共四个部

第一部分：一般项目

儿童姓名：

儿童学号：

性别：男☐ 女☐

年龄： ，出生日期： 年 月 日

年级： ，种族：

父母职业（请填具体，例如车工、鞋店售货员、主妇等）

父亲职业：

母亲职业：

父母教育程度（包括：小学、初中、高中、大专、本科、硕士、博士）

父亲教育程度：

母亲教育程度：

家庭收入（无收入，少于 2000 元/月，2000-4000 元/月，4001-8000 元/月，8001-15000 元/月，15000 以上/月）

家庭月收入：

填表者：父☐，母☐，其他人 ☐

填表日期： 年 月 日

第二部分：社会能力

Ⅰ

[320]请列出你孩子最爱好的体育运动项目（例如游泳，棒球等）：

无爱好☐

爱好： a.

b.

c.

（2）与同龄儿童相比，他（她）在这些项目上花去时间多少？

不知道 较少 一般 较多

☐ ☐ ☐ ☐

[320]与同龄儿童相比，他（她）的运动水平如何？

不知道 较低 一般 较高

☐ ☐ ☐ ☐

Ⅱ

[320]请列出你孩子在体育运动以外的爱好（例如集邮、看书、弹琴等，不包括看电视）

无爱好☐

爱好： a.

b.

c.

（2）与同龄儿童相比，他（她）花在这些爱好上的时间多少？

不知道 较少 一般 较多

☐ ☐ ☐ ☐

[320]与同龄儿童相比，他（她）的爱好水平如何？

不知道 较低 一般 较高

☐ ☐ ☐ ☐

Ⅲ

[320]请列出你孩子参加的组织、俱乐部、团队或小组的名称

未参加☐

参加： a.

b.

c.

（2）与同龄儿童相比，他（她）在这些组织中的活跃程度如何？

不知道 较差 一般 较高

☐ ☐ ☐ ☐

Ⅳ

[320]请列出你孩子有无干活或打零工的情况（例如送报、帮人照顾小孩、帮人搞卫生等）

没有☐

有： a.

b.

c.

（2）与同龄儿童相比，他（她）工作质量如何？

不知道	较差	一般	较好
□	□	□	□

Ⅴ

[320]你孩子有几个要好的朋友？

无	1 个	2—3 个	4 个及以上
□	□	□	□

（2）你孩子与这些朋友每星期大概在一起几次？

不到一次	1—2 次	3 次及以上
□	□	□

Ⅵ. 与同龄孩子相比，你孩子在下列方面表现如何？

	较差	差不多	较好
a. 与兄弟姊妹相处	□	□	□
b. 与其他儿童相处	□	□	□
c. 对父母的行为	□	□	□
d. 自己工作和游戏	□	□	□

Ⅶ

[320]当前学习成绩（对六岁以上儿童而言）

未上学 □

	不及格	中等以下	中等	中等以上
a. 阅读课	□	□	□	□
b. 写作课	□	□	□	□
c. 算术课	□	□	□	□
d. 拼音课	□	□	□	□
其他课（如历史、地理、常识、外语等）				
e. ________	□	□	□	□
f. ________	□	□	□	□
g. ________	□	□	□	□

（2）你孩子是否在特殊班级？

不是 □

是 □，什么性质？

[320]你孩子是否留级？

没有 □

留过 □，几年级留级质？

留级理由：

（4）你孩子在学校里有无学习或其他问题（不包括上面三个问题）？

没有 □

有问题 □，问题内容：

问题何时开始：

问题是否已解决？

未解决 □

已解决 □，何时解决：

第三部分：行为问题

Ⅷ. 以下是描述你孩子的项目。只根据最近半年内的情况描述。每一项目后面都有三个数字（0，1，2），如你孩子明显有或经常有此项表现，圈 2；如无这些表现，圈 0。

1. 行为幼稚与其年龄不符	0	1	2
2. 过敏性症状（填具体表现）	0	1	2
3. 喜欢争论	0	1	2
4. 哮喘病	0	1	2
5. 举动向异性	0	1	2
6. 随地大便	0	1	2
7. 喜欢吹牛或自夸	0	1	2
8. 精神不能集中，注意力不能持久	0	1	2
9. 老是想某些事情，不能摆脱，强迫观念（说明内容）	0	1	2
10. 坐立不安活动过多	0	1	2
11. 喜欢缠着大人或过分依赖	0	1	2
12. 常说感到寂寞	0	1	2
13. 胡里胡涂，如在云里雾中	0	1	2
14. 常常哭叫	0	1	2
15. 虐待动物	0	1	2
16. 虐待、欺侮别人或吝啬	0	1	2
17. 好做白日梦或呆想	0	1	2
18. 故意伤害自己或企图自杀	0	1	2
19. 需要别人经常注意自己	0	1	2
20. 破坏自己的东西	0	1	2
21. 破坏家里或其他儿童的东西	0	1	2
22. 在家不听话	0	1	2
23. 在学校不听话	0	1	2
24. 不肯好好吃饭	0	1	2
25. 不与其他儿童相处	0	1	2
26. 有不良行为后不感到内疚	0	1	2
27. 易嫉妒	0	1	2
28. 好吃不能作为食物的东西（说明内容）	0	1	2
29. 除怕上学外，还害怕某些动物、处境或地方（说明内容）	0	1	2
30. 怕上学	0	1	2
31. 怕自己想坏念头或做坏事	0	1	2
32. 觉得自己必须十全十美	0	1	2
33. 觉得或抱怨没有人喜欢自己	0	1	2
34. 觉得别人存心捉弄自己	0	1	2
35. 觉得自己无用或有自卑感	0	1	2
36. 身体经常弄伤，容易出事故	0	1	2
37. 经常打架	0	1	2
38. 常被人戏弄	0	1	2
39. 爱和出麻烦的儿童在一起	0	1	2
40. 听到某些实际上没有的声音（说明内容）	0	1	2
41. 冲动或行为粗鲁	0	1	2
42. 喜欢孤独	0	1	2
43. 撒谎或欺骗	0	1	2
44. 咬指甲	0	1	2
45. 神经过敏，容易激动或紧张	0	1	2
46. 动作紧张或带有抽动性（说明内容）	0	1	2
47. 做恶梦	0	1	2
48. 不被其他儿童喜欢	0	1	2
49. 便秘	0	1	2
50. 过度恐惧或担心	0	1	2
51. 感到头昏	0	1	2

