Effects Active Video Games On Motor Coordination Of Early Childhood-Focusing On Children In Zhengzhou, China

Lu Chenxi, Borhannudin Bin Abdullah, Hazizi Bin Abu Saad

Children are in the early stages of development, with limited bones and limited muscle mass. When you complete your activities, you rely on your body's coordination system. Therefore, strong motor coordination skills are the basis for children to develop motor skills and host skills. Furthermore, the development of motor coordination is fundamental to advanced motor and specific motor skills.This study aims to determine the effect of active video games on the coordination of movement in young children. The research problem is divided into two stages: (1) Descriptive analysis determined the developmental level of motor coordination in children aged 4, 5, and 6; (2) MANOVA and MANCOVA analyses determined the intervention's effect. Motor coordination development was measured using the Movement Assessment Battery for Children-Second Edition. Scientific evaluation addressed the three basic motor abilities of manual dexterity (MD), aiming and catching (A&C), and balance (Bal). The analysis results support and show that the proactive planning of electronic games for playing electronic games improves the coordinated sports development level of the experimental group. Although other factors influenced the findings, the analysis showed that after examining these factors, the intervention protocol continued to influence coordinated level of motor development.

Key words: *Active video games; Early childhood; Motor coordination*

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Introduction

Research background

Physical inactivity stands as the fourth leading mortality risk factor worldwide (Bull et al., 2020; Guthold et al., 2018). Diminished physical activity in early childhood specifically influences future health outcomes in senior years (Bull et al., 2020; Olive et al., 2016). Promoting children's active lifestyles has emerged as a crucial global concern (Thomas et al., 2022). The Ministry of Education in China released guidelines in 2012 for children aged 3 6, prioritizing physical development as a critical educational component (Qi & Melhuish, 2017). The 'Healthy China 2030' Plan, introduced by the CPC Central Committee and State Council in 2016, initiated the first children's sports program (Xiang et al., 2023). Research indicates China's growing emphasis on children's 1 health advancement (Chen et al., 2020). This necessitates developing effective, health centered exercise programs to boost physical activity and foster balanced physical mental development through active lifestyle habits (Pangrazi & Beighle, 2019). Children are in the initial stage of development, with small bones, small muscle size, and small lung capacity (Birnkrant et al., 2018). When they complete any activity, they rely on the coordination system of the body to cooperate (Shen et al., 2019), and good coordination is the basis of the physical quality of the best level (Boichuk et al., 2018), but also the basis of the development of the athletic ability and mastery of sports skills (Wormhoudt et al., 2017). In addition, the children's nervous system, the brain between the speed of conversion between excitement and printing speed up, so the coordination ability to accelerate progress (Tomporowski et al., 2015; Connell & McCarthy, 2013); at this time, the children's strength, endurance, speed, and other physical qualities of the inevitable link between the good coordination is to promote the ability to play a comprehensive role of these catalysts (Liefeith, 2019), but also the children's sports ability to create the basis of the comprehensive (Shi et al., 2023; Fang, 2024). Stephen believes that through sports intervention during childhood, a foundation can be laid for participation in sports activities in adulthood (Weinberg & Gould, 2023).

Problem Statement

Motor skills for children and their whole body are always accompanied by coordination. Coordination is limited by the development of the brain and nervous system. However, coordinated positive progress has promoted the growth and development of the brain and nervous system. Exercise coordination is the basis for developing health and exercise ability. The smooth development of law and sports coordination can meet the needs of children to participate in sports. However, the ability to coordinate as the basic mass of the human body is not independent. It embodies the state of coordination between the mobile organism and the contact environment. All physiological qualities and skills of the human body are closely related to the nervous system, especially those related to the growth and development of the nervous system. Movement coordination is the ability of the human body to control the body and maintain correct and stable movement. It is closely related to sports and is present in basic sports and feasible skills. Good physical rules and coordination of movement can also reduce and prevent emergencies. This study focused on teacher curriculum at preschool age and proposed an active video game module as an alternative teaching method for improving children's motor coordination. The goal is to understand the impact of active video games on the coordinated development of young children's movements.

Research Objectives

This study aimed to assess the effects of Active Video Games on motor coordination (aiming and catching, manual dexterity, and balance) in early childhood.

