Assessment of Gross Motor Development in Children Aged 5-6 from The Perspective of Sensory Integration

Wei Huang

A Thesis Submitted in Partial Fulfillment of Requirements for
degree of Doctor of Philosophy in Exercise and Sport Science
May 2025

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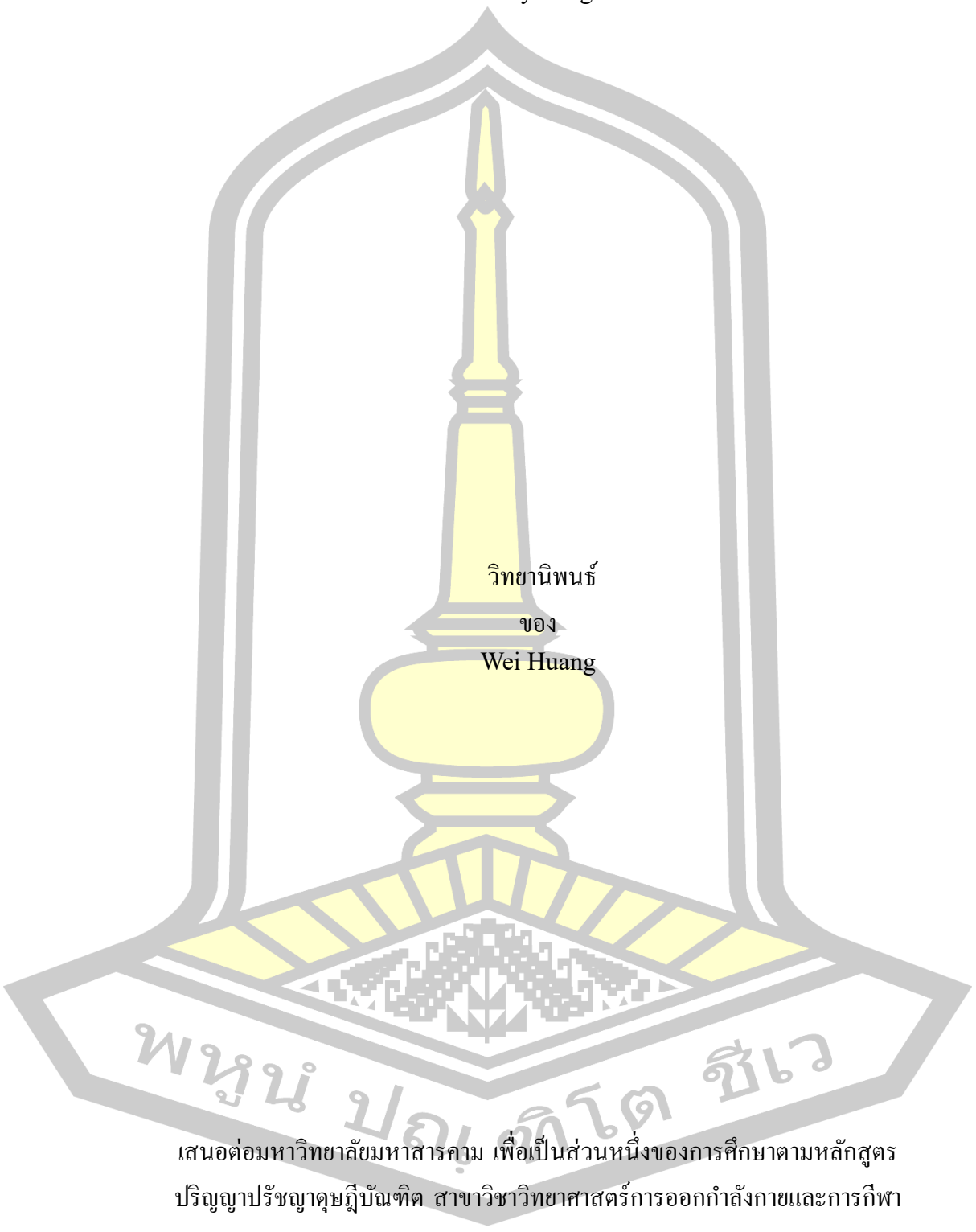

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May 2025

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

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TITLE Assessment of Gross Motor Development in Children Aged 5-6 from The Perspective of Sensory Integration

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ABSTRACT

This study aims to establish an evaluation model of gross motor development in children aged 5-6 from the perspective of sensory integration.1. To explore the significance and feasibility of building a gross motor development model for children aged 5-6 from the perspective of sensory integration;2. Determine the Angle of sensory integration to construct gross motor development indicators and weights for children aged 5-6;3. Establish an evaluation model of gross motor development of children aged 5-6 from the perspective of sensory integration, and verify its validity.

The main purpose of this study is to establish and improve the detection tools of children's gross motor development in China, and better understand the health level of children. It can also be integrated into the preschool physical education curriculum to promote the development of children's physical fitness and provide guidance for children's healthy development.

In this study, 450 children aged 5-6 years old in Guangxi, China were selected from 14 cities: Nanning, Liuzhou, Guilin, Wuzhou, Beihai, Fangchenggang, Qinzhou, Guigang, Yulin, Baise, Hezhou, Hechi, Laibin and Chongzuo.

The research methods include literature review, expert interview, t test, retest test, calibration test, etc., which ensures the scientificity and applicability of the selection system.

Phase 1: Through literature review and expert interviews, the significance and feasibility of building a gross motor development model for children aged 5-6 from the perspective of sensory integration were studied.

This study analyzed the existing motor development theory and sensory integration theory at home and abroad, combined with expert feedback, put forward a preliminary index framework. After literature review and expert interviews, 50 main indicators were finally identified, and this stage laid a solid theoretical foundation for

subsequent data collection and analysis.

Phase 2: Using three rounds of Delphi method, pre-test method and project-objective consistency (IOC) method, From the perspective of sensory integration, the evaluation indexes of major movements of children aged 5-6 were determined. Step forward on the balance beam, Horizontal bar suspension move, 4 legs crawl forward, Crawl forward, 10 meters back run, Double hop, Overhand throw, Throw the ball with both hands, Side roll, Lie on your stomach and so on stand up immediately.

Phase 3: Through the Test of large samples, the percentile method was adopted to construct the scoring model of Gross Motor Development grade of children aged 5-6, and the validity of the criterion (Test of Gross motor development-third Edition) was tested.

Keyword : Gross Motor Movement, Sensory Integration, Evaluation Model

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Wei Huang

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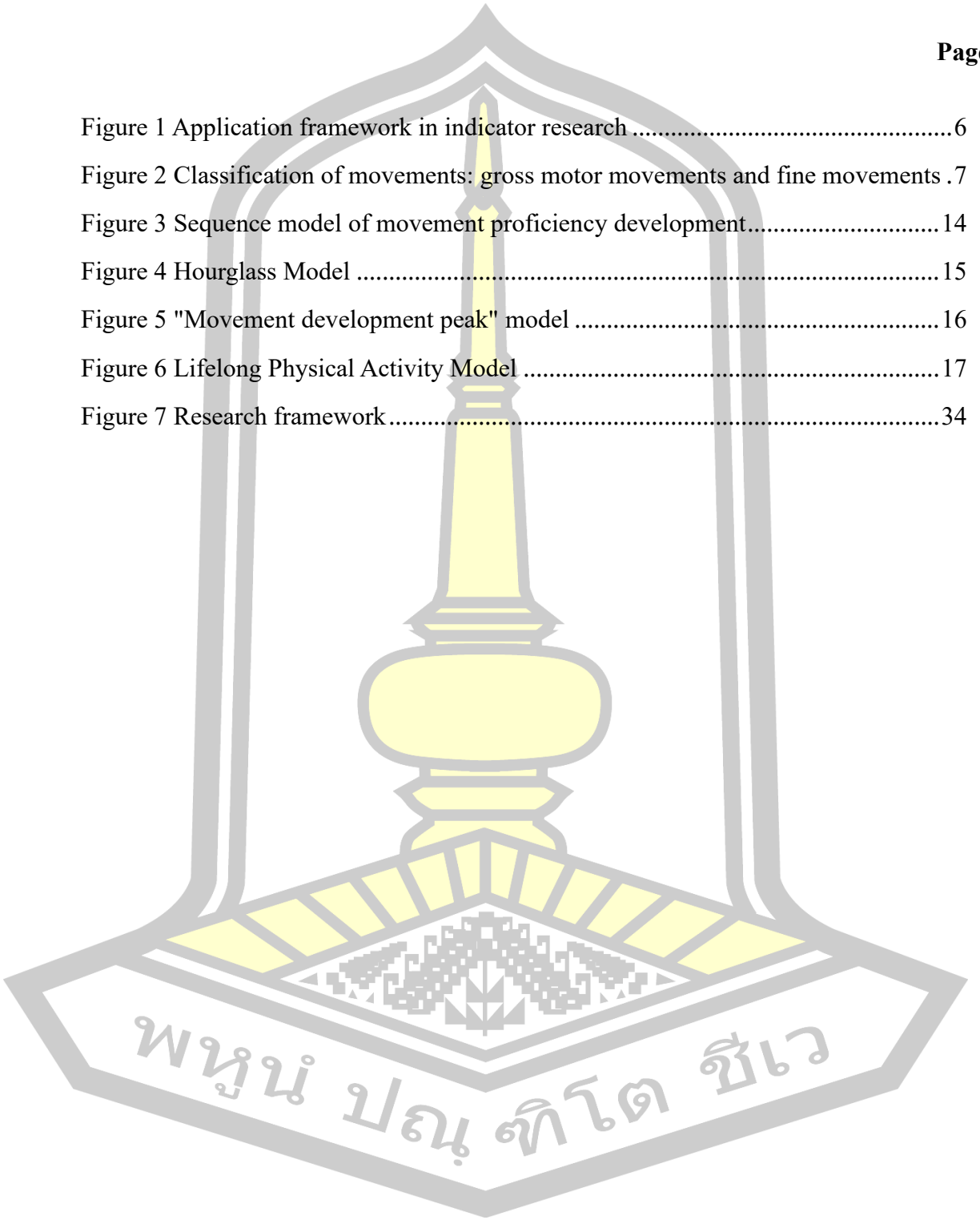


CHAPTER I

INTRODUCTION

1.1 Research Background

In recent years, with the development of economy and society and the change of material life, children's physical health is worrying (2021 The fifth Chinese Citizens' Physical Fitness Monitoring Communique). Nowadays, the physical fitness level of teenagers is declining, and the trend of younger people is gradually showing. The development of various body functions in early childhood is the basic stage in life. In early childhood, its growth and development in various aspects of development have a certain promoting effect on the learning, development and mastery of various body movements in later life stages and also have a positive promoting effect on the healthy growth of physical and mental health of children.

China has a population of 1.4 billion, of which children between the ages of 3 and 6 account for about 5%. Children are the future of the motherland, and the growth of children is of great significance to the future development of the motherland (2022 Report of The State Council on child health promotion). In China, the Regulations on Kindergarten Work issued in 1996 required that "children should be educated in all aspects and develop their physical, intellectual, moral and beauty", which highlighted the importance of "physical". In 2012, the Ministry of Education issued the "Guide to Learning and Development for Children aged 3-6", which classified gross motor development as a health field; The 2016 "Kindergarten work Regulations" stipulates: "We should actively carry out sports activities in line with the age of children, and exercise children's bodies in a planned and purposeful way." The 2019 "Outline for the Construction of a Sports Power" points out the development of early childhood sports, the improvement of relevant policies and security systems, the strengthening of the construction of early childhood sports projects, and the establishment of physical education courses and teacher training systems. Chinese parents are increasingly attaching importance to the healthy development of their young children.

5 to 6 years old is the preparation stage before children enter primary school. Society pays more attention to this stage of pre-school preparation. At the same time, they are in the critical period of growth, in the sensitive period of gross motor development, sensory integration ability and neuromuscular control ability is gradually approaching the peak（2022Jin Rui）. However, in most kindergartens in China, PE teachers are not professional PE graduates and do not have professional PE knowledge, so they are not professional in guiding children's sports development and have difficulties in assessing children's sports development (2023Gu shi li). The commonly used "National Physical Fitness Measurement Standard Manual (Children's part)" tools mainly measure the 10-meter run back, standing long jump, tennis throw, continuous jump of both feet, sitting forward bend and walking balance beam, which only measures the physical development of children, and cannot reflect the development of children's sports.

The level of gross motor development is closely related to people's intellectual, physical, health and behavioral development. The ability of gross motor development is not only related to physical activity, but also to cognitive ability (Casey, B. J., 2005; Chia, L, 2009) is associated with psychological development (Cairney, J, 2010). Human movements are generally considered to be divided into two types of gross muscle movements and fine movements. Gross muscle movements, also known as gross motor movements, are the basis of various sensory movements and are the earliest motor skills for children and adolescents. AND gross motor development is the development of body movements controlled by nerve centers, nerves and muscles, and is also a learning process in which the brain and body coordinate with each other. (Ayres,1978) believes that the brain responds flexibly to receiving information, making choices and comparisons in the face of various sensory information, and forming the instructions for comprehensive judgment by the body. In this process, it is also called "sensory integration". (Luo Yijun, 2021) Movement itself is a process to complete sensory integration, and the completion of an action project may contain a variety of sensory stimuli at the same time. Increasing the sensory stimulation of

children's vestibular sense, local sense and touch can promote their neural development, which is of great help to the overall healthy development of children.

Before this, most of the gross motion assessment tools used in China were modified on the basis of foreign scales without establishing the latest norms. There were various biases in the evaluation process and no standard evaluation tools were fully implemented. Foreign tools (such as the gross motor development Test, Peabody gross motor development Scale, Children's Motor Assessment Scale, children's motor test, etc.) have too large age span, too many indicators, too high measurement requirements, and inconsistent cultural expression. It cannot more correctly evaluate the gross motor development level of 5–6-year-old children.

Therefore, on the basis of analyzing the gross muscle gross motor development of Chinese children and combining the concept of sensory integration, we constructed a gross muscle gross motor development evaluation model from the perspective of sensory integration of 5-6 year old children, so that it has a set of local norms, easy to grasp, easy to obtain and easy to promote an evaluation system. It provides a new idea for promoting the development of the general motor of preschool children, increases the comprehensiveness, effectiveness and scientific of the assessment, can evaluate the current situation of children's gross motor development, understand the shortcomings of Chinese children's gross motor development, and provide a theoretical basis for kindergartens and other institutions to carry out physical and mental activities, improve the level of children's physical and mental health, and promote the health of the whole people.

1.2 Research Problem

1. There are a large number of children in China, their physical health has declined, and gross motor development has not been paid attention to.

2. 5-6 years old is the most important stage in children's development, motor development and neural development reach the peak, and there is no good gross movement evaluation tool at this stage.

3. The existing evaluation tools, foreign scale does not conform to the national conditions, domestic scale is not comprehensive, complicated procedures, poor promotion.

4. Gross motor is highly positively correlated with the theoretical function of sensory integration. At present, there is no evaluation model of gross motor development from the perspective of sensory integration.

1.3 Research Objectives

1. To summarize the relevant theories of sensory integration and gross motor development in children aged 5-6.

2. To explore the evaluation indicators of gross motor development of children aged 5-6 based on sensory integration theory.

3. To establish evaluation criteria for gross motor development of children aged 5-6 based on sensory integration theory.

4. To establish an evaluation model of gross motor development of children aged 5-6 based on sensory integration theory.

1.4 Research Questions

1. Can sensory integration theory be applied to the gross motor evaluation model for children aged 5-6?

2. What are the evaluation indicators of the gross motor movement evaluation model for 5–6-year-old children based on sensory integration theory?

3. How to establish evaluation criteria for gross motor development of children aged 5-6 based on sensory integration theory?

4. How to demonstrate the evaluation model of gross motor movement evaluation model for 5–6-year-old children based on sensory integration theory?

1.5 Research Hypothesis

The gross motor evaluation index of 5–6-year-old children based on sensory integration theory can accurately evaluate the gross motor development.

1.6 Research Significance

Children are our future, and their health is very important. The healthy development of children and adolescents has always been the focus of attention of various countries and social organizations. 5-6 years old plays a role in the physical and mental development of individuals and is the key period of young children. According to the characteristics and changes of children's physical fitness, the gross motor evaluation of preschool children based on sensory integration theory can become a detection tool for the gross motor development of Chinese children and screen the gross motor development ability and sensory integration function of most children in the country, so as to better understand the health level of children. The evaluation model of gross motor movements of children aged 5-6 based on the sensory integration theory can also be integrated into the preschool physical education curriculum to promote the development of children's physical fitness and provide guidance for the healthy development of children.

1.7 Definition of Terms

1. Research framework

1.1 On the basis of analyzing the gross muscle gross motor development of Chinese children and combining the concept of sensory integration, we construct a gross muscle gross motor development evaluation model of preschool children from the perspective of sensory integration, so that it has a set of evaluation system that is locally standardized, easy to master, easy to obtain and easy to promote.

1.2 It provides a new idea for promoting the gross motor development of preschool children, and increases comprehensiveness, effectiveness and scientific analysis. It can evaluate the current situation of children's gross motor development, understand the shortcomings of Chinese children's gross motor development, and provide a theoretical basis for kindergartens and other institutions to carry out physical and mental activities and improve children's physical and mental health. Promote health for all.

1.3 To evaluation model of preschool children gross motor movements based on sensory integration theory was demonstrated

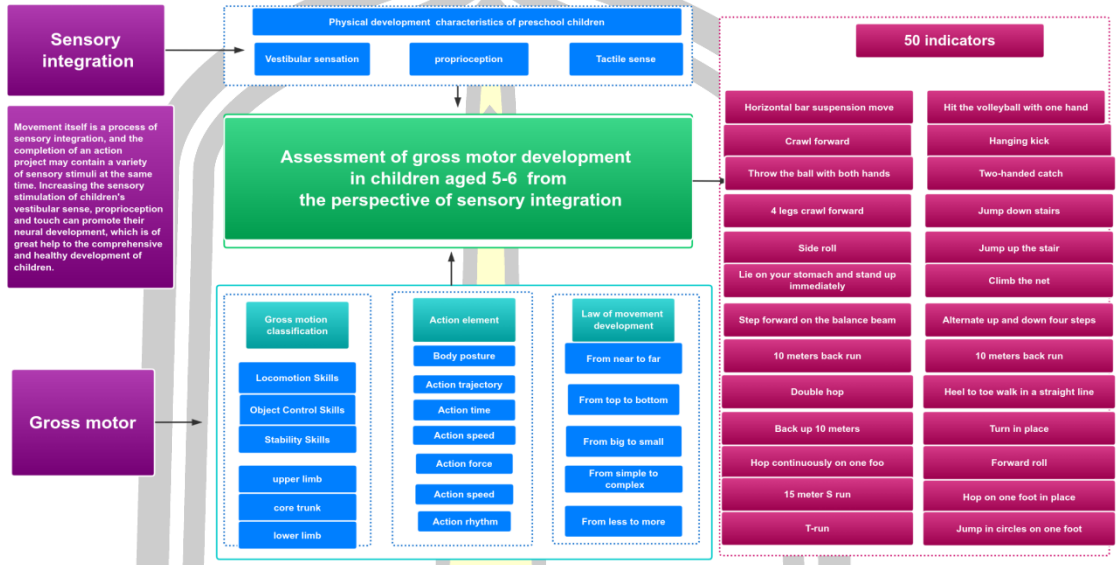


Figure 1 Application framework in indicator research

2. Gross motor development

2.1 Fine and Gross motor development

1. Definition of fine motor skills for toddlers: Fine motor skills for toddlers refer to the movements produced by small muscles or muscle groups in the body, such as writing, using chopsticks, and drawing. The fine motor ability of young children refers to the ability of small muscle groups or small muscles to accomplish specific motor tasks under the conditions of attention and perception.

2. Gross motor movements are produced by the large muscles or muscle groups of the body, such as walking, jumping, throwing, and running. Gross-motor skills in young children refer to motor skills that involve the large muscle groups of the legs, arms, and trunk of the body. Skills such as throwing, jumping, running, and walking are more typical of gross-motor skills.

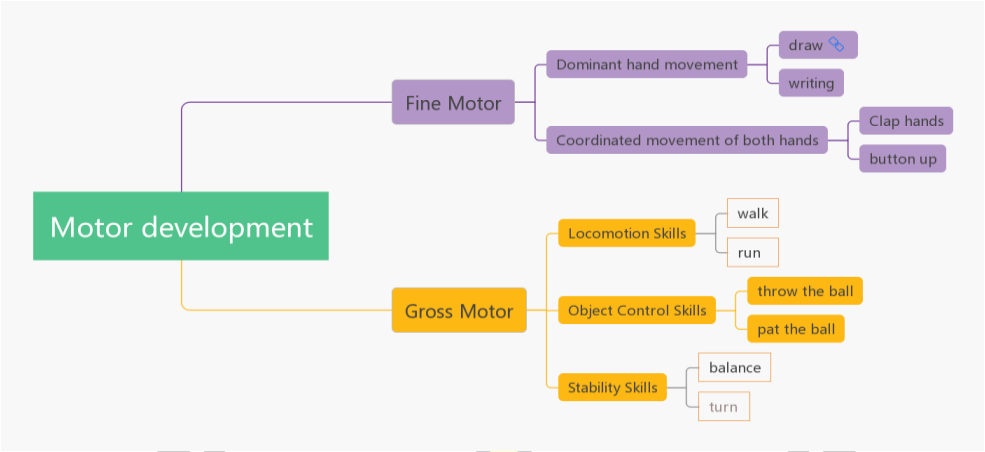


Figure 2 Classification of movements: gross motor movements and fine movements

3. Gross motor movements are categorized as controlled, uncontrolled, and mobile movements.

3.1 Controlled movement is a form of practice that develops manipulative skills through the manipulation of small objects such as balls, ribbons, ropes, hoops, and garlands. These include throwing, catching, collecting, kicking, kicking a hanging ball, volleying, intercepting, hitting, hitting with a paddle, and hitting with a long-handled implement.

3.2 Uncontrolled movements are forms of practice in which the body is held in place. These include turning, twisting, rolling, balancing, weight shifting, jumping and landing, stretching and twisting.

3.3 Mobility movements are forms of exercises in which the body moves from one point to another. These include walking, running, hopping, skipping, sliding, chasing, fleeing, and dodging.

Table 1 Classification of children's gross motor movement types

Classification of children's gross motor movement types				
		definition	Such as	Literature Review
1	Body movement skills	Individual action in space and the ability to move	Run quickly Forward slide step slide Hop on one leg Stride jump Standing long jump	(2013) help button, the development of childhood that bulky action and proprioception ability is correlated to the level of children's body feeling better, the better its gross motor development.
2	The object operation skills	The ability of an individual to manipulate objects using hands, fingers, and other physical objects	Bounce the ball in place Overhand pitch Catch a ball, A static kick The great hit the ball	(Morgan, 2013) points out that the object operation skills are difficult to master because these skills are needed for children sensory integration capability.
3	Stability control skills	Refers to the individual to maintain balance and stability in different positions and activities.	Stretched around scrolling, Rolling back and forth, Walking the balance beam vs Landing buffer	(Gallahue, 2003) pointed out that the improvement of children's stability control skills is crucial for learning basic motor skills (2000) Davids, stability control of the development of skills are beneficial to the development of the sensory system

3. Sensory integration

3.1 The theory of sensory integration

Sensory integration is shortened to "SI", a term first proposed by the British neurophysiologist Sherrington C.S. and the American behaviorist psychologist Lashley K.S., and then systematically put forward by Ayres A.J., a Doctor of Clinical Psychology at the University of California, South America, in 1972.

The theory of sensory integration hypothesized that the achievement of adaptive behavior resulted from the brain’s ability to process and integrate sensory input efficiently (Ayres 1972, 2005). The sensory integration process can be described as an

organized and harmonized interaction of the sensory system that consists of the visual (sight), tactile (touch), vestibular (balance and movement), proprioceptive (joint sense), auditory (hearing), gustatory (taste), and olfactory (smell) senses (Schaaf & Mailloux 2015)

Moving to the right, Ayres described increasingly complex outcomes related to efficient processing of sensation, labeling them “integration of inputs” and “end products.” On the schematic, Ayres used brackets to associate the outcomes with relevant senses. Her schematic clearly shows the hypothesized contributions of the vestibular, proprioceptive, and tactile systems to learning but also includes the auditory and visual systems.

3.2 Sensory System

The human body's sensory system is mainly divided into visual system, auditory system, tactile system, proprioceptive system and vestibular system. Ayres focused on the vestibular, proprioceptive, and tactile systems（her hadn´t ignored the visual and auditory systems.

Proprioception: Control of power and motor coordination

3.2.1 Proprioception refers to the body's ability to sense movement, pressure and tension in muscles, joints and ligaments. It allows children to control movement and strength without relying on vision. Through the perception of muscle strength, adjust the individual grip object strength size; through the action of the muscle sensory feedback, the amplitude of the action, direction, speed adjustment and so on.

For example: jump turn, jump or walk the balance beam, throw the ball and catch the ball.

3.2.2 Vestibular System: Controlling Balance and Spatial Awareness

The vestibular system, located in the inner ear, provides the brain with information about body position, movement direction, speed, and gravity. It plays a crucial role in balance, posture control, and spatial awareness. Key functions of the vestibular system include Stand on one foot, crawl and roll forward

3.2.3 Tactile system: The sense of touch is the most widely distributed sensory

system in the human body. Touch receptors are located in the epidermis, dermis and subcutaneous tissue. The sense of touch allows the body to sense contact with external objects and helps adjust gross motor movements. For example, when tapping the ball, the touch of the hand can perceive the surface material and temperature of the ball and can also judge the elasticity of the ball by touch, so as to adjust the strength and rhythm of the ball.

In my thesis research, like Ayres, I focused on the vestibular system, proprioceptive system, and tactile system.

4. 5–6-year-old children

"5-6-year-old children" Internationally, early childhood is divided into 0-7 years of age, with 0-1 years of age being infancy and 1-3 years of age being toddlerhood, and there is no clear positioning of children aged 3-6 years as term children. In pediatrics, it is pointed out that 0-1year olds are infants, 1-3year olds are toddlers, and 3-6year olds are preschoolers; and in child development psychology and "kindergarten work regulations", the age of young children is set at 3-6 years old. In the Guidelines for the Learning and Development of Children Aged 3-6 issued by the Ministry of Education, although the target group is 3-6 years old, the children in the document are not explicitly referred to as toddlers. From this, we can see that there is no clear definition of the age range of young children both at home and abroad. However, since the age range of children in kindergartens is 3-6 years old, this paper defines children aged 3-6 years old as young children for the time being, with children aged 3-4 years old (including 4 years old) being regarded as young children in small classes, children aged 4-5 years old (including 5 years old) being regarded as middle-class children, and children aged 5-6 years old (including 6 years old) being regarded as older-class children.

5. Perspective

5.1 Basic Meanings

Viewing Angle: refers to the position and direction in which something is observed. For example, photographers shooting scenery, standing on the top of the mountain and standing in the valley, the picture is different, which is the difference brought by different perspectives.

Optical concept: In the field of optics, the Angle of view refers to the Angle between the two ends of an object and the eye. The size of the Angle of view determines the clarity and scope of the object we see, such as observing distant objects with a telescope, can increase the Angle of view, so that the object looks clearer and larger.