52. 过份内疚	0	1	2
53. 吃得过多	0	1	2
54. 过份疲劳	0	1	2
55. 身体过重	0	1	2
56. 找不到原因的躯体症状：	0	1	2
a. 疼痛	0	1	2
b. 头痛	0	1	2
c. 恶心想吐	0	1	2
d. 眼睛有问题（说明内容。译注：不包括近视及器质性眼病）	0	1	2
e. 发疹或其他皮肤病	0	1	2
f. 腹部疼痛或绞痛	0	1	2
g. 呕吐	0	1	2
h. 其他（说明内容）	0	1	2
57. 对别人身体进行攻击	0	1	2
58. 挖鼻孔、皮肤或身体其他部分（说明内容）	0	1	2
59. 公开玩弄自己的生殖器	0	1	2
60. 过多地玩弄自己的生殖器	0	1	2
61. 功课差	0	1	2
62. 动作不灵活	0	1	2
63. 喜欢和年龄较大的儿童在一起	0	1	2
64. 喜欢和年龄较小的儿童在一起	0	1	2
65. 不肯说话	0	1	2
66. 不断重复某些动作，强迫行为（说明内容）	0	1	2
67. 离家出走	0	1	2
68. 经常尖叫	0	1	2
69. 守口如瓶，有事不说出来	0	1	2
70. 看到某些实际上没有的东西（说明内容）	0	1	2
71. 感到不自然或容易发窘	0	1	2
72. 玩火（包括玩火柴或打火机——译注）	0	1	2
73. 性方面的问题（说明内容）	0	1	2
74. 夸耀自己或胡闹	0	1	2
75. 害羞或胆小	0	1	2
76. 比大多数孩子睡得少	0	1	2
77. 比大多数孩子睡得多（说明多多少。译注：不包括赖床）	0	1	2
78. 玩弄粪便	0	1	2
79. 言语问题（说明内容。译注：例如口吃不清）	0	1	2
80. 茫然凝视	0	1	2
81. 在家偷东西	0	1	2
82. 在外偷东西	0	1	2
83. 收藏自己不需要的东西（说明内容。译注：不包括集邮等爱好）	0	1	2
84. 怪异行为（说明内容。译注：不包括其他条已提及者）	0	1	2
85. 怪异想法（说明内容。译注：不包括其他条已提及者）	0	1	2
86. 固执、绷着脸或容易激怒	0	1	2
87. 情绪突然变化	0	1	2
88. 常常生气	0	1	2

89. 多疑	0	1	2
90. 咒骂或讲粗话	0	1	2
91. 声言要自杀	0	1	2
92. 说梦话或有梦游（说明内容）	0	1	2
93. 话太多	0	1	2
94. 常戏弄他人	0	1	2
95. 乱发脾气或脾气暴躁	0	1	2
96. 对性的问题想得太多	0	1	2
97. 威胁他人	0	1	2
98. 吮吸大拇指	0	1	2
99. 过分要求整齐清洁	0	1	2
100. 睡眠不好（说明内容）	0	1	2
101. 逃学	0	1	2
102. 不够活跃，动作迟钝或精力不足	0	1	2
103. 闷闷不乐，悲伤或抑郁	0	1	2
104. 说话声音特别大	0	1	2
105. 喝酒或使用成瘾药（说明内容）	0	1	2
106. 损坏公物	0	1	2
107. 白天遗尿	0	1	2
108. 夜间遗尿	0	1	2
109. 爱哭诉	0	1	2
110. 希望成为异性	0	1	2
111. 孤独、不合群	0	1	2
112. 忧虑重重	0	1	2
113. 请写出你孩子存在的但上面未提及的其他问题：	0	1	2
	0	1	2