Several specific objectives were formulated based on the general objectives. These objectives are listed as follows:

1. To determine the developmental level of motor coordination (aiming and catching, manual dexterity, and balance) in early childhood.
2. To identify groups of early childhood who experience delays in the development of motor coordination (aiming and catching, manual dexterity, and balance).
3. To determine the effects of active video games on the development of motor coordination (aiming and catching, manual dexterity, and balance) in early childhood.
4. To assess if other factors, including BMI, gender, and socioeconomic status, affect motor coordination development in early childhood.

Research Questions

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Significance of the Study

The importance of this study is divided into two parts: theoretical significance and interventions for physical exercise. It not only promotes the development of children's motor coordination abilities, but also reduces problem behaviors and promotes the development of voice communication and emotional perception.Theoretical and empirical knowledge of psychology, exercise science, neuroscience and physiology supports the effectiveness of physical exercise. Based on existing theories, this study created an active electronic game intervention plan, which corresponds to the coordinated development of children's exercise, enriches and develops the existing theoretical system of intervention in physical exercise, and provides guidance for theoretical reference and guidance on kindergarten physical activities. This is discussed further hereafter. The experiment is designed to understand how children can improve their sports coordination through active video games.

Literature Review

Studies on the coordinated development of early childhood exercise were studied, and MABC-2 was particularly considered to be used as an evaluation tool. Although most of the research focused on children with disabilities and children during the school year, collective results highlighted the critical role of early

intervention programs in the development of motor coordination skills.The study also includes discussions on the concept of motor development, including theoretical models and coordination aspects as well as theoretical and conceptual basis for the study. In addition, various factors are studied in this paper that influence the coordinated development of early childhood exercise.

Motor Development

The development of athletic ability is a continuous transformation process (Haddders-Algra, 2018). This phenomenon manifests as continuous motor ability changes, which persist throughout an individual's entire life cycle (Adolph & Hospodar, 2024). Researchers describe motor development as the study of changes related to movement throughout one's life (Crane et al., 2021). This development aspect serves as the foundation for individuals to maintain their health, participate in sports activities, enhance their capabilities, and engage in various other efforts (Griban et al., 2020).

Principles of Motor Development

Human growth and motor development proceed from top to bottom (Haibach-Beach, 2023). For instance, comprehension, reaching out, and grasping were the early uses of the hand. The development of reaching out and grasping can be divided into several stages. The initial stage of grasping occurs four to five months after birth. During this stage, babies use their shoulder joints to control the swinging of large muscle groups in their arms to grasp objects around them.

Motor Development Model

This model starts from an ecological perspective and takes into account individual characteristics, environmental factors, and task requirements (Goodway et al., 2019). It consists of four distinct but overlapping stages: reflective motion, basic motion, basic motion, and specialized motion, and each stage contains multiple stages. As shown in Figure 1, motor coordination ability is systematically advanced through four stages of physical skill acquisition: reflex motor, basic motor, basic motor, and specialized motor.

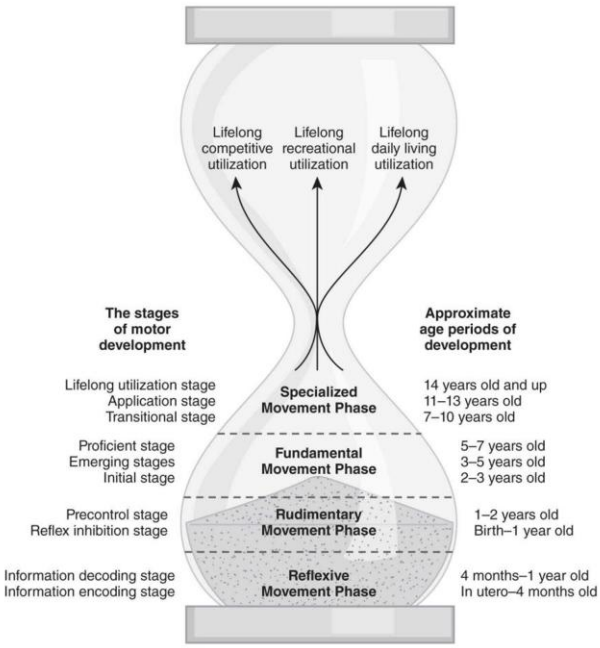

Figure 1: Gallahue's Hourglass Model (Source: Gallahue, DL, 2019)

The Reflexive Movement Phase

The initial movement of the fetus is reflex movement. Through reflex activities, babies can obtain information about their surrounding environment. Babies' responses to light, sound, and pressure changes can trigger involuntary movements. These actions are also regarded as the beginning of the neural network between the brain and the body. The reflex stage of motor development can be divided into two overlapping stages: information encoding and decoding.