5.2 Extended Meaning

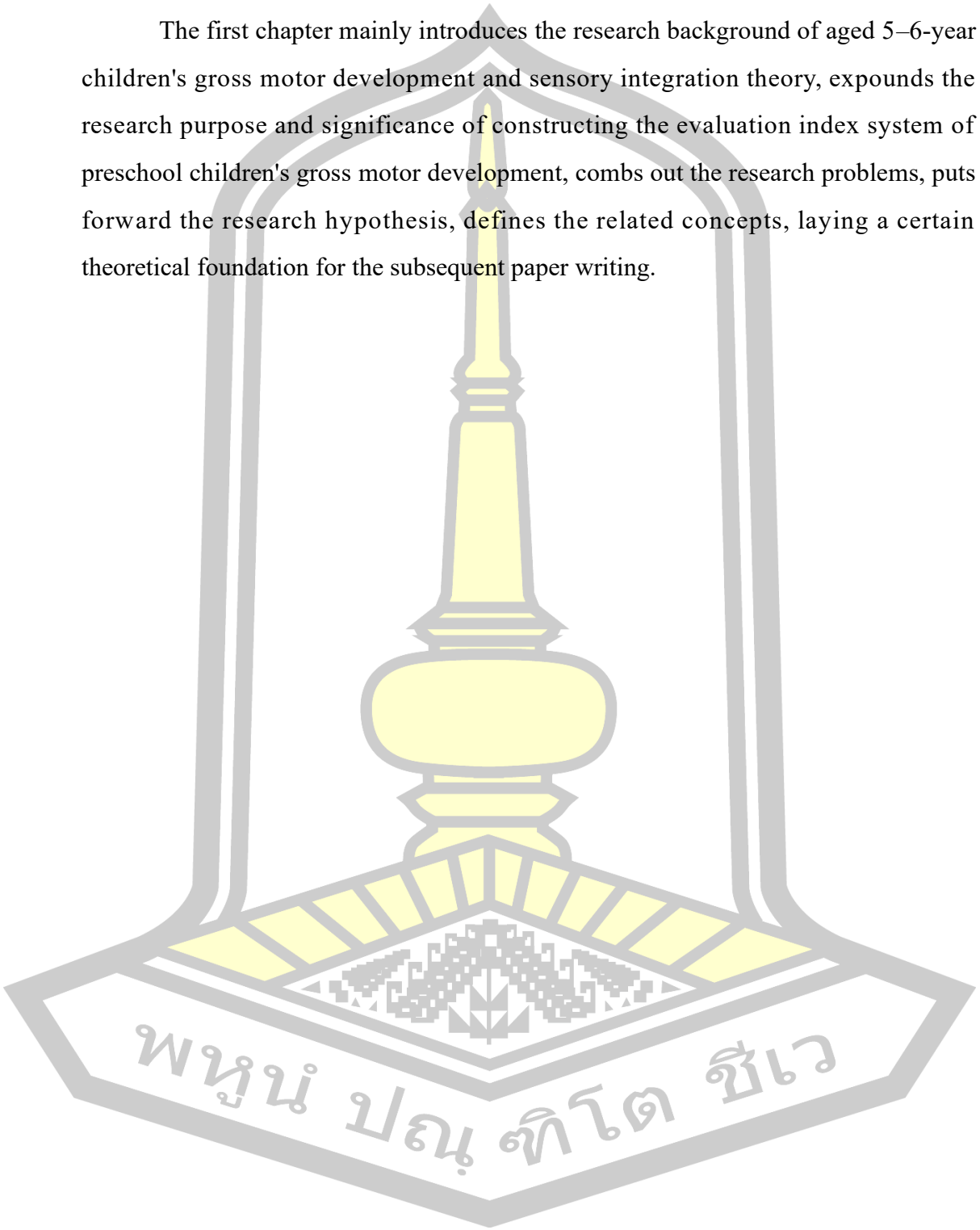
Disciplinary perspectives: Each discipline has its own unique perspective to study and interpret the world. For example, economics analyzes social phenomena from the perspective of resource allocation and interest relationship, while psychology studies from the perspective of human psychology and behavior, helping us to understand the nature and laws of things from different dimensions.

Thinking Angle: refers to the position and point of view of people thinking about problems and looking at things. For example, for the same film, the audience can enjoy it from different perspectives such as plot, picture and music, while the film critics can analyze it from professional narrative structure and lens language, which reflects the differences in different thinking perspectives.

"Perspective" is very important both in the observation of daily life and in the research of professional fields. This paper mainly uses the sensory integration theory of Dr. Ayres, taking proprioception, vestibular sense and touch as the important conditions for constructing the gross motor movement indicators of children.

1.8 Summary

The first chapter mainly introduces the research background of aged 5–6-year children's gross motor development and sensory integration theory, expounds the research purpose and significance of constructing the evaluation index system of preschool children's gross motor development, combs out the research problems, puts forward the research hypothesis, defines the related concepts, laying a certain theoretical foundation for the subsequent paper writing.



CHAPTER II
LITERATURE REVIEW

The researchers have studied the principles, concepts and theoretical viewpoints from the literature and related research results. The aim is to help in defining the conceptual framework of research including the research process and access through conceptual development.

Theories include:

2.1 Theoretical model of children's motor development and its importance.

2.2 Research on international motor development assessment tools.

2.3 Evaluation methods of infant motor development in China.

2.4 Importance of gross motor development at age 5-6.

2.5 Importance of sensory integration theory.

2.6 Scale contents of sensory integration: vestibular sense, proprioception, touch.

2.7 Summarizing gross motor development at age 5-6: gross motor development from the perspective of sensory integration.

2.1 Theoretical model of children's motor development and its importance

The model of child motor development enables us to understand complex concepts more comprehensively and provides help for us to understand the process and changes of motor development. More classical theoretical models of action development can be divided into the following types:

2.1.1 Sequence model of movement proficiency development

The movement proficiency development sequence model is the earliest movement development model proposed by Seefeldt to form a pyramid of age and movement skill development from the bottom up, which is later called the "pyramid" model. The development of motor skills in early childhood directly lays the foundation for the motor level and physical activity level in adulthood. Most of the

reasons for the low motor level and insufficient physical activity in adulthood lie in the lack of appropriate environmental stimulation and motor exercises in the basic motor stage, resulting in insufficient mastery or proficiency of basic motor skills. Therefore, children's basic motor skills should be developed in the basic motor stage.

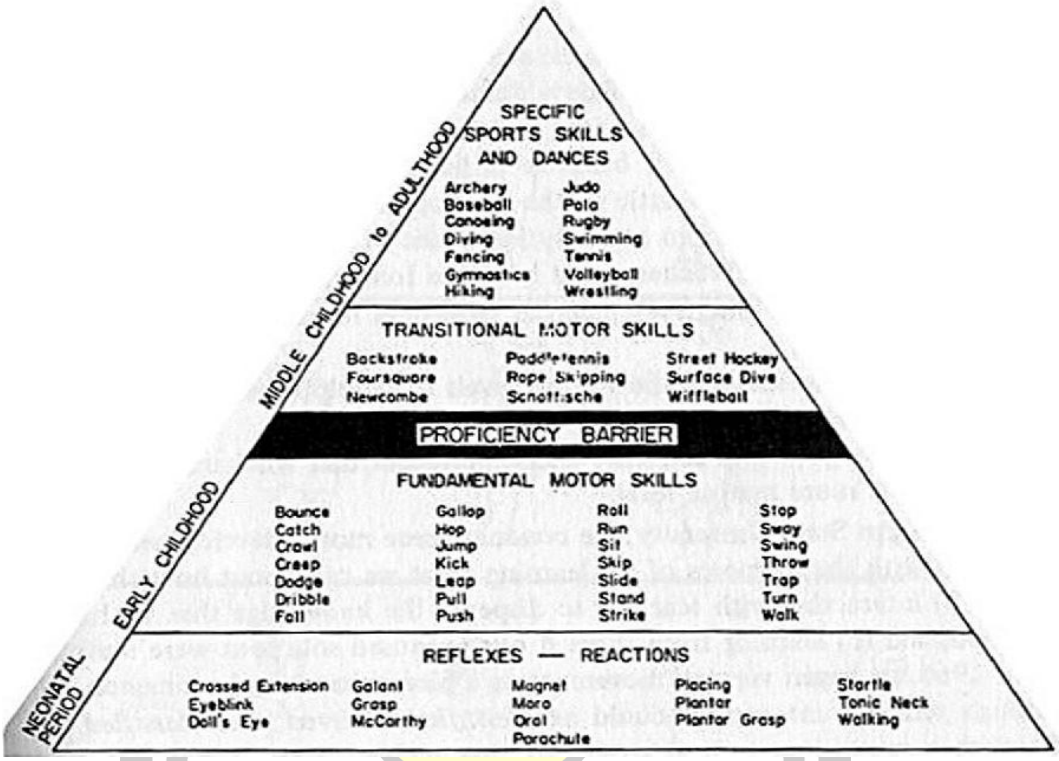


Figure 3 Sequence model of movement proficiency development

2.1.2 Hourglass Model

The "hourglass" model of motor development was proposed by Gallahue et al in 1998 based on the viewpoint of ecology, which emphasized three factors affecting motor development: individual characteristics, environment and tasks. There is a partial overlap between each stage in the model, that is, the end of the previous stage includes the beginning of the next stage. The age range of each stage depends on the individual's own conditions and genetic structure, such as the hourglass inversion, sand reflux, reduced mastery of motor skills in late youth or adults, uncoordinated movements, stiffness and other changes.

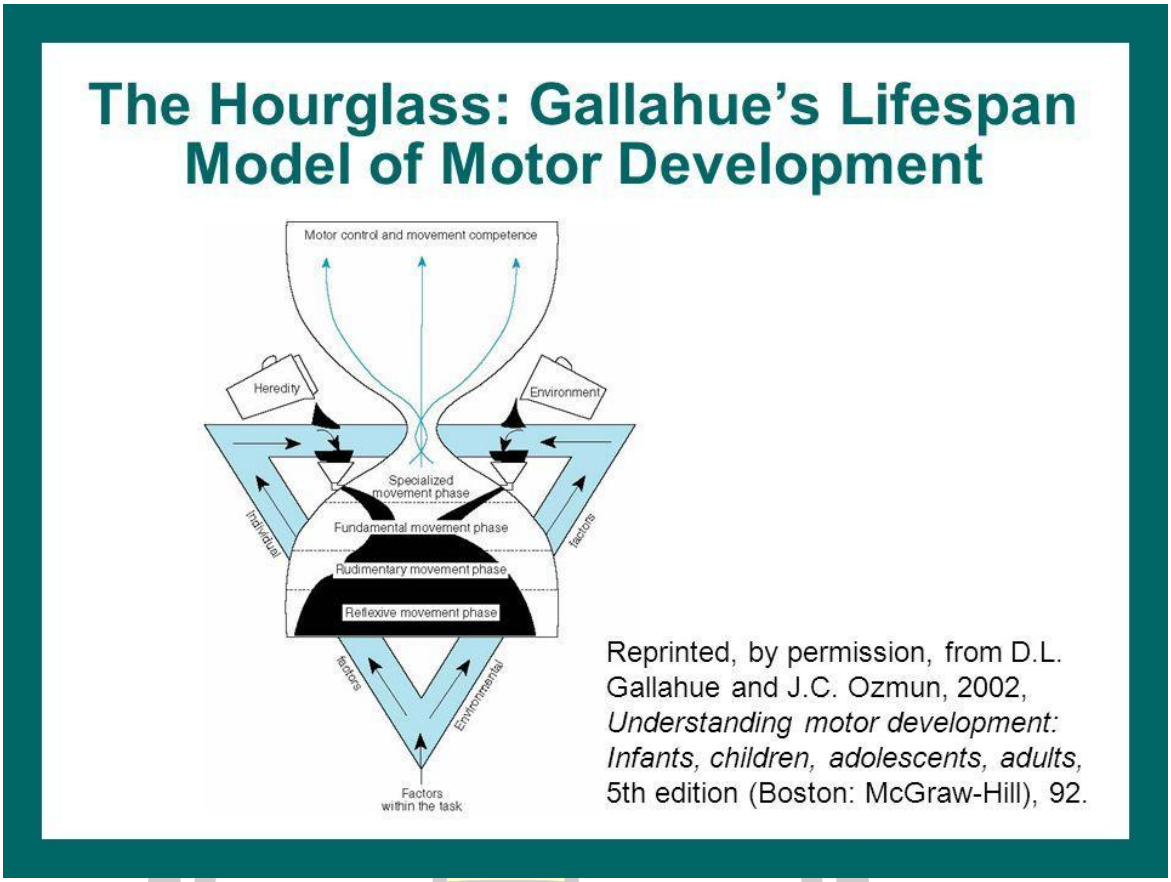


Figure 4 Hourglass Model

2.1.3 “Movement development peak" model

The gross motor development mountain was proposed by Clark and Metcalfe in 2002, based on the motion Development Dynamic Systems Framework. Like human motor development, this process takes years, is a continuous cumulative process, and is affected by the individual skills and characteristics of the climber, which is a non-linear process. The more stimulation, the richer the individual's exercise experience.

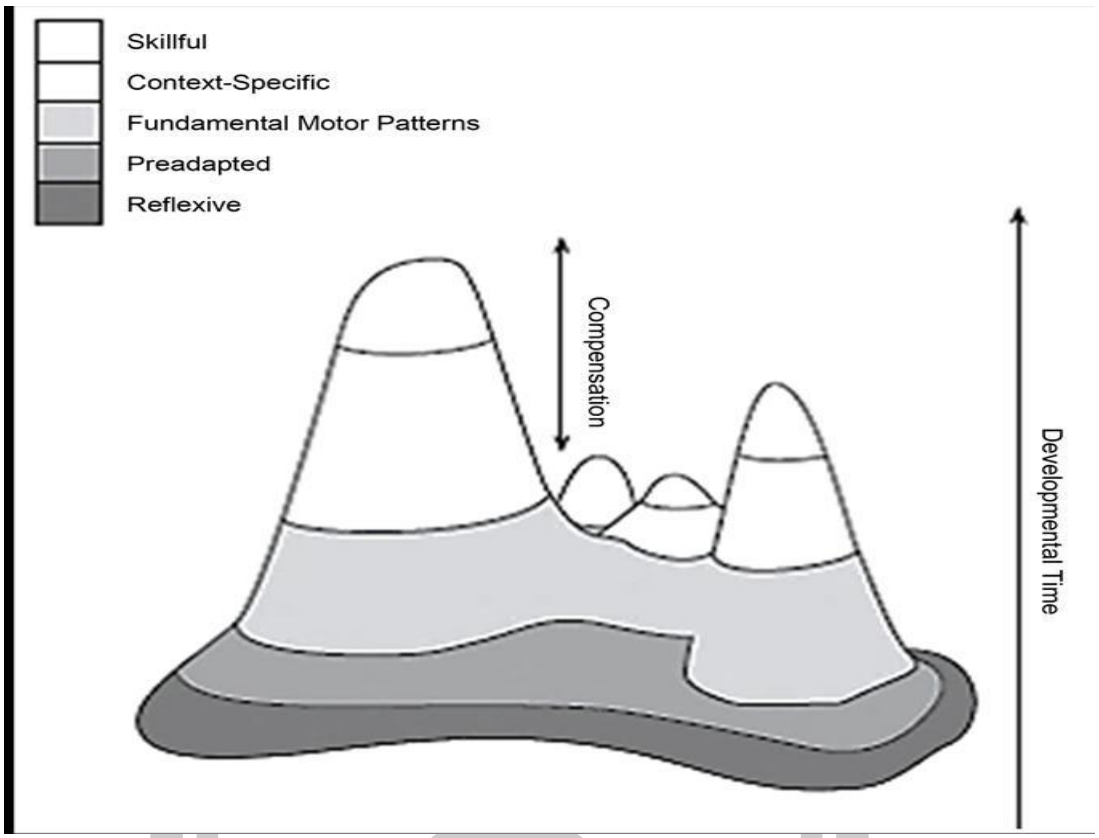


Figure 5 "Movement development peak" model

2.1.4 Lifelong Physical Activity Model

The Lifelong Physical Activity Model was proposed by Ryan et al. Elaborated from the basic opposite the process of development from shooting action to specialized action. Movement development is divided into 1 reflex activity stage (sucking, etc.), 2 basic movement stage (grasping, standing, sitting, climbing, walking, etc.), 3 basic motor skills stage (traditional: running, jumping, throwing, throwing, etc.); Non-traditional: swimming, cycling, weight squats, squats, push-ups, lunges, etc.), ④ special motor skills stage (traditional: basketball, volleyball, soccer, etc.; Non-traditional: weightlifting, diving, rock climbing, etc.), 5 lifetime movement skills stage (cycling, jumping rope, skiing, yoga, football, etc.) five stages. It is pointed out that the reflex stage and the basic motor skill stage of motor development are the basic stages of special motor development and complex motor development.

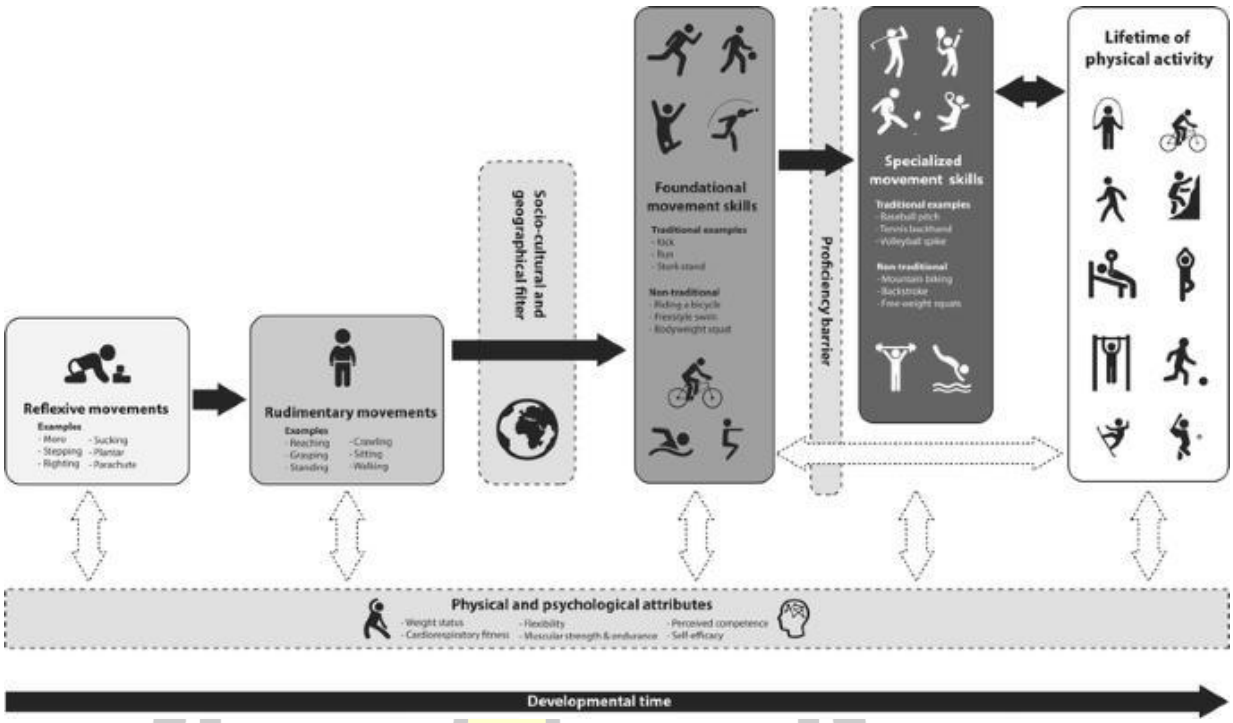


Figure 6 Lifelong Physical Activity Model

2.1.5 Summary

The theoretical model of motor development provides us with a clear process of motor development, and the basic motor skill stage should be paid attention to as the basis of specialized motor development and complex motor development. At this stage, children are basically If motor skills are not developed, then it is difficult for them to reach a higher level of motor skills, This is when motor proficiency disorders occur. Therefore, attention should be paid to the development of basic motor skills in early childhood and timely understanding The present situation of children's motor development, and according to the characteristics of their motor development, formulate appropriate promotion programs for children Provide rich movement experience to ensure the smooth transition of children's various movement stages.

2.2 Research on basic motor skills assessment tools of children in international literature

Since the 20th century, scholars at home and abroad have conducted a large number of experimental studies on the development sequence of human gross motor movements, obtained relatively rich norm data, and formulated such as: KörperkoordinationtestfürKinder（KTK）、Peabody Development Motor Scales（M-ABC）、Peabody Development Motor Scales （PDMS-2)、Test of Gross gross motor development-2（TGMD-2)、Motoriktest für vier- bis sechsjährige Kinder （MOT4-6）、Maastrichtse Motoriek Test（MMT）、Bruininks-Oseretsky Test of Motor Proficiency（BOTMP）、Test of Gross gross motor development-3（TGMD-3)

Table 2 Basic motor skill evaluation scale for each country

Name	Full Name	Author	Year	Country Age	Test Items	Test Time (min)
KTK	Körperkoordinationtest für Kinder	Kiphard& Schilling	1974	Germany 5~14	4	20
M-ABC	Movement Assessment Battery for Children	Henderson&Sugden	2007	Holland 4~12	32：4(4x8)	20-30
PDMS-2	Peabody Development Motor Scales	Folio & Fewell	2000	USA 0~6	249	LV:45~60 STV:20~30
TGMD-2	Test of Gross Motor Development	Ulrich	2013	USA 3~10	12	15~20
MOT 4-6	Motoriktest fürvier-bis sechsjährige Kinder	Zimmer and Volkamer	1987	Germany 4~8	15~20	15~20
MMT	Maastrichtse Motoriek Test	Vles.Kroes & Feron	2004	Holland 5~6	70	20~25
BOT-2	Bruininks-Oseretsky Test of Motor Proficiency，second edition	R. H. Bruininks & B.D. Bruininks	2005	USA 4~21	LF:53 SF:14	LF: 45~60 SF: 15~20

ps：LF=Long Form； SF =Short Form .

2.2.1 Children's Physical Coordination Assessment (KTK)

The Child Physical Coordination Assessment (KTK) is a simplified version of the Hamm-Manburger Korperkoor-dination TestfurKinder scale developed by Kiphard and Schilling in 1974. The age range is: 5 to 14 years old. At present, there are four sub-tests: 1. Reverse balance: walk backward on three wooden strips of different widths, and the width decreases successively; 2. Jump different heights with one leg: skip sponge blocks of different heights with one foot, up to 0.6 meters; 3. Continuous lateral and lateral jumping: jumping around the wooden strip in place,

calculating the number of jumps within 15 seconds; And 4. move the board: standing on two boards and continuously moving sideways, counting the number of moves in 20 seconds, and finally adding these scores to calculate the total, it takes about 20 minutes to evaluate a child. Children's Physical Coordination Assessment (KTK) is a result-oriented assessment tool that can quickly and effectively assess children's physical coordination or homeostatic balance. However, the factor analysis of the assessment scale only includes one factor, which lacks the assessment of body movement skills and object manipulation skills. Although the Child Physical Coordination Assessment (KTK) provides standardized data for the assessment of boys and girls respectively, its data standards are relatively old, there are no recent data norms, and it has certain limitations for the assessment of child coordination or homeostatic balance.

2.2.2 Children’s Motor Development Assessment (M-ABC)

Peabody Development Motor Scales, M-ABC, also known as Movement Assessment Battery for Children, is a Test of Motor Impairment by Henderson and Sugden. Based on TOMI's Oseretsky scales for the motor capacity of children (Oseretsky scales for the motor capacity of children), the age range was extended by 3 to 16 years and divided into three age groups (3 to 6 years old, 3 to 16 years old). Ages 7 to 10 and 11 to 16), focusing on how children manage the daily tasks they encounter at school and at home. This scale is particularly suitable for problems in the integration of motor control functions or problems that occur frequently in kindergarten and early elementary school. At the same time, the limitation of this test scale is that it is mainly aimed at children with movement disorders, and the test efficiency is low (8 items / 20-30 minutes).

2.2.3 Peabody Motor Development Scale - Second Edition (PDMS-2)

The Peabody Development Motor Scales (PDMS-2) are a 2000 revision of the original PDMS (1983) by Follio and Fewell. It is a tool used to assess children's basic motor skills. It consists of six sub-tests, of which two are gross motor assessments and

four are fine motor assessments. Among them, there were 151 gross motor movement tests and 72 fine movement tests. The test is designed to assess the development of basic motor skills in children from birth to 6 years of age, and to identify impairments and deficits in motor development. It can be used as an assessment tool for educators to conduct intervention studies or teaching evaluation. The limitations of the test scale are: high requirements for testers, more items, and a long test time of 45-60 minutes.

2.2.4 Test of Gross motor development-2 (TGMD-2)

The Test of Gross Motor Development-2 (TGMD-2) is a revised version of the original Motor development Test (TGMD) developed by Ulrich in 2000 to assess gross motor development in children aged 3 to 10 years. The content of the test includes two parts: body moving skills and object manipulation skills, a total of 12 tests. In 2013, Ulrich revised TGMD-2 again, that is, TGMD-3, adding the test of one-handed forehand bounce ball to the original operation and control skills, and changed the ground ball into the underhand toss ball, which included 13 tests. It takes about 15 to 20 minutes to assess each child. This scale has good reliability and validity and has also been promoted in China. The limitations of this test scale are that it does not evaluate stability control skills, as well as hitting fixed balls and overhand pitching in object manipulation skills (both of which are highly correlated with baseball skills). Few people in China know about baseball, and the culture is not the same, so it may not be suitable for comprehensive promotion.

2.2.5 Motor Skills Development Assessment for children aged 4-6 (MOT4-6)

Motoriktest fur vier-bis sechsjahrige Kinder (MOT4-6) is a set of assessment tools developed by German scholars Zimmer and Volkamer in 1987 for the assessment of basic motor skills of children aged 4-6. There are 18 different test items covering movement skills, stability control skills, object manipulation skills and fine motor skills, each item is rated on a three-level scale from 0 (not mastered) to 2 (mastered motor skills); It takes about 15 to 20 minutes to assess each child. The limitations of the test scale are: the constant modulus data is old; Since there is no

gender difference, no separate data norms for boys and girls have been established, and the test version and data have not been updated accordingly.

2.2.6 Maastrichtse Motoriek Test (MMT)

The Maastrichtse Motoriek Test (MMT) was developed and designed by Vles et al in 2004 for the assessment of children's motor skills. The assessment age was 5 to 6 years old, and the development pattern of children's movement was evaluated from both qualitative and quantitative aspects, including 70 test items. Among them, there were 36 qualitative evaluations and 34 quantitative evaluations, including object manipulation skills, stability control skills and fine motor development skills. The score is on a three-point scale, that is, 0 ~ 2 points; It takes about 20 to 25 minutes to assess each child. The scale has the following limitations: Lack of physical mobility skills Evaluate.

2.2.7 Bruininks-Oseretsky Test of Motor Proficiency

Bruinks-oseretsky Test of Motor Proficiency (BOTMP) is an assessment tool developed by Bruininks in 1978 for the assessment of fine and gross motor movements. Bruininks et al. [120] revised BOTMP in 2005. The Bruininks-Oseretsky Test of Motor Proficiency,second edition, BOT-2 (BOT-2) has been extended from 4-14 years for BOTMP to 4-21 years Years. There are two versions: full version and lite version. The full version includes a total of 53 test items, and the full version evaluation takes 45 to 60 minutes, and the Lite version evaluation takes 15 to 20 minutes. The scale has the following limitations: 1. lack of European standardized data； 2. focus on children with motor dysfunction; 3. complex test content and long test time.

2.2.8 Summary

The assessment scale of children's basic motor skills is an important means to formulate teaching programs and implement training interventions. Most developed countries have established the assessment scale of children's basic motor skills based on their own motor development status and established norms. In the process of

literature review, it is found that the foreign evaluation scale has the following limitations: 1. The evaluation content is not cross-cultural. 2. The evaluation of basic motor skills is not comprehensive. 3. The test content is complex, and the test time is long.

2.3 Evaluation methods of infant motor development in China

At present, there are few studies on the evaluation of movement development. Although the Guide to Learning and Development for Children aged 3-6 puts forward clear movement requirements, it is confused with physique and does not have specific evaluation requirements for movement. Moreover, the "National physical fitness Measurement Standard" evaluates children's physical form and physical quality as the starting point, only the outcome evaluation, no process evaluation.

2.3.1 Developmental Behavior Assessment Scale for Children aged 0-6

The Developmental Behavior Assessment Scale for children aged 0-6 years has been released by the National Health Commission of China in December 2017, including five ability areas of gross motor, fine motor, adaptive ability, language and social behavior, with a total of 28 months of age, each month group has 8-10 test items, and a total of 261 items. The scale has the following limitations: it is not a scale for major movements, has more content, and has insufficient differentiation in the evaluation of gross motor movements.

2.3.2 National Constitution Test Standard

The issuing body of the infant part of the National Physique Measurement Standard is promulgated by the National Physique Monitoring Center in 2023, including: (1) Body shape indicators: height and weight; ② Physical fitness indicators: 10-meter return run, standing long jump, tennis throw far, continuous jump of both feet, sitting forward bend, walking balance beam, these six indicators are only form indicators and physical fitness indicators, there is no clear evaluation criteria for the action.

2.3.3 The preschooler gross motor quality scale (PGMQ)

The preschooler gross motor quality scale (PGMQ) is a scale developed by Sun Shiheng et al in 2010 to evaluate the gross motor skills of preschool children. It is divided into three tests: movement ability 8, object control ability 5 and balance ability 4, a total of 17 items need 20-30 minutes to complete, in the assessment process to reach the scoring point standard 1 points, otherwise 0 points. After the evaluation, the score and total score of each sub-test can be given according to the scale. The scale has the following limitations: it is rarely applied, and there is no difference between male and female, which still needs further testing.

2.3.4 Learning and Development Guide for Children Aged 3-6

The Guide to Learning and Development for Children aged 3-6, officially released by the Ministry of Education in September 2012, only mentions the requirements of balance, movement coordination, agility, strength and endurance in the motor development part of the health field and points out that children should reach the minimum range of requirements such as walking, running, jumping, throwing and grasping. It is not an evaluation scale, the requirements are low, the differentiation is insufficient.

2.3.5 Summary

In China, most of the assessment of children's gross motor movements exists in other models, and there are few independent scales. These indicators lack comprehensiveness, accuracy and convenience in the evaluation of gross actions compared with international ones.

2.4 The importance of gross motor development at age 5-6

2.4.1 Zhu Chenguang (2024) Human motor development is related to age, has a certain sequence and continuous accumulation, and the direction is affected by multiple factors, and finally reaches the qualitative change of movement. Children aged 5-6 are in the basic motor mode stage, mainly developing basic movements, and this stage plays a fundamental and important role in later motor development. Poor

development of basic movements can hinder the development of skilled movements in the future.