一、 请检查一下是否每条都已填好

请在你最关心的条目下划线

Please print **CHILD BEHAVIOR CHECKLIST FOR AGES 6-18**

For office use only
ID #

CHILD'S FULL NAME First Middle Last

PARENTS' USUAL TYPE OF WORK, even if not working now. *(Please be specific — for example, auto mechanic, high school teacher, homemaker, laborer, lathe operator, shoe salesman, army sergeant.)*

FATHER'S TYPE OF WORK ____________________

MOTHER'S TYPE OF WORK ____________________

CHILD'S GENDER ☐ Boy ☐ Girl

CHILD'S AGE

CHILD'S ETHNIC GROUP OR RACE

TODAY'S DATE Mo.____Day____Year ______

CHILD'S BIRTHDATE Mo.____Day____Year ____

THIS FORM FILLED OUT BY: (print your full name)

____

Your gender: ☐ Male ☐ Female

Your relation to the child:

☐ Biological Parent ☐ Step Parent ☐ Grandparent

☐ Adoptive Parent ☐ Foster Parent ☐ Other (specify)

GRADE IN SCHOOL __________

NOT ATTENDING SCHOOL ☐

Please fill out this form to reflect *your* view of the child's behavior even if other people might not agree. Feel free to print additional comments beside each item and in the space provided on page 2. ***Be sure to answer all items.***

I. Please list the sports your child most likes to take part in. For example: swimming, baseball, skating, skate boarding, bike riding, fishing, etc.

None ☐

	Compared to others of the same age, about how much time does he/she spend in each?				Compared to others of the same age, how well does he/she do each one?			
	Less Than Average	Average	More Than Average	Don't Know	Below Average	Average	Above Average	Don't Know
a. ____________	☐	☐	☐	☐	☐	☐	☐	☐
b. ____________	☐	☐	☐	☐	☐	☐	☐	☐
c. ____________	☐	☐	☐	☐	☐	☐	☐	☐

II. Please list your child's favorite hobbies, activities, and games, other than sports. For example: stamps, dolls, books, piano, crafts, cars, computers, singing, etc. (Do ***not*** include listening to radio or TV.)

None ☐

	Compared to others of the same age, about how much time does he/she spend in each?				Compared to others of the same age, how well does he/she do each one?			
	Less Than Average	Average	More Than Average	Don't Know	Below Average	Average	Above Average	Don't Know
a. ____________	☐	☐	☐	☐	☐	☐	☐	☐
b. ____________	☐	☐	☐	☐	☐	☐	☐	☐
c. ____________	☐	☐	☐	☐	☐	☐	☐	☐

Please list any organizations, clubs, teams, or groups your child belongs to.

None ☐

	Compared to others of the same age, how active is he/she in each?			
	Less Active	Average	More Active	Don't Know
a. ____________	☐	☐	☐	☐
b. ____________	☐	☐	☐	☐
c. ____________	☐	☐	☐	☐

Please list any jobs or chores your child has. For example: paper route, babysitting, making bed, working in store, etc. (Include both paid and unpaid jobs and chores.)

None ☐

	Compared to others of the same age, how well does he/she carry them out?			
	Below Average	Average	Above Average	Don't Know
a. ____________	☐	☐	☐	☐
b. ____________	☐	☐	☐	☐
c. ____________	☐	☐	☐	☐

Be sure you answered all items. Then see other side.

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Please print. Be sure to answer all items.

1. About how many close friends does your child have? (Do *not* include brothers & sisters)

☐ None ☐ 1 ☐ 2 or 3 ☐ 4 or more

2. About how many times a week does your child do things with any friends outside of regular school hours? (Do *not* include brothers & sisters)

☐ Less than 1 ☐ 1 or 2 ☐ 3 or more

Compared to others of his/her age, how well does your child:

	Worse	Average	Better	
a. Get along with his/her brothers & sisters?	☐	☐	☐	☐ Has no brothers or sisters
b. Get along with other kids?	☐	☐	☐	
c. Behave with his/her parents?	☐	☐	☐	
d. Play and work alone?	☐	☐	☐	

1. Performance in academic subjects. **Does not attend school because** ______________________________

Check a box for each subject that child takes

		Failing	Below Average	Average	Above Average
	a. Reading, English, or Language Arts	☐	☐	☐	☐
Other academic subjects–for example: computer courses, foreign language, business. Do ***not*** include gym, shop, driver's ed., or other nonacademic subjects.	b. History or Social Studies	☐	☐	☐	☐
	c. Arithmetic or Math	☐	☐	☐	☐
	d. Science	☐	☐	☐	☐
	e. ______________	☐	☐	☐	☐
	f. ______________	☐	☐	☐	☐
	g. ______________	☐	☐	☐	☐

2. Does your child receive special education or remedial services or attend a special class or special school?

☐ **No** ☐ **Yes—kind of services, class, or school:**

3. Has your child repeated any grades? ☐ **No** ☐ **Yes—grades and reasons:**

4. Has your child had any academic or other problems in school? ☐ **No** ☐ **Yes—please describe:**

When did these problems start? ______________

Have these problems ended? ☐ **No** ☐ **Yes–when?**

Does your child have any illness or disability (either physical or mental)? ☐ **No** ☐ **Yes—please describe:**

What concerns you most about your child?

Please describe the best things about your child.

