Application of Transtheoretical Model on the physical exercise behavior of adolescents

Yuan Zhou

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Doctor of Philosophy in Exercise and Sport Science
November 2024

การนำรูปแบบการปรับเปลี่ยนพฤติกรรมสุขภาพ (TTM)ไปใช้ในการปรับเปลี่ยนพฤติกรรมการออกกำลังกายของวัยรุ่น

วิทยานิพนธ์

ของ

Yuan Zhou

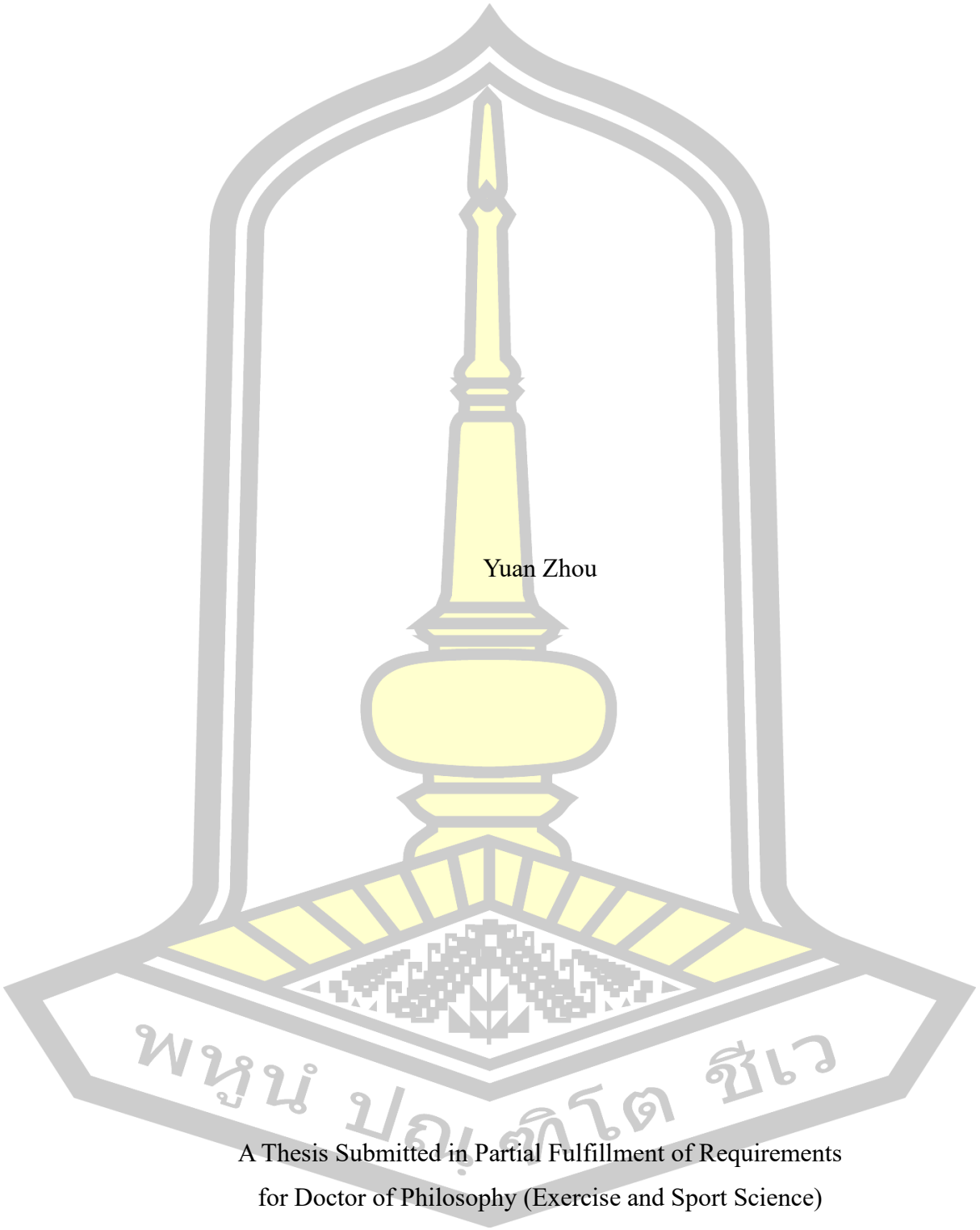
เสนอต่อมหาวิทยาลัยมหาสารคาม เพื่อเป็นส่วนหนึ่งของการศึกษาตามหลักสูตร

ปริญญาปรัชญาดุษฎีบัณฑิต สาขาวิชาวิทยาศาสตร์การออกกำลังกายและการกีฬา

พฤศจิกายน 2567

Application of Transtheoretical Model on the physical exercise behavior of adolescents

Yuan Zhou



A Thesis Submitted in Partial Fulfillment of Requirements

for Doctor of Philosophy (Exercise and Sport Science)

November 2024

The examining committee has unanimously approved this Thesis, submitted by Mr. Yuan Zhou , as a partial fulfillment of the requirements for the Doctor of Philosophy Exercise and Sport Science at Mahasarakham University

Examining Committee

..... Chairman
(Asst. Prof. Thanakorn Panyasaisophon , Ph.D.)

..... Advisor
(Asst. Prof. Napatsawan Thanaphonganan , Ph.D.)

..... Committee
(Assoc. Prof. Vorapoj Promasatayaprot , Ph.D.)

..... Committee
(Asst. Prof. Yada Thadanatthaphak , Ph.D.)

..... Committee
(Archrawadee Srijaroon , Ph.D.)

Mahasarakham University has granted approval to accept this Thesis as a partial fulfillment of the requirements for the Doctor of Philosophy Exercise and Sport Science

....
(Assoc. Prof. Chowwalit Chookhampaeng , Ed.D.)
Dean of The Faculty of Education

(Assoc. Prof. Krit Chaimoon , Ph.D.)
Dean of Graduate School

TITLE Application of Transtheoretical Model on the physical exercise behavior of adolescents

AUTHOR Yuan Zhou

ADVISORS Assistant Professor Napatsawan Thanaphonganan , Ph.D.

DEGREE Doctor of Philosophy **MAJOR** Exercise and Sport Science

UNIVERSITY Mahasarakham University **YEAR** 2024

ABSTRACT

The global decline in adolescent physical activity is a critical public health issue, with over 80% of adolescents failing to meet the WHO's recommendation of 150 minutes of weekly exercise, a concern mirrored in China. This study applies the Transtheoretical Model (TTM) to promote exercise behavior among Chinese adolescents.

The study developed and validated the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ) and explored the relationships among TTM variables. Phase 1 validated APEBCQ's reliability and validity in a sample of 300 adolescents, demonstrating strong differentiation in Decisional Balance (DB), Processes of Change (POC), and Self-Efficacy (SE). Phase 2 surveyed 2,100 adolescents across 14 cities, revealing significant correlations between stages of change (SOC), DB, POC, SE, and exercise frequency, with gender and grade differences influencing outcomes. Phase 3 evaluated a 12-week TTM-based intervention, showing significant improvements in exercise behavior, POC, and SE in the experimental group.

In conclusion, this study validated the APEBCQ, analyzed key TTM variables, and confirmed the effectiveness of TTM-based interventions. The findings offer valuable insights for designing targeted strategies to promote healthy behaviors in adolescents. Future research should expand sample sizes, include additional variables, and develop more personalized interventions for diverse populations.

Keyword : Adolescent Physical Exercise Behavior, Transtheoretical Model, Self-Efficacy, Processes of Change, Intervention Experiment

ACKNOWLEDGEMENTS

I would like to express my deepest gratitude to my advisor, Asst. Prof. Napatsawan Thanaphonganan, Ph.D. Her unwavering support and guidance throughout my doctoral journey have been invaluable. Her kindness, wisdom, and dedication have shaped my academic path and inspired me to pursue excellence in all areas of my life. I am truly fortunate to have had such a supportive mentor, and I will carry her lessons with me throughout my career.

I am also deeply grateful to Asst. Prof. Chairat Choosakul, Ph.D., Asst. Prof. Chamnan Chinnasee, Ph.D., Assoc. Prof. Vorapoj Promasatayaprot, Ph.D., Asst. Prof. Yada Thadanatthaphak, Ph.D., Dr. Archrawadee Srijaroon and Asst. Prof. Thanakorn Panyasaisophon, Ph.D. for their generous guidance and insightful feedback.

A special note of appreciation goes to Asst. Prof. Arporn Popa, Ph.D. Her rigorous research approach and dedication set a standard for me to follow. Although she has left us and is now in heaven, her influence remains a guiding beacon in my future work and studies. I hope she can witness my growth from above, and I dedicate this work, in part, to her memory.

I would also like to thank my research assistants, Mingshu Cen and Yinqi Mo, for their hard work and dedication to this project. Their contributions were essential to the completion of this research.

Finally, I would like to acknowledge the support of Wuzhou High School for their involvement and assistance in this research. Their cooperation significantly contributed to the success of this study, and I deeply appreciate their help.

I also extend my gratitude to Mahasarakham University Faculty of Education for providing a supportive learning environment for Chinese students and fostering our development.

Yuan Zhou

TABLE OF CONTENTS

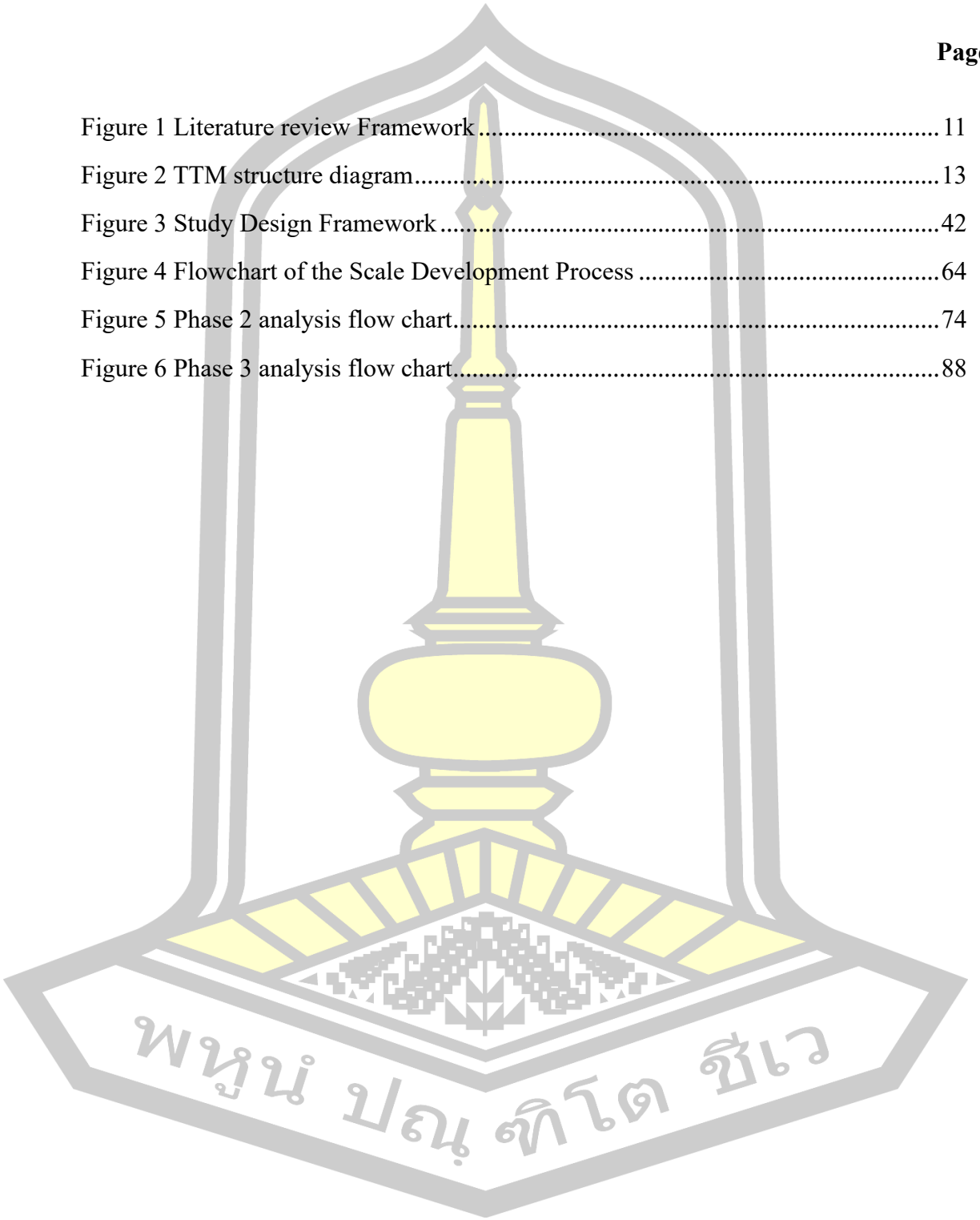
Page

LIST OF TABLES

Page

LIST OF FIGURES

Page



CHAPTER I
INTRODUCTION

1. Background

All the time, "insufficient physical activity" has become an important problem affecting the physical and mental health of young people all over the world. Many studies have found that lack of physical activity leads to potential harm to the body. Therefore, in order to prevent diseases and keep health, people should maintain active physical exercise behaviors to promote health. International physical activity guidelines recommend that adolescents get an average of 150 minutes of moderate to vigorous physical activity per week(WHO, 2020). Despite this, recent studies estimate that more than 80% of adolescents do not meet physical activity recommendations(WHO, 2022). The survey showed that 34.3% of college students said they had never exercised (men: 25%; women: 43%). In addition, 32.5% of college students participate in sports activities less than three times a week(WHO, 2018). More than four in five 11- to 17-year-olds are not physically active, little change since 2001(Guthold R, 2020). Physical fitness and physical activity levels among children and adolescents have declined over the past few decades(Fühner, T. et al, 2021). In northern Europe and the United States, rising rates of physical and mental health complaints among adolescents have been observed(Hogberg et al., 2022; Twenge et al., 2018). Additionally, during the COVID-19 pandemic, many countries have implemented government-enforced social distancing restrictions, which in part has affected physical activity levels among children and adolescents around the world(Hale, T. et al., 2021). In conclusion, physical inactivity and a sedentary lifestyle have become a serious global health problem(Kim & Kang, 2020).

In China, the situation is not optimistic either. The Eighth National Survey Report on Students' Physical Fitness and Health pointed out that 23.8% of the national students aged 6 to 22 had an excellent physical fitness and health standard, and the areas with a relatively high excellent rate were the economically developed eastern and coastal areas(Chinese Ministry of Education, 2021). In 2020, nearly 20% of people are overweight and obese, and the rate of myopia among adolescents reaches

52.7%(Chu Renyuan, & Xu Ye, 2021). Inadequate physical activity among adolescents has also been reported in various regions across the country. The current physical and health status of young people is worrying, and phenomena such as declining physical fitness and obesity frequently occur(Wang Hongting, 2018). The vital capacity index of urban boys and girls aged 13 to 15 in Guangdong Province has a significant downward trend (Wang Min, 2018). In Guangxi Province, there are many overweight adolescents, and great attention should be paid to the vital capacity indicators of school boys. Among them, the failure rates of boys in the first, second, and third grade of high school are 33.6%, 42.0%, and 40.1% respectively (Dang Chuanqi et al, 2019).

The normal compliance rate of junior high school students in Jinan City is low (Qin Guoyang, 2022). Compared with foreign countries, there is still a gap in the overall physical condition of adolescents in Beijing, and there is still a lot of room for improvement in the physical condition and healthy lifestyle of adolescents (Ji Gang et al, 2020). The physical health of adolescents in Shandong Province is not ideal, with an excellent rate of only 7.4%, and a failure rate as high as 14.3% (Huang Shuyuan, 2020). There is growing evidence of harmful associations between physical inactivity and obesity, hypertension, cancer, and cardiovascular disease (Piercy, K. L., & Troiano, R. P., 2018). Adolescents with low levels of physical activity are more likely to experience mental health and well-being problems from adolescence into adulthood (Shlack et al., 2021). Therefore, the behavioral problems of adolescents who lack physical exercise deserve attention.

In the field of behavioral science, Transtheoretical Model (TTM) is a popular theory, and many researchers have used TTM to study motor behavior. TTM proposes from the perspective of individual cognition that the change of exercise behavior is a dynamic change process, which needs to be divided into different stages to analyze the psychological factors that affect exercise behavior. Mozhde Hashemzadeh (2019) reviewed 103 articles and found that research on exercise behavior and physical activity used TTM extensively because TTM can effectively explain and predict exercise behavior. TTM can explain adults' physical activity levels and can also be used as a theoretical basis for intervention design, with Self efficacy being the most important predictor (Oba, T. et al, 2019; Ghaffari, M. et al, 2021). TTM is also

available for college students. Kim, Y. et al. (2021) believes that the Stages of change can accurately divide the exercise behavior of college students, and Self efficacy is the most effective factor in predicting the stage of physical activity. Kim, H. et al. (2021) found that the processes of change may be an effective factor in promoting physical activity in specific groups of people, and applying Self efficacy and Decisional balance making to set intervention strategies can achieve better results. There is a positive correlation between TTM structure and physical activity, which can be used as an excellent baseline model for physical activity intervention or motivational intervention (Liu, K. T. et al, 2021). TTM is also suiTable for studying adolescent exercise behavior. Kamran, A. et al. (2023) found that TTM can effectively improve the physical activity level of primary school students under the epidemic. Rizal, H. (2019) verified the validity of the TTM questionnaire in Malaysian children and can explain and predict physical activity.

Romain, A. J. (2018) reviewed the research on Transtheoretical Model (TTM) over the past 30 years and found that most TTM based studies are only horizontal studies, and longitudinal investigations in multiple regions are needed in the future to determine the link between physical activity and TTM structure. Nigg, C. R. (2019) analyzed 700 articles and believed that intervention should focus on cognitive processes related to Self efficacy and Decisional balance. Many studies have demonstrated that TTM-based interventions can significantly improve exercise levels. Basic TTM interventions can improve the physical activity behavior of Chinese college students (Abula, K. et al, 2018). Internet based interventions based on TTM can promote adolescent physical activity levels, but the process of intervention may be influenced by other factors, such as economic, cultural and family factors (Pirzadeh, A. et al, 2020). Multimedia intervention designed based on TTM is effective and can significantly improve adults' physical activity (Jalali, S. et al, 2022). It should be pointed out that TTM intervention can effectively improve the level of individual exercise, but the intervention may also have defects. Pennington, C. G. (2021) believes that researchers need to understand the various dimensions and correlations in the TTM structure and recognize how these relationships will affect intervention measures. Romain, A. J. et al. (2018) summarized 33 TTM based intervention experiments and found that TTM based interventions significantly

improved exercise behavior, but future intervention studies should specify how to combine TTM to construct interventions.

There is no doubt that lack of physical activity among adolescents is a global problem. In this regard, researchers need to focus on research on changes in adolescent physical exercise behavior. Exercise behavior is a dynamic process. Judging from many studies, Transtheoretical Model (TTM) can well explain and predict individual exercise behavior, and it has also been verified in various groups. Although TTM has been widely used in physical exercise behavior, the theory still has certain limitations in practical application. First, the relevant questionnaires of TTM are in English, and there may be cultural differences in each area after translation. Therefore, when researchers use the TTM questionnaire in non-English-speaking area, they must translate and verify the validity of the questionnaire. In China, some researchers have designed and validated TTM questionnaires for college students (Si Qi, 2006; Yin Bo, 2009), but a TTM questionnaire for Chinese adolescents has not yet been discovered. Second, in terms of the internal structure of TTM, few studies have in-depth analysis of variables and the relationship between variables. Future research should comprehensively and in-depth analyze the components of TTM and diversify research objects and intervention methods (Guo Zhengmao, 2019). Third, most of the existing studies are cross-sectional studies, which only provide descriptive analysis of the exercise stages of the group. They lack experimental intervention studies and lack basis and detailed plans for the formulation of intervention measures.

To sum up, it is still of great significance to study the physical health of adolescents from the perspective of physical exercise behavior. A large number of applied studies have confirmed that Transtheoretical Model (TTM) can explain physical exercise behavior. Therefore, this study takes TTM as the theoretical basis for research, develops and studies TTM questionnaires for Chinese adolescent groups, and provides a measurement instrument for the study of adolescent exercise behavior. Secondly, conduct an in-depth study of each structural variable of TTM, explain the interrelationship between variables, and provide a basis for formulating intervention plans. Finally, a detailed intervention plan was developed based on the TTM structure, a 12-week experimental intervention was carried out, and the TTM intervention effect was verified through comparative analysis with the Control Group.

2. Research Questions

1. Transtheoretical Model (TTM) research began relatively late in China, with most studies focusing on college students. There is limited research applying TTM to adolescents, and no specific TTM questionnaire for adolescents has been identified. Additionally, there is a lack of tools available to measure adolescent exercise behavior.

2. When applying Transtheoretical Model (TTM) to study the physical exercise behavior of Chinese adolescents, the relationships among the internal structural variables of TTM remain unclear, and further analysis is required to explore the connection between the Processes of Change and the Stages of Change.

3. The application of Transtheoretical Model (TTM) in China predominantly involves cross-sectional studies, with a notable lack of longitudinal experimental research. In particular, no TTM intervention studies lasting more than 10 weeks have been identified in adolescent populations. Additionally, the design of experimental interventions often lacks a solid foundation and detailed planning.

3. Objectives

This study, based on the Transtheoretical Model (TTM), explored the psychological mechanisms underlying adolescent exercise behavior, developed a measurement scale tailored to Chinese adolescents, and validated the effectiveness of TTM-based interventions through experimentation. The specific research objectives are as follows:

1. To develop a measurement scale for adolescent exercise behavior in China, the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ) was created and validated through IOC and preliminary testing, ensuring its reliability and accuracy for future research..

2. To analyze relationships between TTM structural variables, a large-scale survey of 2,100 adolescents from 14 cities in Guangxi Province was conducted using APEBCQ. The study examined correlations among SOC, DB, POC, and SE, and explored gender and grade differences, providing insights into the psychological mechanisms of adolescent exercise behavior and supporting targeted interventions..

3. To design and validate a TTM-based intervention, a 12-week program was

developed considering individual differences among adolescents. By comparing the experimental and control groups, the study assessed the impact on exercise behavior, processes of change, and self-efficacy, confirming the intervention's effectiveness and feasibility for future studies.

4. Significant of Study

This study makes significant theoretical, empirical, methodological, data, practical, and policy contributions. Theoretically, it extends the Transtheoretical Model (TTM) to adolescent physical exercise behavior, enriching its application in sports science, and supports cross-cultural research by developing the Chinese version of the "Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ)." Empirically, it provides extensive data on Chinese adolescents' exercise behavior through a large-scale survey across 14 cities in Guangxi, and demonstrates the effectiveness of TTM through a 12-week intervention experiment, offering evidence for both theoretical and practical applications. Methodologically, the study uses various research methods to enhance the reliability of its findings and provides valuable references for future research.

The study also contributes by establishing a comprehensive database on adolescent physical exercise behavior, serving as a valuable resource for future research. Practically, the APEBCQ is an effective tool for educators, coaches, parents, and community workers, enabling the design of targeted interventions and supporting adolescents' exercise behavior. In terms of policy, the findings provide empirical data that can assist governments and organizations in formulating policies to increase physical activity and reduce health issues among adolescents, while supporting the education sector in developing improved physical education curricula. Lastly, the study achieves innovation in the cross-cultural applicability of measurement tools and intervention strategies, providing new ideas for behavior change research in other fields.

5. Definitions of Terms

1. Adolescent

In this study, adolescents are defined as middle and high school students aged 13 to 17, including both males and females. In Phase 1, 300 adolescents will be recruited; in Phase 2, 2100 adolescents will be recruited; and in Phase 3, 100 adolescents will be recruited.

2. Physical exercise

In this study, physical exercise refers to deliberate physical activity undertaken by individuals to achieve specific goals, such as improving body shape, enhancing athletic ability, relieving stress, or increasing enjoyment. The Physical Exercise Behavior Scale (PEB-Scale) will be used to collect participants' exercise information, and exercise behavior will be classified into five levels.

3. Intervention

Intervention refers to using a efficacy test, that is to determine whether an intervention (a new technique, treatment, degree, or program) would work better in a practical situation. In this study, intervention is defined as interventions designed based on TTM.

4. Transtheoretical Model (TTM)

The Transtheoretical Model (TTM) is a purposeful behavior change model that focuses on the decision-making ability of individual behavior changes, rather than social and biological influences. TTM believes that individual behavioral change is a dynamic and continuous process, including four major contents: Stages of change (SOC), Processes of change (POC), Decisional Balance (DB), Self efficacy (SE).

4.1 Stages of change (SOC)

SOC is the core structure, pointing out that the individual behavior change is a dynamic stage, reflecting when the individual behavior change. The change of individual behavior goes through 5 stages: precontemplation, contemplation, preparation, action, and maintenance. Using Physical exercise behavior Stages of change scale to test. Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1. Strongly disagree, 2. Not agree, 3. Indeterminacy, 4. Agree, 5. Strongly agree.

4.2 Decisional Balance (DB)

DB refers to the cause and importance of individual behavior change. Includes two contents: Exercise pros (pros) and Exercise cons (cons). also known as perceived benefits and perceived barriers to behavior change, are two important intermediate outcome variables in TTM. Using by Physical exercise Decisional balance scale to text. Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1. Strongly disagree, 2. Not agree, 3. Indeterminacy, 4. Agree, 5. Strongly agree.

4.3 Processes of change (POC)

POC refers to the cognitive, emotional, behavioral and interpersonal strategies and skills that individuals use when making behavior changes, reflecting the process of individual behavior change. There are 10 most common factors in the change process, which can be summarized into two types: Cognitive processes(CP) and Behavior processes(BP). Using by Physical exercise Processes of change scale to text. Using by Physical exercise behavior Processes of change scale to text. Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1.Never, 2. Seldom, 3. Occasionally, 4. Frequently, 5. Always.

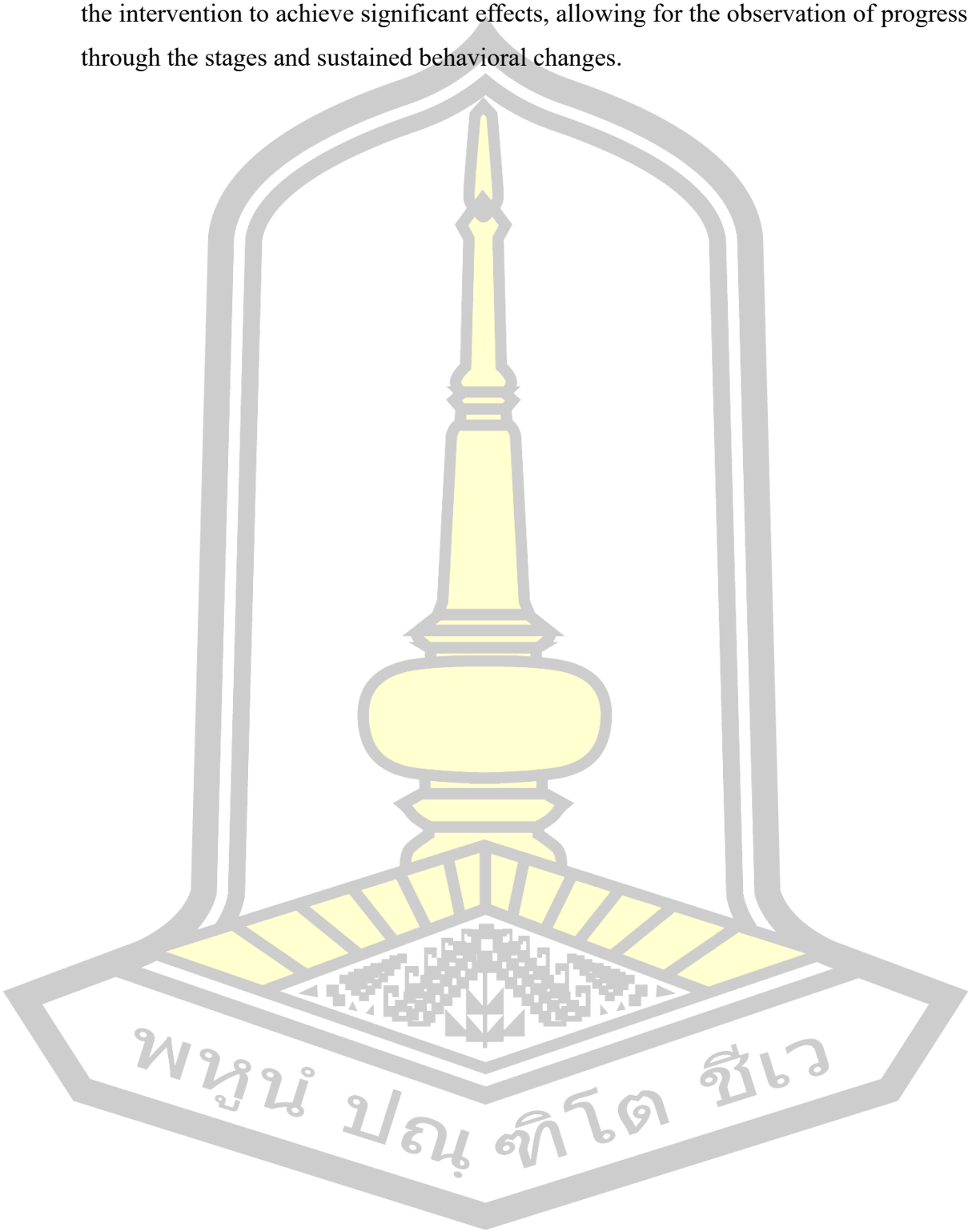
4.4 Self efficacy (SE)

SE refers to an individual's confidence and evaluation of whether he or she can complete a task. In TTM, SE plays an important role in influencing individual behavior change and transformation. Using by Physical exercise Self efficacy scale to text. Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1.No confidence at all, 2. A little confidence, 3. Medium degree confidence, 4. Have confidence, 5. Strongly confidence.

5. Transtheoretical Model (TTM) Plan:

In this study, the TTM plan is defined as an intervention program designed based on the Transtheoretical Model (TTM), utilizing knowledge dialogue, experience sharing, and exercise recording to influence decisional balance, processes of change, and self-efficacy, thereby enhancing exercise behavior and advancing exercise stages. The intervention is conducted over a 12-week period, with weekly 60-minute sessions, aimed at gradually improving the exercise behavior of participants in the

experimental group. The 12-week duration is intended to provide sufficient time for the intervention to achieve significant effects, allowing for the observation of progress through the stages and sustained behavioral changes.



CHAPTER II
REVIEW OF RELATED LITERATURE

The purpose of this study is to develop a handbook aimed at promoting physical exercise behavior change among Chinese adolescents based on the Transtheoretical Model (TTM). This research includes a review of the relevant literature on the subject.

1. Concepts about Adolescent
2. A review of Transtheoretical (TTM) research
   2.1 The origin of Transtheoretical (TTM)
   2.2 The main content of Transtheoretical (TTM)
   2.3 Concept of Transtheoretical (TTM)
   2.4 Measurement of Transtheoretical (TTM)
3. Study on the application of TTM in physical exercise
   3.1 Application in Western countries
   3.2 Application in Eastern countries
   3.3 Application in China
4. Study on exercise behavior intervention
   4.1 Concept of Intervention
   4.2 Types of intervention
   4.3 Scenarios and methods of intervention implementation
   4.4 Study on the effectiveness of intervention
   4.5 Intervention research based on TTM

In the past year, this study mainly searched Chinese and foreign databases such as Elsevier, bbs.chinatopfit.com, PubMed, CNKI, Sports Discus, Web of science, etc., using Transtheoretical model, adolescent physical health, adolescent physical exercise, physical activity, exercise behavior, exercise intervention and other keywords for literature retrieval. At the same time, I consulted "Exercise Psychology", "Sports Psychology" and other books, screened out literature materials closely related to the theme and of great significance to the research, and made reference materials for text research. (Figure 1)

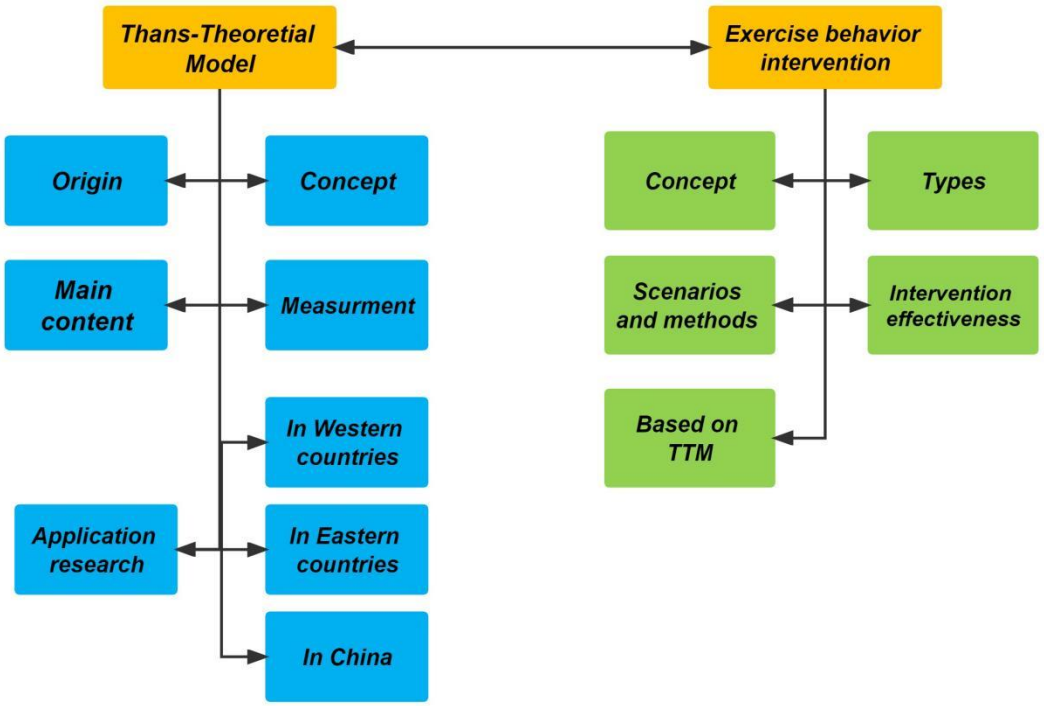


Figure 1 Literature review Framework

1. Concepts about Adolescent

The word adolescence derives from the Latin adolescere to grow up. However, defining the phase of life that stretches between childhood and adulthood has long posed a conundrum. At the start of the 20th century, G Stanley(1905) Hall loosely defined adolescence as the developmental period ranging from age 14 to 24 years in his treatise on adolescence. WHO(2006) defines the age of "youth" as 15 to 24 years old, and the age of "adolescents" as 10 to 19 years old. Since these two age groups partially overlap, 10 to 24 years old is defined as "young people". In world organizations, The UN Convention on the Rights of the Child defines a child as an individual aged 0–18 years and, in time, the UN has come to formally define adolescence as the period between 10 and 19 years of age(Kuruvilla, S. et al, 2016). In research in the medical field, Most definitions of the more recently introduced terms young adulthood and emerging adulthood range from about 18 to 26 years of age(Patton et al, 2016). It is worth noting that how we conceptualise and define adolescence influences the scope and focus of laws, policies, and programmes intended to protect and empower adolescents. An expanded and more inclusive definition of adolescence as 10–24 years of age aligns more closely with contemporary patterns of adolescent growth and popular understandings of this life phase(Sawyer, S. et al, 2018). Considering the above, Adolescents are defined as students aged 13-17 years old, in junior high school and high school grades, including males and females in this study.

2. A review of Transtheoretical (TTM) research

The main content of Transtheoretical (TTM)

TTM consists of four parts: Stages of change, Decisional balance, Processes of change, and Self efficacy (Figure 2).

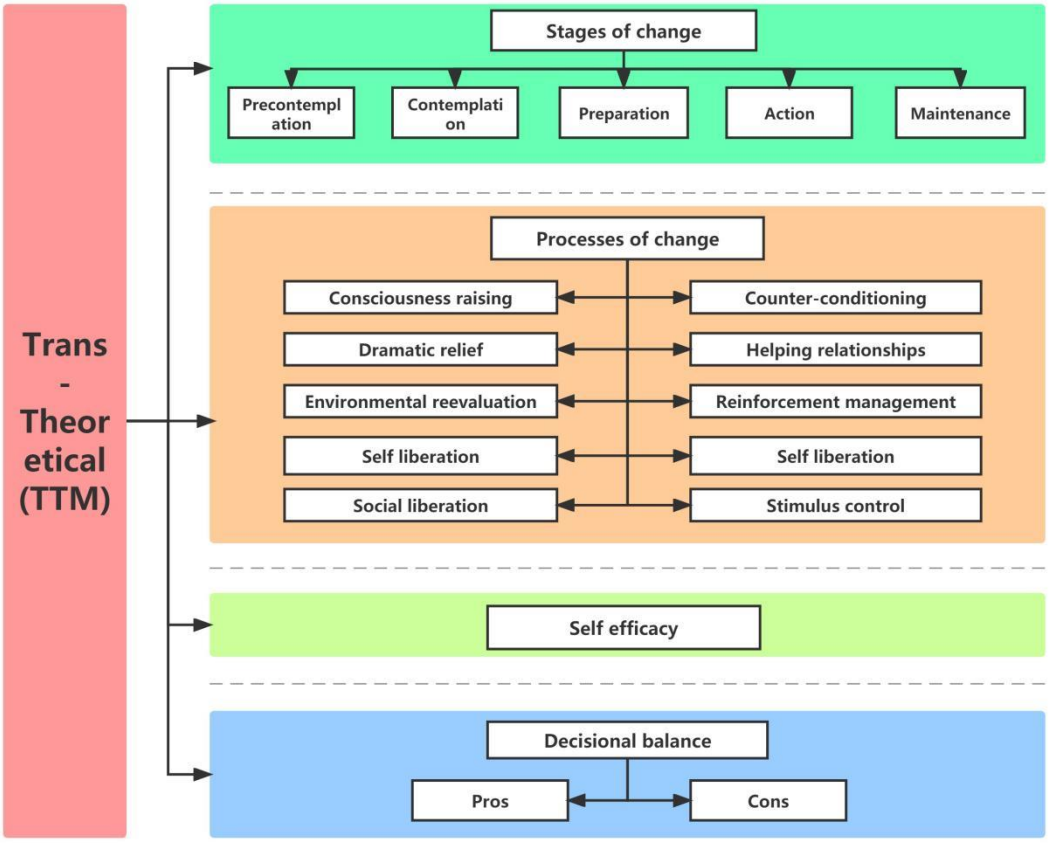


Figure 2 TTM structure diagram

Stages of change (SOC)

Stages of change is the core structure, pointing out that the individual behavior change is a dynamic stage, reflecting when the individual behavior change. The change of individual behavior goes through 5 stages: Precontemplation, Contemplation, Preparation, Action, and Maintenance.