2.4.2 Jinrui (2022) 5-6 years old is the transitional stage of children's movement from the primary stage to the mature stage. The intervention of gross motor movement practice at this stage can not only enrich children's experience of gross motor movement but also ensure the stability of mastering gross motor movement skills through the amount of practice, so as to make children's gross motor movement development more mature. Lay the foundation for future study and life.

2.4.3 Wang Hui (2022) The importance of the stage of 5-6 years old for the development of gross motor of preschool children. Gross motor exercise can positively improve the physical quality, basic motor ability and motor development of preschool children, and also positively promote their nutriregulation ability and mental health development.

2.4.4 Zhao Jinghui (2021) The motor development in early childhood is a critical and sensitive period of motor development in the whole life, so the exploration and development of the motor are discussed. It is of great significance to try to design a more scientific, reasonable and standardized evaluation index. At the same time, it can also find timely the problems of children during this period, correct them, and promote the better development of children's movements.

2.4.5 Liu Huannan (2021) Infant motor development has received extensive attention in the field of infant health. A good motor development level is a guarantee to promote infant health, which can not only improve children's enthusiasm to participate in lifelong sports activities, but also has great significance in promoting their intelligence, cognition, physical and mental health and other aspects of development.

2.4.6 Guo Chen (2017) The sensitive period of gross motor development happens to be the whole early school age, and children in the early school age usually spend their time in kindergartens. Therefore, if the kindergarten uses the scale to test and evaluate children's gross motor development, it will be very helpful to discover

the situation of children's motor development and monitor and intervene their development level.

2.4.7 Gao Xuelei (2014) 3 ~ 6 years old is the key period for the development of children's gross motor ability. Scientific cultivation and training of children's gross motor ability during this period will not only enhance children's physical quality and motor ability, but also positively promote children's intellectual, psychological and social adaptability.

2.4.8 Summary

5-6 years old is a critical period for children's physical development. The evaluation model can accurately locate children's gross motor development, such as walking, running and jumping ability, and find problems in time. The development of children's gross motor movements can promote the better development of skeletal muscles and nervous system and lay the foundation for a healthy body.

2.5 Importance of sensory integration

2.5.1 Ayres (1972) Sensory Integration refers to the process by which the brain organizes, analyzes, organizes, and makes decisions about sensory information received from various organs of the body for the coordinated operation of the whole body. Every action is a process of sensory integration.

2.5.2 Barnett L. M. (2008) et al., in their research, discussed the relationship between sensory integration ability and children's motor skill proficiency, physical activity and health, emphasizing the necessity of sensory integration intervention for children's physical activity and health.

2.5.3 The study of Robinson L. E. (2011) confirmed that sensory integration ability is related to children's basic motor skills, and children with low sensory integration ability may be at risk of showing low basic motor skills.

2.5.4 Sollerhed A. C. et al. (2007) found in their study that children with higher sensory integration ability showed higher frequency and intensity of physical activity, and boys showed higher motor ability than girls.

2.5.5 Luo Fang (2020) Sensory integration is a process in which the brain and body coordinate with each other. It is a process in which individuals input information from different sensory pathways into the brain in an environment, and the brain processes and processes the different information received by the sensory organs of the body and then gives appropriate responses accordingly.

2.5.6 Montessori (1999) believed that sensory integration is of great significance to children's development.

2.5.7 summary

Sensory integration is very important for young children. The completion of each movement is also a process of sensory integration. However, our existing child development measurement scale does not comprehensively evaluate the movement from the perspective of sensory integration. We try to comprehensively evaluate the gross motor development of children from the perspective of sensory integration, which may scientifically and comprehensively discover the problems of children. It is of great significance to the healthy development of children.

2.6 Vestibular sense, proprioception, touch

2.6.1 Sensory Integration Theory and Practice (2022) Proximal and distal senses

Table 3 Sensory Integration proximal and distal sensations

Contrast dimension	Proximal sense: vestibular sense and proprioception, touch	Distal senses: sight, hearing, smell, etc
The receptor site	It is located in the central part of the body or deep tissues, such as muscles, joints, inner ear vestibule, etc., near the central axis of the body	It is distributed on the surface of the body or far from the center of the body, such as the eyes, ears, nose, tongue and skin surface
Sensory information source	Perceives the internal state of the body from its own movement, changes in posture, and its relationship with gravity	From the external environment of the body, the perception of the world around us
Function and effect	Maintaining body balance, coordinating movement, and controlling muscle tension are the basis of physical activity	Obtain information about the external environment, make cognition, judgment and reaction, and interact with the outside world
Developmental sequence	The onset of development in early ontogeny is the basis for the development of other senses	It gradually improves on the basis of proximal sense, and develops with the increase of individual growth and environmental contact

2.6.2 Luo Yijun (2021) The nervous system develops first in the motor system of children. The development of the nervous system represents the improvement of the body's command ability to the motor organs, and shows the improvement of

speed, flexibility and balance ability, which is often closely related to the improvement of visual, auditory, proprioceptive and vestibular sensory organs.

2.6.3 Ren Shaobo (2020) Middle sensory integration (3-6 years old) is the golden age of sensory integration training. From the development of pure sensation to the primary integration of the brain stem, manifested as body movement coordination, hand-eye movement coordination, and the ability to maintain good balance. Conscious attention and memory begin, and various sensory information stimulates the brain.

2.6.4 Gu Yan (2012)

1. Tactile system: the earliest development of human beings, the most extensive and the most influential system, which refers to the use of a variety of sensory receivers on the skin of the whole body to receive the temperature, humidity, pressure, itching, material, shape, and volume of the surrounding environment and other sensory information. The sense of touch is very important to the overall nervous tissue, and if the body does not have a considerable degree of tactile stimulation, the nervous system tends to be unbalanced.

2.Vestibular sense: It uses the three semicircular canals of the inner ear and the otolith to detect gravity and control the orientation of the head or brain, thereby providing information about the body's gravity and space, so that the body can maintain balance regardless of whether it is moving. Through the vestibular system, people can clearly know the position and movement of various parts of the body, and the relative position between themselves and gravity, and maintain the tension and posture of the muscles of the whole body.

3.Proprioception: also known as motion sense or muscle joint motion sense, receiving stimulation from the skin, muscles, muscle tendons, joints, ligaments, bones, etc., so that the individual is aware of joint movement or its position; Detect the direction, speed and size of the action to produce the action at the right point in time; Sensing the amount of force exerted by the muscles allows the individual to decide how much force to use to grip or lift an object; In addition, proprioception

allows individuals to sense the strength and speed of muscle pulling, which is an important source of sensory feedback from movement.

2.6.5 Zeng Meihui (1995) Sensory integration can also refer to the initial reception and combination of information received from the inner ear vestibular balance sensation, skin touch, muscle joint kinesthesia, spatial form vision, ear hearing and other receptors near the brain, and then effectively transferred to the cerebral cortex structure for the brain to serve as the basis for cognition and learning. To enable them to interact effectively with their environment

2.6.6 Summary

Before the age of 6 is the golden age of sensory integration training, vestibular sense and proprioception, touch can reflect the quality of movement.

2.7 Summarizing gross motor development at age 5-6: gross motor development from the perspective of sensory integration.

2.7.1 Sensory integration is the foundation of gross motor development

Mailloux Zoe,GradyDominguez Patricia,Bundy Anita,Parham L Diane,Roley Susanne Smith,Wieland Susan & Schaaf Roseann C.（2023）According to Ayers' sensory integration theory, children's motor development relies on the ability to integrate various sensory information such as the vestibular sense, proprioception, and touch. For example:

Each stage of gross motor skills (such as lifting the head, sitting, crawling, and walking) is based on the sensory integration of the previous stage. For instance, after an infant triggers the foraging reflex through tactile stimulation, the head-turning movement activates the vestibular sense and proprioception, laying the foundation for subsequent neck control and balance abilities.

Children need to adjust their postures and movements by integrating environmental information in motor practice. For example, when cycling, vestibular sense (gravity perception) and visual (spatial distance) information need to be

integrated to maintain balance. Insufficient sensory integration may lead to movement failure.

2.7.2 Hayes Stephen & Sharkey Don. (2023) The gross movements of infants are one of the external manifestations of sensory integration ability. For instance, when a baby can perform a certain gross movement smoothly, it indicates that its sensory system can effectively integrate various sensory information and transmit it to the motor system to achieve precise movement control. On the contrary, if there are abnormalities in gross motor skills, such as stiffness or incoherence, it may suggest that there are certain obstacles in sensory integration, and problems have occurred in the processing and transmission of sensory information.

2.7.3 Le Gall Didier. (2023) Sensory integration is closely related to gross motor skills. Defects in sensory integration can lead to gross motor disorders, while abnormal gross motor skills can reflect the state of sensory integration. Apraxia plays a bridge role between the two, further revealing the complex pathological connection between them.

2.7.4 Whiting Colleen Cameron, Schoen Sarah A & Niemeyer Linda. (2023) The gross motor skills of students are one of the external manifestations of sensory integration ability. In the study, by evaluating students' gross motor performance before and after the intervention, their sensory integration status can be indirectly understood. If students have difficulties in gross motor skills, such as inflexibility and poor balance, it may suggest that there are certain problems with their sensory integration.

2.7.5 Kuhaneck Heather M,Watling Renee & Glennon Tara J.(2023) Sensory integration is closely related to gross motor skills. The vestibular and proprioceptive stimulation felt by the body is conducive to sensory integration, and good sensory integration can enable children to better adjust their body posture and movements, enjoy the fun brought by the swing and improve their movement skills.

2.7.6 Balikci Aymen,MayBenson Teresa A Ilbay Gul. (2023) Children with Rubinstein-Taybi syndrome, sensory integration is closely related to gross motor

skills. The Ayres sensory integration therapy not only improves the sensory integration ability of the children but also plays an important role in enhancing their gross motor function. The two influence each other and jointly affect the overall development of the children.

2.7.7 Raditha Citra,Handryastuti Setyo,Pusponegoro Hardiono D & Mangunatmadja Irawan. (2022) For children with autism spectrum disorder, there is a close connection between sensory integration and gross motor skills. Sensory integration intervention not only improves the sensory integration ability of children but also has a significant positive effect on enhancing their gross motor performance and participation. The two influence and promote each other, jointly affecting the development of children.

2.8 Summary

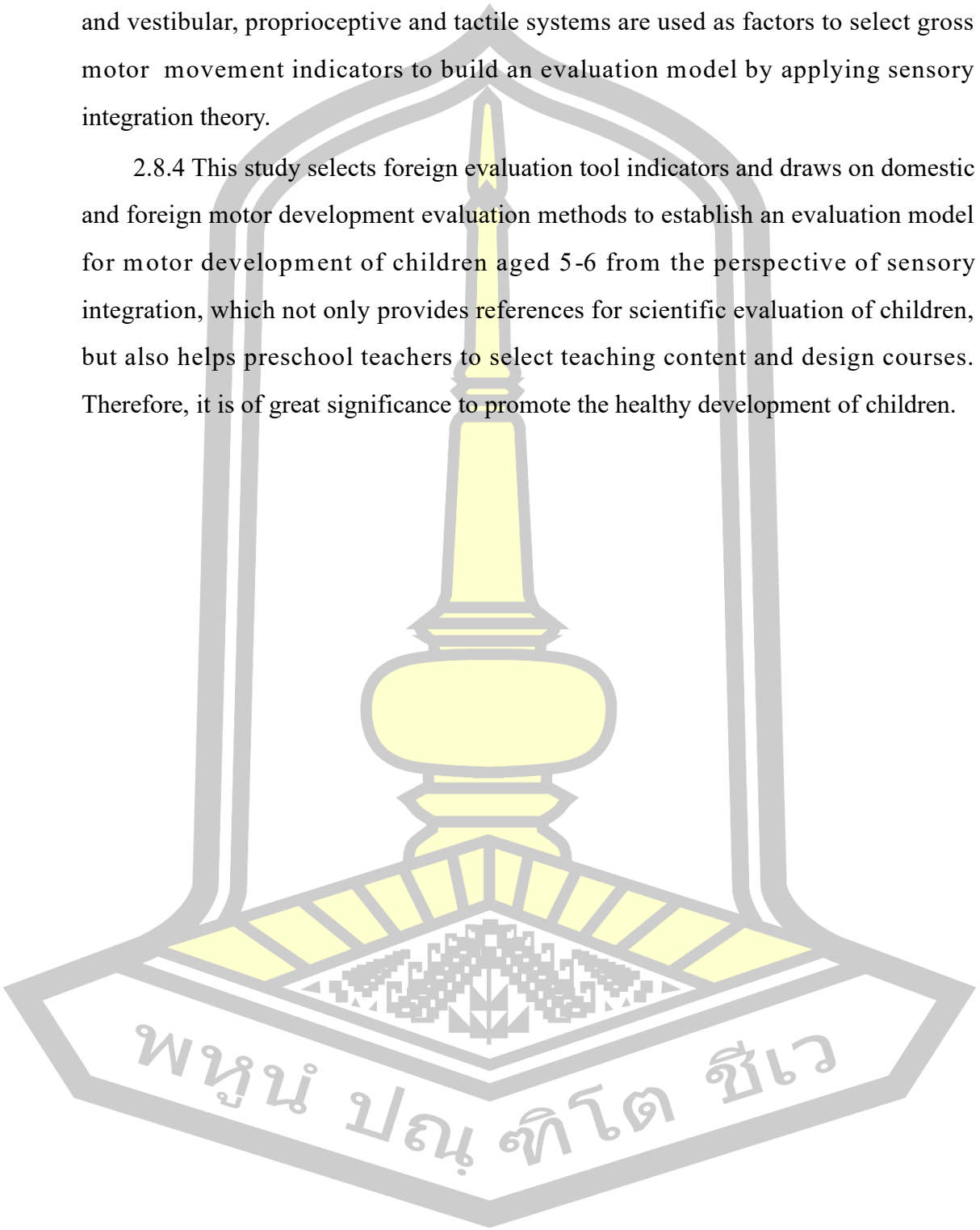
2.8.1 The motor development of children has received extensive attention in the field of infant health. A good motor development level is a guarantee to promote the health of children, which can not only improve the enthusiasm of children to participate in lifelong sports activities but also has great significance in promoting the development of their intelligence, cognition, physical and mental health and other aspects.

2.8.2 The existing evaluation tools are incomplete in terms of evaluation dimension, and due to regional and cultural differences, there are limitations in the content of evaluation tools. Even the newly explored evaluation tools in China still cannot fully reflect the motor development ability and real activity status of Chinese children. Because the current motor development assessment tools lack pertinence and comprehensiveness, it is difficult to popularize in the application of children.

2.8.3 Sensory integration is very important for young children. The completion of each movement is also a process of sensory integration. However, our existing child development scales do not provide a comprehensive assessment of movement from the perspective of sensory integration. Movement is not a simple muscle movement, but also contains the sensory processing mechanism behind it. A

comprehensive and in-depth study of gross motor movement indicators is conducted, and vestibular, proprioceptive and tactile systems are used as factors to select gross motor movement indicators to build an evaluation model by applying sensory integration theory.

2.8.4 This study selects foreign evaluation tool indicators and draws on domestic and foreign motor development evaluation methods to establish an evaluation model for motor development of children aged 5-6 from the perspective of sensory integration, which not only provides references for scientific evaluation of children, but also helps preschool teachers to select teaching content and design courses. Therefore, it is of great significance to promote the healthy development of children.



CHAPTER III
RESEARCH METHODS

3.1 Research Design

The main purpose of this study is to construct the evaluation index system of gross motor movement from the perspective of sensory integration, and to calculate the grade scoring model of gross motor movement of 5-6 years old children through the test data. This study is divided into three stages. In the first stage, literature and expert interviews were used to interview motor development and sensory integration function indicators, sort out and analyze research progress, and select indicators through IOC. The second stage is the use of three rounds of Delphi method, through experts to screen the rough movement evaluation index, the establishment of rough movement evaluation index system. The third stage is to use the experimental method to carry on the weight analysis of the gross action evaluation and finally establish the grade scoring model.

3.2 Research Process

Phase 1: To confirm the application of sensory integration theory to the gross motor evaluation model of 5-6 year old children

Stage1: Literature survey

Stage2: Expert consultation

Stage 3 Processing of data

Phase 2: To determine the evaluation index system of gross motor movement of 5-6 year old children from the perspective of sensory integration.

Stage 1: Delphi expert consultation round one

Stage 2: Delphi expert consultation Round two

Stage 3: Delphi expert consultation Round three

Stage 4 ： Item-Objective Congruence (IOC)

Phase 3: To establish an evaluation model of gross motor development of children aged 5-6 based on sensory integration theory.

Stage 1: Formal testing

Stage 2: Build the grade scoring model

Stage 3: Model validation

Each phase was presented in details consisting of steps of procedures and expected outcomes as shown in figure 7

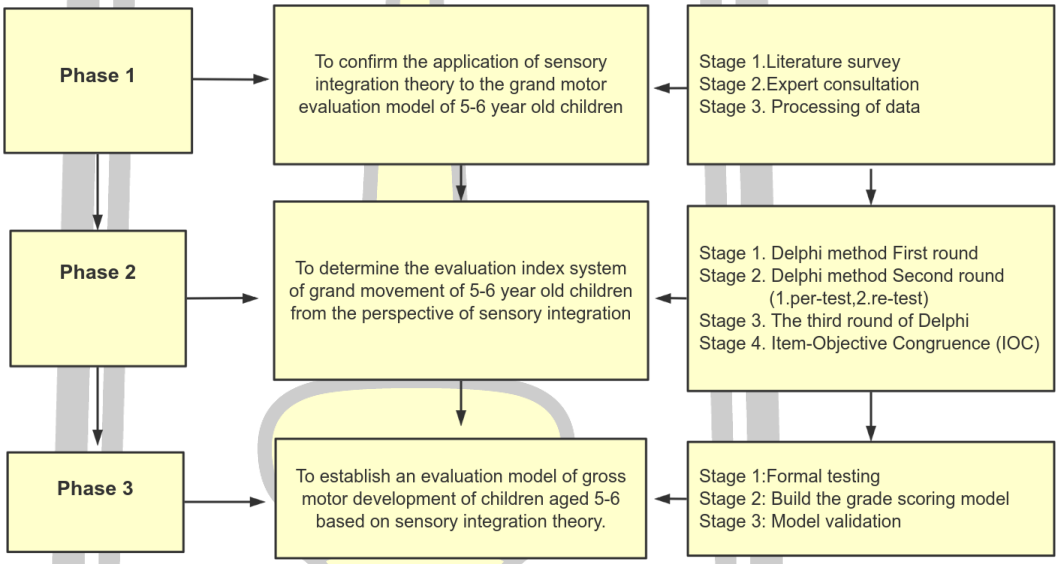


Figure 7 Research framework

3.3 The details of each phase are as follows

Phase 1: To confirm the application of sensory integration theory to the gross motor evaluation model of 5–6-year-old children

Objective: To summarize the gross motor development theory and sensory integration function theory of preschool children, discuss the variables of children's gross motor development from the perspective of sensory integration, and initially determine the evaluation indicators of gross motor development.

Stage 1. Literature survey

The existing theories and practices are summarized to provide sufficient basis for the establishment of children's gross motor development index system from the perspective of sensory integration.

This study consulted books and literature related to infant motor development such as infant motor learning, infant physical education measurement and evaluation in National Library, Guangxi Normal University Library and Beijing Sport University Library, and obtained infant physical education related policy documents, development guidelines, curriculum standards and evaluation materials through the official website; A large number of literatures were searched through domestic and foreign academic databases, including PubMed, Web of Science, Google Academic, CNKI, AND International academic databases, official reports, and related books etc. Common indicators of "Motor development" and "gross motor movements" were collected and summarized by "sensory integration", "gross motor movements" and "sensory integration" to lay a theoretical foundation for the primary indicators.

Stage 2. Expert consultation

In order to design a reasonable and scientific index structure for this study, 30 experts in the fields of infant sports, physical fitness, preschool education and infant medicine were interviewed through email, WeChat and face-to-face interviews, including corresponding consultation with experts who have research on infant motor development and sensory integration ethics. In order to ensure the scientific, reliability and rationality of this paper, the author first set up the relevant interview outline for the study of movement evaluation criteria, so as to provide a certain basis for the smooth development of this study.

Contents include:

1. How do you understand the kinematics field of children's motor development?

2. You think you need to pay much attention to gross motor development evaluation in 5 to 6 years old preschool children?

3. What do you think of the evaluation results of the development of the form?

4. What do you think China's current development evaluation index or tools?

5. What do you think of bulky action assessment tools in China use?

6. What do you think of how to understand the ayres feeling integration theory of the proximal and distal feeling?

7. What do you think whether feel integration theory can be used in rough evaluation indexes on。

8. Movements. What do you think are the indicators for evaluating children's gross motor movements from the perspective of sensory integration?

Stage 3. Processing of data

According to the results of literature survey and expert interviews, it was judged whether it was feasible to construct an evaluation model of gross motor development of children aged 5-6 from the perspective of sensory integration, and the preliminary indicators were found.

Phase 2: To determine the evaluation index system of the gross motor movement of 5–6-year-old children from the perspective of sensory integration

Objective: Delphi method and the method of pre-test and Item-Objective Congruence (IOC) were used to determine the evaluation index system of the gross motor movement of 5–6-year-old children from the perspective of sensory integration.

Instrument:

1. **Delphi**

The Delphi method is a structured decision-support technique that aims to obtain relatively objective information, opinions and insights through the independent. And repeated subjective judgments of multiple experts during the information-gathering process. The survey team conducts multiple rounds of opinion solicitation from selected expert groups in an anonymous manner. The investigation group summarizes

and organizes the opinions of experts in each round, and the opinions gradually converge to get a more consistent and reliable conclusion or plan. Delphi methods are as follows:

1.1 Calculate the degree of authority of the expert. Considering the degree of authority of experts is generally determined by two factors, one is the level of experts and their scoring judgment basis, and the other is the expert's familiarity with the issue, the degree of authority of the expert to self-assessment, and sometimes mutual assessment. An expert's familiarity with the evaluation indicators and the basis of judgment for scoring, which is a table of the expert's familiarity with the evaluation indicators and the basis of judgment for assigning values.

1.2 Experts to the relative importance of the evaluation indicators scoring, usually using the 100-point scoring system or 10-point scoring system, and sometimes according to the need to use the isometric progression scoring method or isometric progression scoring method, the weight is divided into very important, more important, generally important, less important, less important, and then calculate the average score of each evaluation indicator.

2. Pretest and Retest

Pretest

1. Purpose

1.1 Test content validity: Check whether the questions in the scale accurately measure the desired concept or trait, whether they cover a sufficient range of content, whether they omit important aspects or there are irrelevant questions

1.2 Assess the clarity of the question: check whether the question is clear and easy to understand, whether there are vague, ambiguous or difficult to understand words and sentences to ensure that the subject can accurately understand the intention of the question, so as to make a reasonable answer. Identify potential problems: Identify possible problems in the design, structure and logic of the scale in advance, such as too long answering time, unreasonable order of question 1.3, inappropriate setting of options, etc., so as to modify and improve it in time.

2 Implementation Methods

2.1 Sample selection: A small number of samples with similar characteristics to the target population are generally selected. The sample size is usually about 20 to 50 people, but the specific number can be adjusted according to the actual situation.

2.2 Simulation test: Subjects are asked to complete the scale in an environment similar to the formal test. At the same time, they can be asked to record the problems or doubts encountered in the process of answering the test, or interview after the test to collect their feedback on the scale.

3. Result analysis and application

3.1 Data analysis: Analyze the data of the pre-test, including calculating the difficulty coefficient and differentiation of each question, and analyzing the answer mode and error types of the subjects.

3.2 Modify the scale: Modify and optimize the scale according to the analysis results and feedback from the subjects, such as deleting or modifying the problematic questions, adjusting the order of questions, and improving the option, Settings.

Retest

1. Purpose

1.1 Evaluation reliability: mainly used to test the stability of the scale, that is, the degree of consistency of measurement results at different time points. Through the retest, it can be understood whether the scores of the subjects in the two tests have a high correlation. If the correlation is high, it indicates that the scale has a good stability, and the measurement results are more reliable.

2 Implementation Methods

2.1 Selection of retest samples: Generally, the same samples as the pretest are selected, but if the sample size of the pretest is large, a representative sub-sample can also be selected for retest.

2.2 Determine the retest interval: The selection of the retest interval depends on the specific situation, and the general interval of 2 to 4 weeks is more common. If the time interval is too short, the memory effect may be too large, and the stability cannot

be accurately evaluated. If the time interval is too long, it may be affected by subjects' own development, environmental changes and other factors, which will interfere with the judgment of the stability of the scale.

2.3 Retest: Subject is asked to complete the scale again under the same or similar environment and conditions as the first test.

3 Result analysis and application

3.1 Calculation of correlation coefficient: Pearson correlation coefficient and other methods are usually used to calculate the correlation between two test scores. It is generally believed that correlation coefficient above 0.7 indicates that the scale has good retest reliability.

3.2 Analysis of differences: In addition to the correlation coefficient, it is also necessary to analyze the difference of subjects' scores in the two tests, whether there is systematic bias, and which questions or dimensions have poor stability.

3.3 Judging the quality of the scale: Comprehensively judging the quality of the scale according to the retest results. If the retest reliability is low, it is necessary to further analyze the reasons, such as ambiguity in the question, unstable state of the subject, changes in the test environment, and make targeted improvements.

3. 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. Generally, a higher IOC index indicates a stronger alignment between the item and its intended measurement objective.

Stage 1. Delphi method First round

1. Determine the members of the expert group:

A research team including teachers of early childhood education, experts in child kinesiology and data analysts was formed to organize and coordinate the whole process and process data.

The number of senior kindergarten teachers, early childhood education scholars, child rehabilitation therapists and children's sports coaches who have worked in the field of early childhood education for many years is about 12 (Table 4**)**

Table 4 List of Delphi experts

Name	Country	School	Professional title	Research direction
Zhang**	China	Beijing Sport University	Professor	Health theory and method
Huang**	China	Nanning Normal University	Professor	Physical health promotion
Mo**	China	Nanning Normal University	Professor	Physical assessment and health promotion
Zhang**	China	Huhan Sport University	Professor	Growth and physical constitution of children and adolescents
Ao*	China	Guangxi Preschool Teachers College	Professor	Early childhood education
Liu*	China	Guangxi Preschool Teachers College	Professor	Early childhood education
Wei*	China	Guangxi Preschool Teachers College	Professor	Early childhood education
Liang	China	Guangxi Medical University	Professor	Department of pediatrics
Sun**	China	Guangxi Medical University	Professor	Department of pediatrics
Shi**	China	Nanning First Kindergarten	Senior teacher	Preschool education
Gao**	China	Experimental kindergarten	Senior teacher	Preschool education
Lin**	China	Nanning First Kindergarten	Senior teacher	Preschool education

2. To formulate the first-round questionnaire (Annex I).

The research group's previous literature research and practical experience, from 1.A quick and qualitative assessment of gross motor development in preschool children(European,2019), 2.Peabody Developmental Motor Scale (America, 2000), 3.Test of Gross gross motor development-3 (America, 2013), 4.Gross motor function measure (Canada, 1989),5.Learning and Development Guide for Children Aged 3-6(CHINA, 2012),6. Indicators identified in the evaluation scale of the National Constitution Test Standard (CHINA,2023) were sorted into questionnaires with 3 primary indicators and 50 secondary indicators confirmed by 5 experts. It is hoped that experts can start from the perspective of sensory integration (proprioception, vestibular sense, touch) to find indicators that can better reflect the overall development of children's gross motor. The questionnaire should also include open-ended questions.

3 . Issuing and collecting questionnaires:

The questionnaire was sent to the panel members via email, professional survey platform, etc., and a 1-week period was set for them to respond and return the questionnaire., (**using a 1-5 score system).**

4 .Data sorting and analysis:

The research team sorted out the data of the recovered questionnaires, and counted the mean, median and other basic statistics of the importance score of each evaluation indicator

5. Record and sort out the new indicators and opinions put forward by experts in detail.

Stage 2. Delphi method Second round

According to the analysis results of the first round, indicators with low importance scores and large differences of opinions among experts were excluded, and valuable indicators newly proposed by experts were included to form the second

round of questionnaire.

1. In addition to listing the revised evaluation indicators, the questionnaire should also attach the statistical results of the first round and the summary of expert opinions, so that experts can refer to and understand the overall situation.

2. Issue and collect questionnaires again:

Send the second round of questionnaires to the experts and also give them about 1 week to complete and return.

3. Analysis data:

By comparing the first and second round data, we observe the changing trend of the importance scores of indicators and the degree of concentration of expert opinions. Focus on the analysis of those indicators whose scores fluctuate greatly, and the new opinions and questions raised by experts again.

4. The indicators obtained are pre-tested.

4.1. Population and sample

"Just Here" Children's Physical Training Center, Nanning, Guangxi, China, with 60 children aged 5-6, 60 children were divided into groups A and B. Each group of 30 people, each group of 10, first test group A and then test group B.

4.2 Inclusion criteria

1.normal intellectual development and no organic disease.

2. Kindergarten completes physical fitness tests using the National Physical Fitness Test Standards (2023) (Early Childhood section);

3. children’s families were informed about the study, voluntarily participated and signed the consent form.

4.3 Exclusion criteria

1. the children and parents refused or did not cooperate with the test and questionnaire.