Below is a list of items that describe children and youths. For each item that describes your child ***now or within the past 6 months***, please circle the ***2*** if the item is ***very true or often true*** of your child. Circle the ***1*** if the item is ***somewhat or sometimes true*** of your child. If the item is ***not true*** of your child, circle the ***0***. Please answer all items as well as you can, even if some do not seem to apply to your child.

0 = Not True (as far as you know) **1 = Somewhat or Sometimes True** **2 = Very True or Often True**

0 1 2 1. Acts too young for his/her age
0 1 2 2. Drinks alcohol without parents' approval (describe): ____________________
____
0 1 2 3. Argues a lot
0 1 2 4. Fails to finish things he/she starts
0 1 2 5. There is very little he/she enjoys
0 1 2 6. Bowel movements outside toilet
0 1 2 7. Bragging, boasting
0 1 2 8. Can't concentrate, can't pay attention for long
0 1 2 9. Can't get his/her mind off certain thoughts; obsessions (describe): __________
____
0 1 2 10. Can't sit still, restless, or hyperactive
0 1 2 11. Clings to adults or too dependent
0 1 2 12. Complains of loneliness
0 1 2 13. Confused or seems to be in a fog
0 1 2 14. Cries a lot
0 1 2 15. Cruel to animals
0 1 2 16. Cruelty, bullying, or meanness to others
0 1 2 17. Daydreams or gets lost in his/her thoughts
0 1 2 18. Deliberately harms self or attempts suicide
0 1 2 19. Demands a lot of attention
0 1 2 20. Destroys his/her own things
0 1 2 21. Destroys things belonging to his/her family or others
0 1 2 22. Disobedient at home
0 1 2 23. Disobedient at school
0 1 2 24. Doesn't eat well
0 1 2 25. Doesn't get along with other kids
0 1 2 26. Doesn't seem to feel guilty after misbehaving
0 1 2 27. Easily jealous
0 1 2 28. Breaks rules at home, school, or elsewhere
0 1 2 29. Fears certain animals, situations, or places, other than school (describe): _____
____
0 1 2 30. Fears going to school
0 1 2 31. Fears he/she might think or do something bad

0 1 2 32. Feels he/she has to be perfect
0 1 2 33. Feels or complains that no one loves him/her
0 1 2 34. Feels others are out to get him/her
0 1 2 35. Feels worthless or inferior
0 1 2 36. Gets hurt a lot, accident-prone
0 1 2 37. Gets in many fights
0 1 2 38. Gets teased a lot
0 1 2 39. Hangs around with others who get in trouble
0 1 2 40. Hears sound or voices that aren't there (describe): ____________
____
0 1 2 41. Impulsive or acts without thinking
0 1 2 42. Would rather be alone than with others
0 1 2 43. Lying or cheating
0 1 2 44. Bites fingernails
0 1 2 45. Nervous, highstrung, or tense
0 1 2 46. Nervous movements or twitching (describe): ____________
____
____
0 1 2 47. Nightmares
0 1 2 48. Not liked by other kids
0 1 2 49. Constipated, doesn't move bowels
0 1 2 50. Too fearful or anxious
0 1 2 51. Feels dizzy or lightheaded
0 1 2 52. Feels too guilty
0 1 2 53. Overeating
0 1 2 54. Overtired without good reason
0 1 2 55. Overweight

56. Physical problems ***without known medical cause:***
0 1 2 a. Aches or pains (***not*** stomach or headaches)
0 1 2 b. Headaches
0 1 2 c. Nausea, feels sick
0 1 2 d. Problems with eyes (***not*** if corrected by glasses) (describe): __________
____
0 1 2 e. Rashes or other skin problems
0 1 2 f. Stomachaches
0 1 2 g. Vomiting, throwing up
0 1 2 h. Other (describe): __________

0 = Not True (as far as you know) **1 = Somewhat or Sometimes True** **2 = Very True or Often True**

0 1 2 57. Physically attacks people

0 1 2 58. Picks nose, skin, or other parts of body (describe): ______________________

0 1 2 59. Plays with own sex parts in public

0 1 2 60. Plays with own sex parts too much

0 1 2 61. Poor school work

0 1 2 62. Poorly coordinated or clumsy

0 1 2 63. Prefers being with older kids

0 1 2 64. Prefers being with younger kids

0 1 2 65. Refuses to talk

0 1 2 66. Repeats certain acts over and over; compulsions (describe): ______________________

0 1 2 67. Runs away from home

0 1 2 68. Screams a lot

0 1 2 69. Secretive, keeps things to self

0 1 2 70. Sees things that aren't there (describe): ______________________

0 1 2 71. Self-conscious or easily embarrassed

0 1 2 72. Sets fires

0 1 2 73. Sexual problems (describe): ______________________

0 1 2 74. Showing off or clowning

0 1 2 75. Too shy or timid

0 1 2 76. Sleeps less than most kids

0 1 2 77. Sleeps more than most kids during day and/or night (describe): ______________________

0 1 2 78. Inattentive or easily distracted

0 1 2 79. Speech problem (describe): ______________________

0 1 2 80. Stares blankly

0 1 2 81. Steals at home

0 1 2 82. Steals outside the home

0 1 2 83. Stores up too many things he/she doesn't need (describe): ______________________