Precontemplation is when the individual has no intention of taking action in the next 6 months. Take physical exercise as an example, the individual has not considered or planned to do physical exercise. People at this stage often say "I have no plans to engage in purposeful physical activity for the next six months or more." Individuals at this stage are characterized by a lack of motivation or a lack of planning for change, either because they do not understand the consequences of their behavior or because they do not try (Velicer, W. F., Prochaska, J.O., Fava, J.L.,1998).

Contemplation is when the individual is ready to take action in the next 6 months. Taking physical exercise as an example, individuals are already aware of the

possible health risks of a physically inactive lifestyle and are considering starting exercise within the next 6 months. At this stage, individuals are aware of the possible health benefits and drawbacks of exercise and begin to pay attention to information about exercise. If the individual realizes that the benefits outweigh the disadvantages through decision judgment, he will have the motivation to change his behavior and push him to the next stage (Prochaska, J. O., & Velicer, W. F., 1997).

Preparation means that the individual is ready to take action within 30 days and that some preparation measures have been taken. Take physical exercise as an example, the individual has focused on or plans to participate in exercise in the near future, they have not only the intention to start exercise, but also have taken some preparatory activities. At this stage, the individual has a positive understanding of the benefits of exercise and a strong motivation to participate. Some studies suggest that individuals at this stage will attend exercise-related classes, consult an experienced sports health practitioner about exercise plans, and purchase clothing and equipment for physical exercise (O 'Connor, M.J.,1994).

Action means that the individual's behavior change has occurred, but less than 6 months ago. Take physical exercise as an example, the individual has started to exercise, and the exercise behavior has changed significantly, but the individual needs to pay attention to achieve the minimum level of exercise required by the World Health Organization as much as possible, that is, exercise 3 or more times a week, each time lasting 30 minutes or more. It is important to note that individuals at this stage need to work hard to keep from falling back to the previous stage. Studies hold that if an individual insists on regular physical exercise in the past 6 months, it indicates that he is already in the action stage of physical exercise (Marus.B.H.,Rakowski. W.,&Rossi.J.S.,1992).

Maintenance refers to behavior changes that have occurred for more than 6 months. Taking physical exercise as an example, the individual has been exercising regularly for more than 6 months, and physical exercise has become a part of the individual's daily life, indicating that the individual has been in the maintenance stage (O'Hea, E. L. et al, 2003). It is important to note that individuals may still be affected by loss of interest and attention shifts, and only continuous reinforcement of the benefits of persistent exercise can effectively prevent the transition to the lower

stages.

Different individuals in different stages may change forward at different rates of change, may retreat, and may re-enter at different points of change, such stage movements are cyclic (Prochaska & DiClements, 1983). In general, Stages of change breaks the limitation of traditional research on behavior change and uses a dynamic perspective to observe each stage of individual behavior change (Si qi, 2008).

Chinese college students exhibit a U-shaped trend in the Stages of Change (SOC) for physical exercise, with significant gender differences (Zheng Xiao, 2019; Jia Yunting, 2018). This trend indicates that students of different genders show distinct patterns in their physical exercise behavior, especially in the progression through various stages of change. It suggests that factors such as motivation, social support, and external influences play a crucial role in shaping these differences, highlighting the importance of considering gender when studying exercise behavior changes.

Research indicates that males generally have higher SOC levels compared to females, which may be attributed to stronger motivations related to health, competence, and social needs. This suggests that males are more inclined to engage in physical exercise to satisfy their health and social goals, thereby resulting in better overall performance in the SOC. In contrast, females may face more challenges, such as lack of interest or external barriers, which could impede their progress in the stages of change. Understanding these differences is crucial for designing effective, gender-specific interventions to promote physical activity.

Similarly, Kim (2021) found that South Korean college students also demonstrated significant gender differences in SOC, with males generally outperforming females in various stages. This cross-cultural similarity highlights a consistent pattern of gender-related differences in physical exercise behavior across different countries. Males showed greater motivation and higher engagement levels in key stages of change, emphasizing the need to explore the factors that contribute to these differences and how they can be addressed effectively.

Furthermore, the impact of interventions on SOC has been supported by various studies. For instance, Moosavi (2017) and Lapointe (2023) both indicated that effective interventions significantly improve SOC among college students, demonstrating the positive influence of targeted programs on behavior change. These

interventions help participants progress through the stages of change, particularly for those who are initially in the lower stages. Such findings underscore the importance of implementing well-designed intervention programs to effectively enhance physical activity behavior among college students.

These studies collectively emphasize the role of interventions and reveal the gender and cultural differences in SOC. Integrating these findings into practice can help develop more tailored intervention strategies that effectively promote physical exercise behavior among different student groups, ultimately leading to improved health outcomes.

Decisional balance (DB)

The concept of Decisional balance first appeared in 1977 and was proposed by Janis and Mann. It is mainly used for individuals to evaluate the pros (benefits) or cons (disadvantages) that a certain behavior may bring to them. In TTM, Decisional balance describes the cause and importance of individual behavior change. After testing TTM, Prochaska has gradually formed a sTable structure of Decisional balance: Positive and negative factors, also known as perceived benefits and perceived barriers to behavior change, are two important intermediate outcome variables in TTM (Prochaska & Norcross,1992). Perceived benefit is the positive aspect of behavior change, and perceived obstacle is the negative aspect of behavior change. Taking physical exercise as an example, if an individual believes that the benefits of exercise may outweigh the disadvantages, the motivation level of the individual to participate in physical exercise will be relatively high. Therefore, individuals in precontemplation and contemplation are assumed to have more disadvantages than benefits from exercise. The individual in preparation is assumed to believe that the benefits of exercise equal the disadvantages. Individuals in action and maintenance are assumed to believe that the benefits of exercise far outweigh the disadvantages. Some studies have found that evaluating the benefits and drawbacks of exercise can help researchers understand and predict the transformation of exercise behavior between the first three stages, but the prediction ability is extremely limited in the latter two stages (Diclemente & Prochaska, 1991).

There are significant gender differences in Decisional Balance (DB), with males

having higher DB levels compared to females (Kim, 2021). This indicates that males tend to weigh the pros and cons of physical activity more favorably than females, possibly due to stronger motivations related to health, physical competence, and social benefits. Such a difference suggests that males may be more likely to recognize the positive aspects of physical activity, which in turn influences their decision to engage in exercise more positively. Understanding these gender disparities in DB can help in designing targeted interventions that address the specific needs of females to enhance their motivation for physical activity.

For Malaysian college students, however, the influence of Decisional Balance (DB) on exercise behavior appears to be relatively weak (Liu, 2018). This finding highlights the variability of DB's impact in different cultural settings, suggesting that factors such as cultural beliefs, social norms, and accessibility to resources might shape how individuals perceive the benefits and barriers of physical activity. In Malaysia, cultural attitudes toward exercise and the availability of community support may play a critical role in moderating the effect of DB on exercise behavior. Thus, the relatively weak impact of DB might indicate that other factors are more influential in driving physical activity among this population.

These contrasting findings underline the importance of considering cultural context when studying the role of psychological factors like DB in exercise behavior. While gender differences are evident in certain contexts, such as among South Korean college students, the weak influence observed among Malaysian students suggests that DB's role is not universally consistent. This variation emphasizes the need for culturally sensitive approaches to promoting exercise, which take into account the unique motivators and barriers that individuals face in different environments.

Processes of change (POC)

Through the study of a large number of behavioral problems (Prochaska & Redding, 1997), researchers have found that there are 10 most common factors in the change process, which can be summarized into two types: cognitive processes and behavior processes(Table 4). Processes of change refers to the cognitive, emotional, behavioral and interpersonal strategies and skills that individuals use when making behavior changes, reflecting the process of individual behavior change (Yin Bo,2009).

Table 1 Components and concepts of the POC

Factors	Definition
Cognitive processes	
Consciousness raising	Gather all kinds of information about exercise
Dramatic relief	Express and experience the results of exercise
Environmental reevaluation	The perception and evaluation of the influence of the environment on exercise
Self reevaluation	Stick to your commitment to make exercise your daily routine
Social liberation	Use social resources to promote exercise behavior
Behavioral processes	
Counter-conditioning	Replace inactivity with exercise
Helping relationships	Find support to help you keep exercising
Reinforcement management	Reinforce the positive effects of exercise by rewarding yourself
Self liberation	Stick to your commitment to make exercise your daily routine
Stimulus control	Set up prompts for sticking to your workout

Fan Chong (2021) found significant differences in Processes of Change (POC) across gender and age, suggesting that these demographic factors play a crucial role in shaping how individuals engage with behavioral change processes in physical exercise. Specifically, males and younger individuals may exhibit higher POC scores, reflecting more frequent use of strategies to modify exercise behavior. These findings indicate that tailored approaches considering gender and age differences may be more effective in promoting positive changes in physical activity behaviors, as different groups may utilize distinct processes to initiate and sustain exercise habits.

Additionally, college students' POC scores tend to increase as they progress through the Stages of Change (SOC), indicating that POC becomes increasingly important as individuals move towards more advanced stages of exercise behavior change (Zheng Xiao, 2019). This trend suggests that as individuals become more

committed to maintaining their exercise routines, they rely more on specific cognitive and behavioral strategies captured by POC. Thus, promoting the effective use of POC strategies, such as self-liberation and helping relationships, can be instrumental in guiding students from contemplation to maintenance of regular physical activity.

Further research has shown a positive correlation between POC and SOC, indicating that higher POC scores are associated with more advanced SOC stages (Liu, 2021). This implies that individuals who effectively engage in processes such as self-reevaluation or counter-conditioning are more likely to progress through the SOC and reach the action and maintenance stages. Such findings highlight the predictive value of POC in understanding how individuals transition through the stages of behavior change, making it an essential variable for interventions aimed at promoting sustained exercise.

Consequently, POC has emerged as an important variable in explaining college students' exercise behavior and predicting their stage of physical activity (Kim, 2021; Jia Yunting, 2018). By identifying which processes are most effective at different stages, researchers and practitioners can better support individuals in adopting and maintaining a physically active lifestyle. During intervention periods, participants' POC scores often improve, reflecting the effectiveness of structured programs in enhancing motivation for behavior change (Lapointe, 2023). These improvements in POC highlight the role of interventions in equipping individuals with the skills and strategies needed for successful behavioral transitions.

The importance of POC has been emphasized within the Transtheoretical Model (TTM), where it is regarded as one of the key constructs that facilitate behavior change (Romain, 2018). For example, after a six-month intervention, POC scores significantly increased, indicating the success of the intervention in fostering greater use of change processes and promoting lasting exercise behavior (Moosavi, 2017). These findings underscore the significance of incorporating POC-targeted strategies into exercise interventions to effectively guide individuals through the stages of behavior change and support long-term physical activity engagement.

Self-efficacy (SE)

Combined with Self efficacy proposed by Bandura, it refers to an individual's confidence and evaluation of whether he or she can complete a task (Bandura, 1999). Undoubtedly, in TTM, Self efficacy plays an important role in influencing individual behavior change and transformation. Take physical exercise as an example, when an individual overcomes exercise obstacles and converts physical exercise behavior from a low stage to a high stage, Self efficacy shows a tendency to increase.

Fan Chong (2021) found that among adolescents with hearing impairments, there were significant differences in Self Efficacy (SE) across different age groups, with middle school students showing higher SE levels compared to high school students. This finding suggests that younger adolescents may feel more confident in their ability to engage in physical activities despite their impairments, possibly due to greater enthusiasm and fewer perceived barriers at a younger age. The decline in SE as students enter high school may be attributed to increased academic pressure, reduced time for physical activity, or challenges associated with adolescence. These insights highlight the need for tailored interventions to support the self-efficacy of older adolescents with hearing impairments.

Additionally, Guo (2018) reported that among college students in Wuhan, males had higher SE scores than females, and SE levels showed an increasing trend with the advancement of academic years. This gender disparity may be due to societal and cultural factors that encourage males to engage more in physical activities, thus enhancing their confidence over time. Furthermore, the increasing trend in SE with academic progression suggests that as students advance through college, they gain more experience and skills, leading to improved confidence in their physical activity capabilities. Such findings underscore the importance of addressing gender-specific barriers and promoting opportunities for females to build their self-efficacy in physical activities.

For South Korean college students, Kim (2021) found that different stages of physical activity exhibited significant differences in SE, with the scores in the action and maintenance stages being significantly higher than those in the pre-contemplation and contemplation stages. This indicates that individuals in more advanced stages of change are more confident in their ability to maintain regular physical activity. The

higher SE levels in the action and maintenance stages suggest that once individuals start engaging in physical activity and experience its benefits, their confidence in continuing these behaviors strengthens. Therefore, boosting SE during the early stages may be key to helping individuals transition to more advanced stages of physical activity.

Moreover, Heontae Kim (2021) suggested that SE might be a useful predictor for promoting physical activity among male college students. This means that higher SE levels may lead to increased participation in physical activity, particularly among males who may respond better to motivational cues related to self-efficacy. Interventions aimed at enhancing SE could therefore be particularly effective in encouraging male students to adopt and sustain active lifestyles. This reinforces the value of SE as a crucial psychological factor in predicting exercise behaviors, especially for targeted demographics.

However, for Malaysian college students, Liu (2018) found no significant relationship between SE and physical activity (PA). This lack of association could be influenced by cultural factors, such as differing attitudes towards exercise or a lack of supportive environments that encourage physical activity. It suggests that in some populations, factors other than SE may play a more pivotal role in influencing exercise behavior, such as social support or accessibility to exercise facilities. Understanding these contextual differences can inform more culturally relevant approaches to promoting physical activity.

After the intervention, participants showed a significant increase in SE, indicating the effectiveness of the intervention in boosting confidence related to exercise (Pirzadeh, 2020). This highlights the importance of well-structured programs that focus on enhancing SE, as higher SE is associated with a greater likelihood of engaging in and maintaining physical activity. Romain (2018) emphasized that SE is a well-known predictor of behavior change, as it facilitates the transition between Stages of Change (SOC), especially when combined with Processes of Change (POC). The combination of SE and POC provides a powerful framework for understanding and supporting individuals as they move through different stages of exercise behavior, thereby promoting sustained physical activity engagement.

Concept of Transtheoretical (TTM)

TTM is a purposeful and planned behavior change model, which is a systematic model to study individual behavior change based on a variety of theories. Unlike other models, this model does not focus on social, environmental, or biological influences, but on the individual's stage change and decision-making ability in terms of behavior change. The model proposes that individual behavior change is a continuous process rather than a single event. When people make behavior change, they develop in a dynamic cycle of stage changes, and individuals will adopt different behavioral strategies at each stage, prompting individuals to transform in different stages (Prochaska & Velicer, 1997).

The origin of Transtheoretical (TTM)

In 1979, Prochaska, a professor of psychology at the University of Rhode Island, first proposed TTM, which was originally used to study smoking cessation behavior. Based on the theories of psychotherapy and behavior change, this model integrates many theoretical models and gradually develops into a relatively mature theory. TTM is a popular theory in contemporary psychology that attempts to explain people's conscious health behavior and illustrate how that behavior can be applied and maintained (Prochaska & DiClements, 1983). Since its development, this theory has attracted the attention of researchers in many disciplines. Sports psychologists also actively recommend this model when studying sports behavior and exercise behavior (Marcus, Rossi, Selby, Niaura, & Abrams, 1992; Marcus, Selby, Niaura, & Rossi, 1992). Studies have shown that TTM is often used to identify and analyze correlations of physical activity (Han, Gabriel, & Kohl, 2017).

Measurement of Transtheoretical (TTM)

In 1992,Marcus and her colleagues first developed a Scale to measure Stages of change: Stages of Change Scale for Exercise (Marcus,1992). Items 1, 3, 6, and 9 measure precontemplation in which individuals are unconscious in terms of physical exercise. Items 11,19,21,24 measure an individual's conscious precontemplation of physical exercise. Entries 7,13,16,22 measure contemplation of individuals. Items 14,17,20,23 measure individual preparation. Items 4, 8, 10, and 12 measure individual

actions. Entries 2,5,15,18 measure the maintenance of an individual. The scale has been tested by many researchers and has shown good reliability and validity (O 'Connor, M.J.,1994)(Reed, & Richards, 1995). On this basis, through the continuous improvement and development of researchers, the Tables widely used to measure TTM are: SOC Scale, POC Scale, DB Scale, SE Scale.

Due to the cultural differences between the East and the West, there are differences in meaning and context in language translation. Some Chinese researchers believe that the relevant measurement scale of TTM needs to be "Sinicized". Si Qi (2006) translated "Stages of Change Scale for Exercise" into Chinese by using TTM, modified the questionnaire according to the actual situation of Chinese college students, tested 208 college students, and tested the reliability and validity of the scale. Results The results show that the quantitative change after the transformation is applicable to Chinese college students. Jiang Tiefeng (2007) compiled the Chinese version of the Stages of change Scale based on the study of several Stages of Change scales and the English version of Stages of Change Scale for Exercise, and measured 6607 college students in China. The results show that Stage of Change-continuous Measure Scale (Chinese version) has high reliability and validity, and is an effective instrument for measuring the exercise Change stages of Chinese college students. Based on TTM theory, Yin Bo (2009) compiled a physical exercise behavior stage change scale according to the characteristics of Chinese college students, and measured 500 college students in China. The results showed that the scale had high reliability and validity.

There is no doubt that the Stages of Change Scale for Exercise developed by Marcus has made a significant contribution to the measurement of stage change and has been widely applied to various groups in eastern and Western countries. It is worth noting that due to the differences between Eastern and Western cultures and languages, the use of TTM to measure and study people's physical exercise behavior in China requires an accurate understanding of the meaning and context in the translation process. Based on the above analysis, this study plans to use the Questionnaire on Physical Exercise Behavior Changes of College Students (Yin Bo,2009) and adapt it into the Questionnaire on Physical Exercise Behavior Changes of Adolescents.

3. Study on the application of TTM in physical exercise

As a comprehensive and integrated psychological research method, TTM was originally created to reduce the unhealthy behavior of smoking. However, with the application of the researchers, the model has gradually been widely used in the field of health behavior and physical exercise and has been used in most health behavior change studies. This model is often used in cross-sectional studies, mainly to examine exercise behavior, and some researchers have also used TTM to conduct longitudinal studies and quasi-experimental studies on a small scale. In fact, through literature search, it is found that researchers have made many attempts to verify the effectiveness, extensibility and application of TTM in physical exercise.

Application in Western countries

Gorely (1995) uses TTM to research the exercise behavior of 483 elderly people, the purpose is to study the relationship between change stage, change process, self-efficacy, and balanced decision making. The results show that 5 of the 10 factors in the change process have important and unique contributions at each stage, and from the anticipation stage to the maintenance stage, self-efficacy and balanced decision making increase significantly.

Nigg & Courneya (1998) studied all components of TTM in 819 adolescents. The results showed that 2.1% of adolescents were in the pre-anticipation stage, 4.2% in the anticipation stage, 28.7% in the preparation stage, 15.7% in the action stage, and 49.3% in the maintenance stage. Research supports the hypothesis of this theory and indicates that at least one stage of exercise behavior change has been effectively identified.

Marshall & Biddle (2001) analyzed 71 research reports and summarized the results of the empirical application of TTM in the field of physical activity. The results of the study support the application of the theory because the core structure is different at different stages. (a) As more studies incorporate the TTM concept, there is a growing need to standardize tests and improve the reliability of measurements. (b) The available data do not yet confirm whether changes in physical activity behaviour occur in a series of phases of different nature or along adjacent parts of a continuum.

Plotnikoff & Blanchard (2001) examined the validity and reliability of decisional balance scales for exercise in 703 Canadian adults. This study established the content validity and structure validity of decisional balance scales for exercise, etc. The research results supported some views in the past, that is, the Table has good validity and reliability.

Some researchers tried to make cross-cultural comparison of TTM (Cardinal, 2004). They took 169 American college students and 168 Finnish college students as research subjects, translated the measurement questionnaire into Finnish, and then assessed the motor behavior of college students in the two countries on the basis of TTM. The findings support the role of TTM in understanding the motor behavior of college students in the United States and Finland, and the study observes that individuals differ in the core factors assessed at each stage of change, regardless of nationality or gender.

Spencer (2006) made a comprehensive review of TTM, and analyzed 150 studies between 1983 and 2003, among which 38 studies were about behavioral intervention measures, accounting for 25.3%. 70 studies were conducted to test the model with different populations, accounting for 46.%. There were 42 studies verifying this model, accounting for 28%. The findings of this study: (a) preliminary support for the use of this model for intervention in motor behavior. (b) Most current studies have focused on white, middle-class, and female groups, limiting their generality. (c) Measures of change phases, decision equilibria, change processes, and the presence of self-efficacy are validated, but more research is needed to complete these measures.

Pirzadeh's (2016) research on female group exercise behavior found that TTM can be used to find out the factors that affect female physical exercise, which is helpful for sports health practitioners to design effective intervention measures to increase female physical exercise.

Han & Gabriel (2017) used TTM to study the association between sedentary behavior and physical activity in college students, using accelerometers worn for seven days in addition to questionnaires. This study found gender differences in the stages and processes of change, but a lack of association between physical activity and the psychological determinants of sedentary behavior.

Nigg, C. R. (2019) and his colleagues believe that it is crucial to clarify the role

of each structure in the TTM. For example, if the decision balance variable is the determining factor, the intervention needs to focus on the importance of increasing the benefits and harms. Then, if the decision balance variable is the outcome, the intervention focus will affect the upstream variable. The findings suggest that intervention efforts should focus on altering self-efficacy, as well as cognitive processes associated with decision balance, to influence stage change in individuals.

In order to examine the correlation between TTM structures and confirm the role of TTM in predicting the physical activity of African-American Adolescents, Shaver (2019) and his colleagues surveyed the exercise behavior of 109 Adolescents in the community. The results show that self-efficacy shows an upward trend with the rise of stage change, and the factors in this theory are related to Adolescents physical activity, but may vary by gender.

Elezim & Elezi (2020) using a cross-sectional approach conducted a survey of 1066 Macedonian college students to verify the applicability of TTM in understanding college students' exercise behavior. The study found that more than 67% of the sample was in the pre-expected stage and that all TTM structures differed significantly at different stages of change. In addition, college students in the action stage and maintenance stage showed a stronger sense of self-efficacy than students in the pre-anticipation stage.

Ghaffari et al. (2021) conducted a cross-sectional study on predictors of physical activity among employees of Melli Bank in Tehran, based on the Transtheoretical Model (TTM). A multi-stratified sampling method was used to select 612 employees, and data were collected via a tripartite self-administered questionnaire, with statistical analysis performed using SPSS. The results indicated that self-efficacy was the foremost predictor of physical activity ($r = 0.682$, $p < 0.0001$), and nearly half of the participants had inadequate physical activity levels. The gap in this study lies in the use of self-reported data, which may introduce bias, and the lack of comparisons with other occupational groups.

Lapointe et al. (2023) conducted a study to assess the effectiveness of a personalized Transtheoretical Model (TTM) intervention based on "Processes of Change" (POC) to increase physical activity (PA) levels. The study employed an N-of-1 experimental design involving 12 inactive adults over a 10-week intervention,

featuring personalized POC targets and behavior change techniques. The results showed that self-reported PA significantly increased for 6 participants during the intervention, while device-measured PA increased in only two participants. This study provides the first evidence of the behavioral and psychological effects of a POC-personalized TTM intervention in inactive adults. The gap in this study lies in the discrepancy between device-measured and self-reported data, which may be due to high daily variability, and the need for more sophisticated statistical methods to better handle such variability.

Sheng et al. (2023) conducted a systematic review of the predictors of physical activity (PA) behavior transitions in children and adolescents based on the Transtheoretical Model (TTM). The study analyzed 25 articles (26 studies) involving 30,106 children and adolescents aged 11.24 to 17.7 years. The results showed that counter-conditioning, self-liberation, self-efficacy, and decisional balance are key elements that facilitate PA stage transition. Additionally, vigorous physical activity (VPA) was found to be an important discriminator of PA stages. The gap in this study is the lack of systematic analysis of TTM's applicability across different cultural contexts, suggesting future research should design more targeted interventions to optimize TTM applications.

Lu et al. (2022) conducted a systematic review and meta-analysis of changes in physical activity (PA) behavior in children and adolescents based on the Transtheoretical Model (TTM). The main purpose was to test the rationality of TTM and to analyze whether PA can effectively distinguish the stages of change. A total of 17 articles of medium and high quality were included. The results showed that changes in PA behavior in children and adolescents are related to the processes of change (POC), self-efficacy (SEI), and decisional balance (DBL), and these constructs have obvious stage characteristics. With increasing PA intensity, the discrimination of stages of change (SOC) improved, but PA still could not fully distinguish each stage. The gap in this study lies in the lack of systematic analysis across different cultural contexts. It is suggested that future research should use longitudinal surveys or experimental interventions to test the rationality of TTM and design more standardized measurement tools.

Application in Eastern countries

A study of 671 adolescents in South Korea (Kim, 2004) found a significant association between adolescent motor behavior and psychological variables in the stage change model, which may have a good impact on the development of adolescent exercise pattern interventions. Another study on Korean college students found that all structures within TTM were significantly correlated with motor behavior, which supported the application of TTM in the change of motor behavior of college students (Farmanbar, R et al, 2009).

Kim, Y. (2011) and his colleagues used TTM to examine the factors influencing physical activity of students in grades 4-6 in South Korea. The results support the previous view that decision balance, change process and self-efficacy can affect the change stage of individual sports behavior. However, it is important to note that no relevant factors showed significant changes from the behavioral phase to the maintenance phase. The study concluded that TTM can be used to explain the sports behavior of some children in South Korea, which is helpful to develop measures to improve the level of physical activity of children in Korean schools.

Using 202 college students in South Korea, Kang & Kim (2017) examined the full range of variables in the TTM to examine the predictors of naturally occurring (no intervention) phase changes in physical activity over a 6-month period. Research suggests that TTM can provide assistance for physical activity intervention of college students.

Liu & Kueh (2018) examined the relationship between TTM and physical activity in 562 university students in Malaysia. Using consisted of the decisional balance, processes of change, self- efficacy, stages of change scales. It is believed that an individual's stage changes will affect their level of self-efficacy, and then make a positive (or negative) response, thus affecting the individual's level of physical activity. The study confirmed that under TTM, adopting the right measures can improve the physical activity level of college students.

Kim et al. (2021) conducted a study on the physical activity of college students in Korea. The standardized TTM scales were used to assess the physical activity and stage changes of 598 Korean college students, analyzing the associations between different stages of physical activity and TTM constructs (including self-efficacy,

processes of change, and decisional balance). The study found that TTM constructs could distinguish college students across different stages of physical activity, with an overall classification accuracy of 53%. The gap in this study lies in its focus on the Korean cultural context, lacking cross-cultural comparisons, and its cross-sectional design, which limits causal inferences.

Kamran et al. (2023) conducted a study on the action status and willingness to change health-promoting behaviors among elementary school children during the COVID-19 pandemic, based on the Transtheoretical Model (TTM). This cross-sectional study involved 619 sixth-grade male students in Ardabil, Iran, using a researcher-made questionnaire and the Health Promoting Lifestyle Profile-II (HPLP-II) for data collection, analyzed via SPSS and ANOVA. The study found that the majority of students were in the pre-contemplation stage for both physical activity and healthy eating behaviors, with all health-promoting behavior dimensions significantly related to stages of change, self-efficacy, and decisional balance ($p < 0.001$). The gap in this study is its limitation to a single gender, and its cross-sectional design, which does not allow for causal inferences.

Application in China

Si Qi (2005) tested the application of TTM in Chinese college students. According to the study, the exercise behavior of Chinese college students can be divided into five stages (same as TTM), but the definitions of pre-anticipation stage, anticipation stage and TTM are different, which may be related to cultural, economic and other factors of the two countries.

Taking TTM as the theoretical basis and referring to the existing measurement instrument abroad, Yin Bo (2009) investigated college students under the background of Chinese culture, proposed a TTM of physical exercise behavior change with the characteristics of Chinese college students, and compiled a measurement instrument to provide an effective measurement instrument for the study of college students' physical exercise behavior. The study believes that TTM, as a comprehensive and integrated theoretical model, is one of the more effective theoretical models for physical exercise behavior change and intervention. This model can not only distinguish physical exercise behavior change into different stages of change, but also

combine corresponding change procedures in the change stage to propose targeted intervention measures. Thus better intervention effect can be obtained.

Callaghan (2010) took 298 college students from Hong Kong, China as research objects. According to the study, self-efficacy, exercise benefits, and nine lower factors in the process of change have statistically significant effects on the stage change of exercise behavior. It should be noted that the disadvantages of exercise did not change significantly with the stage of exercise behavior. Another study on Chinese male college students also supports this view: TTM can be used to test individual exercise level and promote exercise behavior change (Huo Fangwen, 2011).

Bao huhe (2012) translated the Physical Exercise Behavior Change Scale for College Students and formed a bilingual Chinese-Mongolian questionnaire. A questionnaire survey was conducted among 1000 Mongolian college students to verify the effectiveness of TTM intervention in the physical exercise behavior change of Mongolian college students. The corresponding relationship between the change stages and change procedures of the physical exercise behavior of Mongolian college students was explored, and the study concluded that the physical exercise behavior of Mongolian college students showed a "rugby ball" shape in the change stage.

Guo Yugang (2012) reviewed the research on the application of TTM in the field of college students' physical exercise at home and abroad, and summarized the current status of applying TTM to change college students' physical exercise behavior. He believed that the research on the change of college students' physical exercise behavior by application TTM can effectively promote the formation of college students' physical exercise behavior, but most of the current researches are descriptive. If the experimental intervention research can be carried out in combination with sports projects, it is worth looking forward to.

Cui Shijun (2014) investigated the physical exercise behavior of college students with a large sample based on TTM and adopted the change stage continuity scale and change procedure scale, and found that college students' physical exercise behavior has different characteristics in different stages. It is necessary to intervene according to the characteristics of college students' physical exercise behavior at different stages.

Hu Jubo (2014) believes that foreign scholars' research on TTM has developed from the theoretical discussion level to the clinical practice level, and its application

has also expanded from the withdrawal of addictive dependence (such as smoking cessation and alcohol withdrawal) to various aspects of physical exercise behavior. In China, the research on TTM mainly focuses on the division of change stages and the formulation and verification of stage change scale. The author used the Stage Change Scale (Si Qi, 2005) to study the physical exercise behavior of 533 college students. The study found that in recent years, there was no substantial change in the practice stage of physical exercise behavior of college students, and only a small number of students really participated in exercise. There were significant differences in self-efficacy and balanced decision-making at each stage. The research also conducted a difference test on the 6 factors of the change process and the change stage, and found that there were significant differences between self-release, self-management, consciousness control and the change stage.

Based on TTM theory, Jia Yunting (2018) studied the formation process of sports behavior of higher vocational students by using four questionnaires, including the Subscale of the Stages of Change of Sports Behavior of Students in higher vocational Colleges. The focus was on a comprehensive and in-depth analysis of the stages and procedures of change. It is found that the score of the continuous measurement scale of the change stage of motor behavior of higher vocational students is effective in determining the change stage of the subjects, and the self-efficacy and balanced decision scale have little contribution to the change stage. The structural equation model can be used to analyze the relationship between the change stage of motor behavior, the change procedure, self-efficacy and decision-making. It shows that the corresponding change program at each change stage can predict the movement of students.

Zheng Xiao (2019) application TTM to conduct a questionnaire survey on 932 college students in China, effectively integrated the change stages and change procedures, analyzed the stage changes of college students' physical exercise behavior, explored the role of change procedures in each stage, and built a model of college students' physical exercise behavior. According to the research, the current physical exercise behavior of college students presents the characteristics of "knowing but not doing", which conforms to the structure of TTM.

It has been more than 20 years since TTM was first introduced into China in

1998. Guo Zhengmao (2019) reviews domestic and foreign research articles on TTM based on the concept of TTM and the application of the model in the field of sports, summarizes the latest progress of the components, research objects and research types of TTM, and explores the existing problems in the research. According to the study, TTM describes human physical exercise behavior from a dynamic process, overcoming the limitation of dichotomy (exercise or no exercise), and is worthy of expectation in the application of physical exercise behavior change, but there are still some problems: First, most of the research objects are students, and the sample representation is insufficient. Second, most of the research types are descriptive research, while predictive research is controversial, and there are only two paradigms of intervention research. Future studies should comprehensively and deeply analyze the components of TTM and diversify the research objects and intervention methods.

In conclusion, many studies have verified that TTM can well explain and predict people's physical activity and exercise behavior, and all kinds of groups (adults, college students, adolescents) have good applicability in TTM. However, when application TTM, it is still necessary to pay attention to the following points: (a)Stages of Change Scale for Exercise and other measurement instrument are English version questionnaires. If used in non-English speaking countries, attention should be paid to the accuracy of translation. (b) The role of each variable in the TTM structure needs to be clarified, which will have a very important impact on the intervention. (c) The objects of the study should be diversified and the sample size should be increased. The influence of individual change procedures in different stages of change should be analyzed before intervention studies are carried out, and the design of intervention studies should be diversified.

4. Study on exercise behavior intervention

Concept of Intervention

The emergence of exercise behavior is often seen as a simple response to a health threat. When individuals realize that their health is threatened by their prolonged inactivity, they will take sound advice and make the decision to exercise. We all know that not exercising, or not exercising enough, can cause a host of public health problems. Many researchers and health workers have tried different methods to

increase people's participation in physical activity. This way and method is the intervention of exercise behavior. The purpose of exercise behavior intervention is to change the individual's behavior and make the individual make the decision to participate in exercise.

Types of intervention

Dishman and Buckworth (1996) conducted a meta-analysis of 127 studies using exercise interventions. These exercise interventions can be divided into seven types: Behavior modification, Cognitive behavior modification, Health education, health-risk appraisal, Exercise prescription, Combined interventions, Physical education curriculum. Researchers have found that Behavior modification intervention has a great amount of effect on improving exercise level, while other intervention methods have a small amount of effect. (Table 5)

Table 2 Types and effects of exercise intervention

Intervention characteristics	Effective dose
Intervention type	
• behavior modification	0.92
• cognitive behavior modification	0.10
• health education / health-risk appraisal	0.10
• exercise prescription	0.21
• combined interventions	0.11
• physical education curriculum	0.21

Some researchers have different views on the type of exercise intervention. Kahn et al (2002). conducted a comprehensive review of all published studies related to exercise behavioral interventions. For each study, the interventions were analyzed and the determinants of exercise behavior were identified, and based on this, the interventions were grouped into four categories: informational approaches, behavioral approaches, social approaches, environmental and policy approaches (Table 6).

Table 3 Determinants of intervention methods and exercise behavior

Intervention mode	Determinants of exercise behavior
Informational approaches	Knowledge about the benefits of exercise and how to get moving. Attitude towards exercise
Behavioral approaches	Successful participation in exercise or maintenance of exercise behavior, change required behavior management skills (such as goal setting and self-monitoring)
Social approaches	Social influences and social contexts that motivate exercise behavior (e.g. group exercise)
Environmental and policy approaches	Physical environments that support exercise behavior (such as community centers) and policies that support exercise

Scenarios and methods of implementation of intervention

The setting and way of intervention implementation are very important to the impact of intervention results. Some studies have shown (Dishman, & Buckworth, 1996) : (a) Compared with face-to-face intervention, intervention through intermediaries (media) has better effects. (b) Interventions are more effective in the community than in school or home Settings. (c) The effect of unsupervised intervention is better than that of supervised intervention (Table 7). This may indicate that people prefer to exercise in a relaxed environment.

Table 4 Exercise scenarios, methods and effects

Intervention characteristics	Effective dose
Intervention implementation mode	
• Face to face	0.16
• Mediated	0.91
• Face-to-face and mediated	0.10
Intervention implementation scenario	
• Family	0.08
• School	0.21
• Community	0.82
• Work site	0.17
• Health care site	0.24
Social background	
• Team	0.75
• Individual	0.16
• Family	0.05
Intervention supervision level	
• Supervised	0.23
• Unsupervised	0.78

Table 5 Exercise style, duration, intensity and effect amount

Intervention characteristics	Effective dose
Exercise style	
• Aerobic exercise	0.18
• Leisure activity	0.85
• Strength training	0.46
• Cardio + Other activities	0.15
Duration of exercise	
• Within 20 minutes	0.25
• 20 to 30 minutes	0.14
• 30 to 45 minutes	0.17
• 45 to 75 minutes	0.14
Exercise intensity	
• Less than 50% aerobic capacity	0.94
• 50% to 70% aerobic capacity	0.24
• Higher than 70% aerobic capacity	0.23

Dishman and Buckworth's study also found that the intervention had a greater impact on some exercise items, and the effect of the intervention aimed at leisure activities was better than that of the intervention aimed at strength exercise and aerobic exercise. It is worth noting that the amount of intervention effect did not change much as the frequency and duration of exercise changed. Studies have shown that low-intensity exercise interventions are more effective than high-intensity exercise interventions. (Table 8). This may indicate that most people like to start with easy, low-difficulty exercises.