2. suffering from systemic infectious diseases.

3. with congenital diseases such as severe heart, liver and kidney insufficiency and heart disease.

4.having been diagnosed with cerebral palsy, intellectual disability, autism

spectrum disorder, attention deficit hyperactivity disorder, and other diseases.

4.4 Pre-test time: Group A 10; 00-11: :00, Group B 11:00-12:00

Test content:

Table 5 Contents of pre-test

1	Step forward on the balance beam
2	Horizontal bar suspension move
3	4 legs crawl forward
4	Crawl forward
5	10 meters back run
6	Double hop
7	Overhand throw
8	Throw the ball with both hands
9	Moving racket
10	Side roll
11	Jump in circles on the spot
12	Lie on your stomach and stand up immediately

4.5 Test tools:

obstacle ring, No. 4 basketball, No. 4 rope ball, soft square bag, tennis ball, soft cushion, standing long jump pad, mark bucket, stopwatch, tape measure, etc.

4.6 Sampling Procedure

The six testers were students majoring in physical training in Guangxi Early Childhood Teachers College, and the content was divided into three groups (mobile group, stable group and control group), one organization and one record, and group A was tested first and then group B.

4.7.Test process:

1 Test group A and then group B

2. Warm-up activities: games, running, stretching, action explanation,

3. Demonstrate to children twice,

4. Lead children to do this twice

5. Measure twice, record the best result, if both times are not completed, test a third time, and record the result.

5. Retested.

5.1. Population and sample

"Just Here" Children's Physical Training Center, Nanning, Guangxi, China, with 60 children aged 5-6, 60 children were divided into groups A and B. Each group of 30 people, each group of 10, first test group A and then test group B.

5.2：Pre-test time: Group A 10; 00-11: :00, Group B 11:00-12:00

5.3 Ensure that the test environment is consistent: try to ensure that the retest environment is the same or similar to the initial test. It includes the physical environment such as the space size, layout, light and temperature of the test site, as well as the social environment such as the staffing and noise level during the test. For example, tests are carried out in a specific activity room of the kindergarten, the same toys and sports equipment are placed indoors, and the same testers are present during the test, so as to reduce the impact of environmental factors on children's performance.

5.4 Calibration test tools: Check and calibrate tools and equipment used to evaluate gross motor movements, such as rulers to measure children's jump height, stopwatches to record running time, etc., to ensure their accuracy and reliability.

5.5 Keep the test process consistent: retest in strict accordance with the process and standards of the initial test, including the sequence of test items, instructions, demonstration methods, etc. Each project is given the same demonstration and instructions, allowing young children to test in a familiar pattern to guarantee the comparability of results.

5.6 Accurate recording of data: The tester shall accurately and timely record the performance and data of children in each test item, including the completion of actions, time, distance, etc., to ensure the completeness and accuracy of the record.

6.Data Analysis

Retest reliability coefficient: Pearson correlation coefficient is usually used to calculate retest reliability. The same group of subjects are measured twice at different times, and the Pearson correlation coefficient of the two measurement results is calculated. If the coefficient is high, it indicates that the retest reliability is good, that is, the measurement results are stable in time. Intraclass correlation coefficient (ICC) : to evaluate different measuring time point or different between the consistency of the measurement results. The value ranges from 0 to 1. The closer it is to 1, the higher the retest reliability and the stronger the measurement consistency.

7. Prepare for the next Delphi

The research team sorted out the data of the recovered questionnaires, and counted the mean, median and other basic statistics of the importance score of each evaluation indicator ,and record and sort out the new indicators and opinions put forward by experts in detail.

Stage 3. The third round of Delphi

1. Sorting out the results of the second round

Comprehensively combing the questionnaire data of the second round of experts' feedback on children's gross motor movement indicators. By calculating statistics such as mean, median, mode and standard difference, we accurately grasp the centralized trend, dispersion degree and prediction of each indicator by expert opinions, and mark them in detail to provide a basis for follow-up work.

2. Determine the content with equal weight

According to the research purpose and the first two rounds of feedback, determine the content that needs to be presented with equal weight in the third questionnaire. For example, indicators of gross motor development in young children can be used as isobaric content. When designing questions, the number and type of

questions in each dimension should be reasonably allocated to ensure the balance of all dimensions in the questionnaire.

3. Design of the third round of questionnaire

According to the principle of equal weight, design clear and accurate questions for different indicators of the second round and the contents that need to be further discussed. Questions can take a variety of forms, such as using Likert scales to assess experts' perceptions of the importance of indicators, multiple choice questions to allow experts to select key indicators, and short answer questions to gather detailed opinions from experts. For the content that needs to be evaluated again by experts, attach the results of the second round of statistics and main views to assist experts in thinking.

4. Questionnaire distribution

The final questionnaire will be sent to the experts, asking them to review and confirm the evaluation indicators again, and clearly informing them that this is the last round of investigation, hoping that they will give their final opinions after careful consideration. Remind experts to refer to the second round of feedback, comprehensive and in-depth thinking.

5. Collection and summary

Collect questionnaires within a predetermined time, and conduct systematic statistical analysis of expert feedback. To judge whether the opinions of experts on children's gross motor movement indicators tend to be unified, if there are still large differences, it is necessary to carefully consider whether to conduct a fourth round of investigation. If the opinions are basically reached, the final results can be summarized and a scientific and reasonable research conclusion can be formed.

6. Data Analysis

To determine the evaluation indexes of gross motor development in children aged 5-6 from the perspective of sensation

Stage 4. Item-Objective Congruence (IOC)

1. Expert.Criteria for selecting qualified experts areas follows:

1.1 Educational: Master's degree or above, and graduate students in the above fields

1.2 Experience: Senior kindergarten teachers, early childhood education scholars, child rehabilitation therapists, children's sports coaches and other professionals working in the field of early childhood education for many years

2. Experts include:

1. Peijun Rong, Professor, Guangxi Preschool Teachers College

2.Jintian Liang, Professor, Head of the Early Childhood Care and Education Service and Management Specialty

3.Mingwu Zhang, Professor, Guangxi Children's Rehabilitation Center"

4. Danping Huang, Professor, Guangzhou Women and Children's Hospital

5. Yi Su, Professor, Guangxi University of Chinese Medicine

3. Issue and recovery of the questionnaire:

The questionnaire is sent anonymously to the selected experts, giving sufficient time for response. Collect the questionnaire within the specified time, record the recycling situation, and appropriately remind the experts who do not reply in time.

4. Analysis and inspection results:

Quantitative data analysis: calculate the average score of each indicator on relevance, importance, clarity evaluation, standard difference and other statistics. The higher the average score, the higher the experts' recognition of the index; The smaller the standard deviation, the more concentrated the expert opinion.

Qualitative data analysis:

The open opinions of experts are classified and sorted, and common problems and key suggestions are extracted. If experts generally point out that there is ambiguity in the expression of a coordination ability indicator, it is necessary to restate the indicator.

5. Revised indicators and questionnaires

According to the analysis results, the infant gross motor movement indicator system and the third round of questionnaires were revised. Delete or modify the indicators with low expert recognition; The supplementary indicators proposed by experts should be reasonably incorporated into the system after evaluation; For ambiguities, reorganize the language to ensure clarity and accuracy. After the revision is completed, some experts can be asked to review again to ensure that the revised content meets the requirements.

Phase 3: To establish an evaluation model of gross motor development of children aged 5-6 based on sensory integration theory.

Objective:

1. Test the effectiveness of indicators, distinguish different development levels, can accurately distinguish the different gross motor development levels of 5 to 6 years old children, for example, can effectively identify children with good motor development, general and lagging, so that the evaluation results have a degree of differentiation, providing a basis for targeted education intervention.

2. Reliability of evaluation indicators: Large-scale tests are carried out in different kindergartens, family environments and other scenarios to observe whether the evaluation indicators are affected by environmental factors, so as to ensure that the gross motor development of children aged 5 to 6 can be stably evaluated in various realistic environments and ensure the reliability of indicators.

3.Establish standards and norms and establish age norms: Based on large-scale test data, establish age norms of gross motor development assessment indicators for children aged 5 to 6 years old, provide an objective and standard reference system for the gross motor development of children in this age group, and facilitate educators and parents to understand the development status of children.

4.Standardized assessment process: Through large-scale testing, the assessment process, methods and tools are tested and optimized in practice, so as to form a set of

standardized and standardized assessment system for the development of gross motor movement of children aged 5 to 6, which is easy to promote and apply in different regions and institutions.

1. Stage 1: Formal testing

1.1Population and sample

Select 14 cities in Guangxi, China: Nanning, Liuzhou City, Guilin City, Wuzhou City, Beihai City, Fangchenggang City, Qinzhou City, Guigang City, Yulin City, Baise City, Hezhou City, Hechi City, Laibin City, Chongzuo City. Two kindergartens were selected in Nanning, and one kindergarten in each of the other cities, and one class was randomly selected. All of them were healthy children aged 5-6, with about 30 children, a total of 450 children.

1.2 Inclusion criteria

1. normal intellectual development and no organic disease;

2. kindergarten completes physical fitness tests using the National Physical Fitness Test Standards (2023) (Early Childhood section);

3. children's families were informed about the study, voluntarily participated and signed the consent form.

1.3 Exclusion criteria

1. the children and parents refused or did not cooperate with the test and questionnaire.

2.suffering from systemic infectious diseases.

3.with congenital diseases such as severe heart, liver and kidney insufficiency and heart disease.

4. having been diagnosed with cerebral palsy, intellectual disability, autism spectrum disorder, attention deficit hyperactivity disorder, and other diseases.

1.4 Pre-test time:2024.12

1.5 Test content:

Table 6 Formal test content

1	Step forward on the balance beam
2	Horizontal bar suspension move
3	4 legs crawl forward
4	Crawl forward
5	10 meters back run
6	Double hop
7	Overhand throw
8	Throw the ball with both hands
9	Side roll
10	Lie on your stomach and stand up immediately

1.6 Test tools:

Obstacle ring, No. 4 basketball, No. 4 rope ball, soft square bag, tennis ball, soft cushion, standing long jump pad, mark bucket, stopwatch, tape measure, etc.

1.7 Sampling Procedure

1. Selected 18 outstanding students from Grade 3 of Physical education major of Guangxi Preschool Normal College and divided them into 3 groups with 6 students in each group after professional training.

The test content was divided into three groups (moving group, stable group, object control group). Two people were responsible for one group, one organization, and one record.

2. Teachers from the local kindergarten, main class teacher and deputy class teacher, to help organize and protect

3. Fifteen kindergartens from 14 cities were divided into 3 groups: Group A: Guilin, Liuzhou, Laibin, and Hezhou; Group B: Qinzhou, Beihai, Fangchenggang,

Yulin, and Wuzhou; Group C: Nanning, Chongzuo, Baise, and Hechi.

1.8 Test process:

1. Check the venue, check the equipment, check the personnel status, check the clothing, check the shoes

2. Warm-up activities: games, running, stretching, action explanation,

3. Demonstrate to children twice,

4. Lead children to do this twice

5. Record your best performance ever

Stage 2: Build the grade scoring model

1. Data Preprocessing

1.1 Data cleaning: check the integrity and accuracy of data, and eliminate data records with obvious errors or anomalies. For example, check whether any indicator data is missing or beyond a reasonable range.

1.2 Missing value processing: For the data with missing values, the appropriate processing method is selected according to the data characteristics and actual situation. If the data missing is less, the mean and median substitution method can be used; If there is a lot of missing, more complex methods such as multiple filling can be considered.

1.3 Data standardization: Since the dimension and value range of different indicators may be different, in order to eliminate the impact of dimension and facilitate subsequent analysis, data standardization processing is carried out to make all indicator data comparable. The commonly used standardization methods are Z-score standardization, Min-Max standardization and so on.

2. Exploratory data analysis

2.1 Descriptive statistics: Calculate the mean, median, standard deviation, minimum, maximum and other descriptive statistics of each indicator to understand the central tendency, dispersion degree and distribution range of data.

2.2 Correlation analysis: Pearson correlation coefficient or Spearman correlation coefficient is used to analyze the correlation between indicators, initially understand the relationship between indicators, and determine whether there are highly correlated redundant indicators. If there are highly correlated indicators, consider retaining one of the more representative indicators to avoid duplication of information.

3. Determine the indicator weight

According to the results of Delphi, the index is determined and weighted

4. Establish a grade scoring model

Percentile method and normalization were used to develop a grade scoring model

4.1 **Normalization:** Normalization, in the context of data processing, refers to the process of transforming data to a specific range or scale. It is mainly used to standardize data so that it can be better analyzed and processed, and to make different data sets comparable.

Typically, data is normalized to the range of [0, 1] or [-1, 1]. For example, if we have a set of data with the maximum value x_{max} and the minimum value x_min}, to normalize the data to the range of [0, 1], we use the formula :

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}},$$

where x is the original data and x' is the normalized data.

The main purposes of normalization include eliminating the influence of data dimensions, improving the convergence speed of algorithms such as neural networks, and enhancing the stability and accuracy of models. In short, normalization is an important data preprocessing step that helps to improve the performance and effectiveness of data analysis and machine learning tasks.

4.2 **Percentile method：** The percentile is a set of data sorted from smallest to largest and divided into 100 equal parts, and the PTH percentile indicates that p% of the data is less than or equal to the value. The principle of determining the weight is based on the relative position of the data in the distribution, and the importance of each indicator data is reflected by analyzing its position in the whole. The lower the position is (i.e. the larger the percentile), the greater the impact it has on the whole and the higher the weight it may be assigned.

Method Direct calculation method: for ungrouped data, let X1,X2... Xn is a set of data arranged from smallest to largest, and the p percentile Pp is calculated. First calculate the exponent i=np/100, if i is an integer, then Pp=(x_i+x_{i + 1})/2; If i is not an integer and i is rounded up to j, then Pp = xj. For each indicator, each percentile of each indicator data is calculated according to the above percentile calculation method. For example, calculate the 25th, 50th, 75th percentiles of each indicator to understand how the data is distributed.

Table 7 Percentile calculation method

Grade	Corresponding percentile range	Sample data range (assumed number According to the total number of 100)	score
1Grade	0-10%	Data value less than or equal to the 10th Data (Sorted from smallest to largest In)	1
2Grade	10%-20%	Greater than the 10th data and less than Is equal to the 20th data	2
3Grade	20%-30%	Greater than the 20th value and less than Is equal to the 30th data point	3
4Grade	30%-40%	Greater than the 30th value and less than Is equal to the 40th data point	4
5Grade	40%-50%	Greater than the 40th data and less than Is equal to the 50th number	5

6Grade	50%-60%	Greater than the 50th value and less than Is equal to the 60th data	6
7Grade	60%-70%	Greater than the 60th value and less than Is equal to the 70th data	7
8Grade	70%-80%	Greater than the 70th value and less than Is equal to the 80th data	8
9Grade	80%-90%	Greater than the 80th value and less than Is equal to the 90th data point	9
10Grade	90%-100%	Greater than the 90th value	10

Stage 3: Model validation

Objective: Use the established grade scoring model to score and grade it, compare with the actual situation, calculate the evaluation indicators of the model on the external verification set, and further test the generalization ability and reliability of the model.

Sampling method: Stratified random sampling was adopted, stratified according to factors such as region (such as urban and rural areas) and kindergarten type (public and private), and children aged 5-6 were randomly selected from each layer to ensure that the samples covered children from different backgrounds and were representative.

1. Population and sample

Choose two kindergartens in Nanning, randomly select a class, each class has about 30 children, a total of 60 children.

2. Inclusion criteria

2.1 Normal intellectual development and no organic disease.

2.2 Kindergarten completes physical fitness tests using the National Physical Fitness Test Standards (2023) (Early Childhood section);

2.3 Children's families were informed about the study, voluntarily participated and signed the consent form.

3. Exclusion criteria

3.1 The children and parents refused or did not cooperate with the test and questionnaire.

3.2 Suffering from systemic infectious diseases.

3.3 With congenital diseases such as severe heart, liver and kidney insufficiency and heart disease.

3.4 Having been diagnosed with cerebral palsy, intellectual disability, autism spectrum disorder, attention deficit hyperactivity disorder, and other diseases.

4. Test time: 2025.1.6 And 2025.1.10

5. Test content:

5.1. TGMD - 3 Test of Gross Motor Development - Third Edition

5.2. Test of Gross motor development in children aged 5-6 from the perspective of sensory integration

6. Test tools

Obstacle ring, No. 4 basketball, No. 4 rope ball, soft square bag, tennis ball, soft cushion, standing long jump pad, mark bucket, stopwatch, tape measure, etc.

7. Sampling Procedure

7.1 There are 6 students majoring in physical education from Guangxi Preschool Normal College

7.2 The test content is divided into three groups (moving group, stable group, object control group). Two people are responsible for one group, one organization, one record.

7.3 Two teachers from the local kindergarten, the main class teacher and the deputy class teacher, helped organize and protect

8. Test process

8.1 Check the venue, check the equipment, check the personnel status, check the clothing, check the shoes

8.2 Warm-up activities: games, running, stretching, action explanation,

8.3 Demonstrate to children twice,

8.4 Lead children to do this twice

8.5 Record your best performance ever

9. Data Analysis

9.1 Pearson correlation coefficients are calculated based on covariance and standard deviation. Covariance is a measure of how two variables change together. If two variables tend to be greater or less than their respective means at the same time, the covariance is positive, indicating a positive correlation. If one variable is greater than the mean and the other is less than the mean, the covariance is negative, indicating a negative correlation.

The value of the covariance is affected by the scale of the variable. To eliminate the scale effect, the covariance is divided by the standard deviation of the two variables to obtain the Pearson correlation coefficient, so that its value is between [-1, 1].

The closer the Pearson correlation coefficient r is to 1, the stronger the positive linear correlation is. The closer it is to -1, the stronger the negative linear correlation is. Close to 0 indicates a weak or non-existent linear correlation.

9.2 Independent sample T test: The children are divided into two groups according to certain characteristics (such as gender), and the scores of the two groups in the self-built model and TGMD-3 are compared to determine whether the self-built model can effectively reflect the differences in motor development of different groups of children as TGMD-3.

CHAPTER IV
RESULTS

The purpose of this chapter is to construct the evaluation index system of gross motor movement from the perspective of sensory integration, and to calculate the grade scoring model of gross motor movement of 5-6 years old children through quantitative and qualitative data analysis. The researcher followed the following phases to analyze the data and refine the indicator system:

Data Collection and Analysis Process

- The work of the first phase: 1st Delphi Round
- The work of the second phase: 2nd Delphi Round
- The work of the third phase: Pre - test & Retest
- The work of the fourth phase: 3rd Delphi Round
- The work of the fifth phase: Official Testing
- The work of the sixth phase: Criterion Test

Phase 1: To confirm the application of sensory integration theory to the gross motor evaluation model of 5–6-year-old children

Phase 2: To determine the evaluation index system of gross motor movement of 5–6-year-old children from the perspective of sensory integration.

Phase 3: To construct an evaluation model of Gross motor development in children aged 5-6 from the perspective of sensory integration

1. Phase 1: To confirm the application of sensory integration theory to the gross motor evaluation model of 5–6-year-old children

This paper is based on the university library in China National Knowledge network, Google academic, Baidu academic AND international academic databases, official reports, and related books. A large number of domestic and foreign papers and journals related to motor development, evaluation, and children were retrieved, among which 17,692 articles were retrieved with the keyword "motor development"; 14,054 articles were retrieved with the keyword "gross action"; 14000 articles were retrieved for the keyword "sensory integration"; However, 500 relevant studies were retrieved using the keywords "gross motor movement" and "sensory integration".

Since the theory of sensory integration was put forward, it has been widely concerned and applied in the field of child development and education. As the basic part of sensory integration, proximal sense, including touch, vestibular sense and proprioception, has a profound impact on the development of infants' gross motor movement. Based on this, the research on the construction of infants' gross motor movement evaluation model has gradually become a hot topic.

According to the results of the literature survey and expert interview, it is concluded that the evaluation model of gross motor development of 5-6 years old children can be constructed from the perspective of sensory integration. Through summary, 50 indicators are proposed from the following evaluation tools:

1. A quick and qualitative assessment of gross motor development in preschool children (European,2019)

2. Peabody Developmental Motor Scale （America，2000)

3. Test of Gross motor development-3（America，2013）

4. Gross motor function measure（Canada， 1989）

5. Learning and Development Guide for Children Aged 3-6(CHINA，2012)

6. National Constitution Test Standard（CHINA,2023）

Table 8 Preliminary indexes of Gross motor evaluation in children aged 5-6 from the perspective of sensory integration

NO.	Gross Motor
L1	Step forward on the balance beam
L2	Back off the balance beam
L3	Heel to toe walk in a straight line
L4	Horizontal bar suspension move
L5	Climb four steps on your hands and feet
L6	Alternate up and down four steps
L7	4 legs crawl forward
L8	4 legs crawling backwards
L9	Crawl forward
L10	Climb the net
L11	T-run
L12	10 meters back run
L13	15 meter S run
L14	15 meter steeplechase
L15	Jump up the stairs
L16	Jump down stairs
L17	Stride jump
L18	Hop continuously on one foot
L19	Double hop
L20	Back up 10 meters
C21	Underhand throw
C22	Overhand throw
C23	Two-handed racket
C24	Bounce the ball with one hand
O25	Two-handed toss
C26	Two-handed catch
C27	Throw the ball with both hands
C28	Hanging kick
C29	Big push
C30	Hit the volleyball with one hand
C31	Upstroke
C32	Hit the ball with both hands
C33	Foot stop
C34	Kick the hanging bal

C35	Long kick
B36	Moving racket
B37	Stand with your feet closed in place
B38	Stand with one foot closed
B39	Jump in circles on one foot
B40	Hop on one foot in place
B41	Forward roll
B42	Side roll
B43	Backward roll
B44	Turn in place
B45	Jump in circles on the spot
B46	Hold the air stick roll
B47	Horizontal bar suspension move
B48	Horizontal bar suspension swing
B49	Lie on your stomach and stand up immediately
B50	Lie on your back and get up immediately

Table 9 Evaluation methods of primary indexes of Gross motor evaluation in children aged 5-6 from the perspective of sensory integration

NO.	Gross Motor	Method
L1	Step forward on the balance beam	A balance beam of suitable height (about 0.3 height, 0.15 meters width and 3 meters length) is placed on a flat ground. The child stood at one end of the balance beam, the tester gave instructions, and the child walked forward with alternating feet. During the process, the hands could swing naturally to maintain balance, and the completion time was recorded.
L2	Back off the balance beam	In the same setting as walking forward on the balance beam, the child stands at one end of the balance beam, facing the direction of the end. After the tester gave the order, the children walked backward with alternating feet, paid attention to their physical coordination, sense of direction and ability to maintain balance, and recorded the completion time and mistakes.
L3	Heel to toe walk in a straight line	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance

		for 20 seconds.
L4	Horizontal bar suspension move	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
L5	Climb four steps on your hands and feet	Prepare four steps with a suitable height (about 0.2 meters each) and a width of 0.4 meters. The child stood at the bottom of the step, the tester gave instructions, and the child climbed the step with hands and feet, observed its movement coordination, strength use and climbing speed, and recorded the completion time.
L6	Alternate up and down four steps	Step Settings are the same as above. The child stood at the bottom of the step, after the tester issued the command, the child stepped on a step with one foot first, and then on the other heel, alternately walking up to the top of the step, and then alternately walking down to the starting point in the same way, recording the time to complete the whole process.

L7	4 legs crawl forward	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester issued instructions, and the children's hands and feet coordinated to crawl forward, observing their limbs coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L8	4 legs crawling backwards	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester gave instructions, and the child's hands and feet coordinated to crawl backward, observing its limb coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L9	Crawl forward	Set up a 2-meter-wide crawling area on the ground, and arrange some low obstacles to increase the difficulty. Children lie on the starting point, abdominal landing, arms and legs coordinated force to crawl forward, the tester observed the standardization of their movements, through the obstacle ability to record the distance completed in 10 seconds.

L10	Climb the net	Choose a safe and stable children's climbing net with a suitable height (2 meters) and set protective pads around it. The child stands at the bottom of the climbing net, holding the bar with both hands and stepping on the steady surface of the net with both feet. The tester gave instructions, and the children climbed up on both hands and feet alternately, recording the climbing time. Ensure safety during the process |
L11	T-run	Use tape or markers to draw a T-shaped runway with vertical lines 6 meters long and horizontal lines 3 meters long. Place small plastic buckets at the three ends of the T-shape. The child stands at the beginning of the vertical line with his feet shoulder-width apart. After the tester gave the command, the children started to run, and returned to the starting point after bypassing the plastic buckets at the three ends, recording the completion time.
L12	10 meters back run	A 10-meter-long straight runway is marked on a flat surface with turnback points at both ends. Children stand at the starting point with their feet in the starting position. The tester ordered the children to start, run to the turnback point touch the marker, quickly turn around and run back to the starting point, record the completion time

L13	15 meter S run	The S-shaped route is set up with markers on the ground. The total length of the route is 15 meters, and the spacing of each bend is moderate. The child stood at the starting point, ready to run. The tester gives instructions, and the child runs quickly along the S-shaped route, recording the completion time
L14	15 meter steeplechase	Set 3-5 obstacles suitable for children to cross and bypass on the 15-meter-long runway, such as small stools and conical buckets. The child stands at the starting point, after the tester orders, the child starts to run, passes each obstacle in turn, and records the completion time
L15	Jump up the stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped up one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.
L16	Jump down stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped down one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.

L17	Stride jump	Mark a 5-meter straight line on flat ground. Children stand at the starting point, stand front and back with their feet, push off with their front feet and take a big step forward, keep up with their back feet, and perform step jumps with their feet alternately, and record the completion time.
L18	Hop continuously on one foot	Mark a 5-meter-long straight line on the ground, and the child stands at the starting point, standing on one foot and lifting the other foot. After the tester gives the command, the child jumps forward continuously with a standing foot to reach the end and record the time.
L19	Double hop	Mark a 5-meter long line on the ground, with horizontal lines drawn every 50cm. The child stands at the starting point, feet together, knees slightly bent. The tester issued instructions, and the children's feet were simultaneously forced to continuously jump forward across the line, complete 10, and record the completion time.
L20	Back up 10 meters	Mark a line 10 meters long on flat ground. The child stands at one end of the line, facing the direction of the end. After the tester gave the command, the children walked backward with alternating feet and recorded the completion time.

C21	Underhand throw	Children holding a tennis ball, body side to throwing direction, arms naturally drooping, wrist back bending, using the strength of legs, waist and arms to throw the ball from the bottom up, the tester observed the throwing movement and recorded the distance.
C22	Overhand throw	Children holding a tennis ball, body side to throwing direction, arms bent over the head, the body slightly back, using the twist of the body and the swing of the arm to throw the ball forward and up, record the data.
C23	Two-handed racket	Children naturally stand with their feet apart, hold the basketball with both hands, and slap the ball vertically down the ground to make the ball bounce continuously. The tester recorded the number of successful bounces of the ball within 30 seconds.
C24	Bounce the ball with one hand	Children hold the basketball with one hand, choose the dominant hand, and slap the ball vertically down the ground, so that the ball continues to bounce. The tester recorded the number of times the ball was tapped in 30 seconds.
C25	Two-handed toss	Children stand on their feet, hold the ball in front of their chest with both hands, and throw the ball vertically or forward with both hands. The tester measures the height or distance of throwing the ball.

C26	Two-handed catch	The test personnel threw the ball to the children, and the children stood naturally with their feet and hands ready to catch the ball, caught the ball with both hands, and observed the response speed, hand-eye coordination ability and accuracy of the catching action.
C27	Throw the ball with both hands	The child holds the ball in both hands, throws the ball up (overhead)or forward and catches it with both hands when it falls, and so on. The tester records the number of successful throws and catches within 30 seconds.
C28	Hanging kick	The soccer ball or a similar size ball is suspended with a rope at a height of about 0.5 meters from the ground, and the child stands in front of the ball. After the test personnel gives the order, the child kicks the suspended ball with his foot and records the number of kicks.
C29	Big push	Place a large exercise ball or similar large ball on a flat surface. The child stood next to the ball and pushed the ball forward with both hands. The tester recorded the ball advancing 10 meters and recorded the time.
C30	Hit the volleyball with one hand	Children hold the volleyball with one hand, throw the ball up a certain height, and then hit the ball with the hand, and record the number of 5 strikes.
C31	Upstroke	The child held a balloon with a diameter of 30cm, threw the ball up, and then continuously hit the ball with his

		hand, so that the ball did not fall, and the tester recorded the number of consecutive shots for 10 seconds.
C32	Hit the ball with both hands	Attach a baseball or similar sized ball to a batting cage at a height suitable for young children to swing. The child holds the bat with both hands and makes a good batting position. After the test personnel gives the order, the child swings the bat and hits the fixed ball, and observes the standardization of the swing action, the use of power and the accuracy of the batting.
C33	Foot stop	The tester will kick the football to the child, and the child will stop the ball with his foot during the ball rolling process, and record the completion number of 5 stops.
C34	Kick the hanging bal	In the same kick suspension ball setting, children stand in front of the ball, after the tester gives the order, children kick to the suspended ball with their feet, focus on observing the accuracy of the kick, and record the number of accurate kicks of 5 kicks
C35	Long kick	The child stood at a designated position and kicked the soccer ball with his foot into the distance, and the tester measured the distance of the ball
B36	Moving racket	The child bounces the ball with one hand and moves forward or to one side while bouncing the ball. The tester records the moving distance within 20 seconds.