0 1 2 84. Strange behavior (describe): ______________________

0 1 2 85. Strange ideas (describe): ______________________

0 1 2 86. Stubborn, sullen, or irritable

0 1 2 87. Sudden changes in mood or feelings

0 1 2 88. Sulks a lot

0 1 2 89. Suspicious

0 1 2 90. Swearing or obscene language

0 1 2 91. Talks about killing self

0 1 2 92. Talks or walks in sleep (describe): ______________________

0 1 2 93. Talks too much

0 1 2 94. Teases a lot

0 1 2 95. Temper tantrums or hot temper

0 1 2 96. Thinks about sex too much

0 1 2 97. Threatens people

0 1 2 98. Thumb-sucking

0 1 2 99. Smokes, chews, or sniffs tobacco

0 1 2 100. Trouble sleeping (describe): ______________________

0 1 2 101. Truancy, skips school

0 1 2 102. Underactive, slow moving, or lacks energy

0 1 2 103. Unhappy, sad, or depressed

0 1 2 104. Unusually loud

0 1 2 105. Uses drugs for nonmedical purposes (***don't*** include alcohol or tobacco) (describe): ______________________

0 1 2 106. Vandalism

0 1 2 107. Wets self during the day

0 1 2 108. Wets the bed

0 1 2 109. Whining

0 1 2 110. Wishes to be of opposite sex

0 1 2 111. Withdrawn, doesn't get involved with others

0 1 2 112. Worries

113. Please write in any problems your child has that were not listed above:

0 1 2 ______________________

0 1 2 ______________________

0 1 2 ______________________

Please be sure you answered all items.

Appendix C Rosenberg self-esteem scale (Chinese version and English version)

Rosenberg 自尊量表（RSES）

姓名：　　　　学号：

这是一份自尊情况调查表，下面是一些关于我们对自己看法的问题，请您仔细阅读每一条问题，并根据您的真实情况在在所列的答案中选择一个最适合的选项。

1：我觉得自己是一个有价值的人，至少与其他人在同一水平上。

（）很不符合

（）不符合

（）符合

（）非常符合

2：我觉得我有许多好的品质。

（）很不符合

（）不符合

（）符合

（）非常符合

3：归根到底，我倾向于认为自己是一个失败者。

（）很不符合

（）不符合

（）符合

（）非常符合

4：我能像大多数人一样把事情做好。

（）很不符合

（）不符合

（）符合

（）非常符合

5：我觉得自己值得自豪的地方不多。

（）很不符合

（）不符合

（）符合

（）非常符合

6：我对自己持有肯定的态度。

（）很不符合

（）不符合

（）符合

（）非常符合

7：总的来说，我对自己觉得很满意。

（）很不符合

（）不符合

（）符合

（）非常符合

8：我要是能看得起自己就好了。

（）很不符合

（）不符合

（）符合

（）非常符合

9：有时我确实感到自己很没用。

（）很不符合

（）不符合

（）符合

（）非常符合

10：我时常认为自己一无是处。

（）很不符合

（）不符合

（）符合

（）非常符合

ROSENBERG SELF-ESTEEM SCALE

Description of Measure

A 10-item scale that measures global self-worth by measuring both positive and negative feelings about the self. The scale is believed to be uni-dimensional. All items are answered using a 4-point Likert scale format ranging from strongly agree to strongly disagree.

Instructions

Below is a list of statements dealing with your general feelings about yourself. Please indicate how strongly you agree or disagree with each statement.

1. On the whole, I am satisfied with myself.

Strongly Agree Agree Disagree Strongly Disagree

2. At times I think I am no good at all.

Strongly Agree Agree Disagree Strongly Disagree

3. I feel that I have a number of good qualities.

Strongly Agree Agree Disagree Strongly Disagree

4. I am able to do things as well as most other people.

Strongly Agree Agree Disagree Strongly Disagree

5. I feel I do not have much to be proud of.

Strongly Agree Agree Disagree Strongly Disagree

6. I certainly feel useless at times.

Strongly Agree Agree Disagree Strongly Disagree

7. I feel that I'm a person of worth, at least on an equal plane with others.

   Strongly Agree Agree Disagree Strongly Disagree

8. I wish I could have more respect for myself.

   Strongly Agree Agree Disagree Strongly Disagree

9. All in all, I am inclined to feel that I am a failure.

   Strongly Agree Agree Disagree Strongly Disagree

10. I take a positive attitude toward myself.

   Strongly Agree Agree Disagree Strongly Disagree

Scoring:

Items 2, 5, 6, 8, 9 are reverse scored. Give "Strongly Disagree" 1 point, "Disagree" 2 points, "Agree" 3 points, and "Strongly Agree" 4 points. Sum scores for all ten items. Keep scores on a continuous scale. Higher scores indicate higher self-esteem.