Study on the effectiveness of intervention

Researchers reviewed 22 studies of physical activity in school and community Settings in preschool to college age populations (Stone & Mckenzie, 1998) with the aim of identifying the characteristics and effects of interventions. The results show that in the better studies using effective measurements and a wide range of interventions, there are significant changes in out-of-school physical activity among upper primary school students after the intervention, and some follow-up results show that physical activity is maintained after the intervention. Ruotsalainen (2015) summarized 14 published studies and concluded that: (a) Interventions had small and varied effects on adolescent physical activity, but supervised exercise interventions had significant effects on adolescent body mass index. (b) Interventions are complex and have multiple components, but exercise interventions affect BMI in overweight or obese adolescents.

Studies have also found that the intervention had little or no significant change in exercise behavior or physical activity of participants. A study by Frucht (1998) divided college students into an Experimental Group and a Control Group. After a continuous 6-week intervention, it was found that both the Experimental Group and the Control Group made progress in the behavioral stage, but no significant difference was reached between the two groups. The reason for this may be that the researchers did not design a Control Group that provided no information at all, because the provision of relevant information could lead to consciousness awakening for participants at any stage. Another study found that interventions had a small impact on increasing physical activity in adolescent girls (12-18 years) (Pearson, 2015).

Effective exercise behavior intervention is developed on the basis of the use of relevant theories and previous research results. The intervention method itself can not directly change the behavior of individuals, but it can affect the exercise behavior of individuals by affecting one or more determinants of exercise behavior (Si Qi, 2008).

Intervention research based on TTM

Marcus (1992) and his colleagues application TTM to design an intervention in which 1,559 volunteers were randomly assigned to either the intervention group or the standard group corresponding to the exercise phase, with both informational and behavioral interventions. The study found that over the subsequent three months, the intervention group showed more positive changes than the standard group. Marcus (1992) has also conducted intervention studies on different groups (adults and older adults). A 6-week exercise intervention of 610 adults showed a significant increase in exercise behavior after the 6-week intervention, with 62% of participants in the intention phase increasing exercise behavior, but unfortunately, there was no Control Group in this study. A 6-week intervention study of people over 50 years of age in the pre-anticipation, intention, and preparation stages found that physician-provided physical activity interventions may be an effective way to broadly improve physical activity in older adults (Marcus, 1997).

More researchers have developed behavioral interventions based on broader behavioral theories. Baranowski (1998) and his colleagues reviewed the effectiveness of these interventions and found that 25 studies used at least one theory or model as the basis for constructing the intervention, and TTM was one of the most frequently used theories, with the duration of the intervention being approximately 5-7 weeks.

Adams (2003) looked at 26 publications based on TTM and found that 16 of them were studies on behavioral interventions. Among the 16 studies, 7 used counseling as the main behavioral intervention, 4 application TTM as the basis for writing materials for intervention, and 5 used a combination of the above two approaches. Research results show that the phase-corresponding behavioral intervention is more effective than the unified behavioral intervention in promoting short-term exercise behavior (exercise behavior within 6 months), but for promoting long-term exercise behavior (exercise behavior longer than 6 months), the effect of phase-corresponding behavioral intervention is less than expected.

Carvalho (2016) reviewed 18 studies and found that application TTM based interventions is justified due to the complexity of people's lifestyles and the fact that people are multi-behavioral. At the same time, the study pointed out that future interventions should specify the nature and scale of TTM dimensions, and the use of these dimensions should be applicable to the general population.

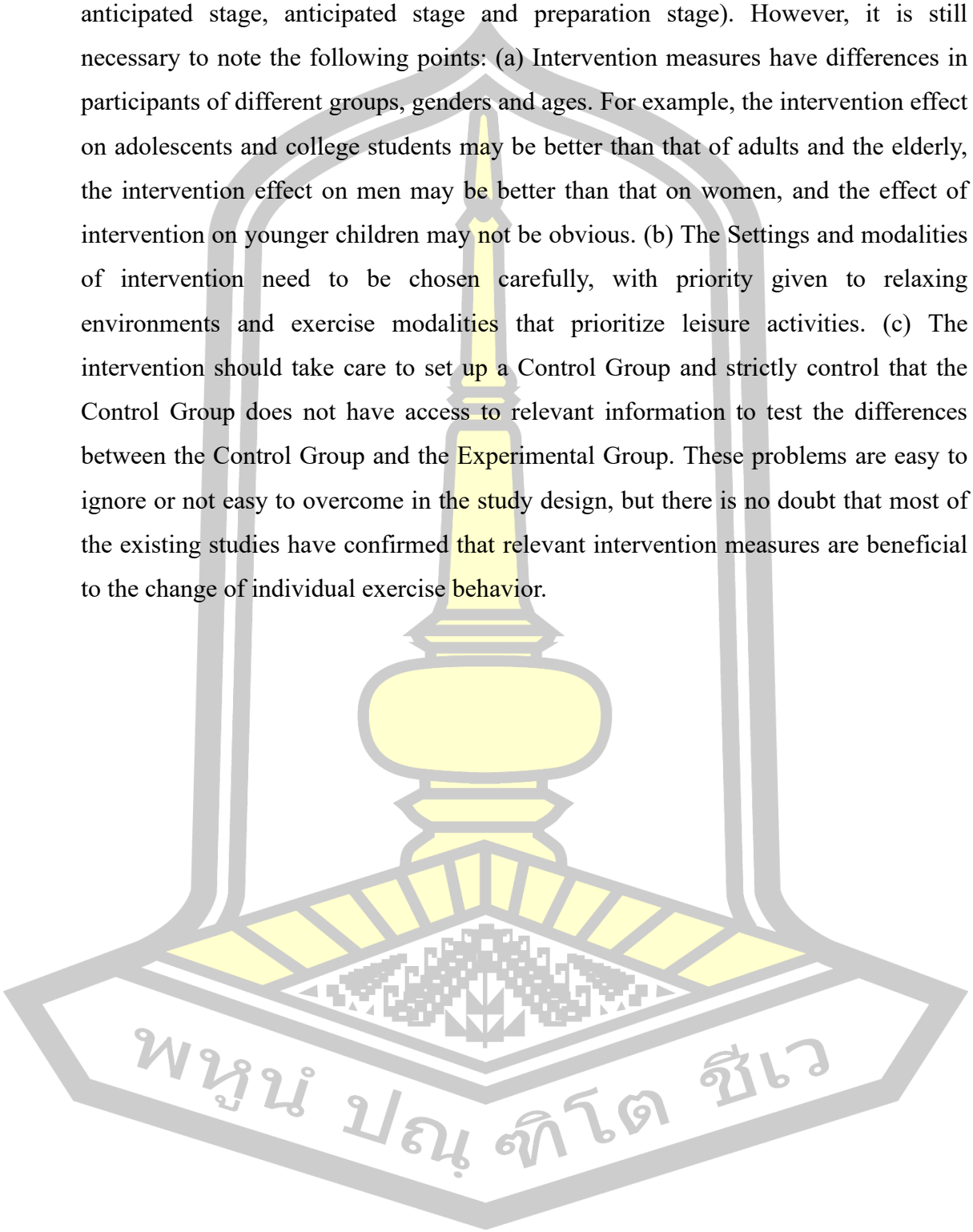
Romain et al. (2018) conducted a meta-analysis of randomized controlled trials to examine the efficacy of matched and nonmatched interventions based on the Transtheoretical Model (TTM) in promoting physical activity. Through systematic identification of 33 trials, the study found that TTM-based interventions effectively promoted physical activity regardless of whether they were matched to individuals' stages of change (SOC). The efficacy of interventions was influenced by TTM theoretical constructs such as self-efficacy and processes of change. The gap in this study is that it did not reveal significant differences between matched and nonmatched interventions and suggests further exploration of other factors affecting intervention outcomes.

To examine the effectiveness of TTM based interventions in improving physical activity in adults, Kleis (2020) searched the literature for studies conducted between 2001 and 2020. Research argues that evidence supporting the application TTM based interventions to improve physical activity in adults is inconsistent, and that interventions are more successful when materials are provided through face-to-face counseling, and when subjects are in the pre-expected or expected stage.

Pennington (2021) conducted a study on the application of the Transtheoretical Model (TTM) to establish physical activity habits. The study reviewed the use of TTM in exercise interventions and analyzed the role of its components in behavior change to help health professionals apply the model more effectively in practice. The results indicated that TTM is generally effective for promoting physical activity behavioral change, but not unconditionally. The gap in this study lies in the partial application of the model's constructs in some studies, especially lacking a multidimensional understanding of behavior change processes and long-term follow-up validation.

To sum up, it can be found that the intervention based on TTM is widely applicable to all groups. At the same time, it is worth affirming that the intervention

has obvious and good effects on the individuals in the first three stages (pre-anticipated stage, anticipated stage and preparation stage). However, it is still necessary to note the following points: (a) Intervention measures have differences in participants of different groups, genders and ages. For example, the intervention effect on adolescents and college students may be better than that of adults and the elderly, the intervention effect on men may be better than that on women, and the effect of intervention on younger children may not be obvious. (b) The Settings and modalities of intervention need to be chosen carefully, with priority given to relaxing environments and exercise modalities that prioritize leisure activities. (c) The intervention should take care to set up a Control Group and strictly control that the Control Group does not have access to relevant information to test the differences between the Control Group and the Experimental Group. These problems are easy to ignore or not easy to overcome in the study design, but there is no doubt that most of the existing studies have confirmed that relevant intervention measures are beneficial to the change of individual exercise behavior.



CHAPTER III
RESEARCH METHODS

This study involves both investigation and experimentation. The first phase focuses on developing the "Adolescent Physical Exercise Behavior Change" questionnaire, with the goal of creating a reliable measurement instrument for adolescent exercise behavior. The second phase involves administering the questionnaire to a sample of 2,100 participants to understand the stages of adolescent exercise behavior change and associated psychological variables. The third phase is a 12-week experimental study conducted with 100 subjects, aiming to verify whether TTM-based intervention has a significant impact on adolescents' exercise behavior.

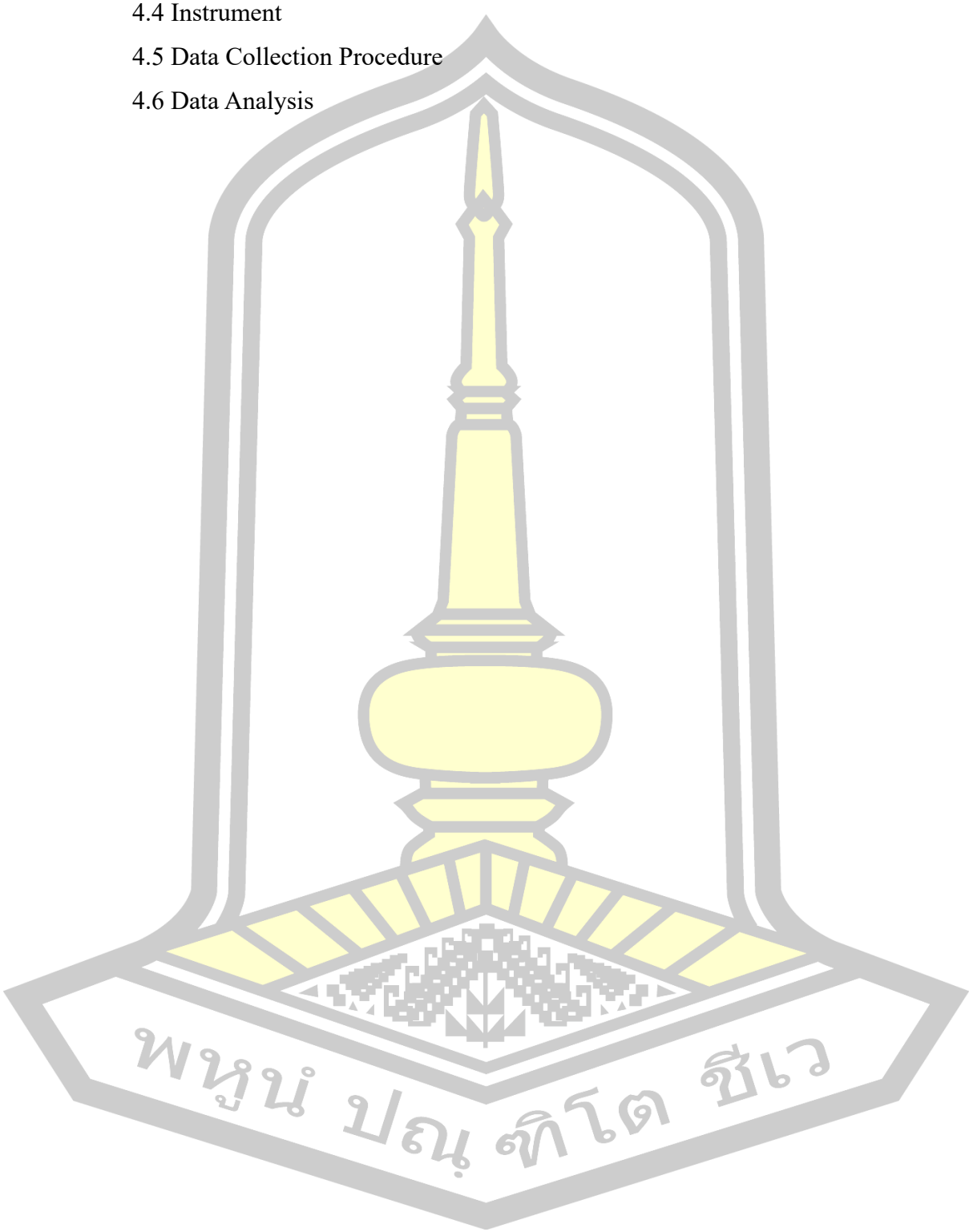
1. Research Design
2. Phase 1: Compile questionnaire
    - 2.1 Population and sample
    - 2.2 Inclusion criteria
    - 2.3 Exclusion criteria
    - 2.4 Instrument
    - 2.5 Sampling Procedure
    - 2.6 Data Collection Procedure
    - 2.7 Data Analysis
3. Phase 2: Extensive investigation
    - 3.1 Population and sample
    - 3.2 Inclusion criteria
    - 3.3 Exclusion criteria
    - 3.4 Instrument
    - 3.5 Sampling Procedure
    - 3.6 Data Collection Procedure
    - 3.7 Data Analysis
4. Phase 3: Experimental research
    - 4.1 Population and sample
    - 4.2 Inclusion criteria

4.3 Exclusion criteria

4.4 Instrument

4.5 Data Collection Procedure

4.6 Data Analysis



1. Research Design

This chapter outlines the overall design of the study, including the selection of test subjects and the data collection process. The core research method employed in this study is a questionnaire survey, followed by analysis using SPSS statistical methods (Figure 3).

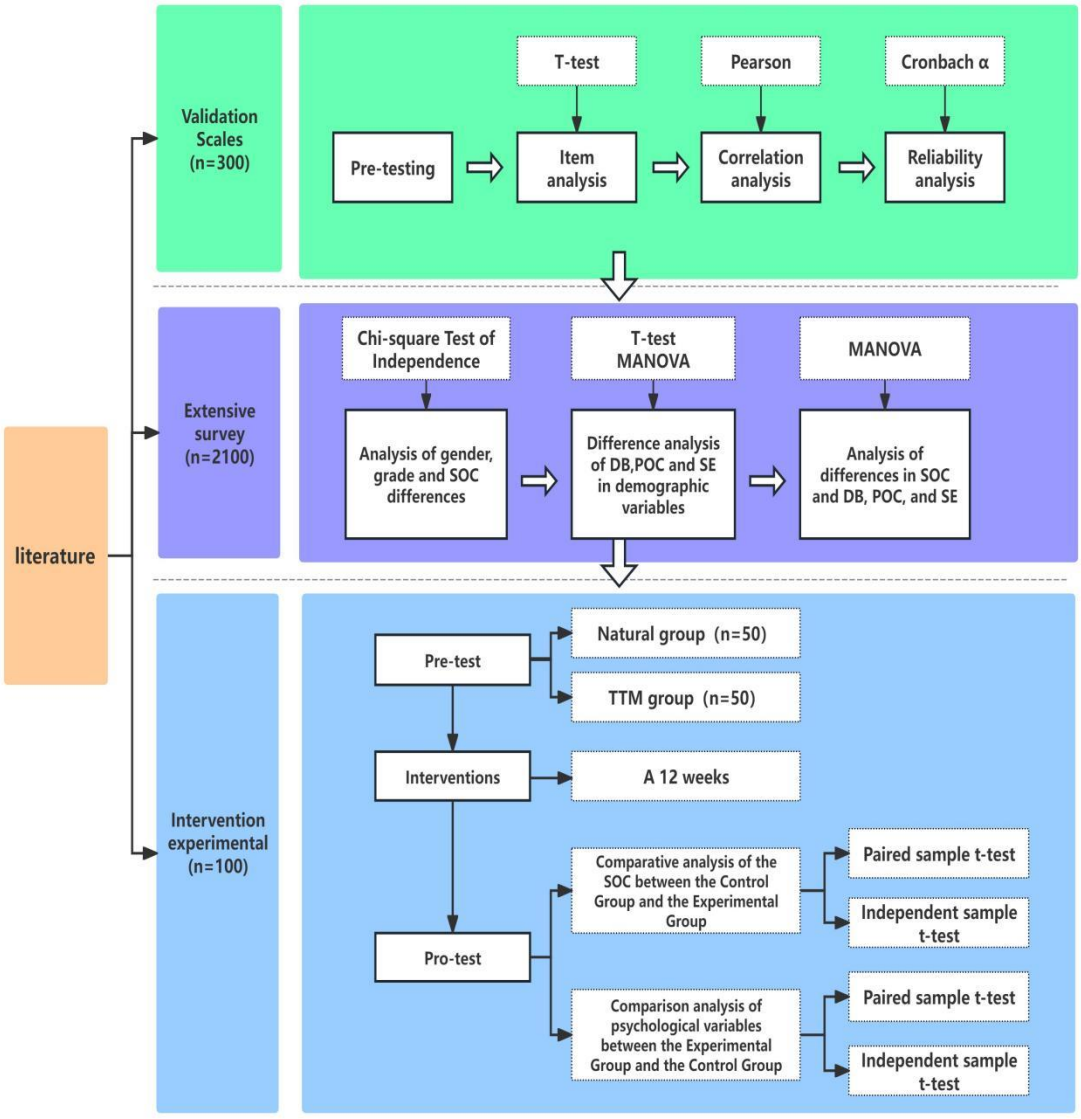


Figure 3 Study Design Framework

2. Phase 1: Develop questionnaire

Population and sample

This study was selected to be 210 for aged 13-17, and Cluster Sampling was conducted in Wuzhou City, Guangxi Province, China.(Table 9)

Inclusion criteria: 1) Adolescents aged 13-17, both male and female. 2) The volunteers were interested in this study and singed consent forms. 3) The volunteer were healthy, and have a certain Chinese language foundation, able to complete the questionnaire independently.

Exclusion criteria: 1) The volunteers are not interested in this study. 2) The volunteers can't exercise, and can't complete the questionnaire independently. 3) Physical deformities or psychiatric disorders. 4) Underlying diseases including musculoskeletal, neurological and cardiopulmonary disorders.

Instrument

The instrument used in this study is the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ), which comprises five subscales: the Stages of Change Scale (SOC-Scale), Physical Exercise Behavior Scale (PEB-Scale), Decisional Balance Scale (DB-Scale), Processes of Change Scale (POC-Scale), and Self-Efficacy Scale (SE-Scale). The APEBCQ was developed in Chinese to ensure cultural relevance, and all respondents provided their responses in Chinese, facilitating accurate comprehension and data collection within the target population.

Stages of Change Scale (SOC-Scale): This ordinal scale is used to assess the participants' stage of exercise behavior. It includes five options: Precontemplation, Contemplation, Preparation, Action, and Maintenance.

Physical Exercise Behavior Scale (PEB-Scale): This interval scale measures the participants' physical exercise behavior using a 5-point Likert scale with options ranging from Never(1 point), Rarely(2 point), Sometimes(3 point), Often(4 point), Always(5 point). The ratings are as follows:

1 = Never (I have never done this)

2 = Rarely (I almost never do this, about 1-2 times per month)

3 = Sometimes (I occasionally do this, about 3-5 times per month)

4 = Often (I frequently do this, about 1-2 times per week)

5 = Always (I do this almost eve)

Referring to the suggestions of Yin Bo (2009) and others, this study was based on the average score of the items, physical exercise behavior can be categorized into 5 levels, with the following standards:

1.00 - 1.80: Never exercise

1.81 - 2.60: Rarely exercise

2.61 - 3.40: Sometimes exercise

3.41 - 4.20: Often exercise

4.21 - 5.00: Always exercise

Decisional Balance Scale (DB-Scale): This interval scale evaluates the participants' perceptions of the pros and cons of engaging in physical exercise, divided into Negative factors and Positive factors. It uses a 5-point Likert scale, with options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point).

Processes of Change Scale (POC-Scale): This interval scale measures ten common strategies used by participants during the process of physical exercise. It also employs a 5-point Likert scale with the same options: Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point).

Self-Efficacy Scale (SE-Scale): This interval scale assesses participants' confidence in their ability to engage in physical exercise, covering dimensions of Exercise willingness and Exercise effort. It uses a 5-point Likert scale, with options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point).

Seven experts from the fields of sport psychology, school physical education, exercise physiology, and physical education evaluated the content validity of the questionnaire. The results of the Item Objective Congruence (IOC) assessment indicated that the Content Validity Index (CVI) for the entire scale was 0.96, demonstrating high content validity (see Appendix B).

Sampling Procedure

To ensure an accurate representation of each grade group, this study employed stratified random sampling. In stratified random sampling, the population is first

divided into homogeneous groups or strata, which may be based on a single criterion, such as grade level (Haque, 2010). This study divided the grades into six strata (corresponding to six grades) and randomly selected samples in equal proportions from each stratum according to a 1:1 ratio. The investigators were organized into six teams, with each team consisting of two staff members responsible for collecting sample information from one grade.

Table 6 Phase 1 Sample

Grade	Sample
Junior high school，First grade	50
Junior high school，Second grade	50
Junior high school，Third grade	50
High school，First grade	50
High school，Second grade	50
High school，Third grade	50
Total	300

Data Collection Procedure

1.Test time and test location

1.1 Test time: May 2024

1.2 Test location: Wuzhou High School, Wuzhou City, Guangxi Province, China

2. Procedure

2.1 The staff arranged and research assistant for the subjects to sit together in a quiet classroom.

2.2 The staff handed out questionnaires, explained the precautions, and told the subjects that they should fill in the questionnaires truthfully according to their own situation. Staff should prepare a number of questionnaires, encountered a format filling in the wrong, to timely issue a new questionnaire to fill in.

2.3 After 40 minutes, the staff will collect the questionnaire.

2.4 Questionnaire processing and data entry.

Data Analysis

1. Item Objective Congruence (IOC)

IOC is a method used to assess the alignment between test items and their intended measurement objectives. Introduced by Rovinelli and Hambleton in 1977, the IOC method ensures through quantitative analysis that each test item accurately measures the intended content, thus enhancing the test's content validity. The core principle of IOC involves expert evaluation to determine the degree of alignment between each test item and its intended objective. These experts are usually scholars or professionals with a deep understanding of the test content and objectives. The IOC method's key feature is its ability to transform subjective evaluations into quantitative indicators, facilitating the analysis and refinement of test items. Typically, 3 to 5 experts are invited to rate the relevance of each test item to its measurement objective on a scale from 0 to 1, where 0 indicates irrelevance and 1 indicates complete relevance. The IOC index for each item is then calculated based on these ratings. The specific calculation method is as follows:

$$IOC = \frac{\sum_{i=1}^{n} S_i}{\mathrm{n}}$$

In this context, (S_i) denotes the relevance score assigned by the (i)th expert to a specific item, while (n) represents the total number of experts. The suitability of each item is assessed based on the IOC index value; generally, a higher IOC index indicates a stronger alignment between the item and its intended measurement objective. For this study, seven experts from the fields of psychology, sports psychology, education, and physical education were invited to evaluate the questionnaire (Table 10).

Table 7 Item Objective Congruence

Name	Affiliation	Title
Zhou Jiaying	Xi'an Physical Education University	Professor
Wan Bingjun	Shanxi Normal University	Professor
Chang Shuzhi	Tianjin University of Sport	Professor
Wang Juhai	Weinan Normal University	Professor
Chen Shanping	Xi'an Jiaotong University	Professor
Cha Yi	Xi'an University	Professor
Liu Changjiang	Xi'an Jiaotong University	Professor

These experts rated each item on a scale from 1 to -1, with 1 indicating "clearly measuring," 0 indicating "degree to which it measures the content area is unclear," and -1 indicating "clearly not measuring." The results of the experts' evaluations unanimously indicated that most questionnaire items clearly measured the intended targets. Therefore, the measurement tool in this study was validated by seven experts (Appendix C).

2. Item analysis

The primary purpose of item analysis is to assess the suitability of items within a constructed scale. The most commonly used discriminative indicator in item analysis is the Critical Ratio (CR), which determines the CR-Value for individual items in a questionnaire. For a well-constructed attitude scale item, the mean scores between the high-score and low-score groups should differ significantly ($p < 0.05$). If the difference is not significant, the item should be considered for removal. Additionally, the t-value obtained from an independent samples t-test can be used as a critical ratio; a higher t-value indicates better item discrimination.

The process begins by calculating the total score for all items in the scale and ranking all participants by their total scores. The top 27% of scores constitute the high-score group, while the bottom 27% form the low-score group. An independent samples t-test is then performed on each item's scores between these two groups. A significant difference between the groups indicates that the item has good discriminatory power and should be retained. It is crucial to first determine whether

the variances of the two groups are equal. If equal, the t-value from the "Equal variances assumed" column is used; if not equal, the t-value from the "Equal variances not assumed" column is referenced.

3. Pearson correlation analysis

Examining the correlation between individual items and the total score using internal consistency testing is another crucial criterion for item selection, typically assessed with the Pearson correlation coefficient. If the correlation between an item and the total score is greater than 0.40 and statistically significant ($P < 0.05$), it indicates a moderate to high relationship. A larger Pearson correlation coefficient signifies a stronger correlation.

4. Reliability analysis

Reliability refers to the stability and consistency of the results obtained from a measurement tool. Higher reliability indicates a smaller standard error of measurement. In social sciences, especially when using Likert scales, Cronbach's alpha coefficient (Cronbach α) is commonly employed for reliability testing. This method was introduced by Cronbach in 1951. The formula is:

$$\alpha = \frac{K}{K-1}\left(1-\frac{\sum S_i^2}{S^2}\right)$$

Where K represents the total number of items included in the scale;

Where $\sum S_i^2$ is the sum of the variances of the items in the scale; and S^2 is the variance of the sum of the items in the scale.

The value of α ranges between 0 and 1, with the probability of extreme values (0 or 1) being very low. In the field of social sciences, there has been considerable discussion regarding the minimum accepTable α coefficient. Many scholars have expressed their views on this matter. Henson (2001) suggests that if the purpose is to develop a pilot questionnaire or measure a construct, an α coefficient between 0.50 and 0.60 is sufficient. However, for basic research purposes, the α coefficient should ideally be above 0.80. Nunnally (1967) posits that in general exploratory research, the

minimum standard for the α coefficient is above 0.50, with values above 0.60 considered relatively good. In applied and confirmatory research, the α coefficient should ideally be above 0.80, with values above 0.90 being preferable. Wu Minglong (2009), after synthesizing the views of several scholars, provided a summary judgment on the α coefficient indicator (Table 11).

Table 8 Judgment of α Coefficient

Cronbach's Alpha	Factor construct	Scale
α<0.50	Not Ideal	Highly UnaccepTable
0.50 ≤ α < 0.60	AccepTable	UnaccepTable
0.60 ≤ α < 0.70	Barely Adequate	Barely AccepTable
0.70 ≤ α < 0.80	Reliability	AccepTable
0.80 ≤ α < 0.90	High Reliability	Ideal
α ≥ 0.90	Very High Reliability	Highly Ideal

When conducting reliability tests, it is important to examine the change in the overall α coefficient of the scale after deleting individual items. If the α coefficient of the scale significantly increases after the deletion of a particular item, it may indicate that this item measures a different attribute or psychological variable compared to the other items, suggesting a low homogeneity with the other items. In such cases, after analysis, it may be necessary to consider removing this item. It is also crucial to note that if the scale encompasses two or more different constructs, the α coefficient for the scale should be calculated separately for each subscale representing these different constructs.

3. Phase 2: Extensive investigation

Population and sample

J. A. & Creswell, J. W. (2002) believes that the number of formal samples should be defined based on the attributes of the questionnaire survey. In general questionnaire research, the number of formal samples should preferably be more than 350 people. Wu Minglong (2010) believes that for a finite population, it should be calculated according to the sample size formula:

$$n \geq \frac{N}{\left(\frac{\alpha}{\kappa}\right)^2 \times \frac{N-1}{P(1-P)} + 1}$$

There are about 500,000 adolescents aged 13-17 in Guangxi Province. The sample size should be:

$$n \geq \frac{N}{\left(\frac{\alpha}{\kappa}\right)^2 \times \frac{N-1}{P(1-P)} + 1} = \frac{500000}{\left(\frac{0.05}{1.96}\right)^2 \times \frac{500000-1}{0.50 \times (1-0.50)} + 1} = 385$$

Based on the above sample size formula, the minimum sample size for the adolescent population should be no less than 385 participants. To ensure that the study results are broadly representative and reflect the overall situation of adolescents in Guangxi Province, this study decided to expand the sample size to 2,100 participants. Considering that there are approximately 500,000 adolescents in Guangxi Province, we will randomly select samples from 14 cities across the province to enhance the study's comprehensiveness and the generalizability of the conclusions.

Inclusion criteria: 1) Adolescents aged 13-17, both male and female. 2) The volunteers were interested in this study and singed consent forms. 3) The volunteer were healthy, and have a certain Chinese language foundation, able to complete the questionnaire independently.

Exclusion criteria: 1) The volunteers are not interested in this study. 2) The volunteers can't exercise, and can't complete the questionnaire independently. 3) Physical deformities or psychiatric disorders. 4) Underlying diseases including musculoskeletal, neurological and cardiopulmonary disorders.

Instrument

The measurement scale used in this study is the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ), which consists of five subscales: the Stages of Change Scale (SOC-Scale), Physical Exercise Behavior Scale (PEB-Scale), Decisional Balance Scale (DB-Scale), Processes of Change Scale (POC-Scale), and Self-Efficacy Scale (SE-Scale). The APEBCQ was developed in Chinese to ensure cultural relevance, and all respondents provided their responses in Chinese, facilitating accurate comprehension and data collection within the target population.

Stages of Change Scale (SOC-Scale): This ordinal scale is used to assess the participants' stage of exercise behavior. It includes five options: Precontemplation, Contemplation, Preparation, Action, and Maintenance.

Physical Exercise Behavior Scale (PEB-Scale): This interval scale measures the participants' physical exercise behavior using a 5-point Likert scale with options ranging from Never(1 point), Rarely(2 point), Sometimes(3 point), Often(4 point), Always(5 point). The ratings are as follows:

1 = Never (I have never done this)

2 = Rarely (I almost never do this, about 1-2 times per month)

3 = Sometimes (I occasionally do this, about 3-5 times per month)

4 = Often (I frequently do this, about 1-2 times per week)

5 = Always (I do this almost eve)

Referring to the suggestions of Yin Bo (2009) and others, this study was based on the average score of the items, physical exercise behavior can be categorized into 5 levels, with the following standards:

1.00 - 1.80: Never exercise

1.81 - 2.60: Rarely exercise

2.61 - 3.40: Sometimes exercise

3.41 - 4.20: Often exercise

4.21 - 5.00: Always exercise

Decisional Balance Scale (DB-Scale): This interval scale evaluates the participants' perceptions of the pros and cons of engaging in physical exercise, divided into Negative factors and Positive factors. It uses a 5-point Likert scale, with

options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Decisional Balance (DB) Scale consists of 8 items, with each item scored on a scale from 1 to 5, resulting in a total score range of 8 to 40. In this study, the total score of the DB Scale will be used to analyze the variable "Decisional Balance (DB)."

Processes of Change Scale (POC-Scale): This interval scale measures ten common strategies used by participants during the process of physical exercise. It also employs a 5-point Likert scale with the same options: Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Processes of Change (POC) Scale consists of 40 items, each scored on a scale from 1 to 5, resulting in a total score range of 40 to 200. In this study, the total score of the POC Scale will be used to analyze the variable "Processes of Change (POC)."

Self-Efficacy Scale (SE-Scale): This interval scale assesses participants' confidence in their ability to engage in physical exercise, covering dimensions of Exercise willingness and Exercise effort. It uses a 5-point Likert scale, with options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Self-Efficacy (SE) Scale consists of 8 items, each scored on a scale from 1 to 5, resulting in a total score range of 8 to 40. In this study, the total score of the SE Scale will be used to analyze the variable "Self-Efficacy (SE)."

Seven experts from the fields of sport psychology, school physical education, exercise physiology, and physical education evaluated the content validity of the questionnaire. The results of the Item Objective Congruence (IOC) assessment indicated that the Content Validity Index (CVI) for the entire scale was 0.96, demonstrating high content validity (see Appendix B).

Sampling Procedure

To accurately capture each grade group, this study employed stratified random sampling, dividing the population into six grade-based strata and selecting samples in equal proportions. Six teams, each with two members, collected data from one specific grade (see Table 12).

Table 9 Phase 2 Sample

Grade/ City	Junior high school			High school			Total
	1 Grade	2 Grade	3 Grade	1 Grade	2 Grade	3 Grade	
Nan Ning	25	25	25	25	25	25	150
Liu zhou	25	25	25	25	25	25	150
Gui lin	25	25	25	25	25	25	150
Wu zhou	25	25	25	25	25	25	150
Bei hai	25	25	25	25	25	25	150
Fang cheng	25	25	25	25	25	25	150
Qin zhou	25	25	25	25	25	25	150
Gui gang	25	25	25	25	25	25	150
Yu lin	25	25	25	25	25	25	150
Bai se	25	25	25	25	25	25	150
He zhou	25	25	25	25	25	25	150
He chi	25	25	25	25	25	25	150
Lai bin	25	25	25	25	25	25	150
Chong zuo	25	25	25	25	25	25	150
Sum	350	350	350	350	350	350	2100

Data Collection Procedure

1.Test time and test location

1.1 Test date: May 2024

1.2 Test location: 14 cities in Guangxi Province, China

2. Procedure

2.1 The research staff and research assistant arranged for the subjects to sit together in a quiet classroom.

2.2 The research assistant handed out questionnaires, explained the precautions, and told the subjects that they should fill in the questionnaires truthfully according to their own situation. The research staff should prepare a number of questionnaires, encountered a format filling in the wrong, to timely issue a new questionnaire to fill

in.

2.3 After 40 minutes, the research assistant will collect the questionnaire.

2.4 Questionnaire processing and data entry.

Data Analysis

1. Descriptive statistics

Descriptive statistics are primarily used to describe and summarize the basic features of data. This involves comprehensively describing the data through measures of central tendency, dispersion, and distribution shape. Measures of central tendency include the mean, median, and mode. Measures of dispersion include standard deviation, variance, range, and interquartile range. Skewness and kurtosis are used to describe the distribution shape of the data. Before conducting data and model analysis, it is necessary to check whether the data follows a normal distribution. According to Kline (1998), if the absolute value of skewness is within 3 and the absolute value of kurtosis is within 8, the data can be considered to approximately meet the normal distribution requirements.

2. Chi-square Test of Independence

The Chi-square Test of Independence is a commonly used non-parametric statistical method to determine whether there is a statistically significant association between two categorical variables. It evaluates the independence of these variables by comparing the observed frequencies with the expected frequencies under the assumption of no association. This test is applicable to data in contingency tables and is typically used to analyze nominal or dichotomous variables. In this analysis, conclusions can only be drawn regarding the relationship between the variables (Turhan, N. S., 2020).

The principle of the Chi-square Test of Independence is to compare the observed frequencies (actual data) with the expected frequencies (the frequencies under the assumption of independence) to calculate the Chi-square statistic (X^2). If the difference between the observed and expected frequencies is significant, it indicates an association between the two variables, meaning they are not independent.

The formula for the Chi-square Test of Independence is as follows:

$$X^2 = \sum \frac{(O_{r,c} - E_{r,c})^2}{E_{r,c}}$$

X^2 : Chi-square statistic

$O_{r,c}$: Is the observed frequency number at the level r of the variable A and the level c at the variable B.

$E_{r,c}$: is the expected frequency number at the level r of the variable A and the level c of the variable B.

The value P is the observation probability of a sample statistic that is as extreme as test statistic. Test statistic is chi-square, so it is used to evaluate a probability that is related to the test statistics.