B37	Stand with your feet closed in place	The child stood with his feet together and his eyes closed, and the tester recorded how long the child was able to remain standing.
B38	Stand with one foot closed	The child stands on one foot with the other foot lifted and closes the eyes. The tester records the time the child can maintain the single-foot standing position.
B39	Jump in circles on one foot	The child stands on one foot with the other foot lifted and rotates in a circle with the standing foot as the axis. The tester records the time it takes to complete 3 circles (1080 degrees).
B40	Hop on one foot in place	The child stands on one foot with the other foot lifted and jumps continuously on the standing foot in place. The tester records the number of continuous jumps within 10 seconds.
B41	Forward roll	The child stands with the feet, bends the knees and squats down, supports the ground with both hands, lowers the head and tucks the chest, and rolls forward, passing through the head, shoulders, back, buttocks in turn, and finally stands up with both feet. The tester observes the smoothness, standardization of the action, and the body coordination during the rolling process.

B42	Side roll	The child lies on the side on the ground, rolls 180° to one side with one side of the body as the axis, and then rolls 180° in the opposite direction. Repeat this 4 times, and then repeat in the opposite direction to return. The tester records the completion time.
B43	Backward roll	The child squats on the feet, supports the ground backward with both hands, leans the body backward, lowers the head and tucks the body, rolls backward through the buttocks, back, shoulders in turn, and finally stands up with both hands supporting the ground. Observe the standardization of the action, the strength application, and the stability of getting up.
B44	Turn in place	The child stands with the feet and rotates quickly with the feet as the axis, alternating the feet. The tester records the time it takes to complete 3 circles.
B45	Jump in circles on the spot	The child stands with the feet and rotates with the feet as the axis. Record the best performance based on the angle of the foot rotation.
B46	Hold the air stick roll	The child holds the air stick with both hands, lies flat on the ground, and then rolls to one side. The tester records the time it takes to complete 4 rolls.

B47	Horizontal bar suspension move	Select a horizontal bar with a height suitable for children (3 cm), and lay a protective mat underneath. The child grasps the horizontal bar with both hands and lifts the feet off the ground, remaining in a suspended state. The tester records the suspension time.
B48	Horizontal bar suspension swing	Select a horizontal bar with a height suitable for children (3 cm), and lay a protective mat underneath. The body swings forward and backward or from side to side. The tester records the number of swings.
B49	Lie on your stomach and stand up immediately	Children lie prone on the ground, hands on the sides of the body, after hearing the instruction, quickly support the body with hands, and then stand up, the tester recorded the completion of 20 seconds of time, the number of completed.
B50	Lie on your back and get up immediately	The child lies on the back on the ground, with the legs straight and open, and both hands on the sides of the body or behind the head. After hearing the instruction, the child stands up. The tester records the completion time.

2. Phase 2: To determine the evaluation index system of gross motor of 5–6-year-old children from the perspective of sensory integration.

1 Stage 1: Delphi method First round.

First-round expert questionnaire: The researchers distributed the preliminary selection criteria framework, based on the literature review and practical experience, to relevant experts in the field in the form of a questionnaire. The experts evaluated and screened the indicators based on their theoretical and practical knowledge. Each expert was asked to rate the relevance and importance of each criterion and provide their professional opinions.

The first round of Delphi method implemented questionnaires were issued, and a total of 12 questionnaires were recovered with a recovery rate of 100%, of which 12 were valid with an effective recovery rate of 100%

Table 10 Delphi method First round Reliability situation

	Kendall W		
Number of experts	Number of evaluation items	Kendall	$\chi 2$
12	50	0.418	245.959

Kendall concordance coefficient (Kandall 's W) is a relative quantity, used to calculate the interrelation between the multiple variables, namely when different raters for multiple objects when grading, Kandall harmonious coefficient, generally obtained consistency to test score results, W at 0.4-0.6: coefficient is moderate in this range. The result of this time is: 0.418, indicating that there is a certain correlation between variables, and there is a certain degree of consistency between evaluators or indicators, but it is not ideal, and there may be some differences that need further analysis and adjustment.

Table 11 The first round of expert indicators screening results

Item	AVG	SD	CV	CP
L19	5	0	0	100
C27	4.833	0.577	0.119	91.7
L9	4.667	0.651	0.14	75
L12	4.667	0.492	0.106	66.7
C22	4.667	0.492	0.106	66.7
C25	4.667	0.492	0.106	66.7
B36	4.667	0.492	0.106	66.7
B42	4.667	0.492	0.106	66.7
L4	4.583	0.515	0.112	58.3
B39	4.583	0.515	0.112	58.3
L1	4.5	0.674	0.15	58.3
L17	4.5	0.674	0.15	58.3
B49	4.5	0.674	0.15	58.3
B50	4.5	0.674	0.15	58.3
C23	4.417	0.9	0.204	66.7
B47	4.417	0.669	0.151	50
L7	4.25	0.866	0.204	50
L20	4.25	0.965	0.227	58.3
B45	4.167	1.03	0.247	58.3

L18	4.083	0.9	0.22	41.7
L5	3.833	0.937	0.245	33.3
B40	3.667	1.231	0.336	33.3
L13	3.583	1.165	0.325	25
B41	3.583	0.793	0.221	16.7
B48	3.583	0.793	0.221	0
L3	3.5	1.314	0.376	33.3
L11	3.5	0.522	0.149	0
L14	3.5	1.314	0.376	33.3
B38	3.5	1.382	0.395	41.7
C26	3.417	1.24	0.363	25
C28	3.333	1.303	0.391	25
L6	3.25	0.866	0.266	0
L15	3.25	1.357	0.417	33.3
C24	3.25	1.288	0.396	25
B43	3.25	1.138	0.35	16.7
L16	3.167	1.267	0.4	25
C30	3.167	0.718	0.227	0
B46	3.167	1.193	0.377	16.7
B37	3.083	0.996	0.323	0
L10	3	1.348	0.449	25

C21	3	1.044	0.348	16.7
C29	3	0	0	0
B44	3	1.206	0.402	16.7
C33	2.917	1.084	0.372	16.7
C32	2.833	0.389	0.137	0
C34	2.75	0.965	0.351	0
L2	2.667	0.651	0.244	0
C31	2.583	0.515	0.199	0
C35	2.583	0.515	0.199	0
L8	2.5	0.798	0.319	0

Importance to expert questionnaire scores for data processing, when screening indicators, mainly refer to score an average value, the average index of less than 3.5 deleted, including: C26, C28, L6, L15, C24, B43, L16, C30, B46, B37, L10, C21, C29, B44, c 33, C32, C34, L2, C31 microcomputer, C35 and L8 21 indicators, the remaining 29 indexes. In the second round, experts were given to measure the importance, comprehensiveness, stability, safety, and effectiveness of the indicators.

2. Stage2: Delphi method second round

Conduct an in-depth analysis of the results of the first round of expert feedback, tease out the similarities, differences, and major disagreements in the expert opinions, and remove those that are clearly irrelevant to the topic or unreasonable.

Based on the results of the first round of analysis, the second round of questionnaire is designed. In order to allow the experts to re-emphasize the basic comprehensiveness, stability, feasibility, safety, etc., on the key points and problems that emerged in the first round.

The second round of Delphi method was implemented questionnaires were issued, and questionnaires were recovered with a recovery rate of 100%, of which 12 were valid with an effective recovery rate of 100%

Table 12 Delphi method second round Reliability situation

Kendall W			
Number of experts	Number of evaluation items	Kendall	$\chi 2$
12	29	0.622	208.965

Table 13 The second round of expert indicators screening results

Item	**AVG**	**SD**	**CV**	**CP**
L19	5	0	0	100
C27	4.917	0.289	0.059	91.7
B49	4.917	0.289	0.059	91.7
L9	4.75	0.452	0.095	75
B42	4.75	0.452	0.095	75
C22	4.667	0.492	0.106	66.7
B36	4.667	0.492	0.106	66.7
B45	4.667	0.492	0.106	66.7
L1	4.583	0.515	0.112	58.3
L4	4.583	0.515	0.112	58.3

L12	4.583	0.515	0.112	58.3
L7	4.5	0.522	0.116	50
C25	4.25	0.452	0.106	25
B39	4.167	0.389	0.093	16.7
L14	4.083	0.289	0.071	8.3
L17	4.083	0.289	0.071	8.3
L20	4.083	0.289	0.071	8.3
B41	4.083	0.289	0.071	8.3
B50	4.083	0.289	0.071	8.3
L5	3.833	0.389	0.102	0
L11	3.833	0.389	0.102	0
C23	3.833	0.389	0.102	0
L13	3.75	0.622	0.166	8.3
B40	3.75	0.452	0.121	0
B48	3.75	0.452	0.121	0
L3	3.583	0.515	0.144	0
L18	3.583	0.515	0.144	0
B38	3.25	0.452	0.139	0
B47	3.083	0.289	0.094	0

With Kendall coordination coefficient W=0.418 in the first round and W=0.622 in the second round, W>0.6 means that in most cases, these rater's ranking or

evaluation results of the evaluated objects are relatively similar, and the research or evaluation results have certain reliability and stability. To some extent, it can be considered that the raters have a common trend and basis for the views of the evaluated objects.

The importance of the expert questionnaire was processed. In the screening of indicators, the average score was mainly referred to, and the indicators with the mean value lower than 4.2 and the coefficient of variation higher than 0.25 were deleted, leaving 12 indicators. Start pretesting.

3 Stage 3:

Table 14 Evaluation index pretest situation

Items	sex	Mean ±SD	Min	Max	PC
L1	male	6.2 ± 2.2	14.2	2.7	95%
	female	6.3 ± 2.5	15	3	95%
L4	male	1.5 ± 0.6	0.6	3	100%
	female	1.2 ± 0.4	0.5	2.6	95%
L7	male	10.1 ± 2.5	6.1	15.1	100%
	female	9 ± 1.5	5.5	13.2	100%
L9	male	8.2 ± 1.8	6.6	10.8	100%
	female	7.5 ± 1.5	5.3	9.6	100%
L12	male	8.1 ± 1.2	9.4	5.8	100%
	female	8 .2 ± 1.3	10.3	6.2	100%
L19	male	9.1 ± 1.6	11.4	4.4	100%
	female	8.8±1.5	12.3	4.1	100%
C22	male	9.3 ± 1.3	5.6	12.5	100%
	female	8.4 ± 1.6	4.1	10.8	100%
C27	male	10 ±2	5	15	100%
	female	9± 3	4	12	100%

B36	male	13.5 ±6	4.5	20.5	50%
	female	10 ±5	1	18.5	60
B42	male	6 .3± 1.7	10.2	3.9	100%
	female	6.9 ± 1.1	12	4	100%
B45	male	240 ± 60	135	450	50%
	female	180±60	90	360	70%
B49	male	6 ±1	4	8	100%
	female	5 ± 1	3	7	100%

Table 15 Evaluate the retesting of indicators

Items	sex	Mean ±SD	Min	Max	PC
L1	male	6.3± 2.2	14.3	3.0	95%
	female	6.4 ± 2.5	15	3.1	100%
L4	male	1.5 ± 0.6	0.6	3	100%
	female	1.3 ± 0.4	0.5	2.6	95%
L7	male	10.2 ± 2.5	6.1	15	100%
	female	9.2 ± 1.5	5.5	13.2	100%
L9	male	8.3 ± 1.8	6.7	10.8	100%
	female	7.5 ± 1.5	5.4	9.6	100%
L12	male	8.2 ± 1.2	9.4	5.7	100%
	female	8 .2 ± 1.3	10.2	6.2	100%
L19	male	9.2 ± 1.6	11.3	4.4	100%
	female	8.8±1.5	12.3	4.1	100%
C22	male	9.5 ± 1.3	5.8	12.5	100%
	female	8.5 ± 1.6	4.2	10.8	100%
C27	male	10 ±2	6	15	100%

	female	9± 3	4	12	100%
B36	male	13.5 ±6	4.5	20.5	50%
	female	10 ±5	2	18.5	60
B42	male	6 .4± 1.7	10.2	3.9	100%
	female	6.9 ± 1.2	12	4	100%
B45	male	240 ± 60	135	450	50%
	female	180±60	90	360	65%
B49	male	6 ±1	4	8	100%
	female	5 ± 1	4	7	100%

Project completion rates reflect the evaluation of feasibility and applicability of the project, project completion rate is lower than 60%, that's eligibility is poorer, (= can complete the project completion rate index test/test sample by the total number of 100% the number of participants in this study the target movement performance score of 0 is divided into was not completed index test). It can be seen from the data in the table above that the completion rate of the 10 items is greater than 90%, and the test items can be retained. Single factor analysis of variance was performed to test whether each test index had good sensitivity to age. As shown in the table, there are significant differences in the mean values of the test results of the 8 items between male and female, indicating that the test items have good sensitivity to gender.

Table 16 Retest reliability test of evaluation index

Items	R	P
L1	0.883*	P<0.05
L4	0.931*	P<0.05
L7	0.912*	P<0.05

L9	0.873*	P<0.05
L12	0.871*	P<0.05
L19	0.913*	P<0.05
C22	0.832*	P<0.05
C27	0.843*	P<0.05
B36	0.932*	P<0.05
B42	0.862*	P<0.05
B45	0.921*	P<0.05
B49	0.790*	P<0.05

Spearman's correlation coefficient was the lowest 0.790 and the highest 0.932, all above 0.70, indicating that the reliability of index raters was good and significant at the level of 0.01. It shows that the evaluation index of motor development ability has good stability and high objectivity.

Conclusion: After completing the second round of Delphi method, we optimized the research direction and indicator setting based on the feedback and suggestions of the experts. Then the preliminary experiment was carried out to practice the preliminary selected indicators. In response to the problems exposed in the pre-experiment, we made adjustments and improvements and then carried out a retest. After two rounds of data collection and analysis, 10 core indicators were finally determined. Prepare the third round of questionnaire

4. Stage 4: The third round of Delphi

Design clear and accurate questions based on the principle of equal weight for the different indicators in the second round and the contents that need to be further discussed. Send it to the experts.

The third round of Delphi law was implemented questionnaires were issued, and questionnaires were recovered with a recovery rate of 100%, of which 12 were valid with an effective recovery rate of 100%.

Table 17 Delphi method third round Reliability situation

Kendall W			
Number of experts	Number of evaluation items	Kendall	$\chi 2$
12	12	0.647	85.348

Summary: W=0.647. Expert scores tend to be consistent, and it is recommended to exclude B36 and B45.

Table 18 The first third of expert indicators screening results

Items	**AVG**	**SD**	**CV**	**CP**
L19	5	0	0	100
B49	5	0	0	100
C27	4.917	0.289	0.059	91.7
B42	4.833	0.389	0.081	83.3
L9	4.75	0.452	0.095	75
L12	4.75	0.452	0.095	75
L1	4.667	0.492	0.106	66.7
L4	4.667	0.492	0.106	66.7
L7	4.667	0.492	0.106	66.7
C22	4.667	0.492	0.106	66.7

B36	0	0	0	0
B45	0	0	0	0

After analyzing the results of the second round and the situation of the pre-test, the evaluation result of the third round of experts is to exclude B36 and B45.

Stage 5: Item-Objective Congruence (IOC)

To validate and examine validity, content validity was established through the Project Objective Concordance Index (IOC) to improve the relevance of the questionnaire items to the term definitions defined in Chapter I. The accuracy of the questionnaire content validity was valid when the IOC standard value is greater than or equal to 0.7. The questionnaire was then revised according to the expert advice and recommendations and returned to the consultant for adjustment before trial. The IOC has made the following considerations:

+ 1 Is a question that the experts all agree to answer

0 Represents that the elements and indicator content are not appropriate

-1 Refers to what the expert does not agree with

Table 19 The IOC results of the questionnaire of the evaluation

NO.	Item	Results
1	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Step forward on the balance beam?	Pass
2	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of	Pass

	gross motor development of children when they Horizontal bar suspension move?	
3	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they v4 legs crawl forward?	Pass
4	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Crawl forward?	Pass
5	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they 10 meters back run?	Pass
6	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Double hop?	Pass
7	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Overhand throw？	Pass
8	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of	Pass

	gross motor development of children when they Throw the ball with both hands？	
9	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Moving racket?	Pass
10	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Side roll?	Pass

The researcher pre-tested the questionnaire to find discriminant and Reli competence values. Index of Conformity (IOC)=0.80-1.00. Item classification competence was found by finding the simple correlation coefficient between the item score and the total score from Pearson's simple correlation coefficient. 0.690 or more, by observing the item-to-item total correlation, the researcher takes the question with a discrimination value and uses Cronbach's alpha coefficient method to find the confidence value of the entire version, with the standard being 0.921 and above.

Experts agree with the advantages of using equal weights.

Simple and easy to implement: Assigning the same weight to each evaluation indicator makes the operation very simple, easy to understand and implement, and enables a quick evaluation of children's gross motor skills.

Avoid subjective bias: It reduces the bias caused by the subjective factors of evaluators when assigning different weights to different indicators, making the evaluation relatively more objective• Avoid subjective biases: It reduces the biases caused by evaluators assigning different weights to different indexes due to their personal subjective factors, making the evaluation relatively more objective.

Stage 6 : Summary： At this stage, in order to obtain a highly scientific and reliable index system, we adopted a rigorous and systematic research process.

In the first round of Delphi method, we sent questionnaires to authoritative experts from different fields and extensively collected their initial opinions and suggestions on potential indicators. A total of [90 valid feedbacks were collected and 29 indicators were initially sorted out. In the second round, we fed back the summarized results of the first round to the experts, asking them to evaluate and screen the importance of these indicators, and at the same time add new ideas. After in-depth thinking, the experts put forward many constructive views, and we optimized the indicators according to these feedbacks, retaining 12 indicators. In the third round of Delphi method, the experts evaluated the adjusted indicators again, further improved the indicator system, and initially identified 10 more concentrated indicators.

Another group of experts in related fields were invited to evaluate the retained indicators to determine whether they fully and accurately reflect the research topic. Experts from the content relevance, integrity and other dimensions of consideration, put forward specific suggestions for modification. According to these opinions, we carried out the final improvement and screening of the indicators and finally determined 10 core indicators.

3. Phase 3: To establish an evaluation model of gross motor development of children aged 5-6 based on sensory integration theory

Stage 1: Data collection

Formal test data collection From December 8 to 22, 2024.

Table 20 The sample size of gross motor movement test of 5–6-year-old children

	Number of people		Number of completers		Valid data	
	male	female	male	female	male	female
Nanning	31	30	30	28	30	28
Hechi	17	13	17	13	17	13
Chongzuo	17	14	16	14	16	14
Baise	14	16	13	15	13	15
Guilin	20	16	18	16	18	16
Liuzhou	18	17	18	17	18	17
Laibin	15	19	14	19	14	19
Hezhou	16	16	15	16	14	16
Qinzhou	13	15	13	15	13	15
Beihai	14	18	14	16	14	16
Fangchenggang	15	23	15	22	15	20
Yulin	18	16	17	13	16	13
Wuzhou	17	15	17	15	17	15
	225	228	217	219	215	217
Add up to	453		436		432	

The test was completed in Nanning, Chongzuo, Baise, Hechi, Guilin, Liuzhou, Laibin, Hezhou, Qinzhou, Beihai, Fangchenggang,Yulin, Wuzhou, Guangxi, China. 453 people participated in the test, 436 people completed the test, and 432 people were excluded from outliers, invalid data and valid data, with a data efficiency of 96.25%.

Stage 2: Significance Testing and Regression Analysis

2.1 Test situation

Table 21 Evaluation index pretest situation

Items	sex	Mean ±SD	Min	Max	percentage complete
L1	male	6.2 ± 2.2	14.2	2.7	95%
	female	6.3 ± 2.5	15.0	3.0	95%
L4	male	1.5 ± 0.6	0.6	3.0	100%
	female	1.2 ± 0.4	0.5	2.6	95%
L7	male	10.1 ± 2.5	6.1	15.1	100%
	female	9 ± 1.5	5.5	13.2	100%
L9	male	8.2 ± 1.8	6.6	10.8	100%
	female	7.5 ± 1.5	5.3	9.6	100%
L12	male	8.1 ± 1.2	9.4	5.8	100%
	female	8 .2 ± 1.3	10.3	6.2	100%
L19	male	9.1 ± 1.6	11.4	4.4	100%
	female	8.8±1.5	12.3	4.1	100%

C22	male	9.3 ± 1.3	5.6	12.5	100%
	female	8.4 ± 1.6	4.1	10.8	100%
C27	male	10 ±2	5.0	15.0	100%
	female	9± 3	4.0	12.0	100%
B36	male	13.5 ±6	4.5	20.5	50%
	female	10 ±5	1.0	18.5	60%
B42	male	6 .3± 1.7	10.2	3.9	100%
	female	6.9 ± 1.1	12.0	4.0	100%
B45	male	240 ± 60	135	450	50%
	female	180±60	90	360	70%
B49	male	6 ±1	4.0	8.0	100%
	female	5 ± 1	3.0	7.0	100%

2. Exploratory data analysis

Table 22 Factor loading coefficients after rotation(Male)

items	Factor loading coefficient		
	factor1	factor2	Factor 3
4 legs crawl forward	0.909	-0.025	-0.057
Crawl forward	0.745	-0.112	-0.084
Side roll	-0.735	-0.060	0.019
Lie on your stomach and stand up immediately	0.805	0.004	0.021
Horizontal bar suspension move	-0.025	0.846	-0.026

items	Factor loading coefficient		
	factor1	factor2	Factor 3
Overhand throw	-0.023	0.918	-0.007
Throw the ball with both hands	-0.012	0.867	0.110
Step forward on the balance beam	-0.016	-0.010	0.801
10 meters back run	-0.042	-0.041	0.792
Double hop	-0.050	0.113	0.719

Table 23 Factor loading coefficients after rotation(female)

items	Factor loading coefficient		
	factor1	factor2	Factor 3
4 legs crawl forward	0.148	0.733	-0.289
Crawl forward	0.165	0.731	-0.328
Side roll	0.014	-0.797	0.033
Lie on your stomach and stand up immediately	0.155	0.681	-0.016
Horizontal bar suspension move	0.824	0.150	-0.207
Overhand throw	0.880	0.131	-0.105
Throw the ball with both hands	0.901	0.089	-0.101
Step forward on the balance beam	-0.104	-0.100	0.798
10 meters back run	-0.107	-0.081	0.840
Double hop	-0.207	-0.331	0.637

1. Through the factor loading coefficient values of men and women, the corresponding relationship between each factor and the question item is analyzed;

2. Based on the correspondence between the factors and the question items, name each factor:1.Upper body action rating sheet（Horizontal bar suspension move、Overhand throw、Throw and catch）、2.Core torso motion rating sheet（4 legs

forward craw、Creeping、Roll）、3.Lower extremity movement rating sheet（Walk forward on the balance beam、Ten meter run、Double hop）

3. Construction of Scoring Standards

Table 24 Percentile method is used to calculate the score of the forward beam

Grade	Corresponding percentile range	score	forward beam	
			Male	Female
1Grade	0-10%	1	13.1	14.01
2Grade	10%-20%	2	12.07	12.89
3Grade	20%-30%	3	11.04	11.75
4Grade	30%-40%	4	10.02	10,63
5Grade	40%-50%	5	8.98	9.55
6Grade	50%-60%	6	7.95	8.45
7Grade	60%-70%	7	6.92	7.36
8Grade	70%-80%	8	5.89	6.27
9Grade	80%-90%	9	4.86	5.18
10Grade	90%-100%	10	3.83	4.09

Table 25 Percentile method is used to calculate the result of the 10-meter return run

Grade	Corresponding percentile range	Score	10-meter return run	
			Male	Female
1Grade	0-10%	1	9.33	9.81
2Grade	10%-20%	2	8.97	9.43
3Grade	20%-30%	3	8.61	9.05
4Grade	30%-40%	4	8.25	8.69
5Grade	40%-50%	5	7.92	8.32
6Grade	50%-60%	6	7.56	7.95
7Grade	60%-70%	7	7.21	7.58

8Grade	70%-80%	8	6.85	7.21
9Grade	80%-90%	9	6.50	6.84
10Grade	90%-100%	10	6.15	6.47

Table 26 Percentile method is used to calculate the score of consecutive jumps on both feet

Grade	**Corresponding percentile range**	**score**	**Jumps on both fee**	
			Male	**Female**
1Grade	0-10%	1	10.92	11.4
2Grade	10%-20%	2	10.26	10.72
3Grade	20%-30%	3	9.62	10.04
4Grade	30%-40%	4	8.94	9.36
5Grade	40%-50%	5	8.31	8.68
6Grade	50%-60%	6	7.67	8.01
7Grade	60%-70%	7	7.02	7.32
8Grade	70%-80%	8	6.35	6.64
9Grade	80%-90%	9	5.71	5.96
10Grade	90%-100%	10	5.05	5.28

Table 27 Percentile method was used to calculate the performance of horizontal bar suspension movement

Grade	**Corresponding percentile range**	**score**	The performance of horizontal bar suspension movement	
			Male	Female
1Grade	0-10%	1	0.50	0.40
2Grade	10%-20%	2	0.75	0.60
3Grade	20%-30%	3	1.00	0.80

4Grade	30%-40%	4	1.25	1.00
5Grade	40%-50%	5	1.50	1.20
6Grade	50%-60%	6	1.75	1.40
7Grade	60%-70%	7	2.00	1.60
8Grade	70%-80%	8	2.25	1.80
9Grade	80%-90%	9	2.50	2.00
10Grade	90%-100%	10	2.75	2.20

Table 28 Percentile method is used to calculate the score of overhand throwing tennis

Grade	**Corresponding percentile range**	**score**	Overhand throwing tennis	
			Male	Female
1Grade	0-10%	1	5.68	4.82
2Grade	10%-20%	2	6.36	5.44
3Grade	20%-30%	3	7.04	6.05
4Grade	30%-40%	4	7.72	6.69
5Grade	40%-50%	5	8.40	7.32
6Grade	50%-60%	6	9.08	7.95
7Grade	60%-70%	7	9.76	8.54
8Grade	70%-80%	8	10.44	9.16
9Grade	80%-90%	9	11.12	9.74
10Grade	90%-100%	10	11.80	10.47

Table 29 Percentile method is used to calculate the score of the throw and catch

Grade	**Corresponding percentile range**	**score**	Throw and catch	
			Male	Female
1Grade	0-10%	1	5	4
2Grade	10%-20%	2	6	5
3Grade	20%-30%	3	7	6
4Grade	30%-40%	4	8	7
5Grade	40%-50%	5	9	8
6Grade	50%-60%	6	10	9
7Grade	60%-70%	7	11	10
8Grade	70%-80%	8	12	11
9Grade	80%-90%	9	13	12
10Grade	90%-100%	10	14	13

Table 30 Percentile method was used to calculate the performance of 4 limbs crawling forward

Grade	**Corresponding percentile range**	**score**	4 limbs crawling forward	
			Male	Female
1Grade	0-10%	1	6.92	6.32
2Grade	10%-20%	2	7.74	6.96
3Grade	20%-30%	3	8.56	7.69
4Grade	30%-40%	4	9.38	8.43
5Grade	40%-50%	5	10.22	9.15
6Grade	50%-60%	6	11.20	9.88
7Grade	60%-70%	7	11.85	10.62
8Grade	70%-80%	8	12.66	11.34
9Grade	80%-90%	9	13.48	12.07
10Grade	90%-100%	10	14.50	12.89

Table 31 Percentile method was used to calculate the crawling performance

Grade	Corresponding percentile range	score	Crawling performance	
			Male	Female
1Grade	0-10%	1	6.68	5.69
2Grade	10%-20%	2	7.28	6.08
3Grade	20%-30%	3	7.67	6.47
4Grade	30%-40%	4	8.06	6.86
5Grade	40%-50%	5	8.45	7.25
6Grade	50%-60%	6	8.84	7.65
7Grade	60%-70%	7	9.23	8.03
8Grade	70%-80%	8	9.92	8.42
9Grade	80%-90%	9	10.02	8.88
10Grade	90%-100%	10	10.44	9.30

Table 32 Percentile method is used to calculate the score of side roll

Grade	**Corresponding percentile range**	**score**	Side roll	
			Male	Female
1Grade	0-10%	1	9.8	11.3
2Grade	10%-20%	2	9.24	10.57
3Grade	20%-30%	3	8.68	9.84
4Grade	30%-40%	4	8.12	9.11
5Grade	40%-50%	5	7.56	8.38
6Grade	50%-60%	6	7.11	7.65
7Grade	60%-70%	7	6.44	6.92
8Grade	70%-80%	8	5.88	6.19
9Grade	80%-90%	9	5.32	5.46
10Grade	90%-100%	10	4.76	4.78

Table 33 The percentile method is used to calculate the score of the Lie on your stomach before standing

Grade	**Corresponding percentile range**	score	Lie on your stomach before standing	
			Male	Female
1Grade	0-10%	1	4.0	3.0
2Grade	10%-20%	2	4.5	3.5
3Grade	20%-30%	3	5.0	4.0
4Grade	30%-40%	4	5.5	4.5