Appendix D Pittsburgh sleep quality index (Chinese version and Engnish version)

匹兹堡睡眠质量指数

（Pittsburgh sleep quality index, PSQI）

姓名：　　　　学号：

下面一些问题是关于您最近 1 个月的睡眠情况，请选择回填写最符合您近 1 个月实际情况的答案。请回答下列问题

1. 近 1 个月，晚上上床睡觉通常（ ）点钟　如 22，以 24 小时计时

2. 近 1 个月，从上床到入睡通常需要（ ）分钟

3. 近 1 个月，通常早上（ ）点起床

4. 近 1 个月，每夜通常实际睡眠（ ）小时(不等于卧床时间)

5a. 近 1 个月，入睡困难(30 分钟内不能入睡)

()　无
()　<1 次 / 周
()　１～２次 / 周
()　≥３次 / 周

5b 近 1 个月，夜间易醒或早醒

()　无
()　<1 次 / 周
()　１～２次 / 周
()　≥３次 / 周

5c 近 1 个月，夜间去厕所

()　无
()　<1 次 / 周
()　１～２次 / 周
()　≥３次 / 周

5d. 近 1 个月，呼吸不畅

()　无

() <1次/周
() 1～2次/周
() ≥3次/周

5e. 近1个月，咳嗽或鼾声高
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

5f. 近1个月，感觉冷
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

5g. 近1个月，感觉热
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

5h. 近1个月，做恶梦
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

5i. 近1个月，疼痛不适
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

5j. 近1个月，其它影响睡眠的事情
() 无
() <1次/周
() 1～2次/周
() ≥3次/周

6. 近 1 个月，总的来说，您认为自己的睡眠质量

（） 很好

（） 较好

（） 较差

（） 很差

7. 近 1 个月，您用药物催眠的情况

（） 无

（） <1 次 / 周

（） １～２次 / 周

（） ≥３次 / 周

8. 近 1 个月，您常感到困倦吗？

（） 无

（） <1 次 / 周

（） １～２次 / 周

（） ≥３次 / 周

9. 近 1 个月，您做事情的精力不足吗

（） 没有

（） 偶尔有

（） 有时有

（） 经常有

Pittsburgh Sleep Quality Index (PSQI)

Name

Date:

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month. **Please answer all questions.**

1. During the past month, what time have you usually gone to bed at night?
2. During the past month, how long (in minutes) has it usually taken you to fall asleep each night?
3. During the past month, what time have you usually gotten up in the morning?
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

5. During the past month, how often have you had trouble sleeping because you…	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
a. Cannot get to sleep within 30 minutes				
b. Wake up in the middle of the night or early morning				
c. Have to get up to use the bathroom				
d. Cannot breathe comfortably				
e. Cough or snore loudly				
f. Feel too cold				
g. Feel too hot				
h. Have bad dreams				
i. Have pain				
j. Other reason(s), please describe:				
6. During the past month, how often have you taken medicine to help you sleep (prescribed or "over the counter")?				
7. During the past month, how often have you had trouble staying awake while driving, eating				

meals, or engaging in social activity?				
	Noproblemat all	Only a very slight problem	Somewhatof a problem	A very big problem
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?				
	Verygood	Fairlygood	Fairlybad	Verybad
9. During the past month, how would you rate your sleep quality overall?				
	No bed partner or room mate	Partner/roommate inother room	Partner in same room but not same bed	Partner in same bed
10. Do you have a bed partner or room mate?				
	Not during the past month	Less than once a week	Once or twice a week	Three or more times a week
If you have a room mate or bed partner, ask him/her how often in the past month you have had:				
a. Loud snoring				
b. Long pauses between breaths while asleep				
c. Legs twitching or jerking while you sleep				
d. Episodes of disorientation or confusion during sleep				
e. Other restlessness while you sleep, please describe:				

Appendix E The illustration of core EF measurement

(English version)

Fish flanker task illustration

1. process

The whole test consists of two parts: practice and formal test。

Practice 20 trials to make the subjects skillful the test process, and then enter the formal test. The formal test consists of 2 blocks (76 trials/2blocks), with 1 minute rest between groups, as shown in Figure 1。

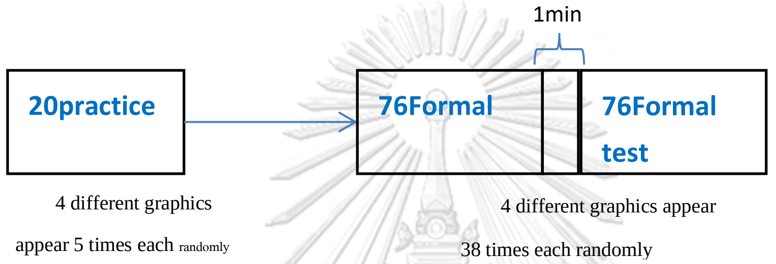
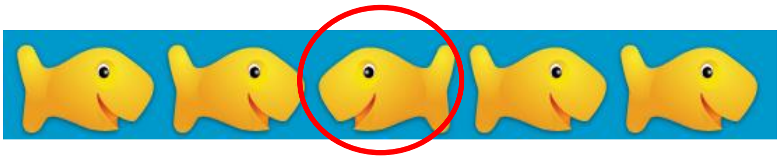


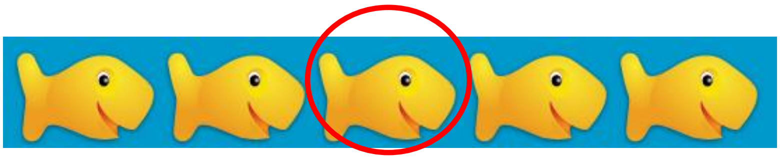
Figure 1 Schematic diagram of the overall test process

2. pre-practice instruction

We will start playing a game soon, your task is to feed the hungry fish.