3. T-test

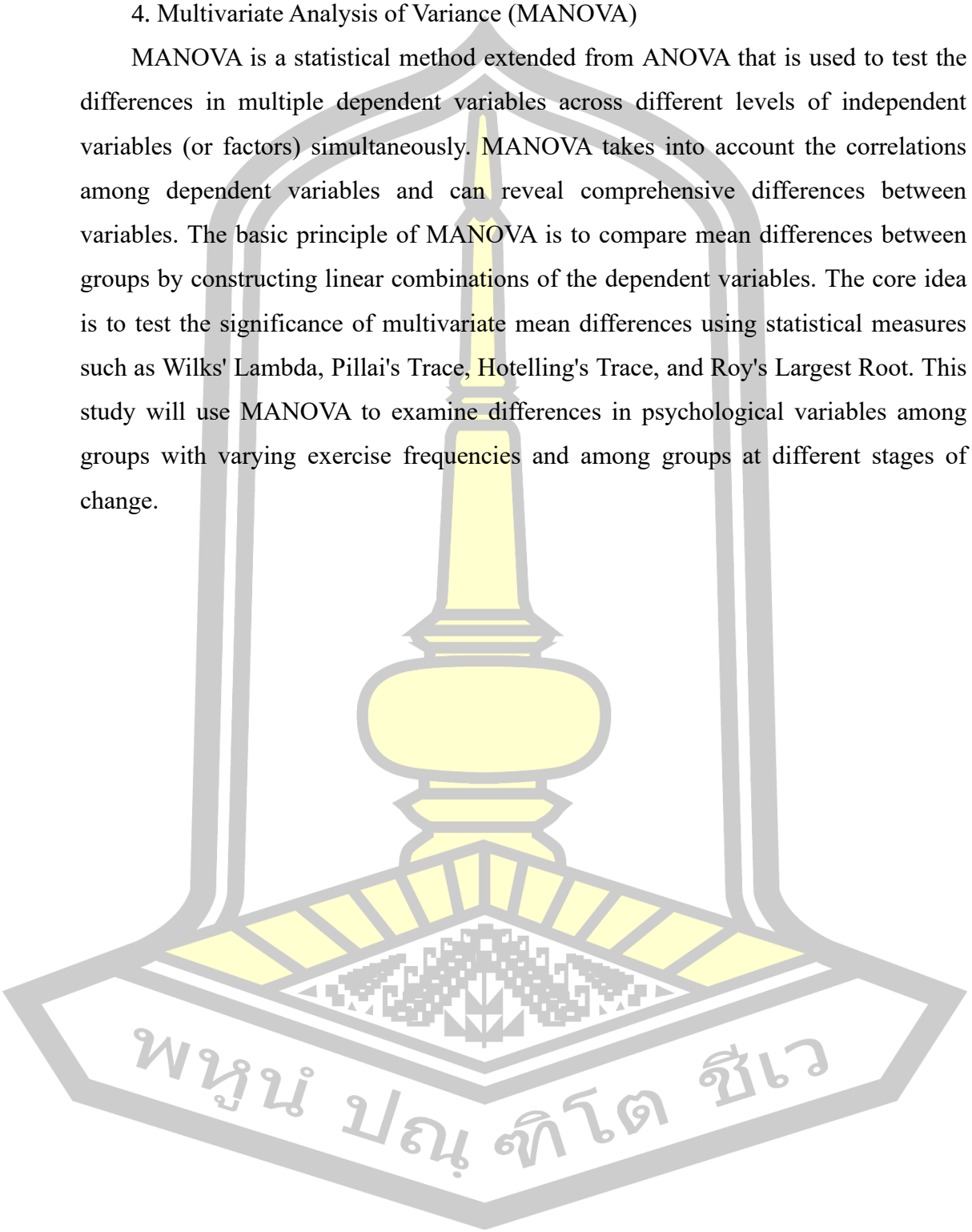
It is a parametric statistical method used to compare the difference in means between two samples, primarily to test whether the samples come from populations with the same mean. The T-test is commonly used when the sample size is small and the data is normally distributed. Depending on the objects of comparison, the T-test can be categorized into Independent Samples T-test, Paired Samples T-test, and One-Sample T-test. The fundamental principle of the T-test is to calculate the T statistic to compare the difference between sample means and the hypothesized mean. The formula for calculating the T statistic is:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}}}$$

Where $\bar{X}_1$ and $\bar{X}_2$ are the means of the two samples, S_1^2 and S_2^2 are the variances of the two samples, and n_1 and n_2 are the sample sizes of the two groups. The T-test assesses whether to reject the null hypothesis (i.e., that the means of the two samples are equal) by comparing the calculated T statistic with the critical values from the T distribution Table. This study will use the Independent Samples T-test to examine differences in psychological variables across different genders and different grade levels.

4. Multivariate Analysis of Variance (MANOVA)

MANOVA is a statistical method extended from ANOVA that is used to test the differences in multiple dependent variables across different levels of independent variables (or factors) simultaneously. MANOVA takes into account the correlations among dependent variables and can reveal comprehensive differences between variables. The basic principle of MANOVA is to compare mean differences between groups by constructing linear combinations of the dependent variables. The core idea is to test the significance of multivariate mean differences using statistical measures such as Wilks' Lambda, Pillai's Trace, Hotelling's Trace, and Roy's Largest Root. This study will use MANOVA to examine differences in psychological variables among groups with varying exercise frequencies and among groups at different stages of change.



4. Phase 3: Experimental research

Population and sample

The subjects were all from Wuzhou City, Guangxi Province, and were adolescents aged 13-17 years old.

Inclusion criteria: 1) 2 Grade for Junior high school students, 2 Grade for High school students, both male and female. 2) The volunteers were interested in this study and singed consent forms. 3) The volunteer were healthy, and have a certain Chinese language foundation, able to complete the questionnaire independently. 4) The volunteers are willing to accept the 12-week intervention experiment.

Exclusion criteria: 1) The volunteers are not interested in this study. 2) The volunteers can't exercise, and can't complete the questionnaire independently. 3) Physical deformities or psychiatric disorders. 4) Underlying diseases including musculoskeletal, neurological and cardiopulmonary disorders. 5) The volunteers unable to complete the 12-week exercise intervention.

Instrument

1. Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ)

The measurement scale used in this study is the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ), which consists of five subscales: the Stages of Change Scale (SOC-Scale), Physical Exercise Behavior Scale (PEB-Scale), Decisional Balance Scale (DB-Scale), Processes of Change Scale (POC-Scale), and Self-Efficacy Scale (SE-Scale). The APEBCQ was developed in Chinese to ensure cultural relevance, and all respondents provided their responses in Chinese, facilitating accurate comprehension and data collection within the target population.

Stages of Change Scale (SOC-Scale): This ordinal scale is used to assess the participants' stage of exercise behavior. It includes five options: Precontemplation, Contemplation, Preparation, Action, and Maintenance.

Physical Exercise Behavior Scale (PEB-Scale): This interval scale measures the participants' physical exercise behavior using a 5-point Likert scale with options ranging from Never(1 point), Rarely(2 point), Sometimes(3 point), Often(4 point), Always(5 point). The ratings are as follows:

1 = Never (I have never done this)

2 = Rarely (I almost never do this, about 1-2 times per month)

3 = Sometimes (I occasionally do this, about 3-5 times per month)

4 = Often (I frequently do this, about 1-2 times per week)

5 = Always (I do this almost eve)

Referring to the suggestions of Yin Bo (2009) and others, this study was based on the average score of the items, physical exercise behavior can be categorized into 5 levels, with the following standards:

1.00 - 1.80: Never exercise

1.81 - 2.60: Rarely exercise

2.61 - 3.40: Sometimes exercise

3.41 - 4.20: Often exercise

4.21 - 5.00: Always exercise

Decisional Balance Scale (DB-Scale): This interval scale evaluates the participants' perceptions of the pros and cons of engaging in physical exercise, divided into Negative factors and Positive factors. It uses a 5-point Likert scale, with options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Decisional Balance (DB) Scale consists of 8 items, with each item scored on a scale from 1 to 5, resulting in a total score range of 8 to 40. In this study, the total score of the DB Scale will be used to analyze the variable "Decisional Balance (DB)."

Processes of Change Scale (POC-Scale): This interval scale measures ten common strategies used by participants during the process of physical exercise. It also employs a 5-point Likert scale with the same options: Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Processes of Change (POC) Scale consists of 40 items, each scored on a scale from 1 to 5, resulting in a total score range of 40 to 200. In this study, the total score of the POC Scale will be used to analyze the variable "Processes of Change (POC)."

Self-Efficacy Scale (SE-Scale): This interval scale assesses participants' confidence in their ability to engage in physical exercise, covering dimensions of Exercise willingness and Exercise effort. It uses a 5-point Likert scale, with options from Strongly disagree(1 point), Not agree(2 point), Indeterminate(3 point), Agree(4 point), to Strongly agree(5 point). The Self-Efficacy (SE) Scale consists of 8 items,

each scored on a scale from 1 to 5, resulting in a total score range of 8 to 40. In this study, the total score of the SE Scale will be used to analyze the variable "Self-Efficacy (SE)."

Seven experts from the fields of sport psychology, school physical education, exercise physiology, and physical education evaluated the content validity of the questionnaire. The results of the Item Objective Congruence (IOC) assessment indicated that the Content Validity Index (CVI) for the entire scale was 0.96, demonstrating high content validity (see Appendix B).

2. Transtheoretical Model (TTM) Plan

This study adopts the "TTM Group Experimental Intervention Plan," which has been evaluated by seven Chinese experts using the Index of Item-Objective Congruence (IOC) (see Appendix E). The intervention plan includes the following:

Content and Purpose: Intervention factors designed based on the fundamental Transtheoretical Model (TTM).

Objective: To educate participants on health and physical exercise knowledge, share and discuss exercise methods, and assist in developing exercise plans and goals.

Schedule: Every Monday from 4:00 to 5:00 PM, lasting 60 minutes.

Equipment: A quiet classroom within the school and multimedia equipment such as computers, projectors, and microphones.

Activities Form:

Knowledge Lecture: Provide explanations of physical exercise knowledge, focusing on how individuals can seek information about physical activity, and understand the benefits of exercise and the consequences of inactivity. This includes showing exercise-related videos and distributing exercise guides to enhance participants' understanding.

Experience Sharing: Use methods from psychological development involving experience sharing and discussion, such as sharing exercise experiences and skills to encourage peer learning.

Exercise Recording: Have participants record their daily routines over the course of a week to help them understand their time management, guide them in planning physical activities, and set exercise goals.

Process: The intervention activities are divided into 3-4 segments, each lasting 15-20 minutes.

Sampling Procedure

This study used stratified random sampling to divide the population into 5 strata based on the stage of change. A total of 100 students were selected to participate in the experimental study, including 24 in Precontemplation, 20 in Contemplation, 20 in Preparation, 20 in Action, and 16 in Maintenance. The 100 participants were divided into two groups: the Control Group and the TTM group. The grouping criterion was to ensure that the ratio of participants in different stages of change was 1:1 across the two groups (Table 13).

Table 10 Phase 3 Sample

	Precontemplation	Contemplation	Preparation	Action	Maintenance	Total
Control Group	12	10	10	10	8	50
Experimental Group	12	10	10	10	8	50

Data Collection Procedure

1.Test time and test location

1.1 Testing time: May-August 2024

1.2 Test location: Wuzhou High School, Wuzhou City, Guangxi Province, China

2. Procedure

2.1 Pre-intervention testing, identification and examination of research instrument.

2.2 Create a log sheet to record the relevant data of the intervention process (time, place, content, etc.).

2.3 The subjects in the TTM group and the Control Group were pre-tested, and the "Adolescent Physical Exercise Behavior Change Questionnaire" was filled in. SPSS was used to collect and input the data. The process of filling in the questionnaire is the same as in phase 2.

2.4 The experimental research staff explained the experimental methods, procedures and requirements to the subjects.

2.5 The Experimental Group was interfered with once a week for 60 minutes each time for 12 weeks. When carrying out the intervention, the experimental research staff should strictly abide by the experimental requirements and should not impose any intervention on the Experimental Group subjects.

2.6 After 12 weeks, the TTM group and the Control Group were tested after filling in the "Adolescent physical exercise Behavior Change Questionnaire". SPSS was used to collect and input the data.

3. Special instructions

3.1 The testing time of Control Group and TTM group must be different. The experimental staff will test the Control Group first, and then test the TTM group one day apart. Also, the two groups will use different classrooms when testing is conducted.

3.2 Also, the two groups will use different classrooms when testing is conducted.

3.3 Control Group received normal school physical education classes and personal activities, and no other intervention measures were applied. In addition to normal school physical education teaching and personal activities, TTM group also needs to receive experimental intervention once a week, each intervention lasts for 12 weeks. It should be noted that all subjects must not know whether they are Control Group or TTM group when conducting experiments.

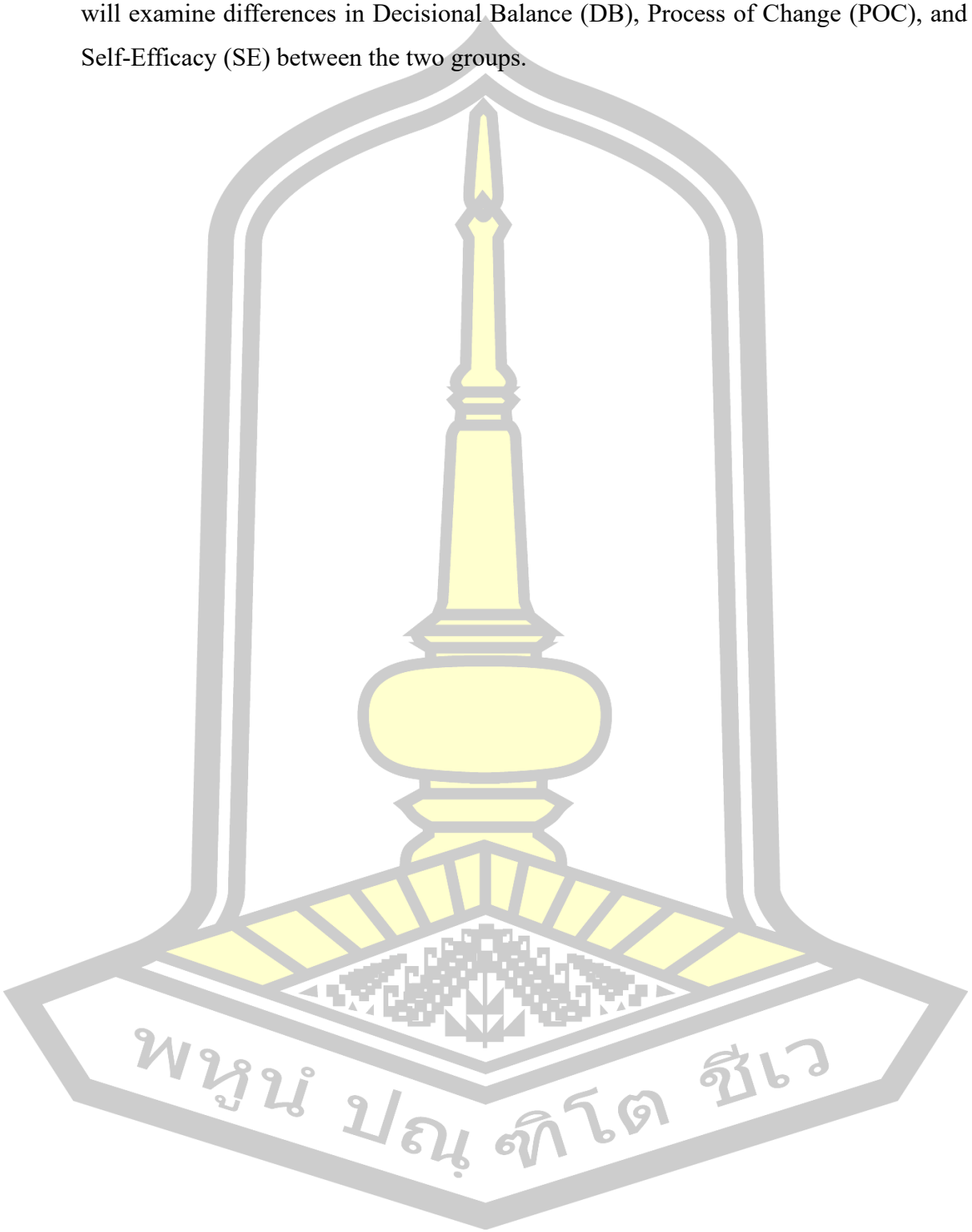
3.4 The research purpose of intervention experiments is mainly to explore whether subjects will change from one stage to another after being intervened, for example: from Preparation stage to Action stage. In addition, in China, the school semester is five months long. Taking into account the Chinese school environment and experimental conditions, this research plan determines the intervention experiment to be 12 weeks.

Data Analysis

1. T-test

This study will utilize paired sample T-tests and independent sample T-tests to analyze the differences in the Stage of Change (SOC) between the Control Group and

the Experimental Group in both pre-test and post-test phases. Additionally, the study will examine differences in Decisional Balance (DB), Process of Change (POC), and Self-Efficacy (SE) between the two groups.



CHAPTER IV

RESULTS

The aim of this study is to develop the Chinese version of the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ) and apply it to assess the applicability of the Transtheoretical Model (TTM) among Chinese adolescents. To achieve this goal, the study will be carried out in three stages. In Phase 1, IOC, item analysis, correlation analysis, and reliability analysis will be employed to construct the APEBCQ. In Phase 2, Chi-square tests, T-tests, MANOVA, and discriminant analysis will be applied to examine the relationship between the structural variables of TTM. In Phase 3, McNemar's test, ordered logistic regression analysis, and T-tests will be utilized to perform pre- and post-experimental comparative analysis(Table 14).

Table 11 The mainly research content

Phase	The mainly research content
Phase 1	To develop the APEBCQ
Phase 2	To analyze the relationship between TTM variables
Phase 3	To implement experiment of the TTM

1. Phase 1: Develop questionnaire

In Phase 1, IOC, item analysis, correlation analysis, and reliability analysis will be employed to construct the APEBCQ.(Figure 4)

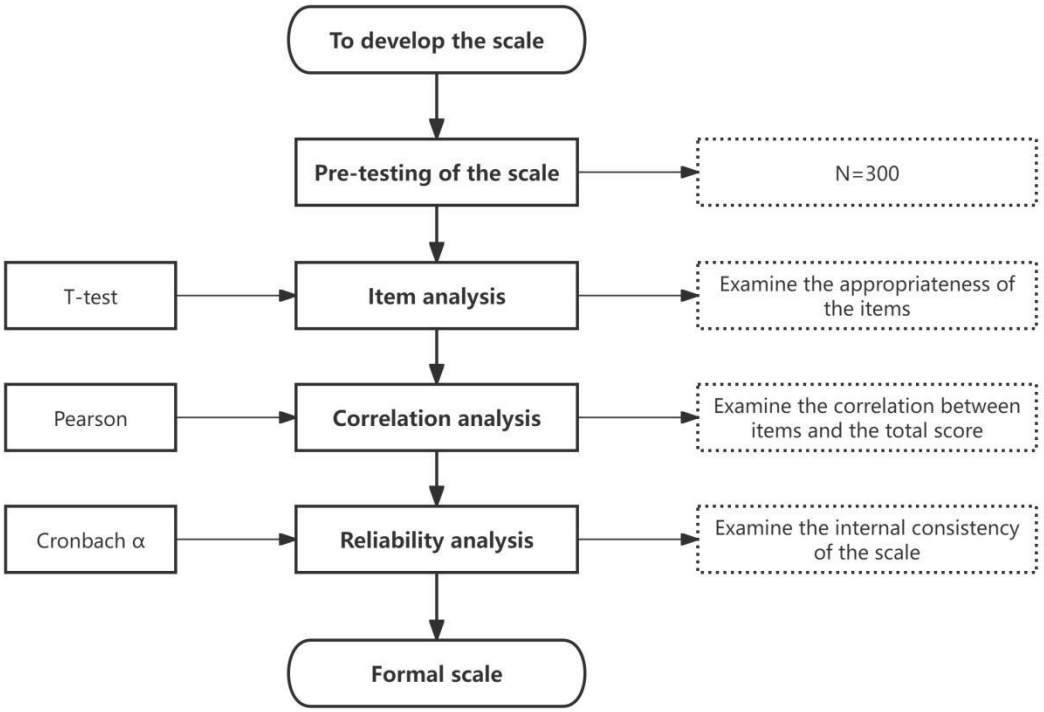


Figure 4 Flowchart of the Scale Development Process

1. Validity Verification of the Decisional Balance Scale (DB-Scale)

Table 12 Validity analysis of the Decisional Balance Scale (DB-Scale) (n=300)

Items	t	Pearson related	Cronbach's α if item deleted	Result
DB1	7.203**	0.460**	0.849	Pass
DB2	9.661**	0.552**	0.694	Pass
DB3	8.918**	0.524**	0.825	Pass
DB4	7.221**	0.461**	0.681	Pass
DB5	8.755**	0.482**	0.814	Pass
DB6	9.087**	0.529**	0.627	Pass
DB7	8.017**	0.442**	0.841	Pass
DB8	7.079**	0.438**	0.602	Pass
Criteria	≧3.000	≧0.400		

* = $p < 0.05$; ** = $p < 0.01$

Table 15 shows that all items have t-values greater than 7.0 and p-values less than 0.05, indicating high discriminative power. The Pearson correlation coefficients are all above 0.40, with p-values less than 0.05, suggesting a moderate to high correlation between the items and the total score.

Table 13 Reliability analysis of Decisional Balance Scale (DB-Scale) (n=300)

Dimensions	Cronbach's Alpha	Items
Negative factors	0.869	DB1, DB3, DB5, DB7
Positive factors	0.715	DB2, DB4, DB6, DB8

Table 16 indicates that the Cronbach's Alpha coefficient is 0.868 for the "Negative Factors" dimension and 0.715 for the "Positive Factors" dimension. Referring to the "Cronbach's α if item deleted" column in Table 15, the overall reliability of the scale decreases after deleting any item, indicating high internal consistency. The statistical values for all items are satisfactory, and thus, all items can be retained.

2. Validity Verification of the Processes of Change Scale (POC-Scale)

Table 14 Validity analysis of the Processes of Change Scale (POC-Scale) (n=300)

Items	t	Pearson	Cronbach's α if item deleted	Result
POC1	11.224**	0.660**	0.865	Pass
POC2	11.619**	0.659**	0.861	Pass
POC3	9.747**	0.598**	0.713	Pass
POC4	15.350**	0.741**	0.865	Pass
POC5	12.934**	0.656**	0.822	Pass
POC6	12.559**	0.688**	0.782	Pass
POC7	10.728**	0.671**	0.824	Pass
POC8	10.405**	0.575**	0.746	Pass
POC9	14.678**	0.755**	0.827	Pass
POC10	12.697**	0.671**	0.830	Pass
POC11	11.179**	0.720**	0.834	Pass
POC12	14.837**	0.782**	0.813	Pass
POC13	12.381**	0.709**	0.661	Pass
POC14	17.480**	0.800**	0.836	Pass
POC15	13.741**	0.719**	0.775	Pass
POC16	14.170**	0.758**	0.763	Pass
POC17	13.427**	0.762**	0.801	Pass
POC18	12.746**	0.671**	0.657	Pass
POC19	15.518**	0.772**	0.805	Pass
POC20	12.437**	0.712**	0.778	Pass
POC21	14.160**	0.789**	0.816	Pass
POC22	15.828**	0.799**	0.818	Pass

Table 17(continued)

Items	t	Pearson	Cronbach's α if item deleted	Result
POC23	13.458**	0.771**	0.750	Pass
POC24	14.987**	0.786**	0.835	Pass
POC25	11.299**	0.665**	0.801	Pass
POC26	10.125**	0.654**	0.809	Pass
POC27	11.993**	0.736**	0.802	Pass
POC28	9.538**	0.587**	0.724	Pass
POC29	14.552**	0.792**	0.783	Pass
POC30	12.925**	0.738**	0.762	Pass
POC31	15.080**	0.798**	0.821	Pass
POC32	14.745**	0.783**	0.819	Pass
POC33	9.534**	0.542**	0.825	Delete
POC34	15.375**	0.781**	0.875	Pass
POC35	14.912**	0.703**	0.838	Pass
POC36	16.290**	0.807**	0.751	Pass
POC37	15.601**	0.777**	0.826	Pass
POC38	11.377**	0.668**	0.669	Pass
POC39	13.738**	0.703**	0.828	Pass
POC40	15.460**	0.725**	0.811	Pass
Criteria	≧3.000	≧0.400		

* = $p < 0.05$; ** = $p < 0.01$

From Table 17, all items have t-values greater than 9.0 and p-values less than 0.05, indicating high discrimination and strong discriminative ability. Four items have Pearson correlation coefficients between 0.50 and 0.60, ten items between 0.60 and

0.70, twenty-four items between 0.70 and 0.80, and two items between 0.80 and 0.90, all with p-values less than 0.05. This suggests a moderate to high correlation between most items and the total score.

Table 15 Reliability analysis of the Processes of Change Scale (POC-Scale) (n=300)

Dimensions	Cronbach's Alpha	Items
Self liberation	0.870	POC1, POC11, POC21, POC31
Helping relationships	0.865	POC2, POC12, POC22, POC32
Reinforcement management	0.791	POC3, POC13, POC23, POC33
Counter-conditioning	0.885	POC4, POC14, POC24, POC34
Stimulus control,	0.850	POC5, POC15, POC25, POC35
Social liberation	0.823	POC6, POC16, POC26, POC36
Self reevaluation	0.853	POC7, POC17, POC27, POC37
Dramatic relief	0.756	POC8, POC18, POC28, POC38
Consciousness raising	0.851	POC9, POC19, POC29, POC39
Environmental reevaluation	0.838	POC11, POC20, POC30, POC40

From Table 18, the Cronbach's alpha is 0.870 for the "Self Liberation" dimension, 0.865 for "Helping Relationships," 0.791 for "Reinforcement Management," 0.885 for "Counter-Conditioning," 0.850 for "Stimulus Control," 0.823 for "Social Liberation," 0.853 for "Self Reevaluation," 0.756 for "Dramatic Relief," 0.851 for "Consciousness Raising," and 0.838 for "Environmental Reevaluation."

It is particularly noteworthy that Table 18 shows that after deleting item POC33, the scale's alpha increases to 0.825, which is higher than the pre-deletion value of 0.791. This suggests that the psychological variable measured by this item is not consistent with the other items (POC3, POC13, POC23), and therefore, its deletion should be considered.

Finally, the items of the Adolescent Physical Exercise Stages of Change Scale are determined as shown in Table 19.

Table 16 Corresponding items for measuring Processes of change(POC) psychological variables

Dimensions	Items
Self liberation	POC1, POC11, POC21, POC31
Helping relationships	POC2, POC12, POC22, POC32
Reinforcement management	POC3, POC13, POC23
Counter-conditioning	POC4, POC14, POC24, POC34
Stimulus control	POC5, POC15, POC25, POC35
Social liberation	POC6, POC16, POC26, POC36
Self reevaluation	POC7, POC17, POC27, POC37
Dramatic relief	POC8, POC18, POC28, POC38
Consciousness raising	POC9, POC19, POC29, POC39

3. Validity Verification of the Self-Efficacy Scale (SE-Scale)

Table 17 Validity analysis of the Self-Efficacy Scale (SE-Scale) (n=300)

Items	t	Pearson related	Cronbach's α if item deleted	Result
SE1	20.217**	0.820**	0.871	Pass
SE2	17.839**	0.818**	0.834	Pass
SE3	22.557**	0.849**	0.848	Pass
SE4	20.372**	0.820**	0.830	Pass
SE5	21.953**	0.848**	0.837	Pass
SE6	19.241**	0.820**	0.849	Pass
SE7	19.590**	0.827**	0.866	Pass
SE8	21.331**	0.848**	0.848	Pass
Criteria	≧3.000	≧0.400		

* = $p < 0.05$; ** = $p < 0.01$

From Table 20, it can be seen that all items have t-values greater than 17.0 and p-values less than 0.05, indicating high discrimination and strong discriminative ability. The Pearson correlation coefficients are greater than 0.80, with p-values less than 0.05, indicating a high correlation between the items and the total score.

Table 18 Reliability analysis of the Self-Efficacy Scale (SE-Scale) (n=300)

Dimensions	Cronbach's Alpha	Items
Exercise willingness	0.888	SE1, SE3, SE5, SE7
Exercise effort	0.875	SE2, SE4, SE6, SE8

Table 21 shows that the Cronbach's alpha for the 'Exercise Willingness' dimension is 0.888 and 0.875 for the 'Exercise Effort' dimension. As indicated in Table 20, the overall reliability coefficient of the scale decreases when any item is removed, which suggests high internal consistency. The statistical values for each item are satisfactory, and all items can be retained.

4. Validity Verification of the Physical Exercise Behavior Scale (PEB-Scale)

Table 19 Validity analysis of the Physical Exercise Behavior Scale (PEB-Scale) (n=300)

Items	t	Pearson related	Cronbach's α if item deleted	Result
PEB1	18.59**	0.78**	0.95	Pass
PEB2	20.49**	0.80**	0.95	Pass
PEB3	17.34**	0.75**	0.95	Pass
PEB4	22.54**	0.82**	0.95	Pass
PEB5	18.60**	0.80**	0.95	Pass
PEB6	17.92**	0.81**	0.95	Pass
PEB7	18.70**	0.80**	0.95	Pass
PEB8	19.12**	0.80**	0.95	Pass
PEB9	19.25**	0.79**	0.95	Pass
PEB10	22.82**	0.80**	0.95	Pass
PEB11	20.33**	0.82**	0.95	Pass
PEB12	20.30**	0.79**	0.95	Pass
PEB13	21.82**	0.83**	0.95	Pass
PEB14	22.62**	0.82**	0.95	Pass
PEB15	19.70**	0.80**	0.95	Pass
Criteria	≧3.000	≧0.400	0.95	Pass

* = $p < 0.05$; ** = $p < 0.01$

From Table 22, it can be seen that all items have t-values greater than 18.50 and p-values less than 0.05, indicating high discrimination and strong discriminative ability. The Pearson correlation coefficients are greater than 0.75, with p-values less than 0.05, indicating a high correlation between the items and the total score.

Table 20 Reliability analysis of the Physical Exercise Behavior Scale (PEB-Scale) (n=300)

Dimensions	Cronbach's Alpha
Physical Exercise Behavior	0.96

Table 23 shows that the Cronbach's alpha for the 'Physical Exercise Behavior' dimension is 0.96. As indicated in Table 22, the overall reliability coefficient of the scale decreases when any item is removed, which suggests high internal consistency. The statistical values for each item are satisfactory, and all items can be retained.

2. Phase 2: Extensive investigation

The primary aim is to verify the applicability of the Transtheoretical Model (TTM) among Chinese adolescents, analyze the relationships between TTM structural variables, predict the Stages of change(SOC), and the analysis flowchart is as follows (Figure 5):

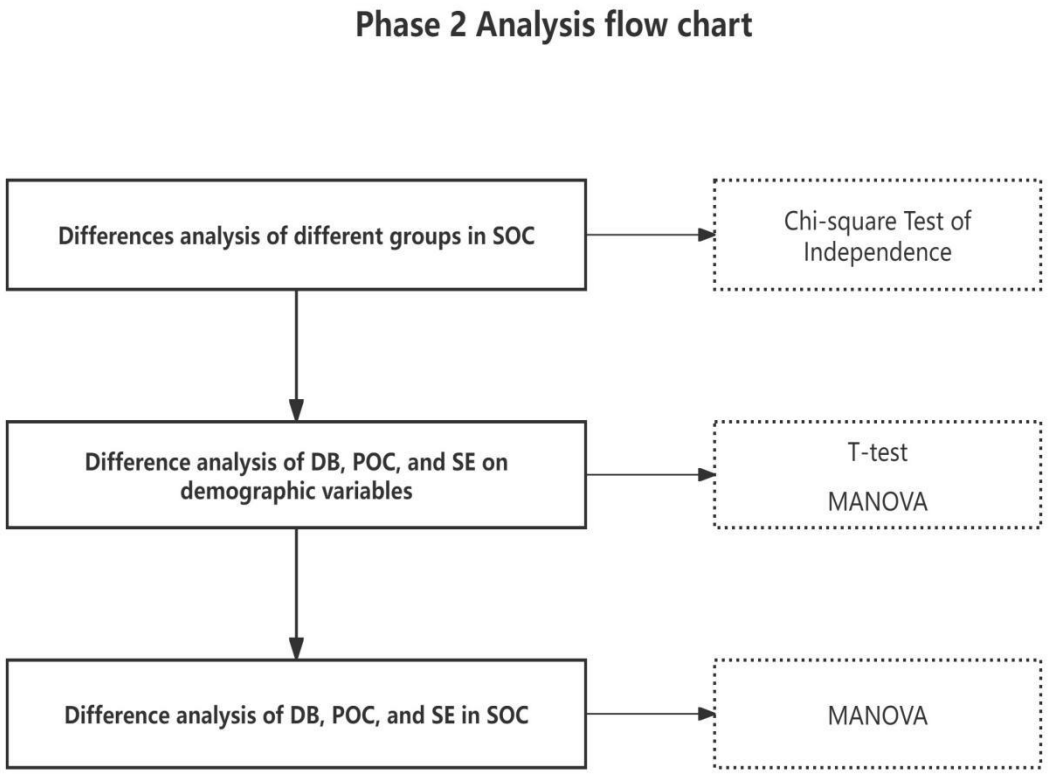


Figure 5 Phase 2 analysis flow chart

1. Descriptive Statistics of the Sample

Table 21 Frequency distribution of Stages of change(SOC)

	Measured number	Percent
Precontemplation	424	20.19%
Contemplation	559	26.62%
Preparation	220	10.48%
Action	634	30.19%
Maintenance	263	12.52%
n	2100	

From Table 24, it can be seen that there are 424 individuals in the Precontemplation stage, accounting for 20.19%; 559 individuals in the Contemplation stage, accounting for 26.62%; 220 individuals in the Preparation stage, accounting for 10.48%; 634 individuals in the Action stage, accounting for 30.19%; and 263 individuals in the Maintenance stage, accounting for 12.52%.

2. Analysis of gender, grade and Stages of change(SOC) differences

2.1 Analysis of gender differences in Stages of change(SOC)

Table 22 Analysis of gender differences in Stages of change(SOC) (n=2100)

SOC		Male	Female	Total
Precontemplation	n	162	262	424
	percentage of SOC	38.2%	61.8%	100%
	percentage of gender	16.4%	23.6%	20.2%
	percentage of total	7.7%	12.5%	20.2%
	AR	-4.1	4.1	
Contemplation	n	231	328	559
	percentage of SOC	41.3%	58.7%	100%
	percentage of gender	23.4%	29.5%	26.6%
	percentage of total	11.0%	15.6%	26.6%
	AR	-3.2	3.2	
Preparation	n	97	123	220
	percentage of SOC	44.1%	55.9%	100%
	percentage of gender	9.8%	11.1%	10.5%
	percentage of total	4.6%	5.9%	10.5%
	AR	-0.9	0.9	
Action	n	310	324	634
	percentage of SOC	48.9%	51.1%	100%
	percentage of gender	31.4%	29.1%	30.2%
	percentage of total	14.8%	15.4%	30.2%
	AR	1.1	-1.1	
Maintenance	n	188	75	263
	percentage of SOC	71.5%	28.5%	100%
	percentage of gender	19.0%	6.7%	12.5%
	percentage of total	9.0%	3.6%	12.5%
	AR	8.5	-8.5	

From Table 25, it can be seen that in the Precontemplation stage, the number of males is significantly lower than that of females, with an Adjusted Residual (AR) value of 4.1. In the Contemplation stage, the number of males is also significantly lower than females, with an AR value of 3.2. In the Preparation stage, the number of males is lower than females, with an AR value of 0.9. In the Action stage, the number

of males is higher than females, with an AR value of 1.1. Finally, in the Maintenance stage, the number of males is significantly higher than females, with an AR value of 8.5.

Table 23 Analysis of significant differences between gender and Stages of change(SOC) (n=2100)

Variable	χ^2	df	p
Gender & SOC	85.32	4	0.001**

* = p < 0.05; ** = p < 0.01

Table 26 shows that the chi-square test results, χ^2=85.362, with a significance p-value of 0.000 (less than 0.05), reach a significant level. This indicates significant differences between gender groups in the Stages of change(SOC).

2.2 Analysis of grade differences in Stages of change (SOC)

Table 24 Analysis of grade differences in Stages of change (SOC) (n=2100)

SOC		JHS	HS	Total
Precontemplation	n	197	227	424
	percentage of SOC	46.5%	53.5%	100%
	percentage of gender	18.4%	22.1%	20.2%
	percentage of total	9.4%	10.8%	20.2%
	AR	-2.1	2.1	
Contemplation	n	279	280	559
	percentage of SOC	49.9%	50.1%	100%
	percentage of gender	26.0%	27.2%	26.6%
	percentage of total	13.3%	13.3%	26.6%
	AR	-0.6	0.6	
Preparation	n	108	112	220
	percentage of SOC	49.1%	50.9%	100%
	percentage of gender	10.1%	10.9%	10.5%
	percentage of total	5.1%	5.3%	10.5%
	AR	-0.6	0.6	
Action	n	377	257	634
	percentage of SOC	59.5%	40.5%	100%
	percentage of gender	35.2%	25.0%	30.2%
	percentage of total	18.0%	12.2%	30.2%
	AR	5.1	-5.1	
Maintenance	n	111	152	263
	percentage of SOC	42.2%	57.8%	100%
	percentage of gender	10.4%	14.8%	12.5%
	percentage of total	5.3%	7.2%	12.5%
	AR	-3.1	3.1	

Note: JHS=Junior High School, HS=High School

From Table 27, it can be seen that in the Precontemplation stage, the number of JHS participants is significantly lower than HS participants, with an Adjusted Residual (AR) value of 2.1. In the Contemplation stage, JHS is significantly lower than HS, with an AR value of 0.6. In the Preparation stage, JHS is lower than HS, with an AR value of 0.6. In the Action stage, JHS is higher than HS, with an AR value of 5.1. Finally, in the Maintenance stage, JHS is significantly lower than HS, with an

AR value of 3.1.

Table 25 Analysis of significant differences between grade and Stages of change (SOC) (n=2100)

Variable	χ^2	df	p
Grade & SOC	30.393	4	0.001**

* = p < 0.05; ** = p < 0.01

Table 28 shows that the chi-square test results, χ^2=30.393, with a significance p-value of 0.000 (less than 0.05), reach a significant level. This indicates significant differences between grade level groups in the Stages of change (SOC).