5Grade	40%-50%	5	6.0	5.0
6Grade	50%-60%	6	6.5	5.5
7Grade	60%-70%	7	7.0	6.0
8Grade	70%-80%	8	7.5	6.5
9Grade	80%-90%	9	8.0	7.0
10Grade	90%-100%	10	8.5	7.5

Table 34 Upper body action rating sheet

	Horizontal bar suspension move				Overhand throw				Throw and catch	
	Male		Female		Male		Female		Male	Female
0	0.50	under	0.4	under	5.68	under	4.82	under	5under	4under
1	0.50	0.75	0.4	0.6	5.68	6.36	4.82	5.44	5	4
2	0.75	1.00	0.6	0.8	6.36	7.04	5.44	6.05	6	5
3	1.00	1.25	0.8	1.0	7.04	7.72	6.05	6.69	7	6
4	1.25	1.50	1.0	1.2	7.72	8.40	6.69	7.32	8	7
5	1.50	1.75	1.2	1.4	8.40	9.08	7.32	7.95	9	8
6	1.75	2.00	1.4	1.6	9.08	9.76	7.95	8.54	10	9
7	2.00	2.25	1.6	1.8	9.76	10.44	8.54	9.16	11	10
8	2.25	2.50	1.8	2.0	10.44	11.12	9.16	9.74	12	11
9	2.50	2.75	2.0	2.2	11.12	11.80	9.74	10.47	13	12
10	2.75	above	2.2	above	11.80	above	10.47	above	14above	13above

Table 35 Core torso motion rating sheet

	4 legs forward crawl				Creeping				Roll				Lie on your stomach before standing (times)	
	Male		Female		Male		Female		Male		Female		Male	Female
0	6.92	under	6.32	under	6.68	under	5.69	under	9.8	above	11.3	above	4 under	3 under
1	6.92	7.74	6.32	6.96	6.68	7.28	5.69	6.08	9.8	9.24	11.3	10.57	4	3
2	7.74	8.56	6.96	7.69	7.28	7.67	6.08	6.47	9.24	8.68	10.57	9.84	4.5	3.5
3	8.56	9.38	7.69	8.43	7.67	8.06	6.47	6.86	8.68	8.12	9.84	9.11	5	4
4	9.38	10.22	8.43	9.15	8.06	8.45	6.86	7.25	8.12	7.56	9.11	8.38	5.5	4.5
5	10.22	11.2	9.15	9.88	8.45	8.84	7.25	7.65	7.56	7.11	8.38	7.65	6	5
6	11.2	11.85	9.88	10.62	8.84	9.23	7.65	8.03	7.11	6.44	7.65	6.92	6.5	5.5
7	11.85	12.66	10.62	11.34	9.23	9.92	8.03	8.42	6.44	5.88	6.92	6.19	7	6
8	12.66	13.48	11.34	12.07	9.92	10.02	8.42	8.88	5.88	5.32	6.19	5.46	7.5	6.5
9	13.48	14.5	12.07	12.89	10.02	10.44	8.88	9.3	5.32	4.76	5.46	4.78	8	7
10	14.5	above	12.89	above	10.44	above	9.3	above	4.76	under	4.78	under	8.5 above	7.5 above

Table 36 Lower extremity movement rating sheet

	Walk forward on the balance beam				Ten-meter run				Double hop			
	Male		Female		Male		Female		Male		Female	
0	13.1	above	14.01	above	9.33	above	9.81	above	10.92	above	11.4	above
1	13.1	12.07	14.01	12.89	9.33	8.97	9.81	9.43	10.92	10.26	11.4	10.72
2	12.07	11.04	12.89	11.75	8.97	8.61	9.43	9.05	10.26	9.62	10.72	10.04
3	11.04	10.02	11.75	10,63	8.61	8.25	9.05	8.69	9.62	8.94	10.04	9.36
4	10.02	8;98	10,63	9.55	8,25	7.92	8.69	8.32	8.94	8.31	9.36	8.68
5	8;98	7.95	9.55	8.45	7.92	7.56	8.32	7.95	8.31	7.67	8.68	8.01
6	7.95	6.92	8.45	7.36	7.56	7.21	7.95	7.58	7.67	7.02	8.01	7.32
7	6.92	5.89	7.36	6.27	7.21	6.85	7.58	7.21	7.02	6.35	7.32	6.64
8	5.89	4.86	6.27	5.18	6.85	6.5	7.21	6.84	6.35	5.71	6.64	5.96
9	4.86	3.83	5.18	4.09	6.5	6.15	6.84	6.47	5.71	5.05	5.96	5.28
10	3.83	under	4.09	under	6.15	under	6.47	under	5.05	under	5.28	under

4. Model validation

A total of 65 young children were tested, including 32 boys and 33 girls. The test contents were: TGMD - 3 Test of Gross Motor Development - Third Edition and Test of Gross motor development in children aged 5-6 from the perspective of sensory integration，results are as follows：

Table 37 Correlation analysis of TGMD-3 and SIGM test results

	Pearson correlative			
	AVG	SD	TGMD3	SIGM
TGMD3	34.123	7.447	1	
SIGM	71.662	10.966	0.767**	1

* $p<0.05$ ** $p<0.01$

The correlation value between TGMD3 and SIGM is 0.767, and it shows significance at the 0.01 level. Therefore, it indicates that there is a significant positive correlation between TGMD3 and SIGM

CHAPTER V
CONCLUSION, DISCUSSION, AND SUGGESTIONS

In this chapter, the main findings of the study, Assessment of Gross motor development in children aged 5-6 from the perspective of sensory integration, are summarized. The conclusion part emphasizes the process of three stages. The discussion section emphasized their consistency with practical requirements and the existing theoretical framework. Finally, the Suggestions section provides directions for potential improvements in future research and the selection process.

5.1 Conclusion

This research successfully established an evaluation system for the gross motor development of 5-6-year-old children from the perspective of sensory integration through a systematic three-stage research process. Through literature review, expert discussion, three rounds of Delphi method and testing method, the scientific and practicality of the research results were ensured. The following is a detailed summary based on the three research objectives:

Phase 1:

Research Objective:

To summarize the relevant theories of sensory integration and gross motor development in children aged 5-6.

To explore the evaluation indicators of gross motor development of children aged 5-6 based on sensory integration theory

The first objective of this phase was To confirm the application of sensory integration theory to the gross motor evaluation model of 5-6 year old children. To achieve this, the research team conducted literature reviews, expert interviews, and combining both theoretical knowledge and practical experience to develop a comprehensive and scientific selection criteria framework.

Through literature review and expert interviews, the significance and feasibility of building a gross motor development model for children aged 5-6 from the

perspective of sensory integration were studied. . After literature review and expert interviews, This study analyzed the existing motor development theory and sensory integration theory at home and abroad, combined with expert feedback, put forward a preliminary index framework, and 50 main indicators were finally identified.

Phase 2:

Research Objective:

To establish evaluation criteria for gross motor development of children aged 5-6 based on sensory integration theory.

The objective of this phase was to determine the evaluation index system of gross motor movement of 5–6-year-old children from the perspective of sensory integration. Using three rounds of Delphi method, pre-test method and project-objective consistency (IOC) method, From the perspective of sensory integration, the evaluation indexes of major movements of children aged 5-6 were determined. Experts identified 29 from 50 indicators, then 12, and finally 10 indicators. Kendall W ranged from 0.418 to 0.622 and finally was 0.647. The experts highly agreed with these indicators.

Step forward on the balance beam, Horizontal bar suspension move, 4 legs crawl forward, Crawl forward, 10 meters back run, Double hop, Overhand throw, Throw the ball with both hands, Side roll, Lie on your stomach and so on stand up immediately.

Phase 3:

Research Objective:

To determine the evaluation index system of gross motor movement of 5–6-year-old children from the perspective of sensory integration

The objective of this phase was model construction for assessment of gross motor development in 5-6year-old children from the perspective of sensory integration. Through the Test of large samples, 432 valid data were obtained， the percentile method was adopted to construct the scoring model of Gross Motor Development grade of children aged 5-6 and set out Upper body action rating sheet（Horizontal bar suspension move、Overhand throw、Throw and catch）、Core

torso motion rating sheet（4 legs forward craw、Creeping、Roll）、Lower extremity movement rating sheet（Walk forward on the balance beam、Ten meter run、Double hop）

It was obtained through the validity test of the school standard for 65 children，the correlation value between TGMD3 and SIGM is 0.767, and it shows significance at the 0.01 level. Therefore, it indicates that there is a significant positive correlation between TGMD3 and SIGM

5.2 Discussion

The research topic of this paper is develop an assessment of gross motor development of children aged 5-6 from the perspective of sensory integration. This study is divided into four phases, with a total of four research objectives. . Each phase leads to different conclusions depending on the objective of the study. Below, we will discuss one by one according to the research objectives of different phases.

5.2.1 To summarize the relevant theories of sensory integration and gross motor development in children aged 5-6.

1.Summarize theories related to sensory integration and gross motor development in children aged 5-6 years.

It was found that the sensory integration of young children and the development of gross motor skills are closely related. Consistent with Ayers' theory of sensory integration, Mailloux Zoe et al. (2023) the tactile sense, vestibular sense and proprioceptive sense play crucial roles in the development of children gross motor skills. The tactile sense, with its receptors distributed throughout the skin, provides information about touch, pressure, pain, and temperature, which helps infants perceive the texture and characteristics of objects and the surrounding environment, and affects their emotional states. The vestibular sense, located in the inner ear, is responsible for detecting changes in movement and body position, helping infants maintain balance and coordinate movements, and is of great significance for their ability to perform actions such as standing, walking, and running. The proprioceptive sense, which involves muscles, joints, and tendons, enables infants to have a subconscious

perception of the position, movement, and force of their body parts, allowing them to accurately control their movements and ensure coordination in daily activities. In short, these three senses work together to provide the necessary sensory information and feedback for the development and improvement of children's gross motor skills.

2.Also Consistent with Seefeldt (1980) the theoretical concept of Sequence model of movement proficiency development said that children's motor development follows a predictable sequence of stages (such as lifting the head, turning over, sitting and standing, etc.), and emphasizes the influence of neurological maturity on motor ability.

3.Also consistent with the study of Hayes Stephen & Sharkey Don (2023) found that the gross movements of infants are external manifestations of sensory integration ability; Le Gall Didier (2023) found that Sensory integration deficits can lead to gross motor disorders, and gross motor abnormalities can reflect the state of sensory integration; Kuhaneck Heather M et al.found that a close connection between the two was discovered in children, and sensory integration is helpful for body posture and motor adjustment.

4.Overall, these studies emphasize the mutual influence and significance of sensory integration and the development of large muscle movement. Considering the close relationship between sensory integration and gross motor development, conducting research on the assessment of children's gross motor skills from the perspective of sensory integration can provide a more comprehensive understanding of children's motor development and identify potential problems. It enriches the theoretical framework of children's motor development research.

5.2.2 To explore the evaluation indicators of gross motor development of children aged 5-6 based on sensory integration theory.

The results of the survey of the indicators for the assessment of the development of Gross motor of children aged 5-6 years according to the theory of sensory integration found that the indicators for the assessment of the development of Gross motor of children that Forward Balance Beam Walking 、10 meters back run、Double hop

consistent of the Indicators identified in the evaluation scale of the National Constitution Test Standard (CHINA,2023) ； The 4 legs crawl forward、Crawl forward、 Lie on your stomach and stand up immediately consistent of the indicators identified in the evaluation scale of the Gross motor function measure (Canada,1989)； Overhand throw consistent of the indicators identified in the evaluation scale of the Test of Gross gross motor development-3 (America,2013)； Throw the ball with both hands 、Side Roll consistent of the indicators identified in the evaluation scale of the Peabody Developmental Motor Scale(USA,2000)； The Horizontal bar suspension move consistent of the indicators identified in the evaluation scale of the Learning and Development Guide for Children Aged 3-6(CHINA, 2012).

1. Step forward on the balance beam (CHINA, 2023)

Proprioception: Requires precise perception of lower limb joint angles, trunk stability, and center of gravity shift, with muscle tension regulation to maintain balance.

Vestibular: Relies on the inner ear vestibular system to sense head position changes and dynamically adjust body posture for balance on a narrow support surface.

Tactile: Tactile input from the soles of the feet contacting the beam helps judge support stability, while toe grip enhances tactile feedback.

Su Rong 'er (2014) : In the training of gross motor skills in infants and young children, walking on a balance beam can effectively enhance concentration and promote the integration ability of the nervous system through dynamic balance challenges.

Zhang Yimin (2021) : Balance ability is as important as health indicators such as blood pressure and blood lipid. It is suggested that children's balance ability be improved through diversified training such as standing on one leg and squats combined with a balance beam.

2. Horizontal bar suspension move (CHINA, 2014)

Proprioception: Synergistic activation of upper limb and core muscles requires accurate proprioceptive feedback (e.g., arm flexion/extension range, shoulder joint stability).

Vestibular: In a suspended position, the vestibular system rapidly processes gravitational and spatial orientation changes to maintain body control.

Tactile: Tactile input from the palms on the bars (pressure, friction) influences grip strength and movement fluency

Chen Peijie's team (2021) discovered through biomechanical analysis that the activation degree of the trapius and latissimus dorsi muscles in young children when they are hanging is highly correlated with the stability of their movements, which can serve as an observation window for neuromuscular control.

Wang Lei (2030) said that hanging movements can improve movement coordination, enhance joint flexibility and strengthen muscle strength

3. Four legs crawl forward (Canada, 1989)

Proprioception: Cross-midline coordination of limbs requires integration of proprioceptive signals.

Vestibular: As the head repeatedly lifts and lowers during crawling, the vestibular system adjusts visual-spatial orientation and anti-gravity posture.

Tactile: Tactile tolerance of palms and knees contacting the ground.

Ma Longfei (2021) regarded crawling as an important consideration factor, and to a certain extent, it can be regarded as an evaluation index of crawling behavior to study its effect on gross motor skills and other aspects of young children.

4.Crawl forward. (Canada, 1989)

Proprioception: Abdominal contact with the ground requires coordinated contraction of the trunk and hip joints to propel the body, relying on deep proprioceptive feedback.

Vestibular: During low-center-of-gravity lateral head turns, the vestibular system adapts to restricted visual-spatial input.

Tactile: Widespread tactile stimulation from full-body contact with the ground.

Chen Xue et al. (2023) conducted 12-week crawling training (three times a week, 20 minutes each time) on 48 children with developmental delays (aged 3-6 years). The intervention effect was evaluated using PDMS-2 (Peabody Motor Development Scale). The total score of gross motor skills in the experimental group increased significantly ($p<0.01$). Especially “balance ability ” (the time of standing on one foot was extended by 42%) and “bilateral coordination” (the completion rate of midline crossover movements increased by 35%.It is proposed that crawling can be used as a primary screening method for children with neuromuscular integration disorders.

5. 10 meters back run (CHINA, 2023)

Proprioception: Rapid acceleration, sudden stops, and direction changes require precise coordination of lower limb explosive power and joint position sense.

Vestibular: The vestibular system processes linear acceleration changes during speed-up/slow-down to maintain dynamic balance and spatial orientation.

Tactile: Gait adjustment and movement consistency via foot-ground tactile feedback.

Zhang Yimin (2021) pointed out in his research on the "Physical Health Standards for Chinese Children and Adolescents" that the 10-meter shuttle run is a core indicator for assessing the agility of children aged 5 to 12, especially suitable for the kindergarten to lower grades of primary school.

6. Double hop (CHINA, 2023)

Proprioception: Lower limb pushing force and landing cushioning (joint flexion/extension) depend on proprioceptive timing control.

Vestibular: During airborne jumps, the vestibular system rapidly integrates gravitational perception and mid-air body position adjustment.

Tactile: Tactile input from the soles of the feet.

Zhang Min et al. (2022) : The 10 consecutive jumping distances of 180 children aged 3 to 6 were tested, and the overall motor ability was evaluated using TGMD-3 (Gross Motor Development Test, Third Edition). The continuous jumping distance is

significantly correlated with lower limb explosive power (r=0.61) and dynamic balance (long jump on one foot, r=0.53), and it is an important gross motor indicator for evaluating lower limb strength, coordination, dynamic balance and motor rhythm control in young children.

7. Overhand throw (USA, 2013)

Proprioception: Shoulder rotation range, wrist force timing, and hand-eye coordination relieve precise proprioceptive planning.

Vestibular: Vestibular system maintains dynamic balance during body weight shift while throwing.

Tactile: Palmar tactile perception of the ball’s weight and surface texture influences grip strength and throwing direction.

Liu Yang (2023) Overhand Throwing is an important gross motor indicator for evaluating upper limb strength, hand-eye coordination, and motion sequence control in young children. And over-the-hand throwing of tennis balls (using lightweight tennis balls) is often used in tests for young children due to its safety and operability.

8. the ball with both hands (USA, 2000)

Proprioception: Coordinated control of arm throwing force and接球时 (during catching) arm extension joint position requires high-level coordination.

Vestibular: Vestibulo-visual integration (e.g., spatial distance judgment) when tracking the ball’s trajectory with the head.

Tactile: Hand tactile sensation of the ball’s texture.

Zhou Ting et al. (2023) Throw the ball with both hands is a key gross motor indicator for evaluating children's hand-eye coordination, reaction speed, and bilateral limb integration ability.

9. Side roll (USA, 2000)

Proprioception: Sequential control of core muscle proprioception is needed for coherent trunk curling and extension.

Vestibular: The vestibular system processes head angular acceleration during rolling to suppress dizziness reflexes.

Tactile: Tactile contact of the body’s side with the ground.

Li Fang et al. (2023) is an important gross motor indicator for evaluating the trunk coordination, core strength, bilateral body integration ability and vestibular sense development of young children.

10. Lie on your stomach and stand up immediately (Canada, 1989)

Proprioception: Co-contraction of trunk flexors and extensors during the prone-to-sit/kneel transition relies on proprioceptive feedback.

Vestibular: The vestibular system adjusts gravitational perception and posture when the body shifts from horizontal to vertical.

Tactile: Abdominal contact with the support surface aids in rising movements

Wang Li et al. (2023) Prone standing up is an important gross motor indicator for evaluating a child's core strength, trunk control ability, and coordination of posture changes. Children aged 5-6 can complete 8 to 10 times on average, while those aged 3-4 can only do it 4 to 6 times. There is no significant gender difference

When determining the indicators of gross motor development from the perspective of sensory integration, the Delphi method, pre - test method, and IOC method were effectively used. Compared with traditional assessment tools, which, as Luo Yijun (2021), often have limitations in comprehensively reflecting children’s sports development, our newly - constructed evaluation system selects indicators such as balance beam walking, horizontal bar suspension, and multi - limb crawling.These indicators not only cover various aspects of children’s gross motor skills but also incorporate sensory integration elements, such as the sense of balance, coordination, and body control. This approach overcomes the one - sidedness of previous assessment tools and provides a more comprehensive and accurate assessment of children’s gross motor development.

Overall, there is no evaluation model for young children's gross motor skills from the perspective of sensory integration. The indicators in this study were extracted from other existing models. Compared with other existing indicators, these indicators can better reflect young children's gross motor development level.

5.2.3 To establish evaluation criteria for gross motor development of children aged 5-6 based on sensory integration theory.

1.According to the criteria for evaluating the gross motor development of children aged 5-6 based on the sensory integration theory, the secondary indicators include three upper limb movements, lower limb movements and core movements.
This is consistent with the motor development assessment of the upper limbs, lower limbs and core in the Bruininks-Oseretsky (2005) Motor Function Assessment Scale (BOT-2);

It is also consistent with Jean Piaget's (1960) Cognitive Development Theory, which emphasizes that children's motor development is the basis of cognitive development. Children understand the world through their perception of the environment and motor operations. The development of upper limbs, lower limbs and core movements helps children better explore their surrounding environment and promotes cognitive development. For example, babies gradually understand the characteristics and spatial relationships of objects through the grasping movements of the upper limbs, the kicking movements of the lower limbs, and the stability of the core.

It is also Arnold Gesell (1925), who proposed the theory of maturity in children's development, he believed that children's motor development proceeds in a certain sequence of maturity, and the development of upper limbs, lower limbs and core movements all have their specific timetables. On the basis of maturity, children gradually master various motor skills through interaction with the environment. For instance, babies first learn to lift their heads (which is related to core strength), and then they can sit, crawl, stand, walk, etc. The development of these movements is a gradual process that follows certain rules.

2. The evaluation scale uses the method of equal weight. Jean Piaget (1960) Cognitive Development Theory is consistent. The motor development of young children is the basis of cognitive development. Through interaction with the environment, young children continuously develop and improve their motor skills.

This provides a theoretical basis for the assessment of gross motor skills in young children, emphasizing the importance of evaluating their motor development for understanding their cognitive development.

This is consistent with the "0-6 Years Old Children's Developmental Behavior Assessment Scale", which assesses children's gross motor skills through standardized test items, such as the development levels of actions like lifting the head, turning over, sitting, crawling, standing, walking, running, and jumping in children of different ages. The weights for each functional area are the same, which can comprehensively reflect the development status of children's gross motor skills.

And consistent with the evaluation method of (PDMS-2), a detailed assessment of various gross motor skills of young children is conducted. Each dimension is equally important and can accurately evaluate the development level and existing problems of children's gross motor skills.

5.2.4 To establish an evaluation model of gross motor development of children aged 5-6 based on sensory integration theory.

The results of the evaluation criteria for the gross motor development of children aged 5-6 based on the sensory integration theory reveal that this evaluation system can comprehensively and accurately reflect the gross motor development level of children in this age group. Just as Ayers proposed in 1978, human movement is a process of "sensory integration", in which the brain makes choices and comparisons based on various sensory information, thereby coordinating with the body. Our research echoes this theory, indicating that the assessment criteria considering sensory integration factors can effectively reflect the cooperation between nerves and muscles in gross motor activities.

Previous studies, such as those by Casey and Chia in 2005 and 2009 respectively, have pointed out the connection between gross motor development and cognitive ability. Meanwhile, Cairney's research in 2010 emphasized its connection with psychological development. The new assessment criteria are consistent with these findings, providing a more scientific and comprehensive evaluation that not only

focuses on physical movement but also takes into account the cognitive and psychological aspects related to the development of gross muscle movement. As Luo Yijun (2021) mentioned, traditional assessment tools often have limitations in reflecting children's physical development, and this new assessment system based on the theory of sensory integration fills this gap.

In the reliability test, it was conducted on 65 children aged 5 to 6, including 32 boys and 33 girls. The test contents are: the third Edition of the TGMD-3 Gross Motor Development Test and the Gross Motor Development Test for children aged 5-6 from the Perspective of Sensory Integration. The significant positive correlation ($r = 0.767$, $p < 0.01$) between the newly developed evaluation system (SIGM) and the well - established TGMD3 (USA, 2013)in the validity test provides strong evidence of the concurrent validity of the new system. This indicates that the sensory integration - based evaluation system can effectively measure gross motor development, similar to an existing gold - standard measure, but with the added advantage of considering the underlying sensory integration processes.

It establishes local norms suitable for Chinese children, overcoming the problems of large age spans, inconsistent cultural expressions, and lack of standardization in previous foreign - based or domestic tools. This not only offers a more effective way to evaluate the current situation of children’s gross motor development but also provides a solid theoretical basis for kindergartens and educational institutions to design targeted physical and mental activities, thereby promoting the healthy growth of children and contributing to the overall improvement of public health.

This study constructs an evaluation system for gross motor development in 5- to 6-year-old children from the perspective of sensory integration, completing theoretical integration, indicator screening, standard setting, and model validation in four phases. The research reveals that the collaborative function of tactile, vestibular, and proprioceptive senses constitutes the core mechanism of gross motor development (Ayers, 1978), and motor development follows the stage-based law of neurological maturity. By integrating 10 domestic and international evaluation indicators (such as

balance beam walking and four-limb crawling) and combining the Delphi method with empirical testing, it is confirmed that the new system comprehensively reflects children’s motor abilities and demonstrates a significant correlation with the international standard TGMD-3 ($r=0.767$, $p<0.01$). Breaking through the limitation of traditional tools that only measure physical fitness, this model incorporates upper limb, lower limb, and core movements into an equal-weight evaluation framework, aligning with Piaget’s theory (1960) that "movement promotes cognitive development." It also provides a scientific basis for kindergartens to design targeted activities, facilitating the early identification of issues related to sensory integration and motor development and promoting children coordinated physical and mental growth.

5.3 Suggestions

1. Unique research perspective: In the past, the evaluation of children‘s rough movements has mostly focused on the movement skills themselves, such as the accuracy and fluency of the movements. And this study innovatively integrates the sensory integration theory into the evaluation system, and explores the influence of sensory systems, such as the vestibular perception, proprioception and touch, on the development of children‘s gross motor movements from the perspective of sensory integration. This cross-field research perspective breaks the limitation of traditional research and opens up a new direction for the development of children‘s movements development, so that us to more comprehensively and deeply understand the internal mechanism of the development of children‘s rough movements.

2. Sample limitations: Although kindergartens with different regions and different nature of kindergartens were considered in the sample selection, they still have some limitations. Future research can further expand the sample size to cover more regions and children in different economic and cultural backgrounds, so as to make the research results more universal and better reflect the characteristics and

rules of children's sensory integration and the development of gross motor movements in different environments.

3. Lack of dynamic research: The current evaluation model is mainly aimed at children aged 5-6 years old, and fails to fully consider the rapid change characteristics of children in different stages of development. In fact, the sensory integration and the development of gross motor movements of 3-4 and 4-5 years old children also have their own unique rules and characteristics. In the future research, longitudinal research can be carried out to track the development and change of children in different ages, and establish a more perfect dynamic evaluation mechanism, so that the evaluation model can better adapt to the whole development process of children, and provide more accurate evaluation and guidance for children at different stages.

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APPENDIX

List of Abbreviations/Notations/Glossary of Terms

IOC Item Objective Congruence

AVG Mean value

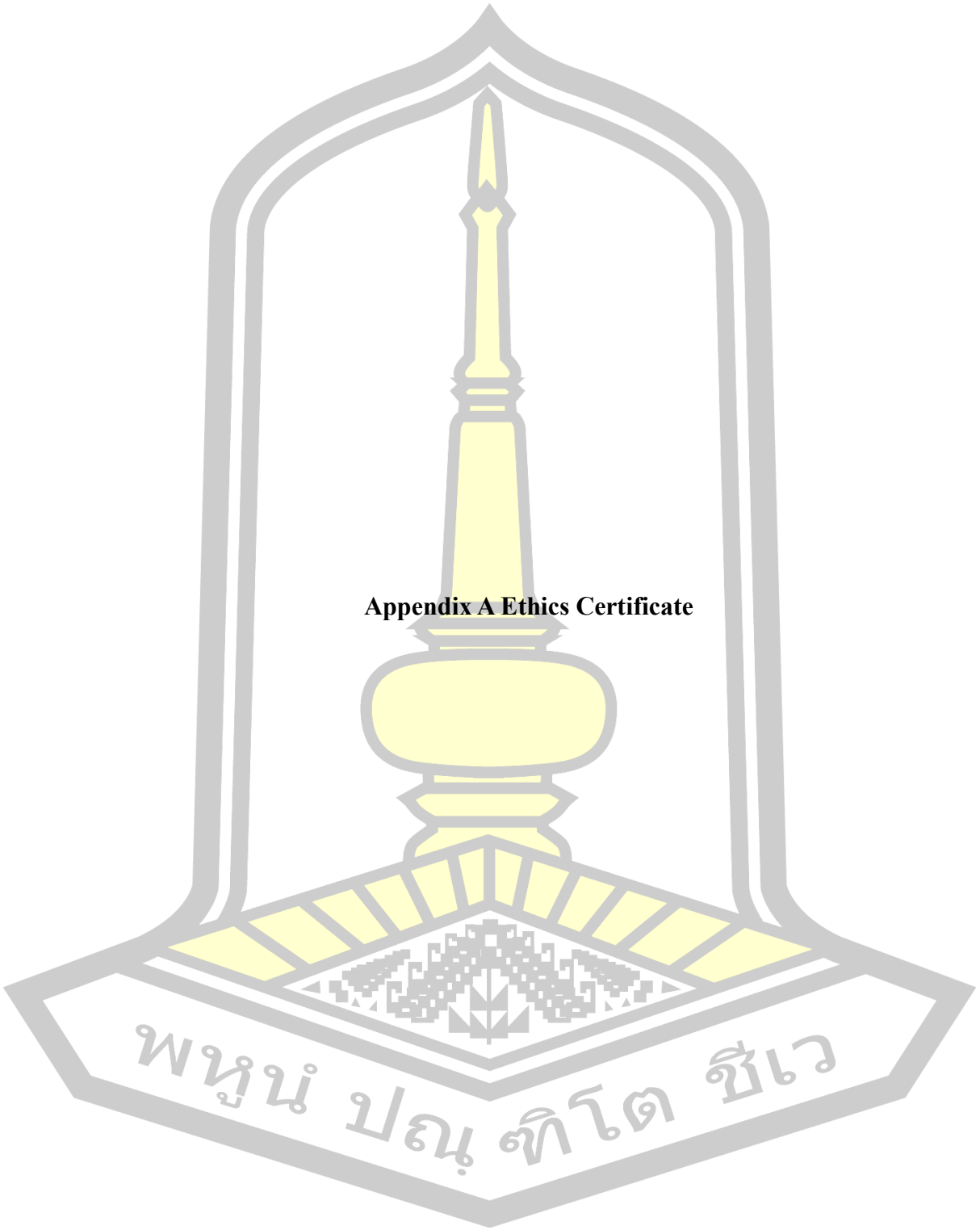
SD Standard deviation

CV Coefficient of variation

CP Full score rate

PC Percentage complete

SIGM Test of Gross motor development in children aged 5-6 from the perspective of sensory integration



Appendix A Ethics Certificate

MAHASARAKHAM UNIVERSITY ETHICS COMMITTEE FOR RESEARCH INVOLVING HUMAN SUBJECTS

Certificate of Approval

Approval number: 555-460/2024

Title : Constructing an assessment model of preschool children's gross motor development from the perspective of sensory integration.