You will see 5 small fishes playing in the water. They are all hungry. You can feed them with the buttons in your hand. But it should be noted that **the little fish in the middle** is the hungry. Therefore, you only need to feed the small fish in the middle. When the middle fish swims to the left, you can press the <A> key with your left hand to feed it; when the middle fish swims to the right, you can press the <L> key with your right hand to feed it.





The next exercise will start right away. In the exercise, you should feed the fish as accurately and quickly as possible, but be careful not to be too fast, otherwise it will be easy to make mistakes. Next, please put the index finger of your left hand and right hand on the <A> key and <L> key of the keyboard respectively. When you are ready, we press the <spacebar> key to start practicing.

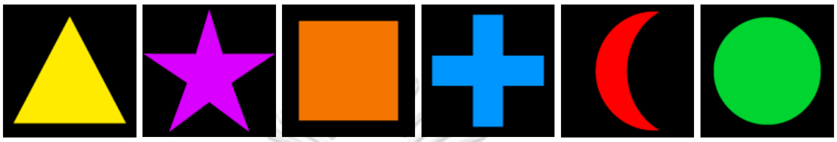
2. Formal test instruction

If you need to practice again, press the <F> key. If you don’t need to practice again, press the <J> key. Starting the formal test, the subject and the subjects said: "Very good, one practice is over, we will start the game officially. Just like you practiced just now, you will see 5 small fish appear in the center of the screen every time. You only need to pay attention to the small fish XX (here, please let the children answer in the form of question and answer to see if they really understand the law) and feed it. When the small fish in the middle swims to the left , Press the <A> key with your left hand to feed it; when the small fish in the middle swims to the right, press the <L> key with your right hand to feed it. Note that you should feed the small fish as accurately and quickly as possible, and try to avoid Error. Next, please place your left and right index fingers on the <A> key and <L> key of the keyboard respectively. When you are ready, we press the <J> key to start the game".

N-back illustration

1. process

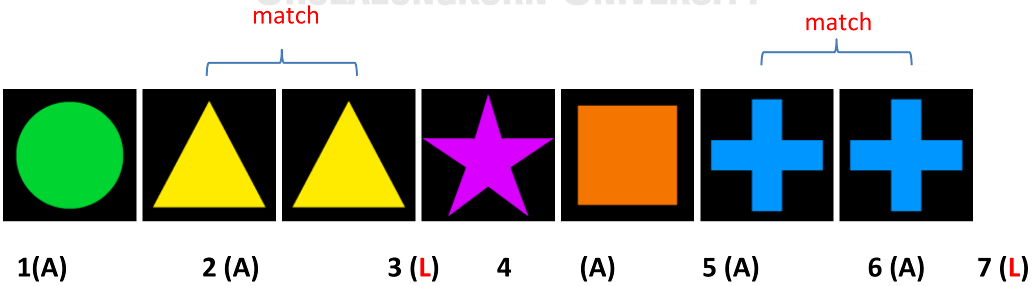
This test uses two conditions, 1-back and 2-back. Each condition includes two links: practice (30 times) and formal test (72 times). The stimulus is composed of six different shapeed images with a black background (as shown below).

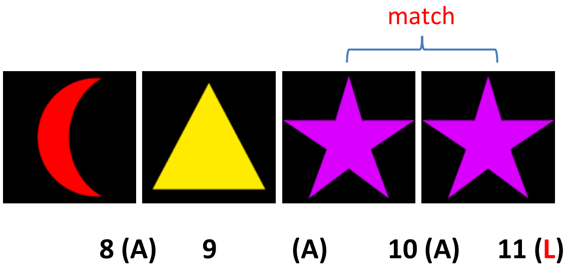


2. 1-back and 2-back instruction

2.1 1-back, pre-practice instruction

We are about to play a game of finding friends, the task of the game is to find the same graphics. You need to confirm whether the graph you see now is the same as the one you saw before. If it is the same, please press the <L> key with your right hand as soon as possible, indicating that you have found your good friend; if the current graph is the same as the previous one It’s not the same, please press the <A> key with your left hand as soon as possible, indicating that your good friend hasn’t appeared yet.” Let’s practice first. If you’re ready, press <spacebar> to start