3. Difference analysis of Decisional balance(DB), Processes of change(POC) and Self efficacy(SE) in demographic variables

3.1 Analysis of differences in gender and Decisional balance(DB), Processes of change(POC), and Self efficacy(SE)

Table 26 Analysis of differences in gender and Decisional balance(DB), Processes of change(POC), and Self efficacy(SE) Total Score

Variable	Gender	n	Total Score	SD	t	p
DB	Male	988	27.34	4.25	2.207	0.001**
	Female	1112	26.97	3.45		
POC	Male	988	152.91	21.79	5.672	0.001**
	Female	1112	147.77	19.41		
SE	Male	988	30.10	5.21	9.944	0.001**
	Female	1112	27.89	4.97		

* = $p < 0.05$; ** = $p < 0.01$

From Table 29, significant gender differences were found in three dependent variables: "DB," "POC," and "SE." Males had significantly higher scores than females in all three variables, with t-values of 2.207 (DB), 5.672 (POC), and 9.944 (SE) ($p < 0.05$).

3.2 Analysis of differences in grade and Decisional balance (DB), Processes of change (POC), and Self efficacy(SE)

Table 27 Analysis of differences in grade and Decisional balance (DB), Processes of change (POC), and Self efficacy (SE) Total Score

Variable	Grade	n	Total Score	SD	t	p
DB	JHS	1072	26.57	3.36	-7.034**	0.001**
	HS	1028	27.74	4.22		
POC	JHS	1072	148.98	19.53	-2.730	0.001**
	HS	1028	151.45	21.83		
SE	JHS	1072	28.58	4.98	-3.082	0.001**
	HS	1028	29.28	5.40		

Note: JHS=Junior High School, HS=High School

* = $p < 0.05$; ** = $p < 0.01$

From Table 30, significant differences were found between grade levels for the dependent variables "DB," "POC," and "SE." High school (HS) students consistently scored higher than junior high school (JHS) students. The t-values were -7.034 (DB), -2.730 (POC), and -3.082 (SE), all with p-values less than 0.05.

3.3 Analysis of differences in Number of exercise (NOE) and Decisional balance (DB), Processes of change(POC), and Self efficacy(SE)

Table 28 Analysis of Differences in Decisional Balance (DB), Processes of Change (POC), Self-Efficacy (SE) Total Score, and Number of Exercise (NOE) (n=2100)

Variables	NOE Group	n	Total Score	SD
DB	0 exercises	86	25.523	5.068
	1-2 exercises	713	27.320	3.744
	3-5 exercises	837	26.968	3.204
	More than 5 exercises	464	27.650	4.657
POC	0 exercises	86	132.988	22.718
	1-2 exercises	713	145.425	19.210
	3-5 exercises	837	150.617	18.015
	More than 5 exercises	464	159.941	22.647
SE	0 exercises	86	23.616	5.526
	1-2 exercises	713	27.433	4.935
	3-5 exercises	837	29.301	4.435
	More than 5 exercises	464	31.556	5.338

From Table 31, the distribution of participants is as follows: 86 individuals reported exercising 0 times per week, 713 reported exercising 1-2 times per week, 837 reported exercising 3-5 times per week, and 86 reported exercising more than 5 times per week.

Table 29 Analysis of differences in NOE and Decisional balance (DB), Processes of change(POC), and Self efficacy(SE) (n=2100)

Source of variation	Variable	SS	df	MS	F	p
NOE	DB	375.985	3	125.328	8.52	0.001**
	POC	85914.582	3	28638.194	73.61	0.001**
	SE	7340.303	3	2446.768	103.43	0.001**
Error	DB	30800.363	2096	14.695		
	POC	815432.311	2096	389.042		
	SE	49582.095	2096	23.656		

* = $p < 0.05$; ** = $p < 0.01$

From Table 32, the multivariate tests show F-values of 8.52, 73.612, and 103.43 for the three dependent variables, all with p-values less than 0.05, indicating significance. This suggests that among the four NOE groups, at least one dependent variable has a significantly different mean.

Table 30 Group comparison of NOE in Decisional balance (DB), Processes of change (POC), and Self efficacy (SE)

Variable	Group	0 exercises	1-2 exercises	3-5 exercises	More than 5 exercises
DB	0 exercises	--	**(-1.70) 0.001****	**(-1.44) 0.001****	**(-2.12) 0.001****
	1-2 exercises	**(1.70) 0.001****	--	(0.26) 0.61	(-0.42) 0.33
	3-5 exercises	**(1.44) 0.001****	(-0.26) 0.61	--	**(-0.68) 0.02***
	More than 5 exercises	**(2.12) 0.001****	(0.42) 0.33	**(0.68) 0.02***	--
POC	0 exercises	--	**(-12.43) 0.001****	**(-17.62) 0.001****	**(-26.95) 0.001****
	1-2 exercises	**(12.43) 0.001****	--	**(-5.19) 0.001****	**(-14.51) 0.001****
	3-5 exercises	**(17.62) 0.001****	**(5.19) 0.001****	--	**(-9.32) 0.001****
	More than 5 exercises	**(26.95) 0.001****	**(14.51) 0.001****	**(9.32) 0.001****	--
SE	0 exercises	--	**(-3.81) 0.001****	**(-5.68) 0.001****	**(-7.93) 0.001****
	1-2 exercises	**(3.81) 0.001****	--	**(-1.86) 0.001****	**(-4.12) 0.001****
	3-5 exercises	**(5.68) 0.001****	**(1.86) 0.001****	--	**(-2.25) 0.001****
	More than 5 exercises	**(7.93) 0.001****	**(4.12) 0.001****	**(2.25) 0.001****	--

* = $p < 0.05$; ** = $p < 0.01$

Post-hoc comparisons from Table 33 indicate the following:

For "Decisional balance(DB)," More than 5 exercises scored higher than 0 exercises and 3-5 exercises, and 1-2 exercises scored higher than 0 exercises.

For "Processes of change(POC)," More than 5 exercises scored higher than 0 exercises, 1-2 exercises, and 3-5 exercises, while 3-5 exercises scored higher than 0 exercises and 1-2 exercises.

For "Self efficacy(SE)," More than 5 exercises scored higher than 0 exercises, 1-2 exercises, and 3-5 exercises, with 3-5 exercises scoring higher than 0 exercises and 1-2 exercises.

4. **Analysis of differences in Stages of change (SOC) and Decisional balance(DB), Processes of change(POC), and Self efficacy(SE)**

Table 31 Total Score, Standard Deviation of Stages of change (SOC) in Decisional balance (DB), Processes of change(POC), and Self efficacy(SE) (n=2100)

Variable	Population	n	Total Score	SD
DB	Precontemplation	424	26.344	3.886
	Contemplation	559	27.490	3.664
	Preparation	220	27.977	3.480
	Action	634	26.799	3.269
	Maintenance	263	27.870	5.231
POC	Precontemplation	424	135.832	20.973
	Contemplation	559	149.284	17.390
	Preparation	220	154.663	17.439
	Action	634	152.635	16.972
	Maintenance	263	165.646	23.007
SE	Precontemplation	424	25.082	5.300
	Contemplation	559	28.554	4.432
	Preparation	220	30.127	4.262
	Action	634	29.755	4.292
	Maintenance	263	32.958	5.192

According to Table 34, there are 424 individuals in the Precontemplation stage, 559 in the Contemplation stage, 220 in the Preparation stage, 634 in the Action stage, and 263 in the Maintenance stage.

Table 32 Analysis of differences in Stages of change(SOC) and Decisional balance(DB), Processes of change(POC), and Self efficacy(SE) (n=2100)

Source of variation	Variable Name	SS	df	MS	F	p
SOC	DB	740.87	4	176.21	12.11	0.001**
	POC	158885.95	4	39721.48	112.08	0.001**
	SE	11370.11	4	2842.53	130.73	0.001**
Error	DB	14.545	2095	14.54		
	POC	354.39	2095	354.39		
	SE	21.74	2095	21.74		

* = $p < 0.05$; ** = $p < 0.01$

From Table 35, it can be observed that the multivariate tests show F-values of 12.116, 112.082, and 103.731 for the three dependent variables, all with p-values less than 0.05, indicating statistical significance. This suggests that among the five SOC groups, at least one dependent variable has a significantly different mean.

Table 33 Group comparison of Stages of change (SOC) in Decisional balance (DB), Processes of change(POC), and Self efficacy(SE) (n=2100)

Variable	Group	Precontemplation	Contemplation	Preparation	Action	Maintenance
DB	Precontemplation	--	**(-1.14) 0.001****	**(-1.63) 0.001****	(-0.45) 0.46	**(-1.52) 0.001****
	Contemplation	**(1.14) 0.001****	--	(-0.48) 0.63	**(0.69) 0.04***	(-0.38) 0.77
	Preparation	**(1.63) 0.001****	(0.48) 0.63	--	**(1.17) 0.001****	(0.10) 0.99
	Action	(0.45) 0.46	**(-0.69) 0.04***	**(-1.17) 0.001****	--	**(-1.07) 0.001****
	Maintenance	**(1.52) 0.001****	(0.38) 0.77	(-0.10) 0.99	**(1.07) 0.001****	--
POC	Precontemplation	--	**(-13.45) 0.001****	**(-18.83) 0.001****	**(-16.80)0.001****	**(-29.81)0.001****
	Contemplation	**(13.45) 0.001****	--	**(-5.37) 0.01***	(-3.35) 0.05	**(-16.36)0.001****
	Preparation	**(18.83) 0.001****	**(5.37) 0.01***	--	(2.02) 0.75	**(-10.98)0.001****
	Action	**(16.80) 0.001****	(3.35) 0.05	(-2.02) 0.75	--	**(-13.01)0.001****
	Maintenance	**(29.81) 0.001****	**(16.36)0.001****	**(-10.98)0.001****	**(13.01)0.001****	--
SE	Precontemplation	--	**(-3.47) 0.001****	**(-5.04) 0.001****	**(-4.67) 0.001****	**(-7.87) 0.001****
	Contemplation	**(3.47) 0.001****	--	**(-1.57) 0.001****	**(-1.20) 0.001****	**(-4.40) 0.001****
	Preparation	**(5.04) 0.001****	**(1.57) 0.001****	--	(0.37) 0.90	**(-2.83) 0.001****
	Action	**(4.67) 0.001****	**(1.20) 0.001****	(-0.37) 0.90	--	**(-3.20) 0.001****
	Maintenance	**(7.87) 0.001****	**(4.40) 0.001****	**(2.83) 0.001****	**(-3.20) 0.001****	--

* = $p < 0.05$; ** = $p < 0.01$

Post-hoc comparisons from Table 36 reveal:

For "Decisional balance (DB)": Maintenance is greater than Action and Precontemplation, Preparation is greater than Action and Precontemplation, and Contemplation is greater than Precontemplation.

For "Processes of change (POC)": Maintenance is greater than all other groups, Action is greater than Precontemplation, and Preparation is greater than Contemplation and Precontemplation.

For "Self-efficacy(SE)": Maintenance is greater than all other groups, Action is greater than Precontemplation, and Preparation is greater than Contemplation and Precontemplation.

3. Phase 3: Experimental research

A 12-week intervention study was conducted using Transtheoretical Model (TTM) to examine adolescent physical exercise behavior. The primary objective was to determine whether the Transtheoretical Model (TTM)-based intervention could improve the participants' Stages of Change (SOC) and evaluate its impact on the participants' Processes of Change (POC) and Self-Efficacy (SE). The flowchart detailing the analysis process is shown in Figure 6.

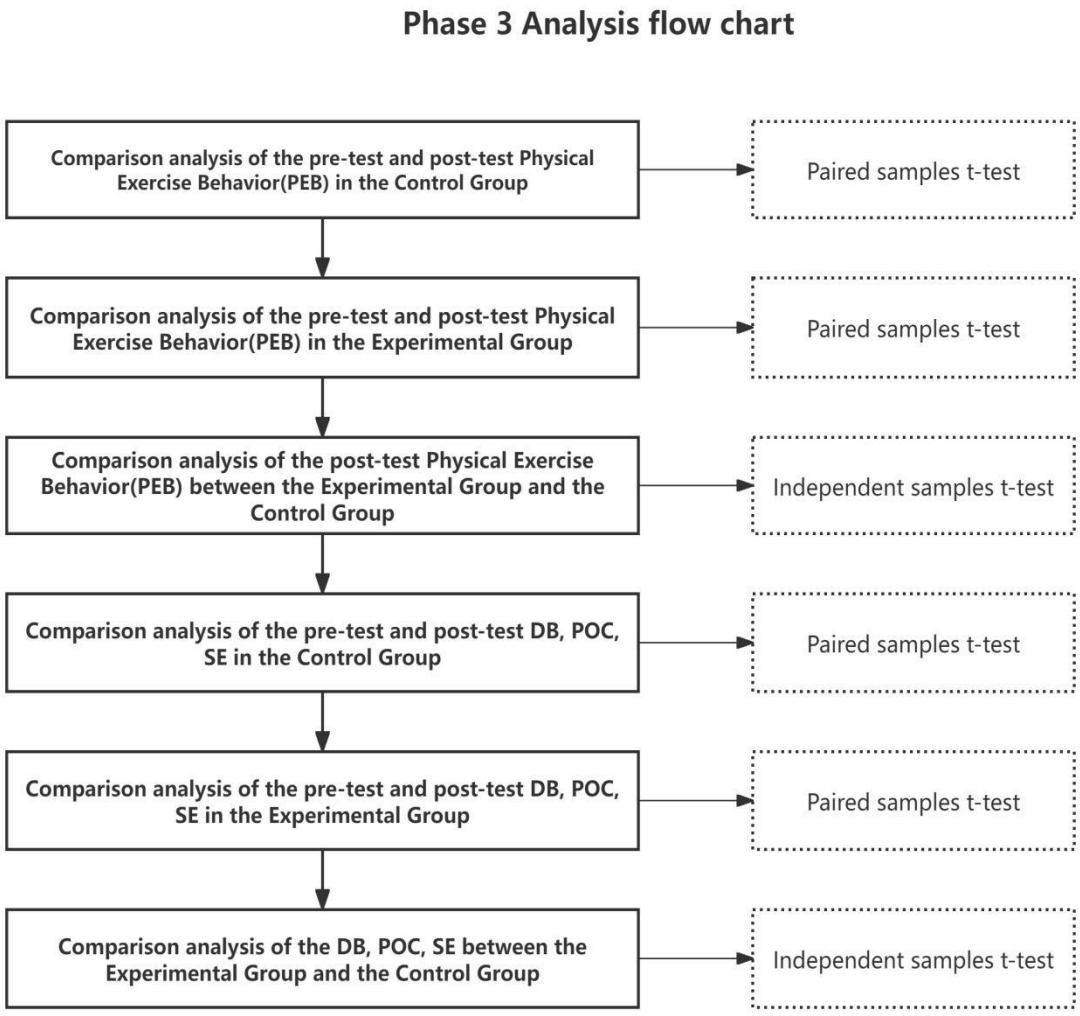


Figure 6 Phase 3 analysis flow chart

1. Experimental plan consistency check

The TTM intervention program in this study was conducted over 12 weeks, with one 60-minute session per week. The program followed the "Experimental Intervention Plan for TTM Group" (Appendix F), which included:

Knowledge Talk: This segment focused on explaining physical exercise knowledge, emphasizing how individuals can seek information on exercise. The goal was to help participants understand the benefits of physical exercise and the risks of inactivity. For example, exercise-related videos were shown, and exercise guidance manuals were distributed to provide a more intuitive understanding of physical activity.

Experience Sharing: This involved using experience-sharing and discussion methods to promote psychological development. Participants shared their experiences and skills related to physical exercise.

Exercise Record: Participants kept a weekly record of their daily routines, including work and rest, to help them evaluate their time management. This reflection was intended to guide them in planning and setting goals for physical exercise.

Prior to the TTM experimental study, seven experts from the fields of psychology, sports psychology, education, and school sports evaluated the TTM intervention program. They used the Item-Objective Consistency (IOC) index to assess and confirm the validity of the questionnaire content. The experts scored each item on a scale from 1 to -1, where 1 indicated "obvious measurability," 0 indicated "unclear measurement content," and -1 indicated "obvious non-measurability." The consistent results from the experts confirmed that the TTM intervention program designed for this study can effectively address the target objectives (Appendix G).

2. Comparative analysis of Physical Exercise Behavior (PEB)

2.1 Comparison analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Control Group

Table 34 Comparison analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Control Group (n=50)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	Level Exercise
I exercise using the sports facilities at school or in the community.	pre-test	2.84	1.28	Sometimes
	post-test	3.28	0.95	Sometimes
I do strength training or endurance exercises to improve my fitness.	pre-test	2.54	1.20	Rarely
	post-test	3.14	0.93	Sometimes
I exercise with my friends.	pre-test	3.30	1.07	Sometimes
	post-test	3.82	0.85	Often
I participate in sports with my family.	pre-test	2.46	0.89	Rarely
	post-test	2.64	0.83	Sometimes
I regularly create and follow my exercise plan.	pre-test	2.08	1.24	Rarely
	post-test	2.98	1.04	Sometimes
I do stretching or flexibility exercises every day.	pre-test	2.82	1.04	Sometimes
	post-test	3.40	0.86	Sometimes
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	pre-test	2.86	1.26	Sometimes
	post-test	3.58	0.91	Often
I participate in school sports (such as basketball, soccer, volleyball, etc.).	pre-test	2.74	1.23	Sometimes
	post-test	3.48	0.81	Sometimes
I use social media to learn new exercise methods or techniques.	pre-test	2.88	1.08	Sometimes
	post-test	3.66	0.90	Often
I schedule fixed exercise times during the week.	pre-test	2.84	1.22	Sometimes
	post-test	3.76	0.77	Often
I participate in health- and sports-related events or competitions.	pre-test	2.60	0.97	Rarely
	post-test	3.38	0.70	Sometimes
I engage in outdoor sports on weekends or holidays.	pre-test	2.50	1.02	Rarely
	post-test	2.98	0.89	Sometimes
I try new types of sports.	pre-test	2.44	1.07	Rarely
	post-test	3.40	0.81	Sometimes
I continue to exercise even when I am busy.	pre-test	2.24	1.02	Rarely
	post-test	2.86	0.86	Sometimes
I use walking or cycling as a form of daily transportation to stay active.	pre-test	2.82	1.08	Sometimes
	post-test	3.80	0.67	Often

As shown in Table 37, in the Control Group, physical exercise frequency increased across all activities, with significant gains in aerobic exercise, exercising with friends, learning new sports via social media, and staying active through walking or cycling, reaching "often exercise" levels. However, improvements in strength training, family involvement, and exercising during busy periods were modest and remained low. This suggests that while natural improvements occurred due to resource availability and environmental changes, some behaviors may need additional support or long-term interventions for greater impact.

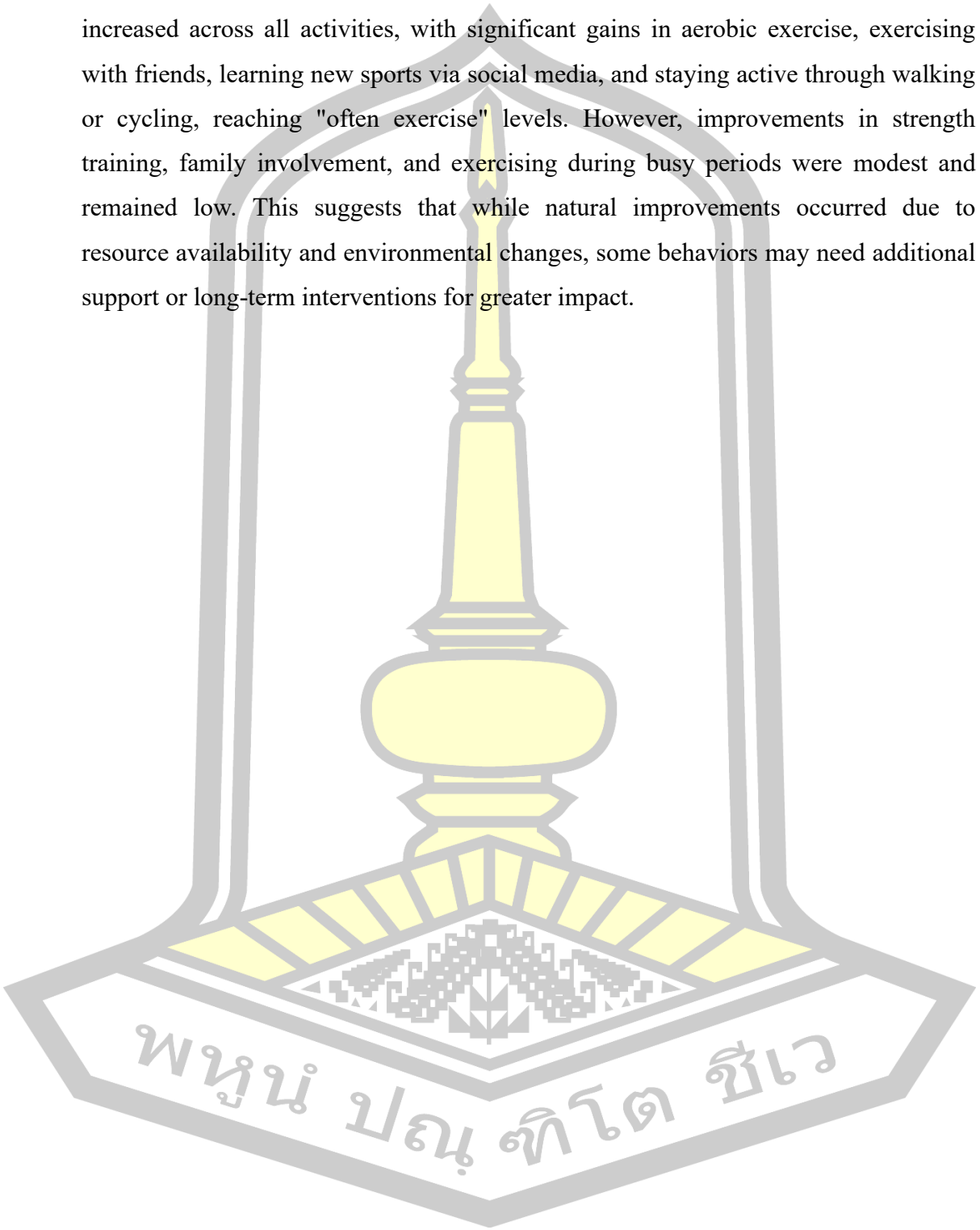


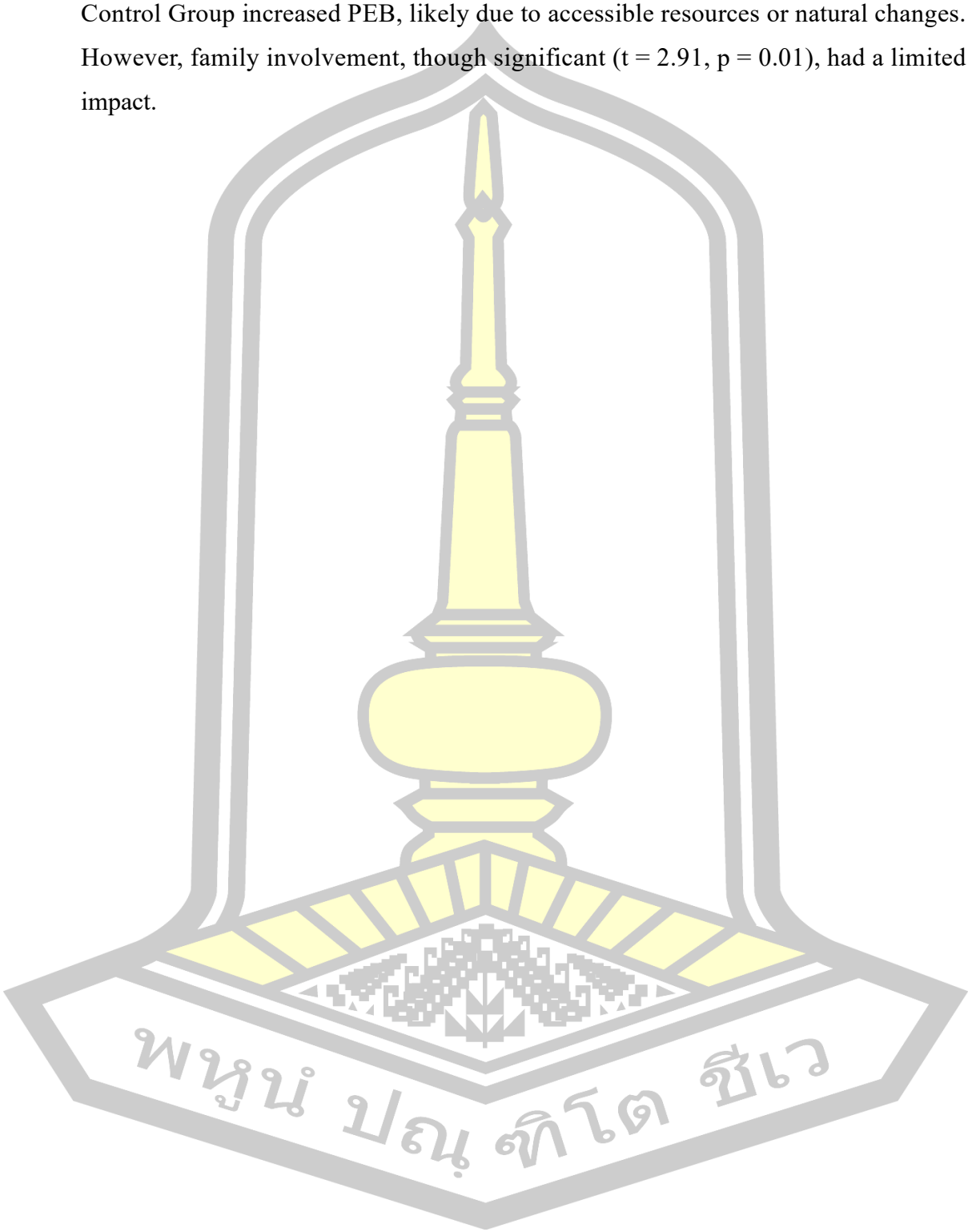
Table 35 Difference Analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Control Group (n=50)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	t	p
I exercise using the sports facilities at school or in the community.	pre-test	2.84	1.28		
	post-test	3.28	0.95	5.09	0.001**
I do strength training or endurance exercises to improve my fitness.	pre-test	2.54	1.20		
	post-test	3.14	0.93	6.64	0.001**
I exercise with my friends.	pre-test	3.30	1.07		
	post-test	3.82	0.85	5.20	0.001**
I participate in sports with my family.	pre-test	2.46	0.89		
	post-test	2.64	0.83	2.91	0.001**
I regularly create and follow my exercise plan.	pre-test	2.08	1.24		
	post-test	2.98	1.04	9.84	0.001**
I do stretching or flexibility exercises every day.	pre-test	2.82	1.04		
	post-test	3.40	0.86	6.73	0.001**
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	pre-test	2.86	1.26		
	post-test	3.58	0.91	7.95	0.001**
I participate in school sports (such as basketball, soccer, volleyball, etc.).	pre-test	2.74	1.23		
	post-test	3.48	0.81	6.51	0.001**
I use social media to learn new exercise methods or techniques.	pre-test	2.88	1.08		
	post-test	3.66	0.90	8.13	0.001**
I schedule fixed exercise times during the week.	pre-test	2.84	1.22		
	post-test	3.76	0.77	8.09	0.001**
I participate in health- and sports-related events or competitions.	pre-test	2.60	0.97		
	post-test	3.38	0.70	7.49	0.001**
I engage in outdoor sports on weekends or holidays.	pre-test	2.50	1.02		
	post-test	2.98	0.89	5.25	0.001**
I try new types of sports.	pre-test	2.44	1.07		
	post-test	3.40	0.81	8.99	0.001**
I continue to exercise even when I am busy.	pre-test	2.24	1.02		
	post-test	2.86	0.86	6.90	0.001**
I use walking or cycling as a form of daily transportation to stay active.	pre-test	2.82	1.08		
	post-test	3.80	0.67	7.98	0.001**

* = $p < 0.05$; ** = $p < 0.01$

As shown in Table 38, all 15 items displayed significant differences ($p < 0.01$), indicating changes in Physical Exercise Behavior (PEB) in the Control Group without intervention. Exercise behaviors, such as using school or community facilities ($t = 5.09$, $p = 0.00$) and aerobic activities ($t = 7.95$, $p = 0.00$), significantly increased. There were also improvements in setting exercise plans ($t = 9.84$, $p = 0.00$) and

scheduling weekly exercise (t = 8.09, p = 0.00). These findings suggest that the Control Group increased PEB, likely due to accessible resources or natural changes. However, family involvement, though significant (t = 2.91, p = 0.01), had a limited impact.



2.2 Comparison analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Experimental Group

Table 36 Comparison analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Experimental Group (n=50)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	Exercise
I exercise using the sports facilities at school or in the community.	pre-test	2.84	1.28	Sometimes
	post-test	3.28	0.95	Sometimes
I do strength training or endurance exercises to improve my fitness.	pre-test	2.54	1.20	Rarely
	post-test	3.14	0.93	Sometimes
I exercise with my friends.	pre-test	3.30	1.07	Sometimes
	post-test	3.82	0.85	Often
I participate in sports with my family.	pre-test	2.46	0.89	Rarely
	post-test	2.64	0.83	Sometimes
I regularly create and follow my exercise plan.	pre-test	2.08	1.24	Rarely
	post-test	2.98	1.04	Sometimes
I do stretching or flexibility exercises every day.	pre-test	2.82	1.04	Sometimes
	post-test	3.40	0.86	Sometimes
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	pre-test	2.86	1.26	Sometimes
	post-test	3.58	0.91	Often
I participate in school sports (such as basketball, soccer, volleyball, etc.).	pre-test	2.74	1.23	Sometimes
	post-test	3.48	0.81	Often
I use social media to learn new exercise methods or techniques.	pre-test	2.88	1.08	Sometimes
	post-test	3.66	0.90	Often
I schedule fixed exercise times during the week.	pre-test	2.84	1.22	Sometimes
	post-test	3.76	0.77	Often
I participate in health- and sports-related events or competitions.	pre-test	2.60	0.97	Rarely
	post-test	3.38	0.70	Sometimes
I engage in outdoor sports on weekends or holidays.	pre-test	2.50	1.02	Rarely
	post-test	2.98	0.89	Sometimes
I try new types of sports.	pre-test	2.44	1.07	Rarely
	post-test	3.40	0.81	Sometimes
I continue to exercise even when I am busy.	pre-test	2.24	1.02	Rarely
	post-test	2.86	0.86	Sometimes
I use walking or cycling as a form of daily transportation to stay active.	pre-test	2.82	1.08	Sometimes
	post-test	3.80	0.67	Often

As shown in Table 39, in the Experimental Group, exercise behaviors improved, with significant gains in aerobic exercise, exercising with friends, learning through

social media, and staying active, reaching the "Often exercise" level. Strength training, family involvement, and weekend outdoor activities saw smaller improvements, remaining at "Sometimes" or "Rarely" levels. Overall, the intervention boosted self-planning and social media-based learning, though some behaviors may need more support or extended intervention for further progress.

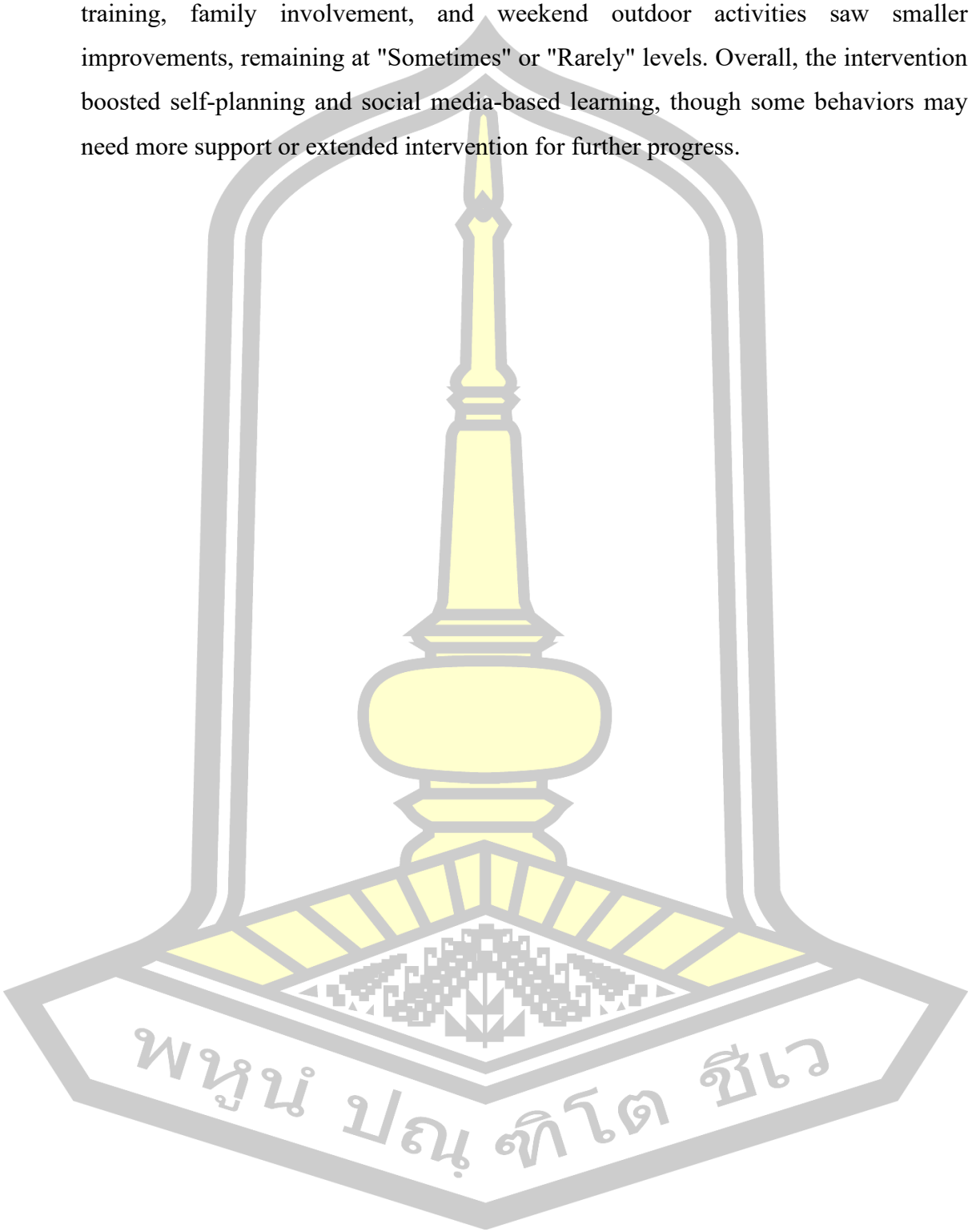


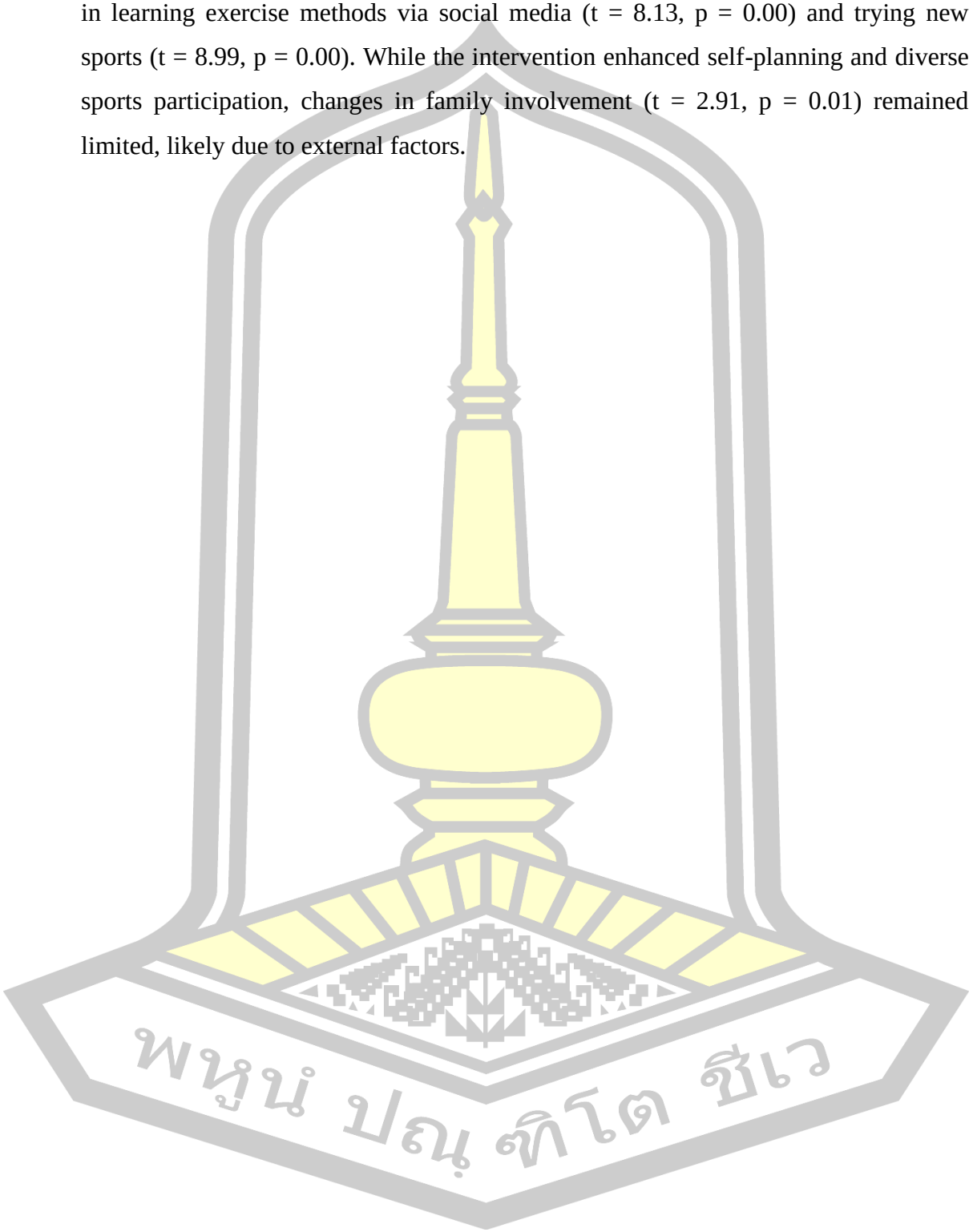
Table 37 Difference Analysis of the pre-test and post-test Physical Exercise Behavior (PEB) in the Experimental Group (n=50)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	t	p
I exercise using the sports facilities at school or in the community.	pre-test	2.84	1.28		
	post-test	3.28	0.95	5.09	0.001**
I do strength training or endurance exercises to improve my fitness.	pre-test	2.54	1.20		
	post-test	3.14	0.93	6.64	0.001**
I exercise with my friends.	pre-test	3.30	1.07		
	post-test	3.82	0.85	5.20	0.001**
I participate in sports with my family.	pre-test	2.46	0.89		
	post-test	2.64	0.83	2.91	0.01 *
I regularly create and follow my exercise plan.	pre-test	2.08	1.24		
	post-test	2.98	1.04	6.73	0.001**
I do stretching or flexibility exercises every day.	pre-test	2.82	1.04		
	post-test	3.40	0.86	7.95	0.001**
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	pre-test	2.86	1.26		
	post-test	3.58	0.91	6.51	0.001**
I participate in school sports (such as basketball, soccer, volleyball, etc.).	pre-test	2.74	1.23		
	post-test	3.48	0.81	8.13	0.001**
I use social media to learn new exercise methods or techniques.	pre-test	2.88	1.08		
	post-test	3.66	0.90	8.09	0.001**
I schedule fixed exercise times during the week.	pre-test	2.84	1.22		
	post-test	3.76	0.77	7.49	0.001**
I participate in health- and sports-related events or competitions.	pre-test	2.60	0.97		
	post-test	3.38	0.70	7.49	0.001**
I engage in outdoor sports on weekends or holidays.	pre-test	2.50	1.02		
	post-test	2.98	0.89	5.25	0.001**
I try new types of sports.	pre-test	2.44	1.07		
	post-test	3.40	0.81	8.99	0.001**
I continue to exercise even when I am busy.	pre-test	2.24	1.02		
	post-test	2.86	0.86	6.90	0.001**
I use walking or cycling as a form of daily transportation to stay active.	pre-test	2.82	1.08		
	post-test	3.80	0.67	7.98	0.001**

* = $p < 0.05$; ** = $p < 0.01$

Table 40 shows significant improvements in the Experimental Group (n = 50) after the intervention, with all items showing differences between pre- and post-tests ($p < 0.01$). Notable gains were seen in setting and following exercise plans ($t = 6.73$, p

= 0.00) and scheduling regular exercise (t = 7.49, p = 0.00). The group also improved in learning exercise methods via social media (t = 8.13, p = 0.00) and trying new sports (t = 8.99, p = 0.00). While the intervention enhanced self-planning and diverse sports participation, changes in family involvement (t = 2.91, p = 0.01) remained limited, likely due to external factors.