The Rudimentary Movement Phase

Galahue believes that the basic movement stage is the second stage of human movement development. This stage includes the autonomous movement of infants from birth to age two. These actions follow a predictable sequence of development and are mainly determined by maturity. Although the sequence is fixed, it may differ for each child due to the influence of physiological, environmental, and task-related factors. Gallahue classified these basic children's autonomous movements into three categories: stable movements (controlling the muscles of the head, neck, and trunk), operational activities (reaching out, grasping, releasing), and motor movements (crawling, crawling, walking).

The Fundamental Movement Phase

In Galacheu's hourglass model, the basic motion stage represents the third stage. These basic actions include observable basic behavioral patterns. In early childhood, they include motor activities, operational activities, and stability activities. The development of these basic motor skills is greatly influenced by environmental factors. The basic action stage consists of three distinct but overlapping stages: the initial stage, the emerging primary stage, and the proficiency stage (Goodway, Ozmun, and Gallahue, 2013).

The Specialized Movement Press

During the specialized movement stage of the Galacheu hourglass model, basic stability, movement, and operational skills will be refined, combined, and refined to be applied in increasingly complex situations such as daily activities, entertainment, and sports. Gallahue, Ozmun, and Goodway (2013) pointed out that at this stage, many factors influence the time and degree of skill development, including reaction time, movement speed, coordination, physical characteristics, cultural factors, social influence, and emotional factors. This stage consists of three distinct phases: the transitional phase, the application phase, and the lifetime use phase.

Theories of Motor Development

For a long time, researchers have studied the continuous changes in exercise behavior over time, and the factors behind these changes include biological, environmental, and task factors (Haywood & Getchell, 2024). The opportunity to participate in sports activities and the guidance throughout the activity process are also crucial (Ennis, 2017). For centuries, developmental scientists have contributed valuable knowledge to human development. Every developmental theorist has impacted and contributed to children's and adults' motor development and education (Haywood & Getchell, 2024).

Ecological Theory

Nowadays, many researchers in sports development use ecological theories. It emphasizes the relationships among individuals, the environment, and among individuals (Haywood & Getchell, 2024). From an ecological perspective, people should consider the interactions of all elements (Haywood & Getchell, 2024). Although a particular element or system is essential and significantly impacts every movement, all systems play a role.

Dynamic Systems Branch

Many developmental scientists favor dynamic system theory (Guccione, Neville, & George, 2019). The concept of dynamics indicates that development is regarded as a discontinuous process, suggesting that the changes an individual undergoes over time are not uniform, smooth, or hierarchical. This liberates the understanding of development from the traditional linear model (Haywood & Getchell, 2024).

Behavior Setting Branch

Behavioral setting theory is a branch of ecological psychology. Lewin is widely recognized as the founder of Gestalt psychology. He proposed the concept of topological psychology, which borrows the geometric properties in mathematics and remains unchanged even under distortion. Luin proposed the concept of "living space" to cover all the factors that affect children's behavior at any moment.

Motor Coordination

Motor coordination ability is an important foundation for the formation of sports techniques. Motor coordination is the ability of the nervous system manifested in the form of motor coordination. Yang Xiliang (2010) proposed that coordination ability refers to the synchronous movement of various muscle groups in the human body. Lagarde (2005) believed that the coordination ability needs to be flexible and stable, and energy consumption must be optimized. Changes in the external environment make it difficult to interfere with this state.

Development of Motor Coordination

Early childhood is an important stage for developing motor coordination ability (Maciak et al.). Because at this stage, children will acquire various new motor skills. Motor coordination is important in most preschool and early school physical education curricula (Bao, 2024). Fundamental motor skills begin to form early in children's development (Newell, 2020). Therefore, it is necessary to formulate and implement early childhood physical education intervention plans and motor coordination measurement methods in a standardized manner to meet children's needs for motor coordination skills more effectively.

Importance of Motor Coordination

Mastering motor coordination ability during childhood is the most important aspect of children's development, as it ensures the effectiveness of more specific skills (Haywood & Getchell, 2024). Motor development demonstrates the interactive influence of biological and environmental factors on changes in motor behavior throughout the life cycle (Haywood & Getchell, 2024). Good motor coordination ability helps children adapt to various environments more confidently, laying an important foundation for their future physical health and social participation (Pangrazi & Beighle, 2019).