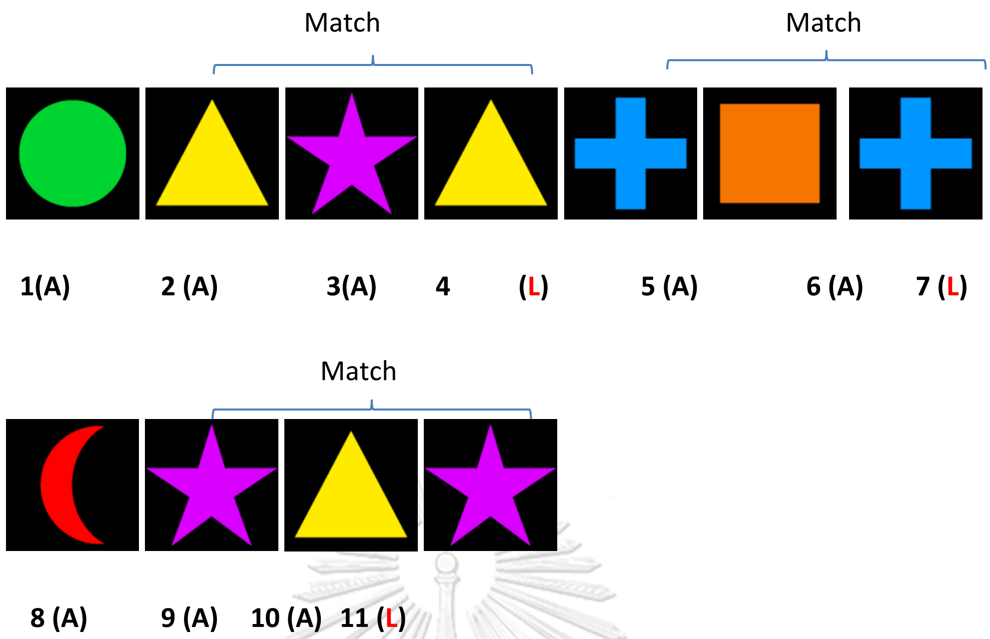


2.1.1 1-back, pre-test instruction

If you need to practice again, press the <F> key. If you don’t need to practice more, the subject should told the participant: "We performed very well in the previous practice. Now we are going to officially start. As with the rules of the practice just now, you need to confirm whether the graphics you see now are the same as your previous The graphics you see are the same. If they are the same, please press the <L> key with your right hand as soon as possible to indicate that you have found your good friend; if the current graphic is different from the previous one, please press the <A> key with your left hand as soon as possible to indicate you 'S good friend has not yet appeared." If you are ready, please press <J> to officially start".

2.2 2-back, pre-practice instruction

Next, we still play the game of finding friends, but the difficulty has increased. You need to confirm whether the graph you see now is the same as the previous two graphs you saw. If it is the same, please press the <L> key with your right hand as soon as possible, indicating that you have found your good friend; if the current graph is the same as your first two The graphics are not the same, please press the <A> key with your left hand as soon as possible, indicating that your good friend has not appeared." Let’s practice first, if you are ready, please press <J> to start practicing



2.2.1 2-back, pre-test instruction

If you need to practice again, press the <F> key. If you don’t need to practice more, the subject should told the participant: "The performance was very good in the previous practice. Now we are going to officially start. The same as the rules of the practice just now, you need to confirm whether the graphics you see now are the same as your first two. If the graphics you see are the same, please press the <L> key with your right hand as soon as possible, indicating that you have found your good friend; if the current graphic is different from your previous two graphics, please press the <A> key with your left hand as soon as possible. It means that your good friend has not yet appeared." If you are ready, press <J> to officially start

Dimensional change card sort (DCCS) illustration

1 Process

The test consists of three parts: Pre-switch, Post-switch, and Border (two blocks, 72 trials/block, two-minute breaks between blocks), without intermittent, see Figure 1 below for details.

Pre-switch Phase (Color game)	Post-switch Phase (Shape game)	Border Phase (Mixed)
1. pre-practice instruction 2. 15 practice trials 3. pre-test	1. pre-practice instruction 2. 15 practice trials 3. pre-test	1. pre-practice instruction 2. 20 practice trials

Figure 1 details of process

Figure 2 diagram of the parameters of each trial

2. Pre、Post、Mixed procesdure of three parts

2.1. Pre-switch Phase（Shape game）

Including (1) pre-practice instruction; (2) 15 practice; (3) pre-test instruction (4) 60 trials.

(1) pre-practice instruction（Figure 3）

There are two cards here, one is the blue rabbit and the other is the red boat. Now let’s play a card game called a **shape game**. In this game, put all the blue cards together (indicating here, don’t say left and right), press <F> to complete; put all the red cards together (instruct over there, don’t say left and right), press < J> key to complete. Put your hands on the two buttons and get ready, press <Spacebar> to start practicing.

Note: As shown in the picture on the right, the plan is to print out the pictures and paste them on F and J for the subjects to click 

Figure 3 Sample picture of instruction interface

(2) 15 practice

Two stimulating pictures () of red rabbit and blue boat appear randomly, ensuring that the same card appears twice in a row at most.

After the exercise, enter the pre-test instruction interface.

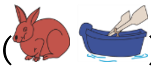
(3) pre-test instruction

(Figure 3 is displayed in the interface)

Remember, if it is blue, press the <F> key to place it here; if it is red, press the <J>

key to place it there. Now it’s your turn, please get ready, press the <Spacebar> key to enter the official game session. “

(4) 60 trials

Let the subjects complete it independently without feedback. The stimulus pictures include two kinds of red rabbit and blue boat () , to ensure that the same card appears twice in a row.Whether the record is correct (such as 0 and 1) and the accuracy percentage.