2.3 Comparison analysis of the Physical Exercise Behavior (PEB) between the Experimental Group and the Control Group

Table 38 Comparison analysis of the Physical Exercise Behavior (PEB) between the Experimental Group and the Control Group (n=100)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	Level Exercise
I exercise using the sports facilities at school or in the community.	Control Group	3.12	1.24	Sometime
	Experimental Group	3.28	0.95	Sometime
I do strength training or endurance exercises to improve my fitness.	Control Group	2.90	1.07	Sometime
	Experimental Group	3.14	0.93	Sometime
I exercise with my friends.	Control Group	3.50	0.93	Sometime
	Experimental Group	3.82	0.85	Often
I participate in sports with my family.	Control Group	2.56	0.81	Sometime
	Experimental Group	2.64	0.83	Sometime
I regularly create and follow my exercise plan.	Control Group	2.28	1.20	
	Experimental Group	2.98	1.04	Sometime
I do stretching or flexibility exercises every day.	Control Group	2.88	0.92	Sometime
	Experimental Group	3.40	0.86	Sometime
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	Control Group	3.10	1.17	Sometime
	Experimental Group	3.58	0.91	Often
I participate in school sports (such as basketball, soccer, volleyball, etc.).	Control Group	2.44	1.07	Rarely
	Experimental Group	3.48	0.81	Sometime
I use social media to learn new exercise methods or techniques.	Control Group	3.04	1.11	Sometime
	Experimental Group	3.66	0.90	Often
I schedule fixed exercise times during the week.	Control Group	2.50	1.09	Rarely
	Experimental Group	3.76	0.77	Often
I participate in health- and sports-related events or competitions.	Control Group	2.74	0.99	Sometime
	Experimental Group	3.38	0.70	Sometime
I engage in outdoor sports on weekends or holidays.	Control Group	2.50	1.07	Rarely
	Experimental Group	2.98	0.89	Sometime
I try new types of sports.	Control Group	2.88	1.00	Sometime
	Experimental Group	3.40	0.81	Sometime
I continue to exercise even when I am busy.	Control Group	2.36	1.03	Rarely
	Experimental Group	2.86	0.86	Sometime
I use walking or cycling as a form of daily transportation to stay active.	Control Group	2.96	1.11	Sometime
	Experimental Group	3.80	0.67	Often

1.00 - 1.50: Never exercise; 1.51 - 2.50: Rarely exercise

2.51 - 3.50: Sometimes exercise; 3.51 - 4.50: Often exercise

4.51 - 5.00: Always exercise

As shown in Table 41, The Experimental Group showed better performance than the Control Group in most exercise behaviors, particularly in exercising with friends, learning through social media, regular workouts, and aerobic activities, reaching "Often exercise" levels. This suggests the intervention effectively promoted self-planning and diverse exercise habits. However, strength training, family involvement, and weekend outdoor activities saw less improvement, indicating a need for more external support or long-term intervention.

Table 39 Difference Analysis of the Physical Exercise Behavior (PEB) between the Experimental Group and the Control Group (n=100)

Physical Exercise Behavior(PEB)		$\overline{X}$	SD	t	p
I exercise using the sports facilities at school or in the community.	Control Group	3.12	1.24		
	Experimental Group	3.28	0.95	0.73	0.47
I do strength training or endurance exercises to improve my fitness.	Control Group	2.90	1.07		
	Experimental Group	3.14	0.93	1.20	0.23
I exercise with my friends.	Control Group	3.50	0.93		
	Experimental Group	3.82	0.85	1.80	0.08
I participate in sports with my family.	Control Group	2.56	0.81		
	Experimental Group	2.64	0.83	0.49	0.63
I regularly create and follow my exercise plan.	Control Group	2.28	1.20		
	Experimental Group	2.98	1.04	3.12	0.001**
I do stretching or flexibility exercises every day.	Control Group	2.88	0.92		
	Experimental Group	3.40	0.86	2.93	0.001**
I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	Control Group	3.10	1.17		
	Experimental Group	3.58	0.91	2.30	0.02 *
I participate in school sports (such as basketball, soccer, volleyball, etc.).	Control Group	2.44	1.07		
	Experimental Group	3.48	0.81	5.46	0.001**
I use social media to learn new exercise methods or techniques.	Control Group	3.04	1.11		
	Experimental Group	3.66	0.90	3.08	0.001**
I schedule fixed exercise times during the week.	Control Group	2.50	1.09		
	Experimental Group	3.76	0.77	6.66	0.001**
I participate in health- and sports-related events or competitions.	Control Group	2.74	0.99		
	Experimental Group	3.38	0.70	3.75	0.001**
I engage in outdoor sports on weekends or holidays.	Control Group	2.50	1.07		
	Experimental Group	2.98	0.89	2.43	0.02 *
I try new types of sports.	Control Group	2.88	1.00		
	Experimental Group	3.40	0.81	2.86	0.001**
I continue to exercise even when I am busy.	Control Group	2.36	1.03		
	Experimental Group	2.86	0.86	2.65	0.01*
I use walking or cycling as a form of daily transportation to stay active.	Control Group	2.96	1.11		
	Experimental Group	3.80	0.67	4.59	0.001**

* = $p < 0.05$; ** = $p < 0.01$.

Table 42 shows that 11 items in the post-test comparison between the Experimental and Control Groups displayed significant differences ($p < 0.05$ or $p < 0.01$). The Experimental Group particularly excelled in setting and following exercise plans ($t = 3.12$, $p = 0.00$), participating in school sports ($t = 5.46$, $p = 0.00$), and scheduling regular exercise ($t = 6.66$, $p = 0.00$), indicating a strong intervention effect.

However, no significant differences were found in using facilities (t = 0.73, p = 0.47), strength/endurance training (t = 1.20, p = 0.23), exercising with friends (t = 1.80, p = 0.08), or family involvement (t = 0.49, p = 0.63), suggesting these behaviors were more influenced by external factors. Overall, while the Experimental Group outperformed the Control Group in most areas, no significant differences were seen in these specific behaviors.

3. Comparative analysis of psychological variables in exercise behavior

3.1 Analysis of differences in psychological variables between the pre- and post-tests in the Control Group

Table 40 Comparison analysis of the pre-test and post-test Decisional balance (DB), Processes of change (POC), Self-efficacy(SE) in the Control Group

Variables		$\overline{X}$	SD	t	p
Decisional balance(DB)	pre-test	28.46	3.73		
	post-test	29.72	4.22	1.63	0.10
Processes of change(POC)	pre-test	146.38	17.08		
	post-test	153.94	17.69	3.82	0.001**
Self efficacy(SE)	pre-test	27.54	6.08		
	post-test	29.66	5.86	2.68	0.01*

* = p < 0.05; ** = p < 0.01

Table 43 shows that the pre- and post-test scores for the control group in Decisional Balance (DB)did not exhibit a significant difference (t = 1.63, p = 0.10), indicating no notable change in Decisional Balance during the experiment. In contrast, the pre-test mean for Processes of Change (POC)was 146.38, which increased to 153.94 in the post-test, a significant difference (t = 3.82, p = 0.00), suggesting that even without intervention, the control group showed improvement in Processes of Change. Additionally, the control group's Self-Efficacy(SE) pre-test mean was 27.54, increasing to 29.66 in the post-test, a significant difference (t = 2.68, p = 0.01), indicating a notable improvement in Self-Efficacy during the experiment.

3.2 Analysis of differences in psychological variables between the pre- and post-tests in the Experimental Group

Table 41 Comparison analysis of the pre-test and post-test Decisional balance (DB), Processes of change (POC), Self-efficacy(SE) in the Experimental Group

Variables		$\overline{X}$	SD	t	p
Decisional balance(DB)	pre-test	29.06	3.77		
	post-test	30.56	5.03	1.81	0.07
Processes of change(POC)	pre-test	147.50	19.14		
	post-test	174.74	17.36	10.43	0.001**
Self efficacy(SE)	pre-test	28.42	5.92		
	post-test	35.38	4.87	11.15	0.001**

* = $p < 0.05$; ** = $p < 0.01$

Table 44 shows that the pre-test mean for Processes of Change (POC) in the experimental group was 147.50, which significantly increased to 174.74 in the post-test ($t = 10.43$, $p = 0.00$), indicating that the TTM-based intervention had a substantial positive impact on POC. Similarly, the pre-test mean for Self-Efficacy (SE) was 28.42, which increased to 35.38 in the post-test, showing a significant difference ($t = 11.15$, $p = 0.00$), demonstrating a marked improvement in SE after the 12-week intervention. In contrast, the mean scores for Decisional Balance (DB) were 29.06 and 30.56 for the pre- and post-tests, respectively, but the difference did not reach statistical significance ($t = 1.81$, $p = 0.07$), indicating limited change in DB for the experimental group.

3.3 Analysis of differences in psychological variables between the Experimental Group and the Control Group

Table 42 Comparison analysis of the Decisional balance (DB), Processes of change (POC), Self-efficacy(SE) between the Experimental Group and the Control Group

Variables		$\overline{X}$	SD	t	p
Decisional balance(DB)	Control Group	29.72	4.22		
	Experimental Group	30.77	4.85	1.15	0.25
Processes of change(POC)	Control Group	153.94	17.69		
	Experimental Group	174.74	17.36	5.93	0.001**
Self efficacy(SE)	Control Group	29.66	5.86		
	Experimental Group	35.38	4.87	5.30	0.001**

* = $p < 0.05$; ** = $p < 0.01$

Table 45 shows the post-test results for the experimental and control groups, indicating that the experimental group scored significantly higher than the control group in both Processes of Change (POC) and Self-Efficacy (SE). Specifically, the experimental group's POC score was 174.74, notably higher than the control group's 153.94, with a statistically significant difference ($t = 5.93$, $p = 0.00$), demonstrating that the TTM intervention had a significant positive impact on the experimental group's POC. In terms of SE, the experimental group scored 35.38, also significantly higher than the control group's 29.66 ($t = 5.30$, $p = 0.00$). However, there was no significant difference between the groups in Decisional Balance (DB) ($t = 1.15$, $p = 0.25$), indicating no notable variation between the two groups on this variable.

CHAPER V

CONCLUSIONS, DISCUSSIONS AND SUGGESTIONS

1. Conclusions

This study systematically investigated the psychological mechanisms underlying adolescent exercise behavior through data analysis and experimental intervention, while validating the effectiveness of the Transtheoretical Model (TTM). The following conclusions summarize the main findings and provide important theoretical and practical insights for future studies and applications.

First, a preliminary test involving 300 adolescents confirmed that the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ) is an effective and reliable measurement scale. This validation provides a solid foundation for subsequent large-scale data collection and analysis.

Second, based on a large-scale questionnaire survey involving 2,100 adolescents, this study systematically analyzed the complex relationships between the structural variables of the Transtheoretical Model (TTM). The results showed significant correlations between stages of change (SOC) and decisional balance (DB), processes of change (POC), and self-efficacy (SE) in adolescents. Specifically, as the stage of change advances, POC and SE scores increase significantly, indicating a positive correlation. Exercise frequency was also positively correlated with POC and SE, suggesting that higher frequency leads to more positive psychological outcomes. While the correlation with DB was significant, it did not show a clear directional trend. Additionally, gender and grade had a significant impact on these psychological variables, with male adolescents and higher-grade students outperforming their peers. Therefore, these results highlight the importance of considering individual differences in the development of effective intervention strategies. These findings highlight the importance of accounting for individual differences in designing effective interventions and provide a basis for experimental intervention strategies.

Thirdly, the 12-week intervention experiment confirmed the positive impact of the Transtheoretical Model (TTM) on adolescent Physical Exercise Behavior (PEB). While the Control Group, which did not receive any intervention, still showed

significant improvements in PEB—likely due to resource availability or environmental changes—the Experimental Group exhibited more substantial gains. These improvements were particularly evident in behaviors such as setting and following exercise plans, scheduling regular workouts, learning new sports via social media, and participating in diverse physical activities. This underscores the effectiveness of the intervention in promoting self-planning and engagement in varied sports activities. However, both groups showed limited progress in increasing family involvement, indicating that this behavior may be more influenced by external factors beyond the scope of the intervention. Comparisons between the Experimental and Control Groups further demonstrated that the Experimental Group outperformed in most exercise-related behaviors, though no significant differences were found in aspects such as using facilities, strength training, exercising with friends, or family involvement. These findings suggest that such behaviors may depend more heavily on external support and resources. Additionally, the Experimental Group experienced significant increases in Processes of Change (POC) and Self-Efficacy (SE), highlighting the intervention's positive influence on these psychological variables. In contrast, Decisional Balance (DB) did not show significant differences between the groups, implying that DB might be more critical in the initial stages of behavior change. Overall, these results emphasize the importance of personalized and sustained interventions for achieving long-term success in behavior change. Therefore, the intervention results emphasize the need for personalized, sustained strategies to ensure long-term behavioral change success.

In conclusion, this study developed and validated the Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ), systematically analyzed the interrelationships among the structural variables of the Transtheoretical Model (TTM), and evaluated the impact of TTM-based interventions on adolescent exercise behavior. The findings offer theoretical support and practical insights for applying TTM in promoting adolescent physical activity. The findings offer theoretical support and practical insights for applying TTM in promoting adolescent physical activity, providing a foundation for future research to expand upon. Future research should expand the sample size, explore its application across diverse populations and health

behaviors, and develop diverse intervention strategies to further promote healthy behaviors.

2. Discussions

"Insufficient physical activity" has long been a significant issue affecting the physical and mental health of young people worldwide. The International Physical Activity Guidelines recommend that adolescents engage in an average of 150 minutes of moderate to vigorous physical activity per week (WHO, 2020). However, recent studies have found that over 80% of adolescents fail to meet these physical activity recommendations (WHO, 2022). The situation in China is equally alarming, with the Eighth National Student Physical Fitness and Health Survey Report indicating that only 23.8% of students aged 6 to 22 exhibit good physical fitness levels (Chinese Ministry of Education, 2021). There is growing evidence linking insufficient exercise to various health issues such as obesity, hypertension, cancer, and cardiovascular diseases (Piercy, K. L., & Troiano, R. P., 2018). Clearly, the lack of physical activity among adolescents is a global concern. In the field of behavioral science, the Transtheoretical Model (TTM) is a widely recognized theory that effectively explains and predicts individual exercise behavior. It has been validated across diverse populations (Kim, Y., 2021; Kamran, A., 2023). Despite its broad application in exercise behavior research, several challenges remain regarding the practical use of TTM. First, TTM-related questionnaires are primarily developed in English, and cultural differences may arise during translation. Although some scholars have designed TTM questionnaires for college students, there is currently no version tailored specifically for Chinese adolescents. Second, for adolescent populations, the internal structural relationships within TTM require further exploration. Lastly, most existing studies are cross-sectional in nature, lacking longitudinal experimental research.

This study will address the aforementioned issues through three approaches. First, it will develop a Chinese version of the "Adolescent Physical Exercise Behavior Change Questionnaire (APEBCQ)" to provide a practical measurement tool for studying adolescent exercise behavior. Second, a large-scale survey will be conducted across 14 cities in Guangxi, China, to assess the current state of adolescent physical

exercise and analyze the relationships between TTM structural variables. Third, TTM will serve as the theoretical foundation for a detailed 12-week intervention program. By comparing the outcomes of the Control Group with those of the TTM intervention group, direct evidence supporting the effectiveness of TTM interventions will be obtained.

Phase 1

In the first phase of this study, our primary goal was to develop and validate a scale capable of effectively measuring the exercise behavior of Chinese adolescents. During this phase, we conducted a series of item analyses, correlation analyses, and reliability assessments to systematically evaluate the scale's metrics, ensuring its scientific rigor and reliability as a valid measurement tool. The following section will discuss the research process and key findings of this phase in detail.

In the first phase, the objective of the study was to develop and validate the scale, ensuring it effectively measures the exercise behavior of Chinese adolescents. During this phase, item analysis was conducted to assess the discrimination of the items, Pearson correlation analysis was used to examine the relationship between individual items and the total score, and reliability analysis was performed to evaluate the consistency of the questionnaire. Through the measurement of 300 adolescents, the validity of the APEBCQ was confirmed. The indicators of the Decisional Balance (DB) Scale, Processes of Change (POC) Scale, and SE-Scale demonstrated good discrimination, correlation, and internal consistency, meeting the criteria for a valid measurement scale. Specifically, the two dimensions of the Decisional Balance (DB) Scale (Positive factors and Negative factors) both showed strong discrimination and internal consistency. Most items within the ten dimensions of the Processes of Change (POC) Scale also exhibited significant statistical characteristics; however, the validity of item POC33 was low, suggesting it should be considered for removal in the final version of the scale. The two dimensions of the Self-Efficacy (SE) Scale (Exercise Willingness and Exercise Effort) also demonstrated high reliability.

Phase 2

In the second phase of this study, the aim was to analyze the internal structural

relationships within the Transtheoretical Model (TTM) and identify key variables that influence the Processes of Change (POC). By thoroughly examining the current state of adolescent exercise behavior, gender and grade differences, and the relationship between exercise frequency and related psychological variables, this phase provided new insights into the complexity of adolescent exercise behavior and further validated the applicability and effectiveness of TTM. The following section will discuss these key findings in detail, along with their theoretical and practical implications.

Firstly, the current state of adolescent exercise behavior is concerning. The study revealed that over half of the adolescents (57.3%) do not engage in regular exercise, with only 42.7% participating in physical activities, and a mere 12.5% being in the maintenance stage of exercise behavior. These findings differ from previous research. For example, Fan Chong (2021) reported a higher proportion of adolescents with hearing impairments in the action stage of exercise behavior. However, the school environment and educational strategies for general adolescents and those with hearing impairments differ significantly, making direct comparisons between the two groups less meaningful. It is also important to note that, aside from the aforementioned study on adolescents with hearing impairments, there have been no studies utilizing TTM to investigate the exercise behavior of Chinese adolescents in the past five years. On the other hand, some researchers have focused on the exercise behavior of Chinese university students. For instance, Zheng Xiao (2019) found that the majority of university students in Shanxi Province were in the contemplation and preparation stages, with the fewest in the action and maintenance stages, and only 22% engaging in regular exercise. Similarly, Jia Yunting (2018) reported that 40.5% of university students in Yunnan Province engaged in physical activity. Adolescence is a critical transition period into university life, and exercise habits formed during adolescence can significantly influence exercise behavior in university students. From this perspective, the lack of exercise among university students may be linked to their exercise behavior patterns during adolescence. In conclusion, this study underscores the widespread insufficiency of exercise behavior among adolescents and highlights the need for targeted interventions.

Secondly, this study revealed significant gender differences in exercise behavior and related psychological variables. The results indicated that male adolescents

outperformed female adolescents across all stages of exercise behavior and scored significantly higher on psychological variables such as Decisional Balance (DB), Processes of Change (POC), and Self-Efficacy (SE). This finding aligns with research conducted on university student populations in various regions (YoungHo Kim, 2021; Heontae Kim, 2021; Zheng Xiao, 2019; Guo Rui, 2018), suggesting that gender differences may affect the stage distribution of exercise behavior and the levels of related psychological variables among adolescents. A possible explanation for this is that males generally exhibit stronger athletic abilities and a greater need for social interaction, which may contribute to better performance in physical exercise behavior. Future research should further investigate the underlying mechanisms of these gender differences and develop targeted interventions to more effectively promote exercise behavior among adolescents of different genders.

Thirdly, the analysis of grade differences revealed variations in the distribution of Processes of Change (POC) among students from different grades. Although no consistent pattern was observed, higher-grade students (high school) generally scored higher on the Decisional Balance (DB), Processes of Change (POC), and Self-Efficacy (SE) scales compared to lower-grade students (junior high). This suggests that as adolescents grow older, their psychological maturity and understanding of physical exercise may increase, which in turn influences their exercise behavior. This finding implies that exercise interventions should be tailored to the developmental characteristics of different grades in order to better support adolescents as they transition through various stages of exercise behavior.

Fourthly, the Number of Exercises (NOE) was found to be significantly correlated with Decisional Balance (DB), Processes of Change (POC), and Self-Efficacy (SE). As NOE increased, individuals' scores on these psychological variables also showed significant improvement. This finding suggests that increasing the frequency of exercise can effectively enhance adolescents' POC and SE, which is consistent with previous research (e.g., YoungHo Kim, 2021). Therefore, actively encouraging and organizing more opportunities for adolescents to engage in physical exercise can lead to positive changes in these psychological variables, thereby promoting healthier exercise behavior.

Fifthly, significant differences were observed in Decisional Balance (DB),

Processes of Change (POC), and Self-Efficacy (SE) across different Stages of Change (SOC). Using SOC as the independent variable and DB, POC, and SE as dependent variables, MANOVA analysis revealed significant main effects of the stages of change. Multiple comparison analysis found no consistent differences among the stages in the DB-Scale. However, in the POC-Scale and SE-Scale, groups that engaged in exercise behavior scored significantly higher than those that did not, indicating that the higher the stage of change, the higher the POC and SE. Studies on university students' exercise behavior in various regions have also shown a positive correlation between SOC and POC, SE (Guo Rui, 2018; Li Zhuo, 2017; Kien Ting Liu, 2021). Thus, this study further validates the practicality and effectiveness of the Transtheoretical Model (TTM). Also, Related studies have also identified these two variables as key components in the process of exercise behavior change (YoungHo Kim, 2021; Heontae Kim, 2021; Fan Chong, 2021; Yin Bo, 2009). Future research should focus on investigating the importance of POC and SE within this model.

Phase 3

In the third phase of this study, we conducted a 12-week longitudinal experiment to gather direct evidence validating the effectiveness of Transtheoretical Model (TTM) interventions. Building on the findings from the previous phases, this phase further explored the impact of TTM interventions on adolescent Physical Exercise Behavior(PEB). The results showed that the intervention significantly improved adolescents' self-planning abilities and their diverse participation in physical activities. Additionally, the study analyzed the roles of key psychological constructs, including Decisional Balance (DB), Processes of Change (POC), and Self-Efficacy (SE), confirming the applicability of TTM. These insights provide valuable understanding of how structured interventions can effectively promote healthy behavior patterns among adolescents.

First, the results showed no significant difference in the Processes of Change (POC) for the Control Group between pre- and post-tests, while the Experimental Group demonstrated significant improvement. This indicates that TTM interventions effectively promoted progress in the stages of behavior change among adolescents. This finding aligns with previous studies, such as Josyanne Lapointe's (2023), which

also showed that TTM-based behavior change techniques successfully increased physical activity levels in adults. In this study, TTM interventions not only improved adolescents' self-planning abilities for physical exercise but also enhanced their willingness to learn new sports through social media and participate in diverse physical activities. However, improvements in strength training and family involvement may require additional external support or longer-term interventions. Therefore, future behavior change programs should focus more on personalized interventions and resource availability to ensure broader behavior change and long-term success.

Secondly, the Control Group showed no significant differences in Decisional Balance (DB) between the pre- and post-tests. However, there were some minor changes in Processes of Change (POC) and Self-Efficacy (SE) between the pre- and post-tests, though these changes were minimal. This could be due to a measurement reactivity effect associated with self-assessment (Konig et al., 2022), where the measurement process itself influences behavior or intentions. For instance, participants may become aware of their insufficient physical activity during the initial assessment, which could prompt them to increase their exercise behavior or intentions.

Thirdly, in the Experimental Group, there were no significant differences in Decisional Balance (DB) between the pre- and post-tests, but there were very significant changes in Processes of Change (POC) and Self-Efficacy (SE) between the pre- and post-tests. These results indicate that the TTM intervention had a substantial positive impact on adolescents' POC and SE. To further validate that the Experimental Group showed more significant improvements compared to the Control Group, an independent samples t-test was conducted. The results confirmed that the TTM intervention significantly enhanced adolescents' POC and SE, supporting previous research that highlights self-efficacy as a powerful predictor of behavior change (Romain, A. J., 2018; Jo, P., 2008).

In adolescent populations, TTM interventions have been proven effective, significantly enhancing self-efficacy (SE) and the sustainability of healthy behaviors (Asiyeh Pirzadeh, 2020; Marshall & Biddle, 2001). This study further validates the theory, demonstrating that TTM interventions have a significant positive impact on

adolescents' physical exercise behavior. Indeed, TTM interventions positively influence POC and SE across various groups. For example, adults' POC improved following the intervention (Josyanne Lapointe, 2023), and university students' SE significantly increased post-intervention (Yin Bo, 2009). These studies highlight the maturity and effectiveness of TTM-based experimental research.

In this study, goal-setting strategies and planning were used for the experimental intervention, incorporating tools such as verbal communication, books, pictures, and videos. These strategies likely contributed to the enhancement of adolescents' Self-Efficacy (SE) and Processes of Change (POC). Kahar Abula (2018) suggested that exercise guidelines could promote exercise intentions and improve exercise behavior levels. Therefore, developing an exercise behavior guide or plan based on the Transtheoretical Model (TTM) could be considered an effective strategy. When designing exercise plans or guides for adolescents, special attention should be given to POC and SE. Romain, A. J. (2018) emphasized that SE and POC are critical constructs in TTM, particularly SE, which can effectively promote transitions through the Stages of Change (SOC) when combined with POC. Vahedian, M., et al. (2013) also identified SE as the most important factor in enhancing individual physical activity levels.

3. Suggestions

Research Limitations

Although this study provides important theoretical and practical support for understanding adolescent exercise behavior, there are still several limitations that future research should address for improvement:

1. Limitations of the sample range

This study's sample was limited to adolescents from a specific region (Guangxi Province, China), which may restrict the generalizability and external validity of the results. Future research should expand the sample range to include adolescents from different regions and cultural backgrounds to better validate the universality of the findings.

2. Measurement reactivity effect

Participants may have been influenced by self-assessment when responding to

the questionnaire, leading to potential bias in the changes of psychological variables. Future research should consider using more objective measurement tools (such as activity trackers) and controlling for potential confounding factors to improve the accuracy of the results.

3. Insufficient control group setup

This study included only a Control Group and an Experimental Group, lacking other intervention Control Groups (such as an exercise prescription group or social support group). Future research should incorporate more types of intervention Control Groups to comprehensively analyze the relative effectiveness of different intervention methods and optimize the TTM intervention approach.

4. Lack of long-term follow-up

The intervention effects in this study were primarily based on short-term data (12 weeks), making it difficult to assess long-term outcomes and sustainability. Future research should incorporate a long-term follow-up design to evaluate the effectiveness of the intervention over an extended period and explore the potential mechanisms and long-term impacts of TTM interventions.

Suggestions for applying research

1. Development of an Adolescent Exercise Behavior Intervention Manual

Based on the significant correlations between Processes of Change (POC), Self-Efficacy (SE), and Stages of Change (SOC), it is recommended to develop an intervention manual specifically targeted at improving exercise behavior among adolescents aged 13-17. This manual aims to effectively enhance self-efficacy and facilitate behavioral change in physical activity. The intervention manual should include scientifically grounded exercise recommendations, practical strategies for creating personalized exercise plans, and methods to boost self-efficacy, such as gradual goal-setting, positive self-talk, and emphasizing the importance of social support. This manual can be widely applied in schools, communities, and families to help adolescents establish and maintain regular exercise habits, thereby improving both their physical health and psychological well-being.

2. Introduction of multidimensional psychological support

Research indicates that POC and SE play a crucial role across different stages of

change. Therefore, it is recommended to integrate multidimensional psychological support—such as motivation mechanisms, goal setting, and feedback systems—in practice to help adolescents enhance self-efficacy at various stages of change, thereby promoting behavior modification. Specifically, in educational and health promotion programs, regular psychological counseling and social support should be introduced, particularly in the early stages of change, to provide additional resources that strengthen adolescents' decisional balance (DB) and exercise motivation.

3. Promotion of TTM-based educational and policy applications

Based on the study results, it is recommended to widely apply the Transtheoretical Model (TTM) framework in promoting adolescent exercise behavior. TTM principles can be integrated into adolescents' daily lives through school education policies, community health initiatives, and parental involvement, enhancing participation in physical activities. Policymakers should develop tailored intervention programs that address the differences in gender, grade level, and cultural background highlighted in the research to better address the diversity and complexity of adolescent exercise behavior.

Suggestions for future research

1. Expand sample range and diversity

Future research should expand the sample range to include adolescents from more regions and cultural backgrounds, enhancing the generalizability and external validity of the findings. Additionally, socioeconomic factors (such as family economic status and cultural background) should be considered to comprehensively explore their impact on adolescent exercise behavior.

2. Conduct longitudinal studies to assess the long-term effects of interventions

It is recommended that future research design long-term follow-up studies to assess the stability and effectiveness of interventions over time. By tracking adolescents' progress across different stages of change (SOC), these studies can provide a better understanding of the persistence of behavior change and its impact on future health behaviors.

3. Introduce more psychological and behavioral variables

Future research should incorporate more psychological and behavioral variables, such as intrinsic motivation, social support, family influence, and mental health, to gain a more comprehensive understanding of the complex psychological mechanisms underlying adolescent exercise behavior. Additionally, exploring how these variables interact with TTM structural variables such as POC, SE, and SOC will further enhance our understanding of behavior change.

4. Integrate multiple theoretical models for intervention design

Although this study was based on the TTM framework, future research should explore integrating other health behavior models, such as the Social Cognitive Theory and Health Belief Model, with TTM to design more comprehensive intervention programs. Particularly in the early stages of behavior change, these models may play a significant role in enhancing adolescent engagement and the effectiveness of behavior change interventions.

5. Explore group differences and personalized intervention strategies

The study found that factors such as gender and grade level significantly influence adolescent exercise behavior. Future research should further explore how these group differences manifest in interventions. Personalized intervention programs should be designed for adolescents of different genders, grade levels, or cultural backgrounds, and the specific effects of these programs in promoting behavior change should be examined. Additionally, attention should be given to adolescents with special needs, such as those with low motivation or greater behavioral resistance, to develop targeted intervention strategies.

REFERENCES

REFERENCES

Abula, K., Gröpel, P., Chen, K., & Beckmann, J. (2018). Does knowledge of physical activity recommendations increase physical activity among Chinese college students? Empirical investigations based on the transtheoretical model. Journal of sport and health science, 7(1), 77-82.

Adams, J., & White, M. (2003). Are activity promotion interventions based on the transtheoretical model effective? A critical review. British Journal of Sports Medicine, 37(2), 106-114.

Bandura, A., Freeman, W. H., & Lightsey, R. (1999). Self-efficacy: The exercise of control.

Bao Huhe. (2012). Research on changes in physical exercise behavior of Mongolian college students using the transtheoretical model. Journal of Shenyang Institute of Physical Education, 31(2), 5.

Baranowski, T., Anderson, C., & Carmack, C. (1998). Mediating variable framework in physical activity interventions: How are we doing? How might we do better?. American journal of preventive medicine, 15(4), 266-297.

Callaghan, P., Eves, F. F., Norman, P., Chang, A. M., & Lung, C. Y. (2002). Applying the transtheoretical model of change to exercise in young Chinese people. British journal of health psychology, 7(3), 267-282.

Cardinal, B. J., Tuominen, K. J., & Rintala, P. (2004). Cross-cultural comparison of American and Finnish college students' exercise behavior using transtheoretical model constructs. Research Quarterly for Exercise and Sport, 75(1), 92-101.

Chu Renyuan, & Xu Ye. (2021). Progress in the prevention and control of myopia in children and adolescents in 2021. Chinese Medical Information Herald, 36(24), 1.

Comrey, A. L. (1988). Factor-analytic methods of scale development in personality and clinical psychology. Journal of consulting and clinical psychology, 56(5), 754.

Cui Shijun. (2014). Study on the change stage of physical exercise behavior of students in higher vocational colleges by using Transtheoretical model. Journal of Guangzhou University of Physical Education (02), 113-115+119. doi:10.13830/j.cnki.cn44 1129/g8.2014.02.032.

Dang Chuanqi, Zhang Zhendong, & Du Songjian. (2019). Research on the current situation of adolescent physical health - taking Guangxi Rongshui National Senior High School as an example. Youth Sports (3), 3.

De Menezes, M. C., Bedeschi, L. B., Dos Santos, L. C., & Lopes, A. C. S. (2016). Interventions directed at eating habits and physical activity using the Transtheoretical Model: a systematic review. Nutricion hospitalaria, 33(5), 1194-1204.

DiClemente, C. C., Prochaska, J. O., Fairhurst, S. K., Velicer, W. F., Velasquez, M. M., & Rossi, J. S. (1991). The process of smoking cessation: an analysis of precontemplation, contemplation, and preparation stages of change. Journal of consulting and clinical psychology, 59(2), 295.

Dishman, R. K., & Buckworth, J. (1996). Increasing physical activity: a quantitative synthesis. Medicine and science in sports and exercise, 28(6), 706-719.

Elezim, A., Elezi, G., Gontarev, S., & Georgiev, G. (2019). Application of the Transtheoretical Model (TTM) to exercise behaviour among Macedonian college students. Journal of Human Sport and Exercise.

Farmanbar, R., Niknami, S., Heydarnia, A., Hajizadeh, E., & Lubans, D. R. (2009). Predicting exercise behavior among Iranian college students using the transtheoretical model and structural equation modeling. European Journal of Scientific Research, 31(3), 355-365.

Frucht, S. S. (1998). An application of the transtheoretical model of behavior change to the adoption of cholesterol-lowering behaviors by college students. University of Missouri-Kansas City.

Fühner, T., Kliegl, R., Arntz, F., Kriemler, S., & Granacher, U. (2021). An update on secular trends in physical fitness of children and adolescents from 1972 to 2015: a systematic review. Sports Medicine, 51, 303-320.

Ghaffari, M., Mehrabi, Y., Rakhshanderou, S., Safari-Moradabadi, A., & Samiei-e-Nasr, M. (2021). Predictors of physical activity among employees in Tehran: a cross-sectional study based on the trans-theoretical model. Journal of Public Health, 29, 503-508.

Gorely, T., & Gordon, S. (1995). An examination of the transtheoretical model and exercise behavior in older adults. Journal of Sport and Exercise Psychology,

17(3), 312-324.

Guo Rui. (2018). Study on extracurricular physical exercise behavior and influencing factors of college students in Wuhan from the perspective of transtheoretical model (Master's thesis, Central China Normal University).

Guo Yugang & Qian Zhangshi. (2012). The research status and prospect of Transtheoretical model in college students' physical exercise behavior. Value Engineering (06), 198-199. doi:10.14018/j.cnki.cn13-1085/n.2012.06.183.

Guo Zhengmao, & Yang Jian. (2019). Research progress, reflection and trend of the transtheoretical model of physical exercise. Journal of Xi'an Institute of Physical Education, 36(1), 8.