Principal Investigator : Wei Huang
Responsible Department : Faculty of Education
Research site : NANNING City, GuangXi Province, China

Review Method : Expedited Review

Date of Manufacture : 29 August 2024 **expire :** 28 August 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 B Delphi method First round

Questionnaire for Experts on Selection Indicators of the Gross motor development in children aged 5-6 from the perspective of sensory integration

Dear expert

I am a PhD student at Mahasarakham University, and my dissertation topic is "Building an Evaluation Model of Gross Motor Development of preschool Children from the perspective of Sensory Integration". In view of your knowledge, I sincerely invite you to fill out this questionnaire.

Motor development ability runs through the whole life cycle of human beings and is the basis for the formation of motor skills. The role of sensory integration theory in the development of preschool children has been widely recognized, but its application in the specific assessment of gross motor development has not been fully explored. Based on relevant theoretical knowledge and previous research experience, I preliminarily determined 3 first-level indicators through expert interview. Secondary indicators 20. The purpose of the expert questionnaire survey is to understand the experts' opinions and suggestions on the constituent indicators of children's motor development ability and each test indicator in this study. Your valuable opinions will be very important for this study.

Thank you for your guidance in this study, and we would like to express our sincerest gratitude for the hard work we have paid!

Expert basic information

1 unit:

2 Position (title):

3. Research direction:

Filling instructions:

1. Please answer the questions in detail based on motor development theory and sensory integration theory according to the information provided in the table. When scoring the indicators, full consideration should be given to whether this action can demonstrate its integration ability of vestibular sense, proprioception and coarse sense.

2. If you need to express another opinion, please fill in the "Supplement and Suggestion" field. 3. You can no longer fill in the level 1 indicator or Level 2 indicator after you have excluded it.

Whether these gross motor movements can reflect the integration ability of vestibular sensation, proprioception and touch sensation.

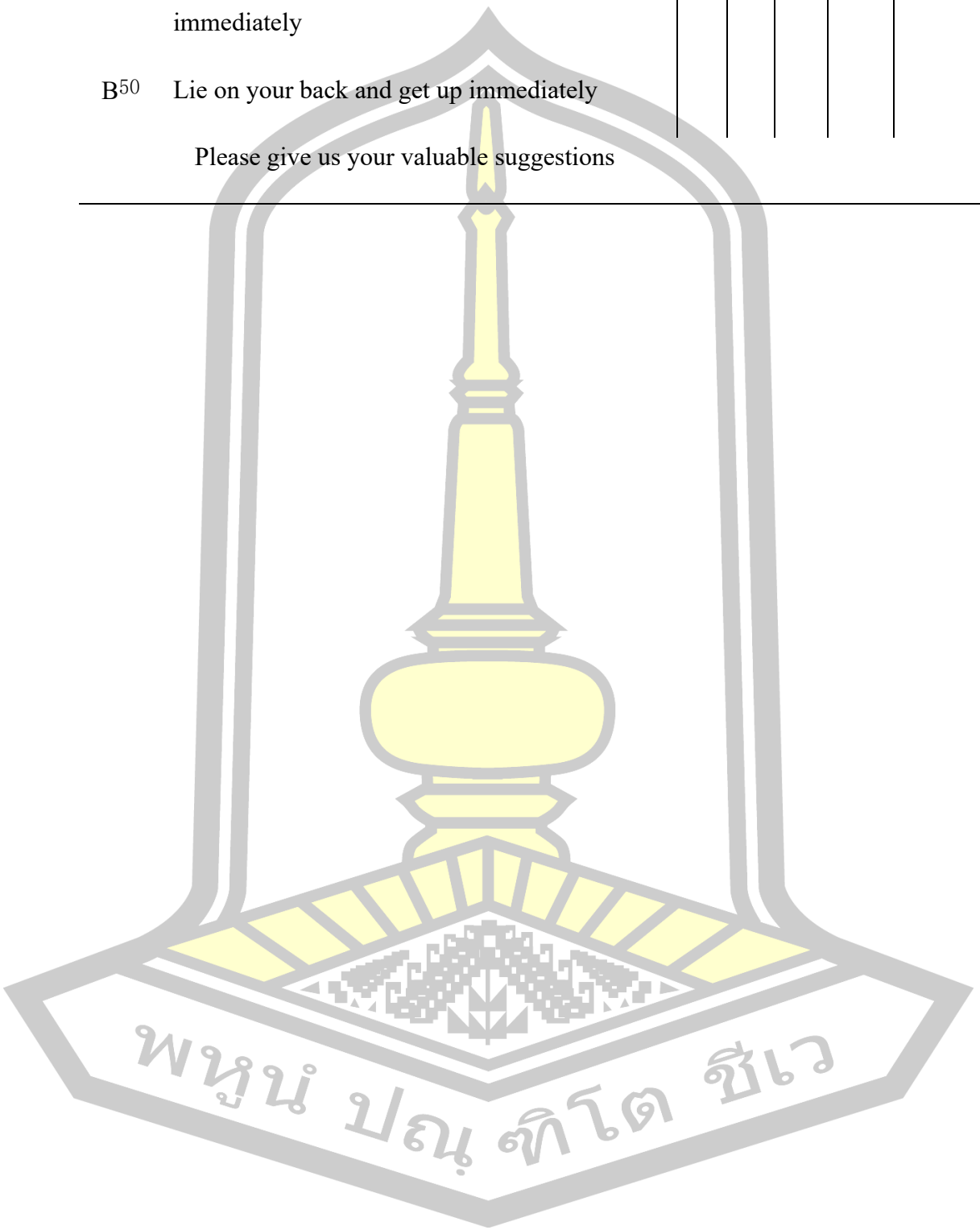
NO.	Item	significance					
		1	2	3	4	5	delete
L^1	Step forward on the balance beam						
L^2	Back off the balance beam						
L^3	Heel to toe walk in a straight line						
L^4	Horizontal bar suspension move						
L^5	Climb four steps on your hands and feet						
L^6	Alternate up and down four steps						
L^7	4 legs crawl forward						
L^8	4 legs crawling backwards						

L^{9}	Crawl forward				
L^{10}	Climb the net				
L^{11}	T-run				
L^{12}	10 meters back run				
L^{13}	15 meter S run				
L^{14}	15 meter steeplechase				
L^{15}	Jump up the stairs				
L^{16}	Jump down stairs				
L^{17}	Stride jump				
L^{18}	Hop continuously on one foot				
L^{19}	Double hop				
L^{20}	Back up 10 meters				
C^{21}	Underhand throw				
C^{22}	Overhand throw				
C^{23}	Two-handed racket				
C^{24}	Bounce the ball with one hand				
O^{25}	Two-handed toss				
C^{26}	Two-handed catch				
C^{27}	Throw the ball with both hands				
C^{28}	Hanging kick				

C^{29}	Big push				
C^{30}	Hit the volleyball with one hand				
C^{31}	Upstroke				
C^{32}	Hit the ball with both hands				
C^{33}	Foot stop				
C^{34}	Kick the hanging ball				
C^{35}	Long kick				
B^{36}	Moving racket				
B^{37}	Stand with your feet closed in place				
B^{38}	Stand with one foot closed				
B^{39}	Jump in circles on one foot				
B^{40}	Hop on one foot in place				
B^{41}	Forward roll				
B^{42}	Side roll				
B^{43}	Backward roll				
B^{44}	Turn in place				
B^{45}	Jump in circles on the spot				
B^{46}	Hold the air stick roll				
B^{47}	Horizontal bar suspension move				
B^{48}	Horizontal bar suspension swing				

B49	Lie on your stomach and stand up immediately					
B50	Lie on your back and get up immediately					

Please give us your valuable suggestions



Gross action scoring method		
N0.	Secondary indicator	methods of marking
L1	Step forward on the balance beam	A balance beam of suitable height (about 0.3 height, 0.15 meters width and 3 meters length) is placed on a flat ground. The child stood at one end of the balance beam, the tester gave instructions, and the child walked forward with alternating feet. During the process, the hands could swing naturally to maintain balance, and the completion time was recorded.
L2	Back off the balance beam	In the same setting as walking forward on the balance beam, the child stands at one end of the balance beam, facing the direction of the end. After the tester gave the order, the children walked backward with alternating feet, paid attention to their physical coordination, sense of direction and ability to maintain balance, and recorded the completion time and mistakes.
L3	Heel to toe walk in a straight line	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
L4	Horizontal bar suspension move	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
L5	Climb four steps on your hands and feet	Prepare four steps with a suitable height (about 0.2 meters each) and a width of 0.4 meters. The child stood at the bottom of the step, the tester gave instructions, and the child climbed the step with hands and feet, observed its

		movement coordination, strength use and climbing speed, and recorded the completion time.
L6	Alternate up and down four steps	Step Settings are the same as above. The child stood at the bottom of the step, after the tester issued the command, the child stepped on a step with one foot first, and then on the other heel, alternately walking up to the top of the step, and then alternately walking down to the starting point in the same way, recording the time to complete the whole process.
L7	4 legs crawl forward	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester issued instructions, and the children's hands and feet coordinated to crawl forward, observing their limbs coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L8	4 legs crawling backwards	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester gave instructions, and the child's hands and feet coordinated to crawl backward, observing its limb coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L9	Crawl forward	Set up a 2-meter-wide crawling area on the ground, and arrange some low obstacles to increase the difficulty. Children lie on the starting point, abdominal landing, arms and legs coordinated force to crawl forward, the tester observed the standardization of their movements, through the obstacle ability to record the distance completed in 10 seconds.
L10	Climb the net	Choose a safe and stable children's climbing net with a suitable height (2 meters) and set protective pads around it. The child stands at the bottom of the climbing net, holding the bar with both hands and stepping on the steady surface of the net with both feet. The tester gave instructions, and the children climbed up on both hands and feet alternately, recording the climbing time.

		Ensure safety during the process |
L11	T-run	Use tape or markers to draw a T-shaped runway with vertical lines 6 meters long and horizontal lines 3 meters long. Place small plastic buckets at the three ends of the T-shape. The child stands at the beginning of the vertical line with his feet shoulder-width apart. After the tester gave the command, the children started to run, and returned to the starting point after bypassing the plastic buckets at the three ends, recording the completion time.
L12	10 meters back run	A 10-meter-long straight runway is marked on a flat surface with turnback points at both ends. Children stand at the starting point with their feet in the starting position. The tester ordered the children to start, run to the turnback point touch the marker, quickly turn around and run back to the starting point, record the completion time
L13	15 meter S run	The S-shaped route is set up with markers on the ground. The total length of the route is 15 meters, and the spacing of each bend is moderate. The child stood at the starting point, ready to run. The tester gives instructions, and the child runs quickly along the S-shaped route, recording the completion time
L14	15 meter steeplechase	Set 3-5 obstacles suitable for children to cross and bypass on the 15-meter-long runway, such as small stools and conical buckets. The child stands at the starting point, after the tester orders, the child starts to run, passes each obstacle in turn, and records the completion time
L15	Jump up the stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped up one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.
L16	Jump down stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped down one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.

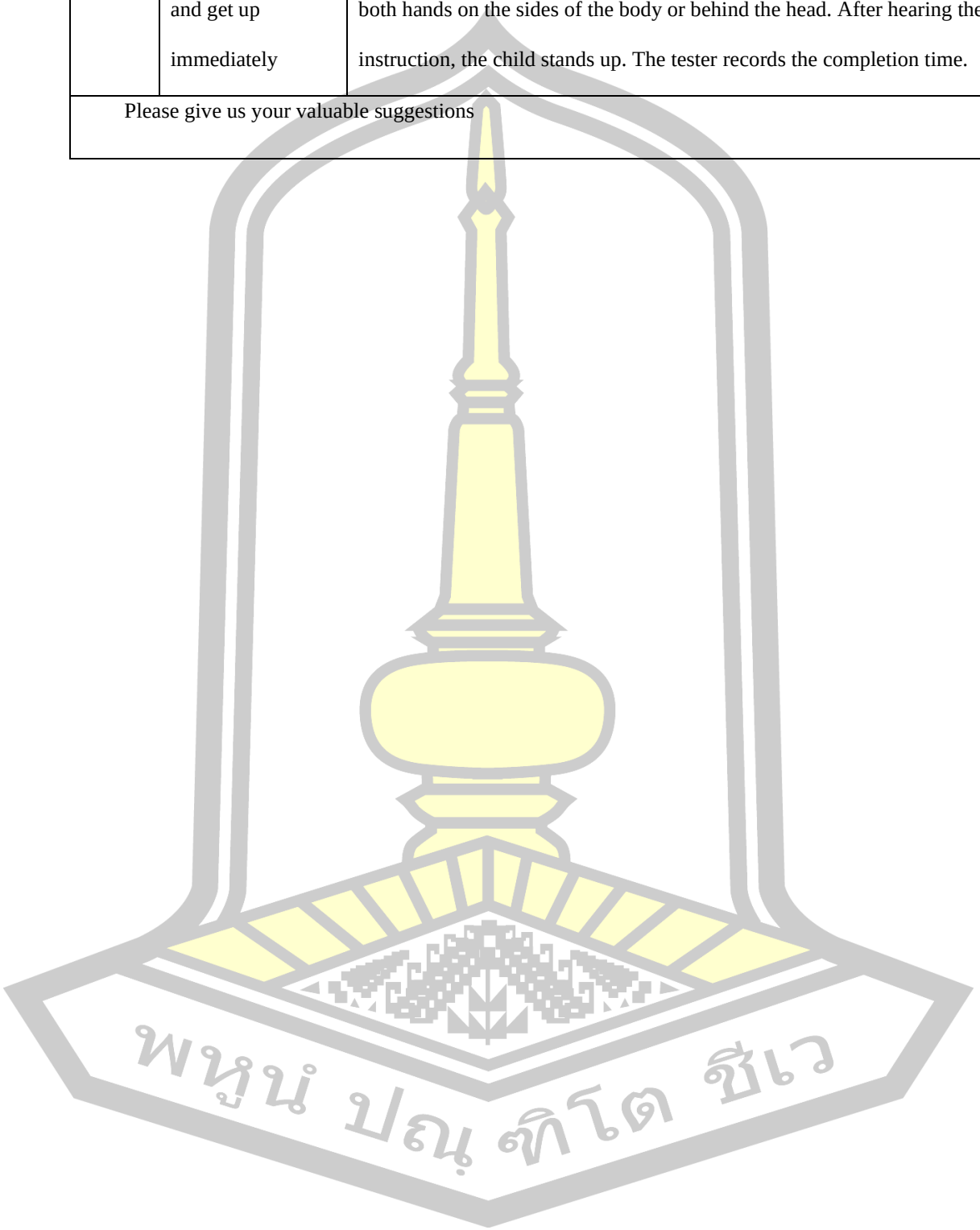
L17	Stride jump	Mark a 5-meter straight line on flat ground. Children stand at the starting point, stand front and back with their feet, push off with their front feet and take a big step forward, keep up with their back feet, and perform step jumps with their feet alternately, and record the completion time.
L18	Hop continuously on one foot	Mark a 5-meter-long straight line on the ground, and the child stands at the starting point, standing on one foot and lifting the other foot. After the tester gives the command, the child jumps forward continuously with a standing foot to reach the end and record the time.
L19	Double hop	Mark a 5-meter long line on the ground, with horizontal lines drawn every 50cm. The child stands at the starting point, feet together, knees slightly bent. The tester issued instructions, and the children's feet were simultaneously forced to continuously jump forward across the line, complete 10, and record the completion time.
L20	Back up 10 meters	Mark a line 10 meters long on flat ground. The child stands at one end of the line, facing the direction of the end. After the tester gave the command, the children walked backward with alternating feet and recorded the completion time.
C21	Underhand throw	Children holding a tennis ball, body side to throwing direction, arms naturally drooping, wrist back bending, using the strength of legs, waist and arms to throw the ball from the bottom up, the tester observed the throwing movement and recorded the distance.
C22	Overhand throw	Children holding a tennis ball, body side to throwing direction, arms bent over the head, the body slightly back, using the twist of the body and the swing of the arm to throw the ball forward and up, record the data.
C23	Two-handed racket	Children naturally stand with their feet apart, hold the basketball with both hands, and slap the ball vertically down the ground to make the ball bounce continuously. The tester recorded the number of successful bounces of the ball within 30 seconds.

C24	Bounce the ball with one hand	Children hold the basketball with one hand, choose the dominant hand, and slap the ball vertically down the ground, so that the ball continues to bounce. The tester recorded the number of times the ball was tapped in 30 seconds.
C25	Two-handed toss	Children stand on their feet, hold the ball in front of their chest with both hands, and throw the ball vertically or forward with both hands. The tester measures the height or distance of throwing the ball.
C26	Two-handed catch	The test personnel threw the ball to the children, and the children stood naturally with their feet and hands ready to catch the ball, caught the ball with both hands, and observed the response speed, hand-eye coordination ability and accuracy of the catching action.
C27	Throw the ball with both hands	The child holds the ball in both hands, throws the ball up (overhead)or forward and catches it with both hands when it falls, and so on. The tester records the number of successful throws and catches within 30 seconds.
C28	Hanging kick	The soccer ball or a similar size ball is suspended with a rope at a height of about 0.5 meters from the ground, and the child stands in front of the ball. After the test personnel gives the order, the child kicks the suspended ball with his foot and records the number of kicks.
C29	Big push	Place a large exercise ball or similar large ball on a flat surface. The child stood next to the ball and pushed the ball forward with both hands. The tester recorded the ball advancing 10 meters and recorded the time.
C30	Hit the volleyball with one hand	Children hold the volleyball with one hand, throw the ball up a certain height, and then hit the ball with the hand, and record the number of 5 strikes.
C31	Upstroke	The child held a balloon with a diameter of 30cm, threw the ball up, and then continuously hit the ball with his hand, so that the ball did not fall, and the tester recorded the number of consecutive shots for 10 seconds.
C32	Hit the ball with both hands	Attach a baseball or similar sized ball to a batting cage at a height suitable for young children to swing. The child holds the bat with both hands and makes a good batting position. After the test personnel gives the order, the child swings

		the bat and hits the fixed ball, and observes the standardization of the swing action, the use of power and the accuracy of the batting.
C33	Foot stop	The tester will kick the football to the child, and the child will stop the ball with his foot during the ball rolling process, and record the completion number of 5 stops.
C34	Kick the hanging bal	In the same kick suspension ball setting, children stand in front of the ball, after the tester gives the order, children kick to the suspended ball with their feet, focus on observing the accuracy of the kick, and record the number of accurate kicks of 5 kicks
C35	Long kick	The child stood at a designated position and kicked the soccer ball with his foot into the distance, and the tester measured the distance of the ball
B36	Moving racket	The child bounces the ball with one hand and moves forward or to one side while bouncing the ball. The tester records the moving distance within 20 seconds.
B37	Stand with your feet closed in place	The child stood with his feet together and his eyes closed, and the tester recorded how long the child was able to remain standing.
B38	Stand with one foot closed	The child stands on one foot with the other foot lifted and closes the eyes. The tester records the time the child can maintain the single-foot standing position.
B39	Jump in circles on one foot	The child stands on one foot with the other foot lifted and rotates in a circle with the standing foot as the axis. The tester records the time it takes to complete 3 circles (1080 degrees).
B40	Hop on one foot in place	The child stands on one foot with the other foot lifted and jumps continuously on the standing foot in place. The tester records the number of continuous jumps within 10 seconds.
B41	Forward roll	The child stands with the feet, bends the knees and squats down, supports the ground with both hands, lowers the head and tucks the chest, and rolls forward,

		passing through the head, shoulders, back, buttocks in turn, and finally stands up with both feet. The tester observes the smoothness, standardization of the action, and the body coordination during the rolling process.
B42	Side roll	The child lies on the side on the ground, rolls 180° to one side with one side of the body as the axis, and then rolls 180° in the opposite direction. Repeat this 4 times, and then repeat in the opposite direction to return. The tester records the completion time.
B43	Backward roll	The child squats on the feet, supports the ground backward with both hands, leans the body backward, lowers the head and tucks the body, rolls backward through the buttocks, back, shoulders in turn, and finally stands up with both hands supporting the ground. Observe the standardization of the action, the strength application, and the stability of getting up.
B44	Turn in place	The child stands with the feet and rotates quickly with the feet as the axis, alternating the feet. The tester records the time it takes to complete 3 circles.
B45	Jump in circles on the spot	The child stands with the feet and rotates with the feet as the axis. Record the best performance based on the angle of the foot rotation.
B46	Hold the air stick roll	The child holds the air stick with both hands, lies flat on the ground, and then rolls to one side. The tester records the time it takes to complete 4 rolls.
B47	Horizontal bar suspension move	Select a horizontal bar with a height suitable for children (3 cm), and lay a protective mat underneath. The child grasps the horizontal bar with both hands and lifts the feet off the ground, remaining in a suspended state. The tester records the suspension time.
B48	Horizontal bar suspension swing	Select a horizontal bar with a height suitable for children (3 cm), and lay a protective mat underneath. The body swings forward and backward or from side to side. The tester records the number of swings.
B49	Lie on your stomach and stand up immediately	Children lie prone on the ground, hands on the sides of the body, after hearing the instruction, quickly support the body with hands, and then stand up, the tester recorded the completion of 20 seconds of time, the number of completed.

B50	Lie on your back and get up immediately	The child lies on the back on the ground, with the legs straight and open, and both hands on the sides of the body or behind the head. After hearing the instruction, the child stands up. The tester records the completion time.
Please give us your valuable suggestions		



Appendix C Delphi method Second round

Questionnaire for Experts on Selection Indicators of the Gross motor development in children aged 5-6 from the perspective of sensory integration

Dear expert:

After the end of the first round of expert consultation, there are still 29 indicators after the index of comprehensiveness, stability, feasibility and safety is deleted. Due to the study of the Delphi method is used to request completed two rounds of expert consultation, given your knowledge and professional achievements, once again sincerely invite you as a second round of the questionnaire of this research consultants.

Thank you for your guidance in this study, and we would like to express our sincerest gratitude for the hard work we have paid!

Expert basic information

1 unit:

2 Position (title):

3. Research direction:

Filling instructions:

1. Please answer the questions in detail based on motor development theory and sensory integration theory according to the information provided in the table. When scoring the indicators, full consideration should be given to whether this action can demonstrate its integration ability of vestibular sense, proprioception and coarse sense.

2. If you need to express another opinion, please fill in the "Supplement and Suggestion" field. 3. You can no longer fill in the level 1 indicator or Level 2 indicator after you have excluded it.

Whether these gross motor movements can reflect the integration ability of vestibular sensation, proprioception and touch sensation.

NO.	Item	significance					
		1	2	3	4	5	delete
L^{1}	Step forward on the balance beam						
L^{3}	Heel to toe walk in a straight line						
L^{4}	Horizontal bar suspension move						
L^{5}	Climb four steps on your hands and feet						
L^{7}	4 legs crawl forward						
L^{9}	Crawl forward						
L^{11}	T-run						
L^{12}	10 meters back run						
L^{13}	15 meter S run						
L^{14}	15 meter steeplechase						
L^{17}	Stride jump						
L^{18}	Hop continuously on one foot						
L^{19}	Double hop						

L^{20}	Back up 10 meters				
C^{22}	Overhand throw				
C^{23}	Two-handed racket				
O^{25}	Two-handed toss				
C^{27}	Throw the ball with both hands				
B^{36}	Moving racket				
B^{38}	Stand with one foot closed				
B^{39}	Jump in circles on one foot				
B^{40}	Hop on one foot in place				
B^{41}	Forward roll				
B^{42}	Side roll				
B^{45}	Jump in circles on the spot				
B^{47}	Horizontal bar suspension move				
B^{48}	Horizontal bar suspension swing				
B^{49}	Lie on your stomach and stand up immediately				
B^{50}	Lie on your back and get up immediately				

Please give us your valuable suggestions

_____

Gross action scoring method		
N0.	Secondary indicator	methods of marking
L1	Step forward on the balance beam	A balance beam of suitable height (about 0.3 height, 0.15 meters width and 3 meters length) is placed on a flat ground. The child stood at one end of the balance beam, the tester gave instructions, and the child walked forward with alternating feet. During the process, the hands could swing naturally to maintain balance, and the completion time was recorded.
L2	Back off the balance beam	In the same setting as walking forward on the balance beam, the child stands at one end of the balance beam, facing the direction of the end. After the tester gave the order, the children walked backward with alternating feet, paid attention to their physical coordination, sense of direction and ability to maintain balance, and recorded the completion time and mistakes.
L3	Heel to toe walk in a straight line	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
L4	Horizontal bar suspension move	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
L5	Climb four steps on your hands and feet	Prepare four steps with a suitable height (about 0.2 meters each) and a width of 0.4 meters. The child stood at the bottom of the step, the tester gave instructions, and the child climbed the step with hands and feet, observed its

		movement coordination, strength use and climbing speed, and recorded the completion time.
L6	Alternate up and down four steps	Step Settings are the same as above. The child stood at the bottom of the step, after the tester issued the command, the child stepped on a step with one foot first, and then on the other heel, alternately walking up to the top of the step, and then alternately walking down to the starting point in the same way, recording the time to complete the whole process.
L7	4 legs crawl forward	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester issued instructions, and the children's hands and feet coordinated to crawl forward, observing their limbs coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L8	4 legs crawling backwards	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester gave instructions, and the child's hands and feet coordinated to crawl backward, observing its limb coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
L9	Crawl forward	Set up a 2-meter-wide crawling area on the ground, and arrange some low obstacles to increase the difficulty. Children lie on the starting point, abdominal landing, arms and legs coordinated force to crawl forward, the tester observed the standardization of their movements, through the obstacle ability to record the distance completed in 10 seconds.
L10	Climb the net	Choose a safe and stable children's climbing net with a suitable height (2 meters) and set protective pads around it. The child stands at the bottom of the climbing net, holding the bar with both hands and stepping on the steady

		surface of the net with both feet. The tester gave instructions, and the children climbed up on both hands and feet alternately, recording the climbing time. Ensure safety during the process |
L11	T-run	Use tape or markers to draw a T-shaped runway with vertical lines 6 meters long and horizontal lines 3 meters long. Place small plastic buckets at the three ends of the T-shape. The child stands at the beginning of the vertical line with his feet shoulder-width apart. After the tester gave the command, the children started to run, and returned to the starting point after bypassing the plastic buckets at the three ends, recording the completion time.
L12	10 meters back run	A 10-meter-long straight runway is marked on a flat surface with turnback points at both ends. Children stand at the starting point with their feet in the starting position. The tester ordered the children to start, run to the turnback point touch the marker, quickly turn around and run back to the starting point, record the completion time
L13	15 meter S run	The S-shaped route is set up with markers on the ground. The total length of the route is 15 meters, and the spacing of each bend is moderate. The child stood at the starting point, ready to run. The tester gives instructions, and the child runs quickly along the S-shaped route, recording the completion time
L14	15 meter steeplechase	Set 3-5 obstacles suitable for children to cross and bypass on the 15-meter-long runway, such as small stools and conical buckets. The child stands at the starting point, after the tester orders, the child starts to run, passes each obstacle in turn, and records the completion time
L15	Jump up the stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped up one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.
L16	Jump down stairs	Prepare stairs of appropriate height (0.2 m per step). The child stood at the bottom of the stairs, and the tester gave instructions, and the child jumped

		down one step with his feet at the same time, and then continued to jump up the other steps, and recorded the completed progression for 10 seconds.
L17	Stride jump	Mark a 5-meter straight line on flat ground. Children stand at the starting point, stand front and back with their feet, push off with their front feet and take a big step forward, keep up with their back feet, and perform step jumps with their feet alternately, and record the completion time.
L18	Hop continuously on one foot	Mark a 5-meter-long straight line on the ground, and the child stands at the starting point, standing on one foot and lifting the other foot. After the tester gives the command, the child jumps forward continuously with a standing foot to reach the end and record the time.
L19	Double hop	Mark a 5-meter long line on the ground, with horizontal lines drawn every 50cm. The child stands at the starting point, feet together, knees slightly bent. The tester issued instructions, and the children's feet were simultaneously forced to continuously jump forward across the line, complete 10, and record the completion time.
L20	Back up 10 meters	Mark a line 10 meters long on flat ground. The child stands at one end of the line, facing the direction of the end. After the tester gave the command, the children walked backward with alternating feet and recorded the completion time.
C21	Underhand throw	Children holding a tennis ball, body side to throwing direction, arms naturally drooping, wrist back bending, using the strength of legs, waist and arms to throw the ball from the bottom up, the tester observed the throwing movement and recorded the distance.
C22	Overhand throw	Children holding a tennis ball, body side to throwing direction, arms bent over the head, the body slightly back, using the twist of the body and the swing of the arm to throw the ball forward and up, record the data.
C23	Two-handed racket	Children naturally stand with their feet apart, hold the basketball with both hands, and slap the ball vertically down the ground to make the ball bounce