Motor Coordination Measurement Instrument

Mastering motor coordination during childhood is the most important aspect of children's development. Motor development demonstrates the interactive influence of biological and environmental factors on changes in motor behavior throughout the life cycle (Haywood & Getchell, 2024). Obtaining good motor coordination

ability helps children adapt to various environments more confidently, which lays an important foundation for their future physical health and social participation (Pangrazi & Beighle, 2019).

Active Video Games and Motor Coordination Development

Regarding the outline of physical activities and physical health education in kindergartens, motor coordination can be cultivated during early childhood. However, the health education syllabus for physical activities in kindergartens needs to emphasize the application of positive video games. However, the application of active video games is an important part of developing motor coordination ability in early childhood. The relationship between active video games and motor coordination ability is shown in Table 1.

Table 1 Relationship between Motor Coordination and Active Video Games

No.	Active video games	Elements of motor coordination
1	Fruit Ninja	Hand-eye coordination, Manual dexterity and precision
2	Kenect Sports	Hand-eye ordination Balance Aiming & Catching
3	Just Dance Kid2	Whole body coordination Balance

Previous Studies Using MABC-2

Improvement in motor coordination ability is an important criterion for measuring children's development. It lays the foundation for more advanced motor skills (Bao, 2024). Direct studies have shown a positive relationship between motor coordination ability and the success of physical fitness intervention programs. Their research aims to collect information on the motor coordination abilities of children with autism and assess the impact of a 12-week physical intervention program to improve these abilities.

Factors Affecting Motor Coordination

Variables include socioeconomic status, body mass index (BMI), age, and gender. BMI plays a crucial role in the motor coordination development of preschool children (Nobre, Ramalho, Ribas & Valentini, 2023). Nobre's research shows that children's motor skills negatively correlate with their body mass index. Roland reached a similar conclusion among Hong Kong boys, indicating a negative correlation between physical exercise and body fat. DuBose (2018) also discovered a negative correlation between physical activity and body weight. Nevertheless, some studies have shown no significant difference in physical activity levels between preschool children of normal weight and overweight (Raistenskis et al., 2016).

Conceptual Framework

The conceptual framework of this study (as shown in Figure 2) identifies the development of motor coordination skills as the dependent variable (DV), which consists of four components: SSMD, SSAC, SSB, and SSTTS. The independent variable (IV) selection is based on its expected influence on motor coordination ability. The study also took gender, age, body mass index, and socioeconomic status as covariates. The research framework explores how positive video games and traditional sports activity teaching modules promote the development of children's motor coordination ability.

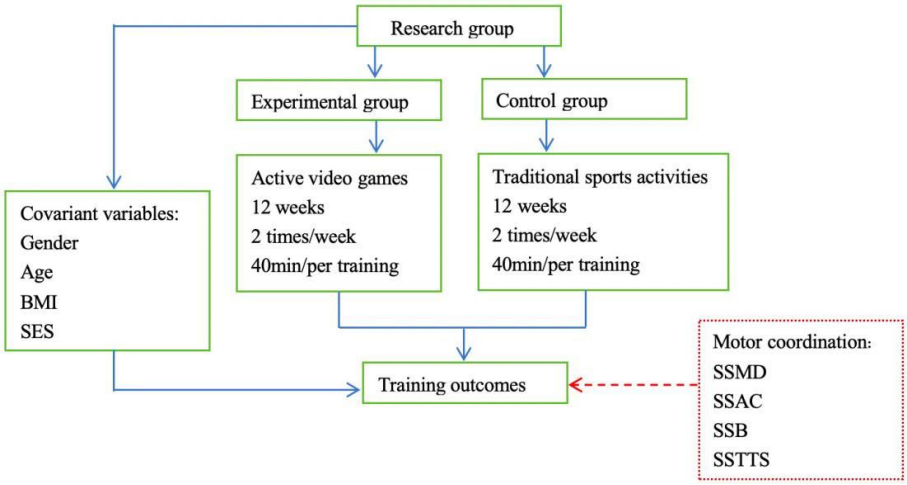

Figure 2: Conceptual Framework

Methodology

Research design

This first phase of the study aims to assess the level of motor coordination development in children aged four, five, and six. It focuses on obtaining basic data and identifying groups of children who should be given interventions based on their level of motor coordination development.