Guthold, R., Stevens, G. A., Riley, L. M., & Bull, F. C. (2020). Global trends in insufficient physical activity among adolescents: a pooled analysis of 298 population-based surveys with 1· 6 million participants. The Lancet Child & Adolescent Health, 4(1), 23-35.

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., ... & Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker). Nature human behaviour, 5(4), 529-538.

Hall, G. S. (1905). Adolescence: Its psychology and its relations to physiology, anthropology, sociology, sex, crime, religion and education (Vol. 2). D. Appleton.

Han, H., Pettee Gabriel, K., & Kohl III, H. W. (2017). Application of the transtheoretical model to sedentary behaviors and its association with physical activity status. PloS one, 12(4), e0176330.

Hashemzadeh, M., Rahimi, A., Zare-Farashbandi, F., Alavi-Naeini, A. M., & Daei, A. (2019). Transtheoretical model of health behavioral change: A systematic review. Iranian journal of nursing and midwifery research, 24(2), 83.

Henson, R. K. (2001). Understanding internal consistency reliability estimates: A conceptual primer on coefficient alpha. Measurement and evaluation in counseling and development, 34(3), 177-189.

Högberg, B., & Horn, D. (2022). National high-stakes testing, gender, and school stress in Europe: A difference-in-differences analysis. European Sociological Review, 38(6), 975-987.

Hu Jubo Et al..(2014). Study on the change of physical exercise behavior of

vocational college students by using Transtheoretical model. Zhejiang Sports Science (01),57-62.

Huang Shuyuan. (2020). Research and analysis on the physical health status of adolescents in Shandong Province - Based on a cross-sectional survey. Ice and Snow Sports Innovation Research (22), 2.

Huo Fangwen. (2011). A study on the relationship between exercise attitude and mental health of male college students under the theory of Stage change of Exercise Behavior (Doctoral dissertation, Central China Normal University).

Jalali, S., Roozbahani, N., & Shamsi, M. (2022). The effectiveness of tailored interactive multimedia software based on the trans-theoretical model for the promotion of physical activity behaviours. The Malaysian Journal of Medical Sciences, 29(4), 140-151.

Ji Gang, Wang Zhiqiang, & Dong Shanshan. (2020). Investigation and analysis of the current situation of adolescent physical fitness assessment and healthy lifestyle. China Health Education (2), 4.

Jia Yunting. (2018). Using the transtheoretical model in higher vocational colleges student movement behavior formation (a master's degree thesis, yunnan normal university).
https://kns.cnki.net/KCMS/detail/detail.aspx?dbname=CMFD201901&filename=101879698 0.nh

Jia, Y. (2018). Study on the formation process of sports behavior of students in higher vocational colleges using the transtheoretical model (Master's thesis, Yunnan Normal University).

Jiang Tiefeng. (2007). A modified study of the Change stage (continuous measurement) scale of college students' physical exercise. Zhejiang Sports Science, 29(2), 6.

Jo, P. (2008). The transtheoretical model and stages of change. Health behavior and health education: Theory, research, and practice, 97-121.

Kahn, E. B., Ramsey, L. T., Brownson, R. C., Heath, G. W., Howze, E. H., Powell, K. E., ... & Corso, P. (2002). The effectiveness of interventions to increase physical activity: a systematic review. American journal of preventive medicine, 22(4), 73-107.

Kamran, A., Aliakbari, P., Nasimi Doost Azgomi, R., & Naeim, M. (2023). Action status and willingness to change health-promoting behaviors during the COVID-19 pandemic among elementary school children: a study based on Prochaska's stages of behavior change theory (TTM). BMC Public Health, 23(1), 248.

Kang, S., & Kim, Y. (2017). Application of the transtheoretical model to identify predictors of physical activity transition in university students. Revista de psicología del deporte, 26(3), 6-11.

Kim, H., Song, T., Lim, S., Kohl, H. W., & Han, H. (2021). Physical activity engagement outside of college physical education: application of the transtheoretical model. American Journal of Health Behavior, 45(5), 924-932.

Kim, Y. H. (2004). Korean adolescents' exercise behavior and its relationship with psychological variables based on stages of change model. Journal of adolescent health, 34(6), 523-530.

Kim, Y. H., & Kang, S. J. (2020). Effects of a weight control intervention based on the transtheoretical model on physical activity and psychological variables in middleaged obese women. J. Women Aging. 10.1080/08952841.2020.1728183.

Kim, Y., Kim, S. K., & Park, I. (2021). Application of the transtheoretical model to understand physical activity in college students. Asian Journal of Sport and Exercise Psychology, 1(2-3), 98-102.

Kleis, R. R., Hoch, M. C., Hogg-Graham, R., & Hoch, J. M. (2020). The effectiveness of the transtheoretical model to improve physical activity in healthy adults: a systematic review. Journal of Physical Activity and Health, 18(1), 94-108.

Kline, R. B. (1998). Structural equation modeling. New York: Guilford, 33.

König, L. M., Allmeta, A., Christlein, N., Van Emmenis, M., & Sutton, S. (2022). A systematic review and meta-analysis of studies of reactivity to digital in-the-moment measurement of health behaviour. Health Psychology Review, 16(4), 551-575.

Kuruvilla, S., Bustreo, F., Kuo, T., Mishra, C. K., Taylor, K., Fogstad, H., ... & Costello, A. (2016). The Global strategy for women's, children's and adolescents' health (2016–2030): a roadmap based on evidence and country experience. Bulletin of the World Health Organization, 94(5), 398.

Lapointe, J., Comtois, A. S., Romain, A. J., & Bernard, P. (2023). The

Transtheoretical model's processes of change in the heart of a physical activity intervention: a series of n-of-1. Psychology of Sport and Exercise, 67, 102430.

Li Zhuo. (2017). Research on the stage characteristics and influencing factors of after-school physical exercise behavior of college students in Liaoning Province (Master's thesis, Shenyang Institute of Physical Education).

Li, X., Wang, Y., Li, X. T., Li, D. F., Sun, C., Xie, M. H., & Wang, Z. Z. (2015). Revision and reliability and validity study of the Chinese version of the Physical Activity Questionnaire for Adolescents (PAQ-A). Journal of Beijing Sport University, 38(5), 63-67.

Liu, K. T., Kueh, Y. C., Arifin, W. N., Kim, Y., & Kuan, G. (2018). Application of transtheoretical model on behavioral changes, and amount of physical activity among university's students. Frontiers in psychology, 9, 2402.

Liu, K. T., Kueh, Y. C., Kim, Y., & Kuan, G. (2021). Structural relationship in transtheoretical model of behavioural change constructs among students at a Malaysian university campus. Asian Journal of Sport and Exercise Psychology, 1(2-3), 83-88.

Marcus, B. H., Goldstein, M. G., Jette, A., Simkin-Silverman, L., Pinto, B. M., Milan, F., ... & Dubé, C. E. (1997). Training physicians to conduct physical activity counseling. Preventive Medicine, 26(3), 382-388.

Marcus, B. H., Rakowski, W., & Rossi, J. S. (1992). Assessing motivational readiness and decision making for exercise. Health psychology, 11(4), 257.

Marcus, B. H., Rossi, J. S., Selby, V. C., Niaura, R. S., & Abrams, D. B. (1992). The stages and processes of exercise adoption and maintenance in a worksite sample. Health psychology, 11(6), 386.

Marcus, B. H., Selby, V. C., Niaura, R. S., & Rossi, J. S. (1992). Self-efficacy and the stages of exercise behavior change. Research quarterly for exercise and sport, 63(1), 60-66.

Marshall, S. J., & Biddle, S. J. (2001). The transtheoretical model of behavior change: a meta-analysis of applications to physical activity and exercise. Annals of behavioral medicine, 23(4), 229-246.

Ministry of Education of China. (2021). The results of the eighth national student Physique and health survey were released. Chinese Journal of School Health,

42(9), 2.

National Bureau of Statistics of China. (2023). Number of households with adolescents aged 0-19 in provinces, autonomous regions and municipalities (city). from http://www.stats.gov.cn/sj/pcsj/rkpc/5rp/html/t0503a.htm

Nigg, C. R., & Courneya, K. S. (1998). Transtheoretical model: Examining adolescent exercise behavior. Journal of adolescent health, 22(3), 214-224.

Nigg, C. R., Harmon, B., Jiang, Y., Ginis, K. A. M., Motl, R. W., & Dishman, R. K. (2019). Temporal sequencing of physical activity change constructs within the transtheoretical model. Psychology of Sport and Exercise, 45, 101557.

Nunnally, J. C., Knott, P. D., Duchnowski, A., & Parker, R. (1967). Pupillary response as a general measure of activation. Perception & psychophysics, 2, 149-155.

O'Connor, M. J. (1994). Exercise promotion in physical education: Application of the transtheoretical model. Journal of teaching in physical education, 14(1), 2-12.

Oba, T., Takano, K., Katahira, K., & Kimura, K. (2023). Revisiting the Transtheoretical Model for Physical Activity: A Large-scale Cross-sectional Study on Japanese-speaking Adults.

O'Hea, E. L., Wood, K. B., & Brantley, P. J. (2003). The transtheoretical model: gender differences across 3 health behaviors. American Journal of Health Behavior, 27(6), 645-656.

Ollerenshaw, J. A., & Creswell, J. W. (2002). Narrative research: A comparison of two restorying data analysis approaches. Qualitative inquiry, 8(3), 329-347.

Patton, G. C., Sawyer, S. M., Santelli, J. S., Ross, D. A., Afifi, R., Allen, N. B., ... & Viner, R. M. (2016). Our future: a Lancet commission on adolescent health and wellbeing. The Lancet, 387(10036), 2423-2478.

Pearson, N., Braithwaite, R., & Biddle, S. J. (2015). The effectiveness of interventions to increase physical activity among adolescent girls: a meta-analysis. Academic pediatrics, 15(1), 9-18.

Pennington, C. G. (2021). Applying the transtheoretical model of behavioral change to establish physical activity habits. Journal of Education and Recreation Patterns, 2(1).

Piercy, K. L., & Troiano, R. P. (2018). Physical activity guidelines for Americans from the US department of health and human services: Cardiovascular benefits

and recommendations. Circulation: Cardiovascular Quality and Outcomes, 11(11), e005263.

Pirzadeh, A., & Mostafavi, F. (2017). Psychological constructs influencing exercise behavior in women according to the transtheoretical model: A questionnaire survey. International Journal of High Risk Behaviors and Addiction, 6(2).

Pirzadeh, A., Zamani, F., Khoshali, M., & Kelishadi, R. (2020). Web-based intervention on the promotion of physical activity among Iranian youth using the transtheoretical model. Journal of education and health promotion, 9.

Plotnikoff, R. C., Blanchard, C., Hotz, S. B., & Rhodes, R. (2001). Validation of the decisional balance scales in the exercise domain from the transtheoretical model: A longitudinal test. Measurement in Physical Education and Exercise Science, 5(4), 191-206.

Prochaska, J. O. , Redding, C. A. , & Evers, K. E. . (1997). The transtheoretical model and stages of change. Health Education & Behavior, 22(22), 97-121.

Prochaska, J. O.& Velicer, W. F.(1997). Response: Misinterpretations and misapplications of the transtheoretical model. American Jounna! of Health Promation. 12,11-12.

Prochaska, J. O., & DiClemente, C. C. (1983). Stages and processes of self-change of smoking: toward an integrative model of change. Journal of consulting and clinical psychology, 51(3), 390.

Prochaska, J. O., & Velicer, W. F. (1997). The transtheoretical model of health behavior change. American journal of health promotion, 12(1), 38-48.

Prochaska, J. O., Norcross, J. C., Fowler, J. L., Follick, M. J., & Abrams, D. B. (1992). Attendance and outcome in a work site weight control program: Processes and stages of change as process and predictor variables. Addictive behaviors, 17(1), 35-45.

Qin Guoyang, & Qin Yong. (2022). Analysis of adolescent physical health status and improvement strategies based on random forest model. Fujian Sports Science and Technology, 41(6), 38-41.

Reed, G. R. (1995). Measuring stage of change for exercise. University of Rhode Island.

Rizal, H., Hajar, M. S., Kueh, Y. C., Muhamad, A. S., & Kuan, G. (2019).

Confirmatory factor analysis of the Malay-language transtheoretical model of physical activity among Malaysian primary school children. The Malaysian journal of medical sciences: MJMS, 26(2), 99.

Romain, A. J., Bortolon, C., Gourlan, M., Carayol, M., Decker, E., Lareyre, O., ... & Bernard, P. (2018). Matched or nonmatched interventions based on the transtheoretical model to promote physical activity. A meta-analysis of randomized controlled trials. Journal of Sport and Health Science, 7(1), 50-57.

Ruotsalainen, H., Kyngäs, H., Tammelin, T., & Kääriäinen, M. (2015). Systematic review of physical activity and exercise interventions on body mass indices, subsequent physical activity and psychological symptoms in overweight and obese adolescents. Journal of advanced nursing, 71(11), 2461-2477.

Sawyer, S. M., Azzopardi, P. S., Wickremarathne, D., & Patton, G. C. (2018). The age of adolescence. The lancet child & adolescent health, 2(3), 223-228.

Schlack, R., Peerenboom, N., Neuperdt, L., Junker, S., & Beyer, A.-K. (2021). The efects of mental health problems in childhood and adolescence in young adults: Results of the KiGGS cohort. Journal of Health Monitoring. https://doi.org/10.25646/8863

Shaver, E. R., McGlumphy, K. C., Gill, A. K., & Hasson, R. E. (2019). Application of the transtheoretical model to physical activity and exercise behaviors in African-American adolescents. American journal of health behavior, 43(1), 119-132.

Si Qi. (2006). Path analysis among the psychological factors that affect the stage changes in college students' exercise behavior. Sports Science, 26(8), 5.

Si Qi. (2008). Exercise Psychology. Zhejiang University Press.

Spencer, L., Adams, T. B., Malone, S., Roy, L., & Yost, E. (2006). Applying the transtheoretical model to exercise: a systematic and comprehensive review of the literature. Health promotion practice, 7(4), 428-443.

Stone, E. J., McKenzie, T. L., Welk, G. J., & Booth, M. L. (1998). Effects of physical activity interventions in youth: review and synthesis. American journal of preventive medicine, 15(4), 298-315.

Tinsley, H. E., & Tinsley, D. J. (1987). Uses of factor analysis in counseling psychology research. Journal of counseling psychology, 34(4), 414.

Turhan, N. S. (2020). Karl Pearson's Chi-Square Tests. Educational Research and

Reviews, 16(9), 575-580.

Turner, R. C., & Carlson, L. (2003). Indexes of item-objective congruence for multidimensional items. International journal of testing, 3(2), 163-171.

Twenge, J. M., Martin, G. N., & Campbell, W. K. (2018). Decreases in psychological well-being among American adolescents after 2012 and links to screen time during the rise of smartphone technology. Emotion, 18(6), 765.

Vahedian, M., Alinia, A., Attarzadeh, R., & Esmaeeli, H. (2013). Assessment of Physical Activity Among Female Students of Tonekabon-Iran Based on Trans-theoretical Model. Thrita, 2(2), 127-32.

Velicer, W. F., Prochaska, J. O., Fava, J. L., Norman, G. J., & Redding, C. A. (1998). Smoking cessation and stress management: applications of the transtheoretical model. Homeostasis, 38(5-6), 216-33.

Wang Hongting. (2018). Current status of adolescents' physical health and ways to achieve it from the perspective of Healthy China. Contemporary Sports Science and Technology, 8(32), 207-208.

Wang Min. (2018). Comparative study on the physical health status of adolescents aged 13 to 18 years old in urban and rural areas of Guangdong Province. Journal of Guangzhou Institute of Physical Education, 38(4), 4.

World Health Organization. (2006). Orientation programme on adolescent health for health care providers.

World Health Organization. (2018). Prevalence of Insufficient Physical Activity. http://www.who.int/gho/ncd/risk_factors/physical_activity/en/. (accessed 13 March 2018).

World Health Organization. (2020). WHO Guidelines on Physical Activity and Sedentary Behaviour. https://apps.who.int/iris/bitstream/handle/10665/337001/9789240014886-eng.pdf

World Health Organization. (2022). Global status report on physical activity report 2022a. https://www.who.int/publications/i/item/9789240059153.

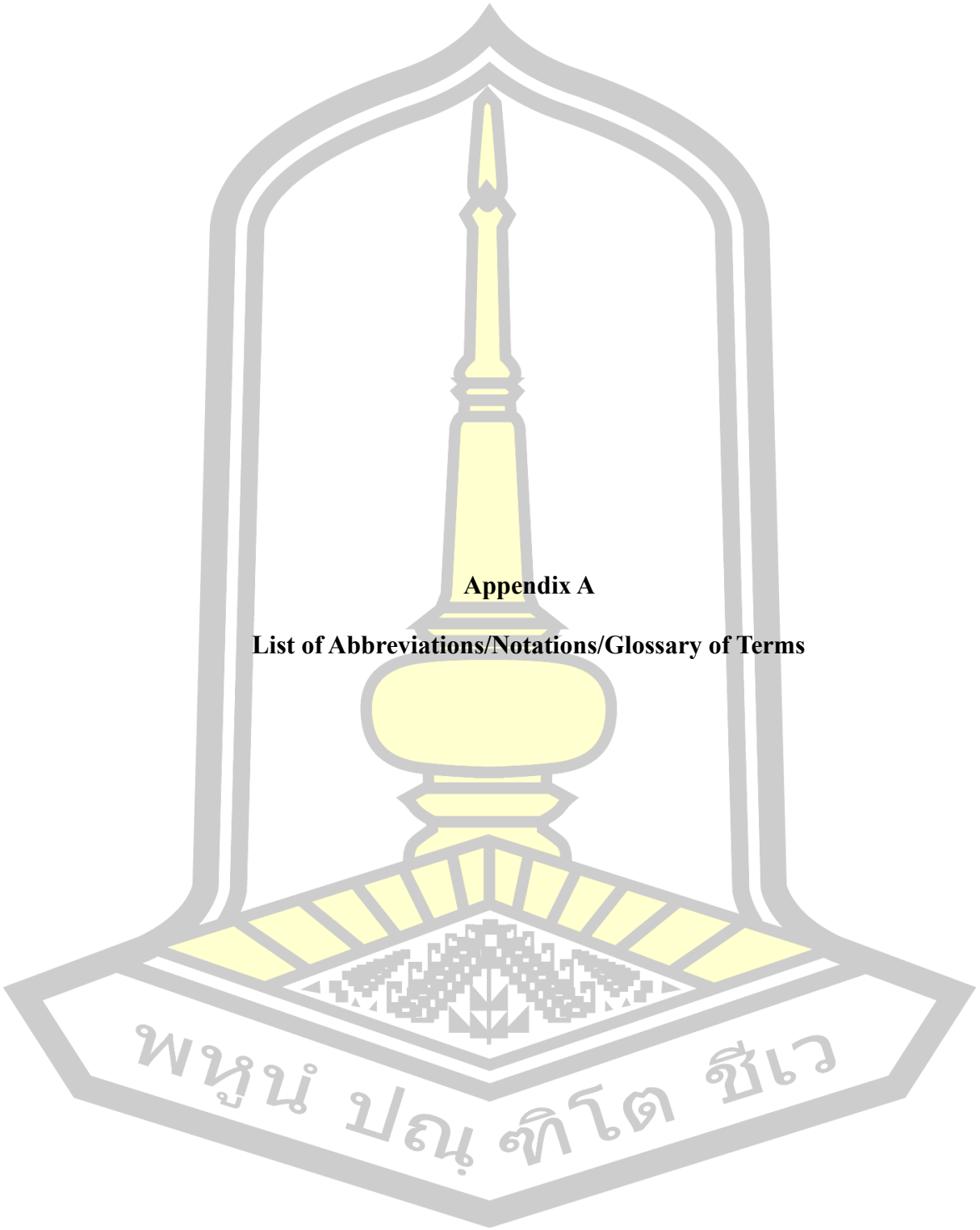
Wu Minglong. (2010). Questionnaire statistical analysis practice: SPSS operation and application. Chongqing University Press.

Yin Bo. (2009). An empirical study on the change of physical exercise behavior of college students using the transtheoretical model. Beijing Sport University Press.

Zhang Xiao, Et al.. & Cai Yuan. (2019). A study on the stages and change procedures of college students' physical exercise behavior based on Transtheoretical model. The Chinese journal of disease control (10), 1186-1190 + 1223. Doi: 10.16462 / j.carol carroll nki ZHJBKZ. 2019.10.006.

Zheng X, Zhang C, Jin Z, Lu J, Hou L, Li M, ... & Cai Y. (2019). Study on the stages and change process of physical exercise behavior of college students based on the transtheoretical model. Chinese Journal of Disease Control, 23(10), 1186-1190.

APPENDIX

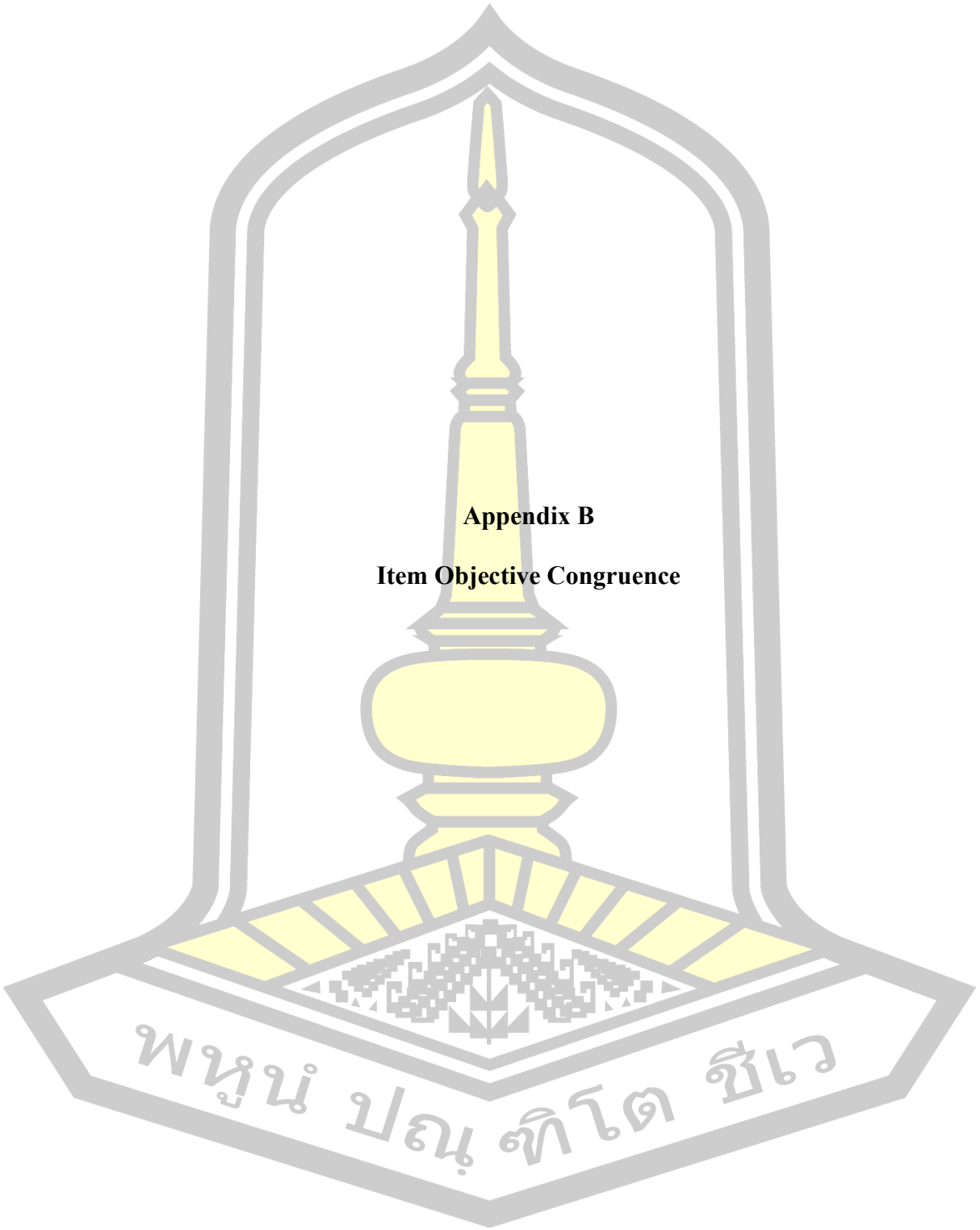


Appendix A

List of Abbreviations/Notations/Glossary of Terms

LIST OF ABBREVIATIONS/NOTATIONS/GLOSSARY OF TERMS

TTM	Transtheoretical Model
APEBCQ	Adolescent Physical Exercise Behavior Change Questionnaire
IOC	Item Objective Congruence
SOC	Stages of change
PEB	Physical Exercise Behavior
DB	Decisional Balance
POC	Processes of change
SE	Self efficacy
CR	Critical Ratio
JHS	Junior High School
HS	High School
NOE	Number of Exercises



Appendix B

Item Objective Congruence

There were seven experts to check and confirm the validity of general contents of demographic information and exercise behavior in this questionnaire using the Index of Item Objective Congruence, as follow:

The Table of Summary for Index of Item Objective Congruence

SECTION 1: Stages of Change Scale (SOC-Scale)									
No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
SOC1	Your gender: Male ( ) Female ( )	1	1	1	1	1	1	1	1
SOC2	Your grade is? Junior high school ( ) Senior high school ( )	1	1	1	1	1	1	1	1
SOC3	How many times do you exercise per week (excluding school physical education classes)? 0 times ( ) , 1-2 times ( ) , 3-5 times ( ) , More than 5 times ( )	1	1	1	1	1	1	1	1
SOC4	Regular physical exercise refers to planned physical activities for the purpose of promoting physical health (such as jogging, playing ball, cycling, etc.): 3-5 times a week, 20-60 minutes each time. Which stage are you currently in? I have no idea of. Exercising and have no plan to exercise in the last 6 months ( ). I have the idea of. Exercising and I plan to start exercising within 6 months ( ). I have a strong idea of. Exercising and I plan to start exercising within 1 month ( ). I have exercised and I have maintained exercise for less than 6 months ( ). I have persisted in exercising and I have maintained exercise for more than 6 months ( )	1	1	1	1	1	1	1	1

SECTION 2: Physical Exercise Behavior Questionnaire

Based on your actual physical exercise behavior over the past month, please choose the option that best describes your situation. Each question has five options representing different frequencies:

1 = Never (I have never done this)
2 = Rarely (I almost never do this, about 1-2 times per month)
3 = Sometimes (I occasionally do this, about 3-5 times per month)
4 = Often (I frequently do this, about 1-2 times per week)
5 = Always (I do this almost every day)

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
PEB1	I exercise using the sports facilities at school or in the community.	1	1	1	1	1	1	1	1
PEB2	I do strength training or endurance exercises to improve my fitness.	1	1	1	0	1	1	1	0.85
PEB3	I exercise with my friends.	1	1	1	1	1	1	1	1
PEB4	I participate in sports with my family.	1	1	1	1	1	1	1	1
PEB5	I regularly create and follow my exercise plan.	1	1	1	1	1	1	1	1
PEB6	I do stretching or flexibility exercises every day.	1	1	1	1	1	1	1	1
PEB7	I engage in regular aerobic exercises (such as running, swimming, etc.) to stay healthy.	1	1	1	1	1	1	1	1
PEB8	I participate in school sports (such as basketball, soccer, volleyball, etc.).	1	1	1	1	1	1	1	1
PEB9	I use social media to learn new exercise methods or techniques.	1	1	1	1	1	1	1	1
PEB10	I schedule fixed exercise times during the week.	1	1	1	1	1	1	1	1
PEB11	I participate in health- and sports-related events or competitions.	1	1	1	1	1	1	1	1
PEB12	I engage in outdoor sports on weekends or holidays.	1	1	0	1	1	1	1	0.85
PEB13	I try new types of sports.	1	1	1	1	1	1	1	1
PEB14	I continue to exercise even when I am busy.	1	1	1	1	1	1	1	1
PEB15	I use walking or cycling as a form of daily transportation to stay active.	1	1	1	1	1	1	1	1

SECTION 3: Decisional Balance Scale (DB-Scale)

Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1. Strongly disagree, 2. Not agree, 3. Indeterminacy, 4. Agree, 5. Strongly agree.

Note: Variables measured by each item
Positive factors: items DB1, DB3, DB5, DB7
Negative factors: items DB2, DB4, DB6, DB8

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
DB1	Physical exercise can increase my self-confidence.	1	1	1	1	1	1	1	1
DB2	I don't know how to do physical exercise because I don't have the necessary exercise methods.	1	1	1	1	1	1	1	1
DB3	Physical exercise can help me study more efficiently.	1	1	1	1	1	1	1	1
DB4	The existing physical exercise methods are monotonous and cannot stimulate my interest in exercise.	1	1	1	1	1	1	1	1
DB5	Physical exercise can make me more energetic to deal with various things.	1	1	1	1	1	1	1	1
DB6	I have too many social activities and no time for physical exercise.	1	1	1	1	1	1	1	1
DB7	Physical exercise puts me in a good mood for the rest of the day.	1	1	1	1	0	1	1	0.85
DB8	I have a lot of study pressure and don't have the energy to do physical exercise.	1	1	1	1	1	1	1	1

SECTION 4: Processes of Change Scale (POC-Scale)

Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1. Strongly disagree, 2. Not agree, 3. Indeterminacy, 4. Agree, 5. Strongly agree.

Note: Variables measured by each item.
Self liberation: Items POC1, POC11, POC21, POC31
Helping relationships: Items POC2, POC12, POC22, POC32
Reinforcement management: Items POC3, POC13, POC23, POC33
Counter-conditioning: Items POC4, POC14, POC24, POC34
Stimulus control: Items POC5, POC15, POC25, POC35
Social liberation: Items POC6, POC16, POC26, POC36
Self reevaluation: Items POC7, POC17, POC27, POC37
Dramatic relief: Items POC8, POC18, POC28, POC38
Consciousness raising: Items POC9, POC19, POC29, POC39
Environmental reevaluation: Items POC10, POC20, POC30, POC40

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
POC1	I can exercise if I want to.	1	1	1	1	1	1	1	1
POC2	If I have friends who exercise with me, it will motivate me to keep exercising.	1	1	1	1	1	1	1	1
POC3	In order to get me started exercising as soon as possible, I will give myself some material rewards.	1	1	1	1	1	1	1	1
POC4	When I feel depressed, I will do some exercise to relieve stress.	1	1	1	1	1	1	1	1
POC5	I always carry sneakers with me so I can exercise more when I have time.	1	1	1	1	1	1	1	1
POC6	I found that there are many sports activities in society and many people participate in them.	0	1	1	1	1	1	1	0.85
POC7	I think physical exercise can make me healthier.	1	1	1	1	1	1	1	1
POC8	I'm worried that if I stop exercising, something bad might happen to my body.	1	1	1	1	1	1	1	1
POC9	I learn about the benefits of exercise through articles and videos.	1	1	1	1	1	1	1	1
POC10	I think staying physically active can reduce medical expenses.	1	1	1	1	1	1	1	1
POC11	I can exercise if I try hard enough.	1	1	1	1	1	1	1	1
POC12	If someone guides me to do physical exercise, it will motivate me to stick to it.	1	1	1	1	1	1	1	1
POC13	To keep me active, I give myself rewards.	1	1	1	1	0	1	1	0.85
POC14	When I am tired of studying, I will choose to do some proper physical exercise.	1	1	1	1	1	1	1	1
POC15	I often wear or carry a set of sportswear that allows me to exercise.	1	1	1	1	1	1	1	1
POC16	I found that many of my classmates would discuss sports activities and plan to participate in them.	1	1	1	1	1	1	1	1
POC17	I think physical exercise can make me more confident.	1	1	1	1	1	1	1	1
POC18	I am worried that if I don't exercise, I	1	1	0	1	1	1	1	0.85

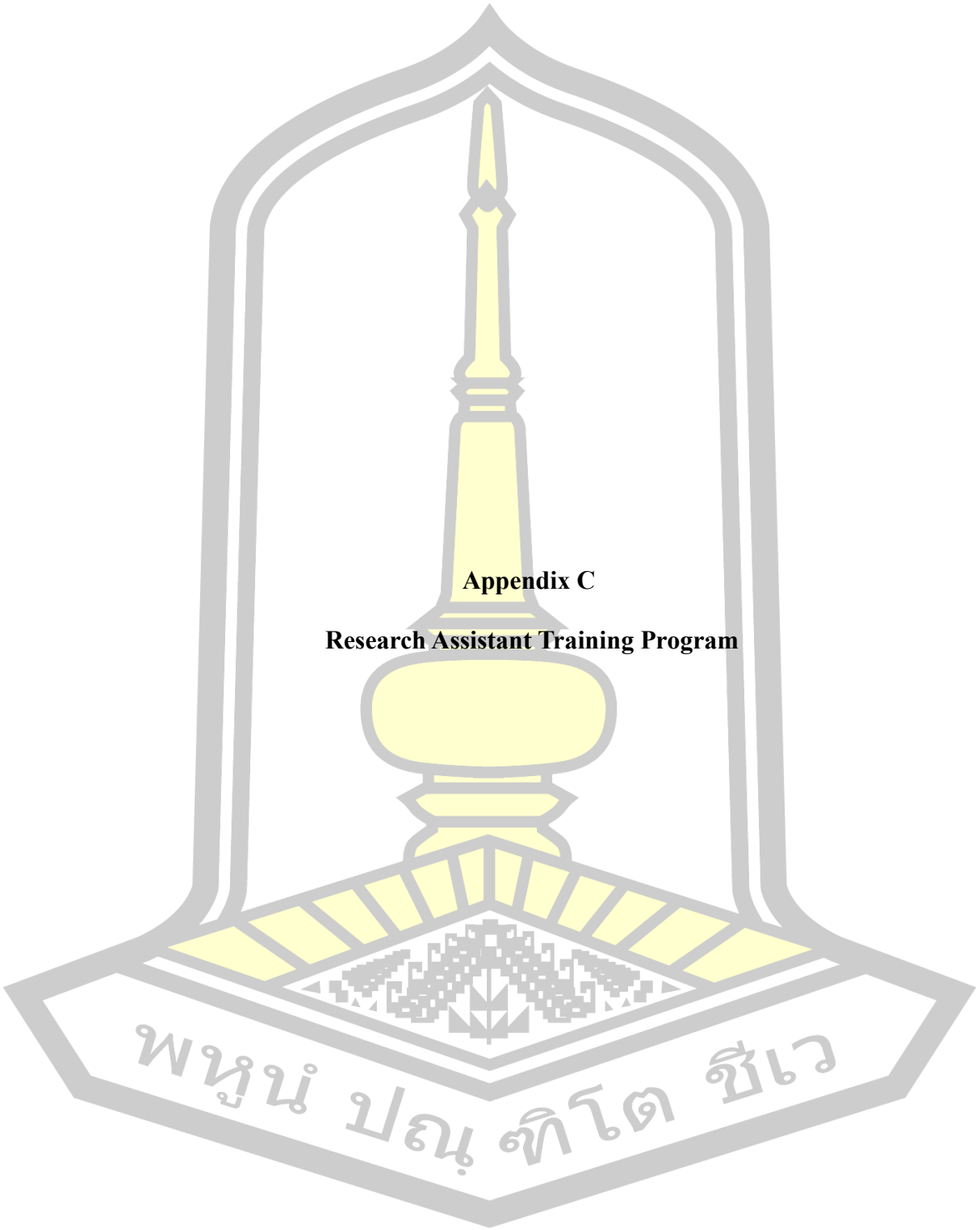
	might get sick easily.								
POC19	My friends give me information about the benefits of physical exercise.	1	1	1	1	1	1	1	1
POC20	I think keeping physically active will keep me from getting sick.	1	1	1	1	1	1	1	1
POC21	I can exercise if I set my mind to it.	1	1	1	1	1	1	1	1
POC22	If someone gives me feedback on my physical activity, it will motivate me to keep exercising.	1	1	1	1	1	1	1	1
POC23	In the process of persisting in exercising, I will often cheer myself up and give myself spiritual rewards.	1	1	1	1	1	1	1	1
POC24	When I am under a lot of stress, I will choose to do some physical exercise.	1	1	1	1	1	1	1	1
POC25	I think setting an alarm to remind me to exercise is a good idea.	1	1	1	1	1	1	0	0.85
POC26	I found that teachers and parents often encourage us to participate in sports activities.	1	1	1	1	1	1	1	1
POC27	I think physical exercise can improve my appearance.	0	1	1	1	1	1	1	0.85
POC28	My family and friends told me that lack of physical exercise is bad for my health.	1	1	1	1	1	1	1	1
POC29	I will learn how to do physical exercise through articles and videos.	1	1	1	1	1	1	1	1
POC30	I think keeping physically active will make my family less worried about my health.	1	1	1	1	1	1	1	1
POC31	As long as I have faith, I can do physical exercise.	1	1	1	1	1	1	1	1
POC32	If someone encourages me to exercise regularly, it will motivate me to keep doing it.	1	1	1	1	1	1	1	1
POC33	My parents told me that if I participated in physical exercise, I would be rewarded.	1	1	1	1	1	1	0	0.85
POC34	I see physical exercise as a pleasure, not a burden.	1	1	1	1	1	1	1	1
POC35	I measure my body weight regularly to remind myself to exercise.	1	1	1	1	1	1	1	1
POC36	I found that the sports activities around me are supported by many people.	1	1	1	1	1	1	1	1
POC37	I think physical exercise can make me energetic.	1	1	1	1	1	1	1	1
POC38	Television media often advertise that lack of physical exercise can lead to a decline in immunity.	1	1	1	1	1	1	1	1
POC39	My friends will tell me the methods and techniques of physical exercise.	1	1	1	1	1	1	1	1
POC40	I think keeping physically active will keep my friends from worrying about my health.	1	1	1	1	1	1	1	1

SECTION 5: Self-Efficacy Scale (SE-Scale)

Use the Likert-type Scale, and the responses were made on a 5-point scale. The scoring criteria were as follows: 1. Strongly disagree, 2. Not agree, 3. Indeterminacy, 4. Agree, 5. Strongly agree.