		continuously. The tester recorded the number of successful bounces of the ball within 30 seconds.
C24	Bounce the ball with one hand	Children hold the basketball with one hand, choose the dominant hand, and slap the ball vertically down the ground, so that the ball continues to bounce. The tester recorded the number of times the ball was tapped in 30 seconds.
C25	Two-handed toss	Children stand on their feet, hold the ball in front of their chest with both hands, and throw the ball vertically or forward with both hands. The tester measures the height or distance of throwing the ball.
C26	Two-handed catch	The test personnel threw the ball to the children, and the children stood naturally with their feet and hands ready to catch the ball, caught the ball with both hands, and observed the response speed, hand-eye coordination ability and accuracy of the catching action.
C27	Throw the ball with both hands	The child holds the ball in both hands, throws the ball up (overhead)or forward and catches it with both hands when it falls, and so on. The tester records the number of successful throws and catches within 30 seconds.
C28	Hanging kick	The soccer ball or a similar size ball is suspended with a rope at a height of about 0.5 meters from the ground, and the child stands in front of the ball. After the test personnel gives the order, the child kicks the suspended ball with his foot and records the number of kicks.
C29	Big push	Place a large exercise ball or similar large ball on a flat surface. The child stood next to the ball and pushed the ball forward with both hands. The tester recorded the ball advancing 10 meters and recorded the time.
C30	Hit the volleyball with one hand	Children hold the volleyball with one hand, throw the ball up a certain height, and then hit the ball with the hand, and record the number of 5 strikes.
C31	Upstroke	The child held a balloon with a diameter of 30cm, threw the ball up, and then continuously hit the ball with his hand, so that the ball did not fall, and

		the tester recorded the number of consecutive shots for 10 seconds.
C32	Hit the ball with both hands	Attach a baseball or similar sized ball to a batting cage at a height suitable for young children to swing. The child holds the bat with both hands and makes a good batting position. After the test personnel gives the order, the child swings the bat and hits the fixed ball, and observes the standardization of the swing action, the use of power and the accuracy of the batting.
C33	Foot stop	The tester will kick the football to the child, and the child will stop the ball with his foot during the ball rolling process, and record the completion number of 5 stops.
C34	Kick the hanging bal	In the same kick suspension ball setting, children stand in front of the ball, after the tester gives the order, children kick to the suspended ball with their feet, focus on observing the accuracy of the kick, and record the number of accurate kicks of 5 kicks
C35	Long kick	The child stood at a designated position and kicked the soccer ball with his foot into the distance, and the tester measured the distance of the ball
B36	Moving racket	The child bounces the ball with one hand and moves forward or to one side while bouncing the ball. The tester records the moving distance within 20 seconds.
B37	Stand with your feet closed in place	The child stood with his feet together and his eyes closed, and the tester recorded how long the child was able to remain standing.
B38	Stand with one foot closed	The child stands on one foot with the other foot lifted and closes the eyes. The tester records the time the child can maintain the single-foot standing position.
B39	Jump in circles on one foot	The child stands on one foot with the other foot lifted and rotates in a circle with the standing foot as the axis. The tester records the time it takes to complete 3 circles (1080 degrees).
B40	Hop on one foot in	The child stands on one foot with the other foot lifted and jumps

	place	continuously on the standing foot in place. The tester records the number of continuous jumps within 10 seconds.
B41	Forward roll	The child stands with the feet, bends the knees and squats down, supports the ground with both hands, lowers the head and tucks the chest, and rolls forward, passing through the head, shoulders, back, buttocks in turn, and finally stands up with both feet. The tester observes the smoothness, standardization of the action, and the body coordination during the rolling process.
B42	Side roll	The child lies on the side on the ground, rolls 180° to one side with one side of the body as the axis, and then rolls 180° in the opposite direction. Repeat this 4 times, and then repeat in the opposite direction to return. The tester records the completion time.
B43	Backward roll	The child squats on the feet, supports the ground backward with both hands, leans the body backward, lowers the head and tucks the body, rolls backward through the buttocks, back, shoulders in turn, and finally stands up with both hands supporting the ground. Observe the standardization of the action, the strength application, and the stability of getting up.
B44	Turn in place	The child stands with the feet and rotates quickly with the feet as the axis, alternating the feet. The tester records the time it takes to complete 3 circles.
B45	Jump in circles on the spot	The child stands with the feet and rotates with the feet as the axis. Record the best performance based on the angle of the foot rotation.
B46	Hold the air stick roll	The child holds the air stick with both hands, lies flat on the ground, and then rolls to one side. The tester records the time it takes to complete 4 rolls.
B47	Horizontal bar suspension move	Select a horizontal bar with a height suitable for children (3 cm), and lay a protective mat underneath. The child grasps the horizontal bar with both hands and lifts the feet off the ground, remaining in a suspended state. The tester records the suspension time.
B48	Horizontal bar	Select a horizontal bar with a height suitable for children (3 cm), and lay a

	suspension swing	protective mat underneath. The body swings forward and backward or from side to side. The tester records the number of swings.
B49	Lie on your stomach and stand up immediately	Children lie prone on the ground, hands on the sides of the body, after hearing the instruction, quickly support the body with hands, and then stand up, the tester recorded the completion of 20 seconds of time, the number of completed.
B50	Lie on your back and get up immediately	The child lies on the back on the ground, with the legs straight and open, and both hands on the sides of the body or behind the head. After hearing the instruction, the child stands up. The tester records the completion time.
Please give us your valuable suggestions		

Appendix D The third round of Delphi

Questionnaire for Experts on Selection Indicators of the Gross motor development in children aged 5-6 from the perspective of sensory integration

Dear expert:

Once again, we cordially invite you to be the third round of consultants for this research questionnaire. After the end of the second round of expert consultation, there are still 12 indicators after eliminating the indicators of poor comprehensiveness, poor stability, poor feasibility, and poor safety. We have made a prediction, please give us help again according to our data and test situation. We also want you to judge the relative weight of various indicators of movement development.

Thank you for your guidance in this study, and we would like to express our sincerest gratitude for the hard work we have paid!

Expert basic information

1 unit:

2 Position (title):

3. Research direction:

Filling instructions:

1.Please answer the questions in detail based on motor development theory and sensory integration theory according to the information provided in the table. When scoring the indicators, full consideration should be given to whether this action can demonstrate its integration ability of vestibular sense, proprioception and coarse sense.

2. If you need to express another opinion, please fill in the "Supplement and Suggestion" field. 3. You can no longer fill in the level 1 indicator or Level 2 indicator after you have excluded it.

Whether these gross motor movements can reflect the integration ability of vestibular sensation, proprioception and touch sensation.

NO.	Item	significance					
		1	2	3	4	5	delete
L^{1}	Step forward on the balance beam						
L^{4}	Horizontal bar suspension move						
L^{7}	4 legs crawl forward						
L^{9}	Crawl forward						
L^{12}	10 meters back run						
L^{19}	Double hop						
C^{22}	Overhand throw						
C^{27}	Throw the ball with both hands						
B^{42}	Side roll						
B^{45}	Jump in circles on the spot						
B^{49}	Lie on your stomach and stand up immediately						

Please fill in the box below with what you think is important

Weight judgment

We gave the same weight to key indicators of gross motor development in young children. Do you think this equal weight setting is appropriate when measuring the overall level of motor development of young children?	Agree
	Disagree

Are there some metrics that are overvalued or underrated because they are equally weighted? If yes, please specify and give reasons.

Appendix E Item Objective Congruence

IOC in the Gross motor development in children aged 5-6 Questionnaire

ITEM OBJECTIVE CONGRUENCE

Dear experts:

Hello! I am (Mr.Wei Huang, PhD Student Health and Sport Science. Faculty of Education, Mahasarakham University) under the advisor of Khongsuebsor ,Ph.D,now doing on research name"To construct an evaluation model of Gross motor development in children aged 5-6 from the perspective of sensory integration" With the objective.

You are a senior expert with rich knowledge and experience. I sincerely ask for your guidance and help. I hope you can give me guidance and evaluation in your busy schedule and put forward your valuable opinions and suggestions.

Thank you very much for your support and help.

Student name: Wei Huang

Advisor: Dr. Khongsuebsor

Email: 49351407@qq.com

Mahasarakham University, Thailand

Please fill in the following personal information:

Expert's name:

Professional title:

Work unit:

Dear experts, We need to validate the questionnaire on gross motor development indicators of children aged 5-6 from the perspective of sensory integration ,Please rate in the score column (**-1 is not suitable, 0 is general, 1 is**

suitable between "√"), and give relevant modification suggestions in the topics that need to be modified. Thank you for your guidance and evaluation in the help.

If you believe there are additional relevant indicators not listed, please fill in the attached table and assign a score.

The Gross motor development in children aged 5-6 Questionnaire

1.Evaluation of indicators

N0.	Secondary indicator	Opinion			Suggestion
		+1	0	-1	
1	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Step forward on the balance beam?				
2	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Horizontal bar suspension move?				
3	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they v4 legs crawl forward?				
4	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Crawl forward?				
5	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they 10				

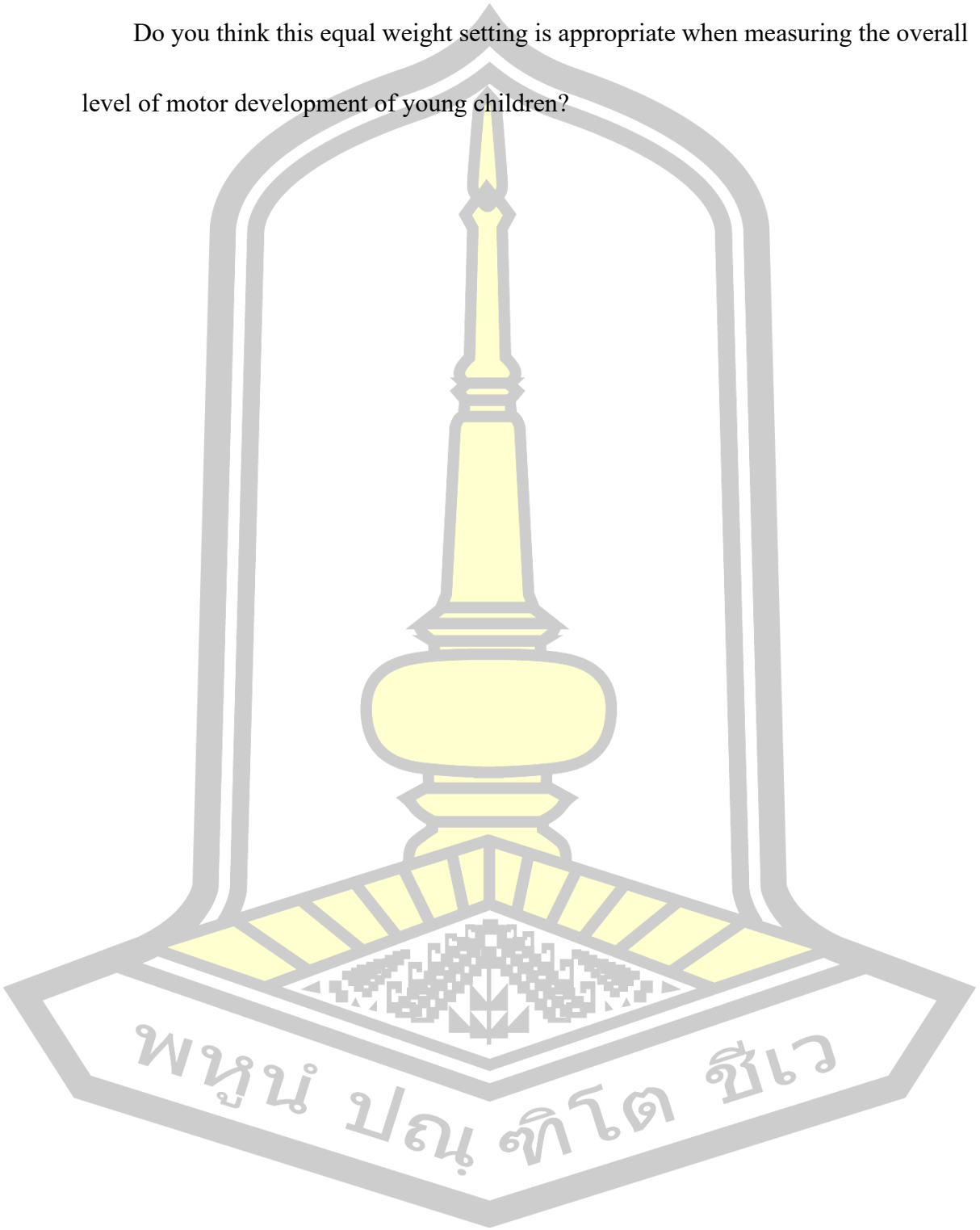
	meters back run?				
6	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Double hop?				
7	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Overhand throw?				
8	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Throw the ball with both hands?				
9	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Moving racket?				
10	Do you think the degree of integration of vestibular sense, proprioception and touch can effectively reflect the level of gross motor development of children when they Side roll?				
Please give us your valuable suggestions.					

Gross action scoring method		
N0.	Secondary indicator	methods of marking
1	Step forward on the balance beam	A balance beam of suitable height (about 0.3 height, 0.15 meters width and 3 meters length) is placed on a flat ground. The child stood at one end of the balance beam, the tester gave instructions, and the child walked forward with alternating feet. During the process, the hands could swing naturally to maintain balance, and the completion time was recorded.
2	Horizontal bar suspension move	Choose a horizontal bar with a height suitable for young children (diameter 3cm) and a protective pad underneath. Children hold the horizontal bar in both hands, feet off the ground, in a suspended state. The tester gave instructions, and the children moved their hands alternately forward or to one side, recording the distance for 20 seconds.
3	4 legs crawl forward	Mark a 2 meter wide crawling area on flat ground. The child lies on the starting point, hands and knees on the ground, the body in a crawling position. The tester issued instructions, and the children's hands and feet coordinated to crawl forward, observing their limbs coordination, crawling speed and direction control, and recording the distance completed in 10 seconds.
4	Crawl forward	Set up a 2-meter-wide crawling area on the ground, and arrange some low obstacles to increase the difficulty. Children lie on the starting point, abdominal landing, arms and legs coordinated force to crawl forward, the tester observed the standardization of their movements, through the obstacle ability to record the distance

		completed in 10 seconds.
5	10 meters back run	A 10-meter-long straight runway is marked on a flat surface with turnback points at both ends. Children stand at the starting point with their feet in the starting position. The tester ordered the children to start, run to the turnback point touch the marker, quickly turn around and run back to the starting point, record the completion time
6	Double hop	Mark a 5-meter long line on the ground, with horizontal lines drawn every 50cm. The child stands at the starting point, feet together, knees slightly bent. The tester issued instructions, and the children's feet were simultaneously forced to continuously jump forward across the line, complete 10, and record the completion time.
7	Overhand throw	Children holding a tennis ball, body side to throwing direction, arms bent over the head, the body slightly back, using the twist of the body and the swing of the arm to throw the ball forward and up, record the data.
8	Throw the ball with both hands	The child holds the ball in both hands, throws the ball up (overhead)or forward and catches it with both hands when it falls, and so on. The tester records the number of successful throws and catches within 30 seconds.
9	Moving racket	The child bounces the ball with one hand and moves forward or to one side while bouncing the ball. The tester records the moving distance within 20 seconds.
10	Side roll	The child lies on the side on the ground, rolls 180° to one side with one side of the body as the axis, and then rolls 180° in the opposite direction. Repeat this 4 times, and then repeat in the opposite direction to return. The tester records the completion time.

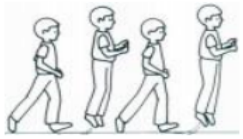
2.The evaluation of the index weights

Do you think this equal weight setting is appropriate when measuring the overall level of motor development of young children?



Appendix F The Big Muscle Movement Development Test (TGMD-3)

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
1.Run Test equipment: ▲ 1 8 meters long runway ▲ 2 sign barrels	▲ The two mark buckets are 1 5 meters away. ▲ Ensure that there is a safe buffer distance of 3 meters above the mark bucket. ▲ When the child hears the password, he quickly runs from one sign bucket to another. ▲ Repeat the run for once.		1 bend the elbow and the arms swing toward the opposite leg.			
			2. Your feet are briefly lifted off the ground.			
			3. There is an obvious heel or the sole of the foot, not the sole of the foot.			
			4 Bend your legs about 90 degrees with the heel close to your hips.			
				The skill scores are		

Basic action skills	Test Guide ·		code of points	Test 1	Test 2	grade
2. Step forward Test equipment: ▲ 7 m long runway ▲ 2 sign barrels	▲ The two mark buckets are 7 meters away. ▲ When the child hears the password, slide from the front of one sign bucket to another one and stop. ▲ Repeat the forward sliding step once.		1. When preparing for the forward slide, naturally bend the elbow on both sides of the waist.			
			2. Step forward with the front leg, with the leg forward with the front leg, without surpassing the front leg.			
			3. Your feet are briefly left in the air.			
			4. Complete 4 consecutive forward steps			
				The skill scores are		

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
3. Jump on one foot Test equipment: ▲ 5 m long runway ▲ 2 sign barrels	▲ Inform children to use the dominant foot four consecutive times. ▲ Repeat this action once.		1. Move the leg up and swing forward to create force.			
			2. Keep the leg swinging the leg behind the supporting leg, not beyond the supporting leg.			
			3. Turn your arms and swing forward to create force.			
			4. Complete 4 consecutive single -foot jumps with the dominant foot.			
				The skill scores are		

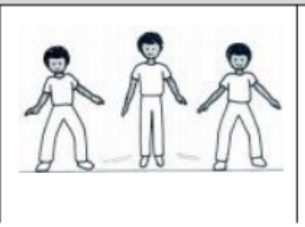
0= means that the action standard is not observed; 1 = means that the standard is observed

This table is compiled by Dr. Ningke. Translation from Test of Gross Motor Development (Third Edition), by Dale A. Ulrich.

Mobility Action Skills Test item 4-6

Basic action skills	Test Guide *	code of points	Test 1	Test 2	grade
4. Jump Test equipment: ▲ 9 m long runway ▲ 2 sign barrels	▲ Divide two lines of about 9 meters, separated with sign buckets. ▲ Inform the child to jump on tiptoe from one sign bucket to another one. ▲ Repeat this action once. 	1. Keep stepping forward and jumping the other foot on one foot at the same time. 2. Bend the elbow joint and swing toward the opposite leg to create strength. 3. Complete four rhythmic and continuous jumps with your feet.			
			The skill scores are		

Basic action skills	Test Guide *	code of points	Test 1	Test 2	grade
5. Standing long jump Test equipment: ▲ 3 m long runway ▲ jump off sign line	▲ Draw the jumper on the floor or runway. ▲ When off, after standing in line. ▲ Inform children to jump forward quickly. ▲ Repeat the jump once. 	1. Before preparing to jump, bend your knees and stretch your arms behind your body. 2. Move your arms forward and forward to your head. 3. Both feet at the same time. 4. Move your arms down when your feet fall.			
			The skill scores are		

Basic action skills	Test Guide *	code of points	Test 1	Test 2	grade
6. Sliding Test equipment: ▲ 7 m long runway ▲ 2 sign barrels	▲ Place the sign bucket at both ends of the 7 m straight line. ▲ Inform the child to slide from one sign bucket to another. ▲ Inform the child to decide to start facing the direction. ▲ Ask the child to slide back to the start point. ▲ Repeat this action once. 	1. In the direction of the body, and the shoulders are straight and parallel to the ground. 2. One foot moves sideways, and the other foot then slides sideways, with the feet flying briefly. 3. Four consecutive side slips on one side of the dominant body. 4. Non-dominant slide steps. One side of the body / Four consecutive sides			
			The skill scores are		

H▶igher scores indicate better development of basic movement skills.

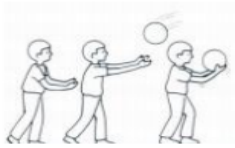
1▶ 5-20 min of testing per subject and an additional 1 0 min for preparation with cleanup. Each test content requires a certain interval.

Tester signature:_____Total score for mobility movement skills:_____This table is compiled by Dr. Ningke. Translation from Test of Gross Motor Development (Third Edition), by Dale A. Ulrich.

Operational action skills test items 1-4

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
1, both hands swing the stick hit solid **Set the ball** Test equipment: ▲ 1 0 cm long children with plastic baseball bats ▲ Fixed to the ball base	▲ The ball is placed on the ball base at the height of the waist. ▲ Inform the child to swing forward to ball. ▲ Aign right ahead. ▲ Repeat this action once.		1. Hold the dominant hand and hold the stick in the non-dominant hand. 2. The hip shoulder of the non-dominant hand faces the direction of the shot. 3. The hip and shoulder will rotate when swinging the stick. 4. Step up the ball against the non-dominant foot. 5. Fly the hit ball forward.			
				The skill scores are		

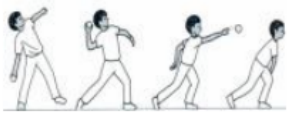
Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
2, the forehand hit the rebound ball Test equipment: ▲ Children's plastic tennis racket, tennis ball ▲ a wall	▲ Children can hold a racket in one hand. ▲ Inform the children to swing and hit the rebound ball hard. ▲ Strike the ball toward the wall. ▲ Repeat this action once.		1. When the ball rebounds, do the racket back. 2. Step up the ball against the non-dominant foot. 3. Fly the ball toward the target wall. 4. After hitting the ball, swing the racket to the shoulder on the non-side of the dominant body.			
				The skill scores are		

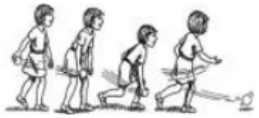
Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
3. Catch the ball with both hands Test equipment: ▲ About 1 0 cm in diameter, the inflatable soft ball is one ▲ A spatial distance of 4.6 meters apart ▲ adhesive tape	▲ Mark the two horizontal lines of 4 meters apart. ▲ The passer and the receiver are on the line. ▲ Pass the ball to the child, the height is roughly in the child's chest area, the height of the ball is wrong, the ball can be thrown again. ▲ Children catch the ball with both hands. ▲ Repeat this action once.		1. Before catching the ball, put your hands in front of your body and bend your elbow joint. 2. When the ball is close, stretch your arms to meet the ball. 3. Catch the ball with both hands.			
				The skill scores are		

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
4. Kit the fixed ball Test equipment: ▲ children use football ▲ Sufficient spatial distance ▲ Mark the bucket with 2 ▲ on one wall	▲ Mark a horizontal line of 6.1 meters away from the wall. ▲ The second line is located away from the first line 2.4 Meters. ▲ Place the ball on the first line. ▲ Stand on the second line to run hard toward the wall to kick the ball. ▲ Repeat this action once.		1. Run up to approach the ball quickly. 2. Lengyour pace or take a long stride before preparing to play. 3. Place the supporting foot (non-kicking foot) close to the ball. 4. Play the ball with the instep of the dominant foot, not on the toes.			
				The skill scores are		

Operational Action Skills Test item 5-7

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
5, one-hand in-situ dribble Test equipment: ▲ Basketball for children, 20.3-25.4 cm diameter for 3-5 years old, and adult basketball for 6-1 0 years old.	▲ Tell children to dribble with one hand. ▲ After stopping, catch the ball by hand. ▲ Repeat this action once.		1. The height of the single-handed dribble in the waist.			
			2. dribble the ball with your fingers, not with your palm.			
			3. Ability to dribble 4 times continuously without moving your feet to save the ball.			
				The skill scores are given * * *:		

Basic action skills	Test Guide *		code of points	Test 1	Test 2	grade
6. Throw ball over the shoulder Test equipment: ▲ Tennis ball ▲ a wall ▲ 6.1 m of the available length and space distance	▲ Prepare a sign line of 6.1 meters away from the wall. ▲ Let the children stand online and face the wall. ▲ Tell the children to head hard into the wall. ▲ Repeat this action once.		1. Start to swing your arm down.			
			2. Turn the hips, shoulders, and the side of the non-throwing hand toward the throwing direction.			
			3. The foot is opposite to the throwing direction.			
			4. After the ball is thrown, swing the arm forward toward the hip on the side of the non-throwing ler.			
				The skill scores are given * * *:		

Basic action skills	Test Guide ·		code of points	Test 1	Test 2	grade
7. Throw the ball in the first hand Test equipment: ▲ Tennis ball ▲ a wall ▲ Available length of 4.6 m Spatial distance from the ▲ tape	▲ Prepare a sign line of 4.6 meters away from the wall. ▲ Let the children stand online and face the wall. ▲ Tell the children to throw them hard to hit the wall. ▲ Repeat this action once.		1. Move the ball backwards and down and place it behind the body.			
			2. The foot is opposite to the throwing direction.			
			3. The ball throws directly on the wall, not on the ground.			
			4. After the ball, the bowler swings forward to the chest.			
				The skill scores are given * * *:		

➢

Prepare a trial process experience to ensure that the test children understand what to do

W➢hen the test children do not understand what to do, provide additional guidance and demonstration

Signature of the test personnel:_____ _____Total score of large muscle movement test:_____

The test form was compiled by Dr. Ningke. Translation from Test of Gross Motor Development (Third Edition), by Dale A. Ulrich.

Appendix G Assessment Form for Gross Motor Development in Children Aged 5-6 from the Perspective of Sensory Integration

SN:	School: Name: Age: Month Gender:	The first score	The second score	The best score
Test item	There are 10 projects. Please fill in the best scores for boys and girls according to your experience			
Step forward on the balance beam (sec)	A balance board with an appropriate height (about 0.3 high, about 0.15 meters wide and 3 meters long) is placed on the flat ground. The child stands at one end of the balance board. When the tester gives instructions, the child walks forward alternately with both feet. During the process, the child can swing his hands naturally to keep balance and record the completion time.			
Horizontal bar suspension move (m)	Select a bar that is highly suitable, over 1 meter in length and 3cm in diameter. Place a protective mat underneath and choose a distance of 1 meter in the middle. The child stands at one end, holding the bar with both hands while keeping their feet off the ground, forming a suspended position. When the tester gives the command, the child alternates moving forward or to the side with their hands, reaching the other end and then moving back. Record the distance covered within 20 seconds.			
4 legs crawl forward (m)	A crawling area 2 meters wide was set up on the ground. The children lay on their stomachs at the starting point and touched the ground with all four limbs. When the tester gave a command, they first put out their hands and then their feet, crawling forward continuously. The tester observed the standardization of their movements and recorded the distance completed in 10 seconds.			
Crawl forward (m)	Set up a 2-meter-wide crawling area on the ground, and arrange some low obstacles to increase the difficulty. Have the child lie face down at the starting point. When the tester gives the command, they should move their right hand and left foot, or left hand and right foot, simultaneously with force on the opposite side, continuously crawling forward. The tester observes the standardization of their movements and records the distance covered in 10 seconds.			
10 meters back run (sec)	A 10-meter long straight track is marked on the flat ground, and a turnaround point is set at both ends. The children stand at the starting point and make running positions with both feet. When the tester gives the order, the children start running, touch the marker at the turnaround point and quickly turn around to run back to the starting point, and record the completion time.			
Double hop(sec)	Mark a 5-meter long straight line on the ground, and connect it with a 50CM diameter jump ring. The children stand at the starting point, with their feet together and knees slightly bent. When the tester gives instructions, the children jump forward with both feet at the same time to jump over the circle continuously, and complete 10 times, recording the completion time.			
Overhand throw (m)	Children hold the standard tennis ball in their hands, stand with their feet front and back, face the direction of throwing on the side, bend their arms over their heads, swing their arms upward, and throw the ball forward and upward from their shoulders. Record the distance (meter) of throwing.			

Throw the ball with both hands(times)	The child holds the ball in both hands (direct 20CM,0.5KG). The tester gives a command to throw the ball upward or forward (above the head), and then catch it with both hands when it falls down. Repeat this. The tester records the number of successful throws and catches within 20 seconds.			
Side roll (sec)	The child lay on the ground on his side, with his legs straight and together, and his arms bent and crossed in front of his chest. When the tester gave the order, he rolled 180° on one side with one side of his body as the axis, and then rolled 180° in the opposite direction. This was repeated four times, and then he rolled back in the opposite direction. The completion time was recorded.			
Lie on your stomach and stand up immediately (times)	The child lies on the ground with his hands on both sides of his body. When the tester gives a command, he quickly supports himself with his hands, then stands up and lies down again. The time from lying down to standing up is 0.5 times, and the time from standing up to lying down is 0.5 times. The tester records the time taken to complete 20 seconds and the number of times completed.			

BIOGRAPHY

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