Note: Variables measured by each item
Exercise willingness: items SE1, SE3, SE5, SE7
Exercise effort: items SE2, SE4, SE6, SE8

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
SE1	If there were exercise facilities near me, I think I would do physical exercise.	1	1	1	1	1	1	1	1
SE2	Do I have the confidence to participate in physical exercise when there is a lack of exercise facilities near where I live?	1	0	1	1	1	1	1	0.85
SE3	If I don't have the pressure of studying, I think I will do physical exercise.	1	1	1	1	1	1	1	1
SE4	Do I have the confidence to take part in physical exercise when I am facing an important stage in my studies?	1	1	1	1	1	1	1	1
SE5	If I am in a good mood, I think I will do physical exercise.	1	1	1	1	1	1	1	1
SE6	I am in a bad mood, do I have the confidence to participate in physical exercise?	1	1	1	1	1	1	1	1
SE7	If I were alone, I think I could still do some physical exercise.	1	1	1	1	1	1	1	1
SE8	Do I have the confidence to participate in physical exercise when my exercise partner is not going to exercise?	1	1	1	1	1	0	1	0.85



Appendix C

Research Assistant Training Program

Research Assistant Training Program

1. Purpose

1.1 Help research assistants to clearly understand research purpose, research plan, intervention requirements.

1.2 Help research assistants learn experimental knowledge and master correct experimental operations.

1.3 Help research assistants to correctly supervise control groups and experimental groups.

2. Instrument

2.1 About TTM knowledge, and manuals for physical exercise.

2.2 Television media.

3. Method

3.1 Knowledge lecture.

3.2 Video learning.

3.3 Group discussion.

3.4 Practical exercises: random sampling, issuing questionnaires, guiding the filling of questionnaires, and collecting questionnaires.

3.5 Ask questions and exchange experiences.

4. Training time: 2 days

5. Training process

5.1 Get to know each other with the research assistant, explain the research purpose, research plan, research process, research steps, research methods, and explain the questionnaires and tools used in the research. (180 minutes)

5.2 Training on the topic of data collection exercises. (120 minutes)

1) Send out questionnaires.

2) Explain the function of the questionnaire and guide the filling of the

questionnaire.

3) Instruct subjects to fill in basic information and use the "Adolescent physical exercise behavior change questionnaire".

4) Instruct subjects to fill in "Physical exercise behavior Stages of change scale", a total of 25 questions.

5) Instruct the subjects to fill in "Physical exercise Processes of change scale", a total of 25 questions.

6) Instruct subjects to fill in the "Physical exercise Decisional balance scale", a total of 28 questions.

7) Instruct subjects to fill in the "Physical exercise Self efficacy scale", a total of 25 questions.

8) Collect questionnaires and enter data into SPSS.

5.3 The theme is training on explaining physical exercise knowledge. (120 minutes)

1) The definition of physical activity, the concept of health and the knowledge of physical activity.

2) Exercise environments in common places such as schools and communities, as well as issues that need to be paid attention to during exercise.

3) How to find effective exercise information.

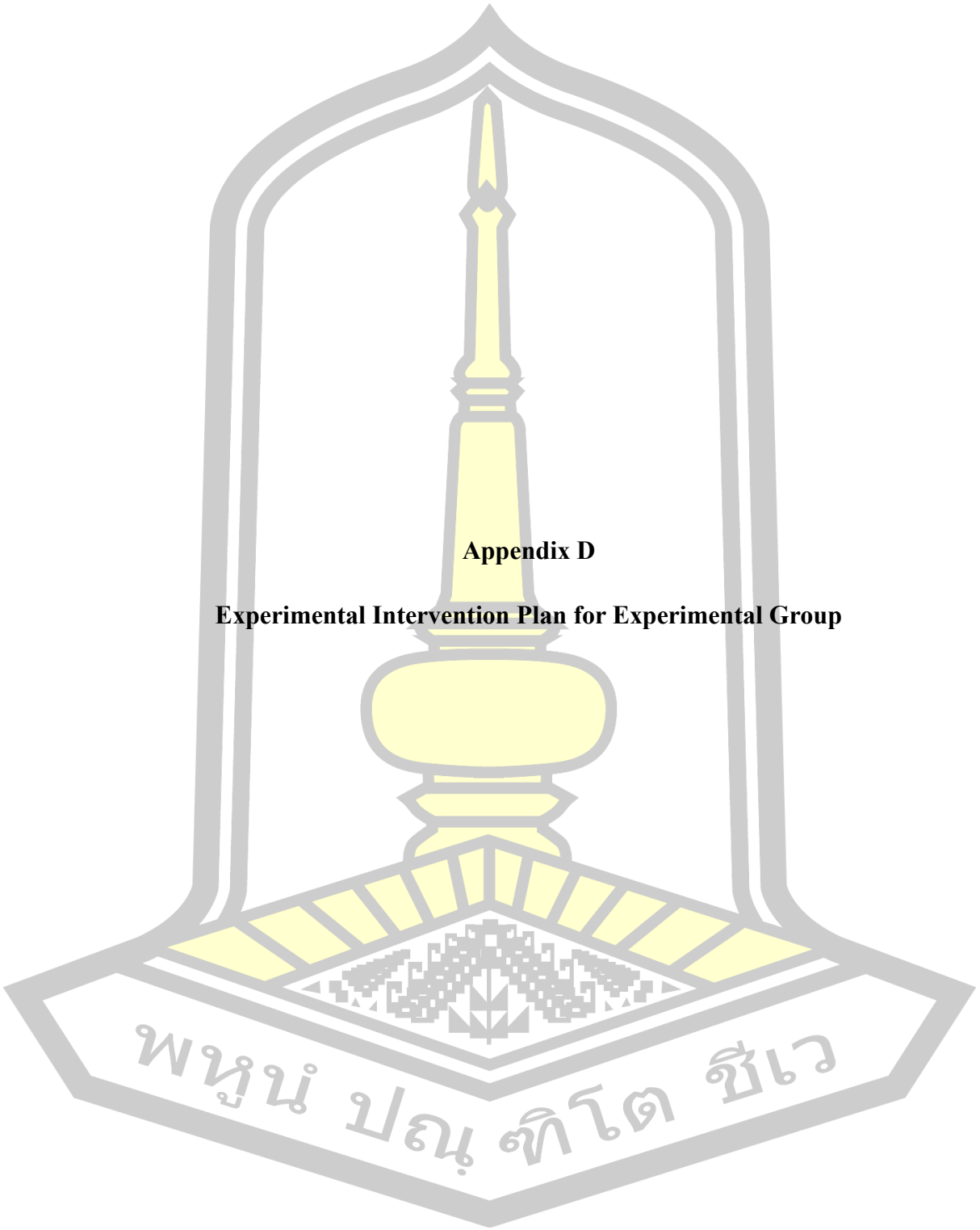
4) The benefits of being physically active.

5.4 Divide the research assistants into two groups to discuss, and simulate the distribution of questionnaires, simulate the recovery of questionnaires, and simulate the data collection. (120 minutes)

5.5 Researchers summarize training sessions, answer questions promptly, receive feedback, and schedule research activities.

6. Training Evaluation

Observe the training performance of research assistants, answer questions promptly, encourage participation in activities, and keep records.



Appendix D

Experimental Intervention Plan for Experimental Group

Experimental Intervention Plan for Experimental Group

Time	TTM constructs	Educational content
Week 1	-Consciousness raising -Decision balance (benefits of PA)	-Understand exercise, collect exercise information -The significance and benefits of exercise
Week 2	-Environmental reevaluation -Dramatic relief	-Exercise video -Evaluate the sports environment of schools and communities
Week 3	-Self reevaluation -Self liberation	-Build a positive, healthy self-image -Set appropriate exercise goals (long-term, short-term)
Week 4	-Social liberation -Decision balance (barriers to PA)	-Use social resources to exercise -Understand the risks of lack of exercise
Week 5	-Helping relationships -Reinforcement management	-Experience sharing -Encourage execution exercise goals
Week 6	-Stimulus control -Self efficacy -Counter-conditioning	-Reward stimulation, exercise reminder -Recall exercise achievements and build exercise confidence -Exercise instead of being sedentary
Week 7	-Consciousness raising -Decision balance (benefits of PA)	-Understand exercise, collect exercise information -The significance and benefits of exercise
Week 8	-Environmental reevaluation -Dramatic relief	-Exercise video -Evaluate the sports environment of schools and communities
Week 9	-Self reevaluation -Self liberation	-Build a positive, healthy self-image -Set appropriate exercise goals

		(long-term, short-term)
Week 10	-Social liberation -Decision balance (barriers to PA)	-Use social resources to exercise -Understand the risks of lack of exercise
Week 11	-Helping relationships -Reinforcement management	-Experience sharing -Encourage execution exercise goals
Week 12	-Stimulus control -Self efficacy -Counter-conditioning	-Reward stimulation, exercise reminder -Recall exercise achievements and build exercise confidence -Exercise instead of being sedentary

Experimental intervention plan for Experimental Group (Week 1)

1. Content

Consciousness raising, Decision balance (benefits of PA).

2. Purpose

Explain the definition of health and physical exercise knowledge to the subjects, explain the exercise environment in schools, social places and other places, explain how to find information about physical exercise, and help the subjects understand the benefits of participating in physical exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain and teach exercise knowledge to subjects.

5.2 Experimental researchers and assistants organize on-site discussions and consultations with subjects.

6. Intervention process

6.1 Use multimedia to explain the basic knowledge of physical exercise, understand the concept of health and the standards for measuring health, and display videos and pictures at the same time. (15 minutes)

6.2 Use multimedia to explain the exercise environment in common places such as

schools and communities, as well as the problems that need attention during exercise. (15 minutes)

6.3 Explain how to find effective physical exercise information, and organize participants to discuss and ask questions. (15 minutes)

6.4 Explain the benefits of participating in physical exercise, and organize subjects to discuss and express their opinions. (15 minutes)

7. Benefits of the event

7.1 Understand the knowledge of physical exercise and help the subjects prepare mentally.

7.2 Learn about physical exercise, help subjects perform physical exercise faster, and deal with difficulties encountered in physical exercise.

7.3 Understand the benefits of physical exercise and stimulate interest in participating in physical exercise.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 2)

1. Content

Environmental reevaluation, Dramatic relief.

2. Purpose

Watch the exercise video, explain to the subjects how to evaluate the exercise environment in schools, society and other places, and help the subjects gain exercise experience.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

4.3 School sports court, as well as easy-to-operate exercise equipment, such as basketball, football, etc.

5. Activity form

5.1 Experimental researchers and assistants explain exercise knowledge to subjects.

5.2 Experimental researchers and assistants organize subjects to exercise.

6. Intervention process

6.1 Use multimedia to explain to the subjects how to evaluate the exercise environment, explain the problems that need attention during exercise, and show exercise videos and pictures at the same time. (15 minutes)

6.2 Organize the subjects to carry out physical exercise in the sports field, and choose exercise items according to their own hobbies. (30 minutes)

6.3 Organize the subjects to discuss and publish their feelings about exercise. (15

minutes)

7. Benefits of the event

7.1 Correctly assess the exercise environment and help subjects prepare for exercise.

7.2 Learn about physical exercise, help subjects perform physical exercise faster, and deal with difficulties encountered in physical exercise.

7.3 Participate in physical exercise and gain exercise experience.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 3)

1. Content

Self reevaluation, Self liberation.

2. Purpose

Help the subjects to evaluate their own exercise behavior and exercise conditions, and help the subjects to establish a positive and healthy image of exercise. Help subjects set short-term and long-term goals for exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain the content to the subjects.

5.2 Experimental researchers and assistants organize subjects for group discussions.

6. Intervention process

6.1 The subjects conducted exercise self-assessment and recorded it, including: favorite exercise items, ideal exercise time, favorite exercise environment, favorite music to listen to during exercise. (15 minutes)

6.2 Researchers and research assistants help participants summarize exercise assessments. Watch workout videos to build a healthy, active workout image. (15 minutes)

6.3 Organize subjects to set short-term exercise goals and long-term exercise goals. (15 minutes)

6.4 The subjects had a group discussion, and the researchers encouraged the subjects to exercise.(15 minutes)

7. Benefits of the event

7.1 Conduct exercise self-assessments to help subjects prepare for exercise.

7.2 Watch workout videos to build a healthy, active workout image and build confidence in your workouts.

7.3 Set exercise goals and stick to your commitment to complete them.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 4)

1. Content

Social liberation, Decision balance(barriers to PA).

2. Purpose

Help subjects understand and utilize social sports resources for physical exercise, and help subjects understand the potential harm of lack of physical exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain to the subjects.

5.2 Experimental researchers and assistants organize on-site discussions and consultations with subjects.

6. Intervention process

6.1 Use multimedia to explain sports social resources to the subjects, including material resources (such as financial help from parents), public facilities resources (including community gyms, sports fields, etc.), media resources (video learning, etc.). (20 minutes)

6.2 Explain to the subjects that lack of physical activity can lead to potential risks, such as obesity, chronic diseases, and poor body shape. (20 minutes)

6.3 The subjects were organized to discuss and express their opinions, and the researchers encouraged the subjects to exercise. (lasts 20 minutes)

7. Benefits of the event

7.1 Help the subjects understand social sports resources, and make reasonable use of social resources to carry out physical exercise.

7.2 Help the subjects to build up the awareness of social sports.

7.3 Help subjects understand the potential risks of lack of physical exercise.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 5)

1. Content

Helping relationships, Reinforcement management

2. Purpose

Help subjects to provide mutual assistance and encouragement in exercise, encourage subjects to implement exercise goals, and strengthen exercise management.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants organize subjects to share their exercise experiences.

5.2 Experimental researchers and assistants encouraged subjects to complete set exercise goals.

6. Intervention process

6.1 The subjects summarized their exercise behavior in the previous four weeks, shared their gains during the exercise process, and their experience in solving difficulties. (20 minutes)

6.2 Experimental researchers and assistants encouraged subjects to complete short-term exercise goals and long-term exercise goals. (20 minutes)

6.3 Organize subjects into exercise groups to achieve mutual assistance and encouragement. (20 minutes)

7. Benefits of the event

7.1 Participants shared their exercise experiences in a timely manner, received recognition and encouragement from others, and listened to useful exercise suggestions.

7.2 Completing the set exercise goals can help subjects gain a sense of accomplishment and enhance exercise execution.

7.3 Help subjects divide into exercise groups to exercise together and encourage each other.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 6)

1. Content

Stimulus control, Self efficacy, Counter-conditioning

2. Purpose

Help subjects set reward stimuli for themselves and set exercise reminders. Help subjects recall their exercise achievements and strengthen their confidence in exercise. Help subjects change their view of sedentary life and replace sedentary life with exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants organized subjects to explain how to set self-rewards and exercise reminders.

5.2 Subjects review exercise achievements and share them with others.

5.3 Experimental researchers and assistants organize on-site discussions and consultations with the subjects.

6. Intervention process

6.1 Explain to the subjects how to reward themselves in a timely manner, such as: reward yourself with something you like after completing the short-term exercise goal. (20 minutes)

6.2 Explain to the subjects how to set exercise reminders, such as setting exercise

alarm clocks, exercise ringtones, exercise music, etc., and replace sedentary behavior with physical exercise. (20 minutes)

6.3 The subjects shared their exercise achievements and gained exercise self-confidence. (20 minutes)

7. Benefits of the event

7.1 Self-rewarding can allow subjects to feel reward stimulation and increase their motivation to exercise.

7.2 Setting exercise reminders can help subjects be stimulated by exercise and remember the exercise tasks.

7.3 Encourage subjects to replace sedentary behavior with physical exercise, positive change.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 7)

1. Content

Consciousness raising, Decision balance (benefits of PA).

2. Purpose

Explain the definition of health and physical exercise knowledge to the subjects, explain the exercise environment in schools, social places and other places, explain how to find information about physical exercise, and help the subjects understand the benefits of participating in physical exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain and teach exercise knowledge to subjects.

5.2 Experimental researchers and assistants organize on-site discussions and consultations with subjects.

6. Intervention process

6.1 Use multimedia to explain the basic knowledge of physical exercise, understand the concept of health and the standards for measuring health, and display videos and pictures at the same time. (15 minutes)

6.2 Use multimedia to explain the exercise environment in common places such as

schools and communities, as well as the problems that need attention during exercise. (15 minutes)

6.3 Explain how to find effective physical exercise information, and organize participants to discuss and ask questions. (15 minutes)

6.4 Explain the benefits of participating in physical exercise, and organize subjects to discuss and express their opinions. (15 minutes)

7. Benefits of the event

7.1 Understand the knowledge of physical exercise and help the subjects prepare mentally.

7.2 Learn about physical exercise, help subjects perform physical exercise faster, and deal with difficulties encountered in physical exercise.

7.3 Understand the benefits of physical exercise and stimulate interest in participating in physical exercise.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 8)

1. Content

Environmental reevaluation, Dramatic relief.

2. Purpose

Watch the exercise video, explain to the subjects how to evaluate the exercise environment in schools, society and other places, and help the subjects gain exercise experience.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

4.3 School sports court, as well as easy-to-operate exercise equipment, such as basketball, football, etc.

5. Activity form

5.1 Experimental researchers and assistants explain exercise knowledge to subjects.

5.2 Experimental researchers and assistants organize subjects to exercise.

6. Intervention process

6.1 Use multimedia to explain to the subjects how to evaluate the exercise environment, explain the problems that need attention during exercise, and show exercise videos and pictures at the same time. (15 minutes)

6.2 Organize the subjects to carry out physical exercise in the sports field, and choose exercise items according to their own hobbies. (30 minutes)

6.3 Organize the subjects to discuss and publish their feelings about exercise. (15

minutes)

7. Benefits of the event

7.1 Correctly assess the exercise environment and help subjects prepare for exercise.

7.2 Learn about physical exercise, help subjects perform physical exercise faster, and deal with difficulties encountered in physical exercise.

7.3 Participate in physical exercise and gain exercise experience.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 9)

1. Content

Self reevaluation, Self liberation.

2. Purpose

Help the subjects to evaluate their own exercise behavior and exercise conditions, and help the subjects to establish a positive and healthy image of exercise. Help subjects set short-term and long-term goals for exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain the content to the subjects.

5.2 Experimental researchers and assistants organize subjects for group discussions.

6. Intervention process

6.1 The subjects conducted exercise self-assessment and recorded it, including: favorite exercise items, ideal exercise time, favorite exercise environment, favorite music to listen to during exercise. (15 minutes)

6.2 Researchers and research assistants help participants summarize exercise assessments. Watch workout videos to build a healthy, active workout image. (15 minutes)

6.3 Organize subjects to set short-term exercise goals and long-term exercise goals. (15 minutes)

6.4 The subjects had a group discussion, and the researchers encouraged the subjects to exercise.(15 minutes)

7. Benefits of the event

7.1 Conduct exercise self-assessments to help subjects prepare for exercise.

7.2 Watch workout videos to build a healthy, active workout image and build confidence in your workouts.

7.3 Set exercise goals and stick to your commitment to complete them.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 10)

1. Content

Social liberation, Decision balance(barriers to PA).

2. Purpose

Help subjects understand and utilize social sports resources for physical exercise, and help subjects understand the potential harm of lack of physical exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants explain to the subjects.

5.2 Experimental researchers and assistants organize on-site discussions and consultations with subjects.

6. Intervention process

6.1 Use multimedia to explain sports social resources to the subjects, including material resources (such as financial help from parents), public facilities resources (including community gyms, sports fields, etc.), media resources (video learning, etc.). (20 minutes)

6.2 Explain to the subjects that lack of physical activity can lead to potential risks, such as obesity, chronic diseases, and poor body shape. (20 minutes)

6.3 The subjects were organized to discuss and express their opinions, and the researchers encouraged the subjects to exercise. (lasts 20 minutes)

7. Benefits of the event

7.1 Help the subjects understand social sports resources, and make reasonable use of social resources to carry out physical exercise.

7.2 Help the subjects to build up the awareness of social sports.

7.3 Help subjects understand the potential risks of lack of physical exercise.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 11)

1. Content

Helping relationships, Reinforcement management

2. Purpose

Help subjects to provide mutual assistance and encouragement in exercise, encourage subjects to implement exercise goals, and strengthen exercise management.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants organize subjects to share their exercise experiences.

5.2 Experimental researchers and assistants encouraged subjects to complete set exercise goals.

6. Intervention process

6.1 The subjects summarized their exercise behavior in the previous four weeks, shared their gains during the exercise process, and their experience in solving difficulties. (20 minutes)

6.2 Experimental researchers and assistants encouraged subjects to complete short-term exercise goals and long-term exercise goals. (20 minutes)

6.3 Organize subjects into exercise groups to achieve mutual assistance and encouragement. (20 minutes)

7. Benefits of the event

7.1 Participants shared their exercise experiences in a timely manner, received recognition and encouragement from others, and listened to useful exercise suggestions.

7.2 Completing the set exercise goals can help subjects gain a sense of accomplishment and enhance exercise execution.

7.3 Help subjects divide into exercise groups to exercise together and encourage each other.

Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.

Experimental intervention plan for Experimental Group (Week 12)

1. Content

Stimulus control, Self efficacy, Counter-conditioning

2. Purpose

Help subjects set reward stimuli for themselves and set exercise reminders. Help subjects recall their exercise achievements and strengthen their confidence in exercise. Help subjects change their view of sedentary life and replace sedentary life with exercise.

3. Time

4:00-5:00 pm on Monday, lasts 60 minutes.

4. Instrument

4.1 Quiet classroom in the school that can accommodate 50 people.

4.2 Multimedia equipment, such as computers, projectors, microphones, etc.

5. Activity form

5.1 Experimental researchers and assistants organized subjects to explain how to set self-rewards and exercise reminders.

5.2 Subjects review exercise achievements and share them with others.

5.3 Experimental researchers and assistants organize on-site discussions and consultations with the subjects.

6. Intervention process

6.1 Explain to the subjects how to reward themselves in a timely manner, such as: reward yourself with something you like after completing the short-term exercise goal. (20 minutes)

6.2 Explain to the subjects how to set exercise reminders, such as setting exercise

alarm clocks, exercise ringtones, exercise music, etc., and replace sedentary behavior with physical exercise. (20 minutes)

6.3 The subjects shared their exercise achievements and gained exercise self-confidence. (20 minutes)

7. Benefits of the event

7.1 Self-rewarding can allow subjects to feel reward stimulation and increase their motivation to exercise.

7.2 Setting exercise reminders can help subjects be stimulated by exercise and remember the exercise tasks.

7.3 Encourage subjects to replace sedentary behavior with physical exercise, positive change.

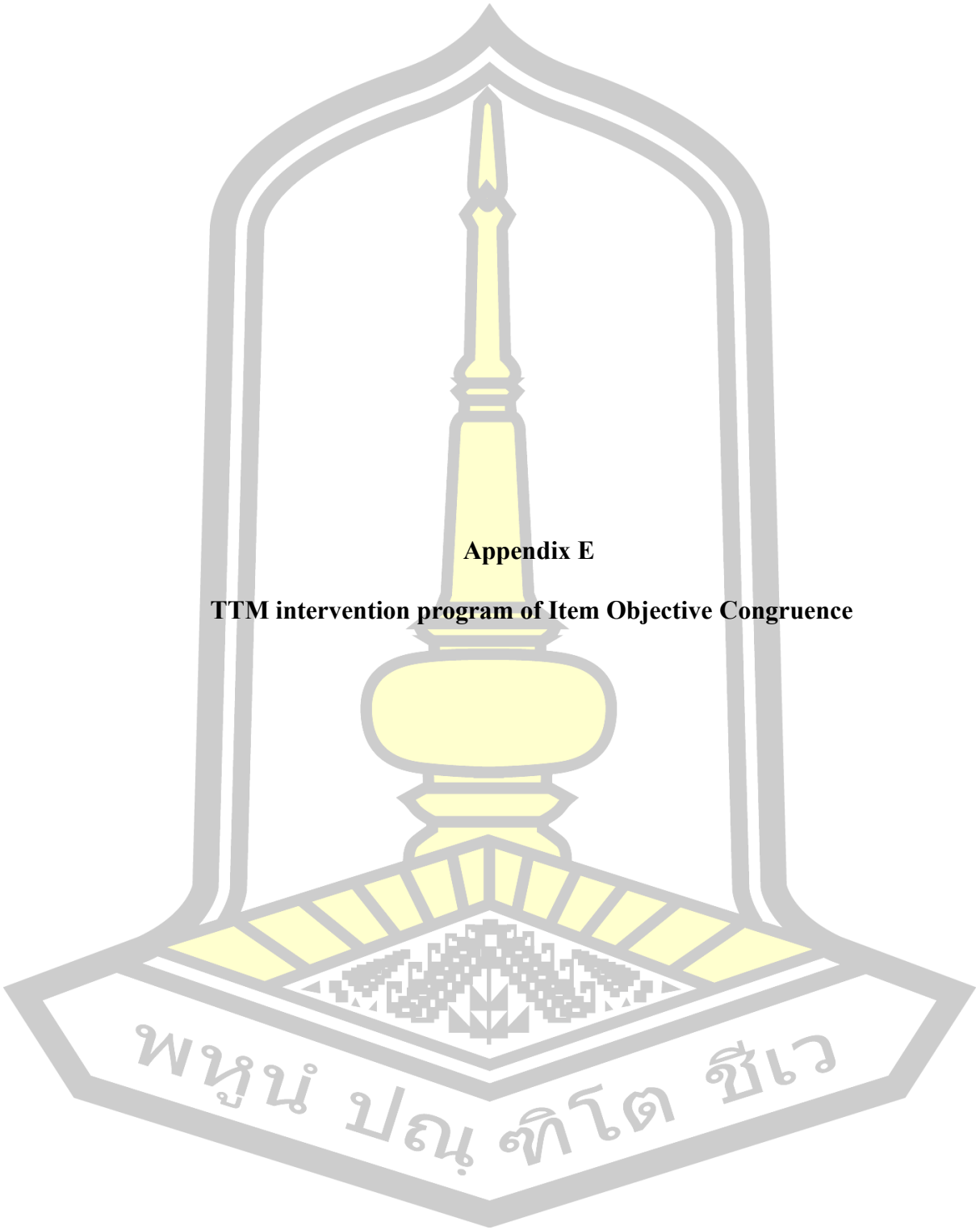
Health promotion	Benefits of exercise
Body Function	Improve cardiopulmonary function and promote bone and muscle development
Psychology, Emotion	Increases self-confidence and promotes a happy, positive mood
Society	Meet friends and increase social interaction skills

8. Practicality

Physical exercise can help adolescents improve their cardiopulmonary function, enhance their physical fitness, help them relieve study pressure and release negative emotions, help them integrate into collective life, and enhance their social skills.

9. Evaluate

Researchers and assistants observe and record results.



Appendix E

TTM intervention program of Item Objective Congruence

There were seven experts to check and confirm the validity of the overall content of the TTM intervention program in this questionnaire using the Index of Item Objective Congruence, as follow:

Experimental intervention plan for Experimental Group (Week 1)

Purpose: Explain the definition of health and physical exercise knowledge to the subjects, explain the exercise environment in schools, social places and other places, explain how to find information about physical exercise, and help the subjects understand the benefits of participating in physical exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain and teach exercise knowledge to subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize on-site discussions and consultations with subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Use multimedia to explain the basic knowledge of physical exercise, understand the concept of health and the standards for measuring health, and display videos and pictures at the same time. (15 minutes) Is it OK?	1	0	1	1	1	1	1	0.85
7	Use multimedia to explain the exercise environment in common places such as schools and communities, as well as the problems that need attention during exercise. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Explain how to find effective physical exercise information, and organize participants to discuss and ask questions. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	Explain the benefits of participating in physical exercise, and organize subjects to discuss and express their opinions. (15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 2)

Purpose: Watch the exercise video, explain to the subjects how to evaluate the exercise environment in schools, society and other places, and help the subjects gain exercise experience.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	School sports court, as well as easy-to-operate exercise equipment, such as basketball, football, etc. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants explain exercise knowledge to subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Experimental researchers and assistants organize subjects to exercise. Is it OK?	1	0	1	1	1	1	1	0.85
7	Use multimedia to explain to the subjects how to evaluate the exercise environment, explain the problems that need attention during exercise, and show exercise videos and pictures at the same time. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize the subjects to carry out physical exercise in the sports field, and choose exercise items according to their own hobbies. (30 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	Organize the subjects to discuss and publish their feelings about exercise. (15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 3)

Purpose: Help the subjects to evaluate their own exercise behavior and exercise conditions, and help the subjects to establish a positive and healthy image of exercise. Help subjects set short-term and long-term goals for exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain the content to the subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize subjects for group discussions. Is it OK?	1	1	1	1	1	1	1	1
6	The subjects conducted exercise self-assessment and recorded it, including: favorite exercise items, ideal exercise time, favorite exercise environment, favorite music to listen to during exercise. (15 minutes) Is it OK?	1	0	1	1	1	1	1	0.85
7	Researchers and research assistants help participants summarize exercise assessments. Watch workout videos to build a healthy, active workout image. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize subjects to set short-term exercise goals and long-term exercise goals. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	The subjects had a group discussion, and the researchers encouraged the subjects to exercise.(15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 4)

Purpose: Help subjects understand and utilize social sports resources for physical exercise, and help subjects understand the potential harm of lack of physical exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain to the subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize on-site discussions and consultations with subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Use multimedia to explain sports social resources to the subjects, including material resources (such as financial help from parents), public facilities resources (including community gyms, etc.), media resources. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
7	Explain to the subjects that lack of physical activity can lead to potential risks, such as obesity, chronic diseases, and poor body shape. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	The subjects were organized to discuss and express their opinions, and the researchers encouraged the subjects to exercise. (lasts 20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 5)

Purpose: Help subjects to provide mutual assistance and encouragement in exercise, encourage subjects to implement exercise goals, and strengthen exercise management.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants organize subjects to share their exercise experiences. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants encouraged subjects to complete set exercise goals. Is it OK?	1	1	1	1	1	1	1	1
6	The subjects summarized their exercise behavior in the previous four weeks, shared their gains during the exercise process, and their experience in solving difficulties. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
7	Experimental researchers and assistants encouraged subjects to complete short-term exercise goals and long-term exercise goals. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize subjects into exercise groups to achieve mutual assistance and encouragement. (20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 6)

Purpose: Help subjects recall their exercise achievements and strengthen their confidence in exercise. Help subjects change their view of sedentary life and replace sedentary life with exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants organized subjects to explain how to set self-rewards and exercise reminders. Is it OK?	1	1	1	1	1	1	1	1
5	Subjects review exercise achievements and share them with others. Is it OK?	1	1	1	1	1	1	1	1
6	Experimental researchers and assistants organize on-site discussions and consultations with the subjects. Is it OK?	1	0	1	1	1	1	1	0.85
7	Explain to the subjects how to reward themselves in a timely manner, such as: reward yourself with something you like after completing the short-term exercise goal. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Explain to the subjects how to set exercise reminders, such as setting exercise alarm clocks, exercise ringtones, exercise music, etc., and replace sedentary behavior with physical exercise. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	The subjects shared their exercise achievements and gained exercise self-confidence. (20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 7)

Purpose: Explain the definition of health and physical exercise knowledge to the subjects, explain the exercise environment in schools, social places and other places, explain how to find information about physical exercise, and help the subjects understand the benefits of participating in physical exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain and teach exercise knowledge to subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize on-site discussions and consultations with subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Use multimedia to explain the basic knowledge of physical exercise, understand the concept of health and the standards for measuring health, and display videos and pictures at the same time. (15 minutes) Is it OK?	1	0	1	1	1	1	1	0.85
7	Use multimedia to explain the exercise environment in common places such as schools and communities, as well as the problems that need attention during exercise. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Explain how to find effective physical exercise information, and organize participants to discuss and ask questions. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	Explain the benefits of participating in physical exercise, and organize subjects to discuss and express their opinions. (15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 8)

Purpose: Watch the exercise video, explain to the subjects how to evaluate the exercise environment in schools, society and other places, and help the subjects gain exercise experience.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	School sports court, as well as easy-to-operate exercise equipment, such as basketball, football, etc. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants explain exercise knowledge to subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Experimental researchers and assistants organize subjects to exercise. Is it OK?	1	0	1	1	1	1	1	0.85
7	Use multimedia to explain to the subjects how to evaluate the exercise environment, explain the problems that need attention during exercise, and show exercise videos and pictures at the same time. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize the subjects to carry out physical exercise in the sports field, and choose exercise items according to their own hobbies. (30 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	Organize the subjects to discuss and publish their feelings about exercise. (15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 9)

Purpose: Help the subjects to evaluate their own exercise behavior and exercise conditions, and help the subjects to establish a positive and healthy image of exercise. Help subjects set short-term and long-term goals for exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain the content to the subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize subjects for group discussions. Is it OK?	1	1	1	1	1	1	1	1
6	The subjects conducted exercise self-assessment and recorded it, including: favorite exercise items, ideal exercise time, favorite exercise environment, favorite music to listen to during exercise. (15 minutes) Is it OK?	1	0	1	1	1	1	1	0.85
7	Researchers and research assistants help participants summarize exercise assessments. Watch workout videos to build a healthy, active workout image. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize subjects to set short-term exercise goals and long-term exercise goals. (15 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	The subjects had a group discussion, and the researchers encouraged the subjects to exercise.(15 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 10)

Purpose: Help subjects understand and utilize social sports resources for physical exercise, and help subjects understand the potential harm of lack of physical exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants explain to the subjects. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants organize on-site discussions and consultations with subjects. Is it OK?	1	1	1	1	1	1	1	1
6	Use multimedia to explain sports social resources to the subjects, including material resources (such as financial help from parents), public facilities resources (including community gyms, etc.), media resources. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
7	Explain to the subjects that lack of physical activity can lead to potential risks, such as obesity, chronic diseases, and poor body shape. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	The subjects were organized to discuss and express their opinions, and the researchers encouraged the subjects to exercise. (lasts 20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 11)

Purpose: Help subjects to provide mutual assistance and encouragement in exercise, encourage subjects to implement exercise goals, and strengthen exercise management.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants organize subjects to share their exercise experiences. Is it OK?	1	1	1	1	1	1	1	1
5	Experimental researchers and assistants encouraged subjects to complete set exercise goals. Is it OK?	1	1	1	1	1	1	1	1
6	The subjects summarized their exercise behavior in the previous four weeks, shared their gains during the exercise process, and their experience in solving difficulties. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
7	Experimental researchers and assistants encouraged subjects to complete short-term exercise goals and long-term exercise goals. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Organize subjects into exercise groups to achieve mutual assistance and encouragement. (20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Experimental intervention plan for Experimental Group (Week 12)

Purpose: Help subjects recall their exercise achievements and strengthen their confidence in exercise. Help subjects change their view of sedentary life and replace sedentary life with exercise.

No.	Items	Expert Evaluation							IOC Value
		1	2	3	4	5	6	7	
1	Time: Lasts 60 minutes. Is it OK?	1	1	1	1	1	1	1	1
2	Classroom for 50 people, Is it OK?	1	1	1	1	1	1	1	1
3	Multimedia equipment, such as computers, projectors, microphones, Is it OK?	1	1	1	1	1	1	1	1
4	Experimental researchers and assistants organized subjects to explain how to set self-rewards and exercise reminders. Is it OK?	1	1	1	1	1	1	1	1
5	Subjects review exercise achievements and share them with others. Is it OK?	1	1	1	1	1	1	1	1
6	Experimental researchers and assistants organize on-site discussions and consultations with the subjects. Is it OK?	1	0	1	1	1	1	1	0.85
7	Explain to the subjects how to reward themselves in a timely manner, such as: reward yourself with something you like after completing the short-term exercise goal. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
8	Explain to the subjects how to set exercise reminders, such as setting exercise alarm clocks, exercise ringtones, exercise music, etc., and replace sedentary behavior with physical exercise. (20 minutes) Is it OK?	1	1	1	1	1	1	1	1
9	The subjects shared their exercise achievements and gained exercise self-confidence. (20 minutes) Is it OK?	1	0	1	1	1	1	0	0.7

Appendix F

Ethics Committee for Research Human Certificate of Approval

MAHASARAKHAM UNIVERSITY ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS

Certificate of Approval

Approval number: 225-614/2024

Title : Application of Transtheoretical Model on the physical exercise behavior of adolescents.

Principal Investigator : Mr. YUAN ZHOU
Responsible Department : Faculty of Education
Research site : Wuzhou City, Guangxi Province, China

Review Method : Expedited Review

Date of Manufacture : 25 April 2024 **expire : 24 April 2025**

This research application has been reviewed and approved by the Ethics Committee for Research Involving Human Subjects, Mahasarakham University, Thailand. Approval is dependent on local ethical approval having been received. Any subsequent changes to the consent form must be re-submitted to the Committee.

Ratree S.

(Assistant Professor Ratree Sawangjit)
Chairman

Approval is granted subject to the following conditions: (see back of this Certificate)

Appendix G

Experimental activity photos

BIOGRAPHY

NAME	Mr. Zhou Yuan
DATE OF BIRTH	August 3, 1990
PLACE OF BIRTH	Wuzhou City, Guangxi Province, China
ADDRESS	No.82 Fumin 3rd Road, Wuzhou City, Guangxi Province, China
POSITION	Lecturer
PLACE OF WORK	Wuzhou University
EDUCATION	2010 to 2014 Bachelor's Degree, Field of Study Physical education, Admitted to the College of Physical Education of Guangxi Normal University 2014 to 2016 Master's Degree, Field of Study Sports training, Admitted to the Graduate School of Guangxi Normal University 2021 to 2024 Doctor of Philosophy Program in Exercise and Sport Sciences, Mahasarakham University