Research Population

The study subjects were children aged four to six in Zhengzhou City, Henan Province, China. They were taught physical education subjects through a kindergarten activity program and participated in physical education activities twice a week for 40 minutes each time.

Research Sample Size

The sample size was calculated using GPower software. According to the preset parameters, the calculation results show that at least 159 people must make estimations in three groups. As the failure rate is 10%, this study predicts 59 cases in each group, totaling 177 research subjects, which can ensure the accuracy and scientific nature of the research results. The first stage of the research is a descriptive study, which uses the mean and standard deviation to describe the characteristics of the variables. This study will determine the development level of motor coordination ability of children aged four, five, and six. According to the results of the Gpower software, the appropriate sample size for each group was 59. This study involved 177 children in three age groups.

Research Locations

This research was conducted in a kindergarten in Jinshui District, Zhengzhou City, Henan Province. This kindergarten was selected through the sampling method adopted in this study, and the subjects of the kindergarten met all the criteria, needs and requirements of this study. This kindergarten also has a sufficient number of research subjects. In particular, the reason for choosing this kindergarten is that it has a suitable population for this study, and the subjects selected from this population are expected to be able to answer the research questions raised.

Research Equipment and Procedures

The research on the motor coordination level of young children used various materials. Including a timer, a tape measure, colored tape (25 mm wide), a dark blue table mat, an AB1 record sheet with drawing thread insert, a red Berol fine-tipped pen, 12 yellow beads, red lace, bean bags and six-floor MATS (3 pure yellow, two pure blue and one blue with orange target). Participants were divided into two groups by gender and were evaluated at different test stations, respectively. Each participant completed all the assessment contents.

Pilot Study

Before conducting the primary research, a pilot study was carried out first to investigate the reliability of the research variables and the feasibility of the intervention plan procedure. This helps researchers familiarize themselves with the test protocol and intervention plan and calibrate the instruments before starting the main study. The pilot study lasted for two weeks. Sixteen five-year-old children were recruited and randomly assigned to the experimental group (8 children) or the control group (8 children).

Experimental procedure

This study adopted the quasi-experimental method and the framework of the control group before the test. This survey aims to assess how positive video games affect the development of children's coordinated motor skills. The experimental group participated in active video game conferences, while the control group participated in traditional sports activities. The research design involves evaluating the initial levels of the participants and analyzing the results before the experiment to identify significant changes. After the experiment, the children's motor skills were evaluated and examined through group tests. Figure 3 shows the experimental process.

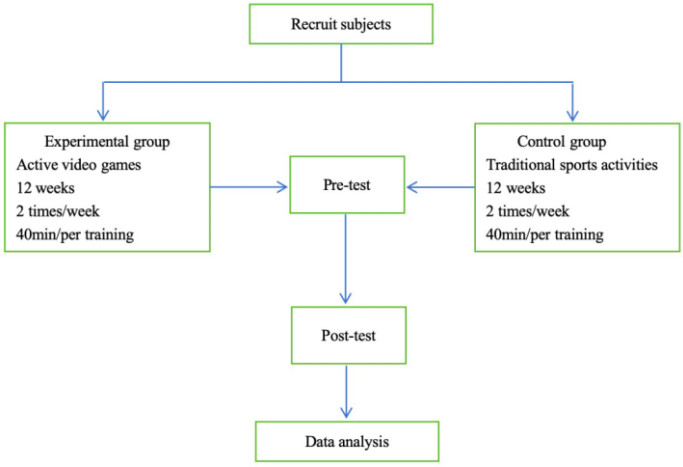

Figure 3: Research Framework

Sample Size

This study employs two independent sample information hypothesis tests, using the difference menu between the two independent means (two groups) of the Gpower software. After calculation, 34 cases are needed in each group. Considering that the dropout rate was 10%, there were 38 cases in each group of this study, totaling 76 subjects, ensuring the scientific nature of the research design.

Control Variables

Field tests require much thinking and meticulous management to control irrelevant external variables, thereby obtaining meaningful test results. The research subjects must not have participated in any special sports training within the first three months of the study and have no history of muscle or bone injuries. 2. The teachers and teaching assistants in the experimental and control groups were the same. 3. Parents are required not to provide additional after-school physical activity intervention to participants. 4. If participants take leave during the research period, they should make up for it as soon as possible. 5. Staff members participating in the research only need to understand the work plan and do not need to explain the research purpose. 6. Ensure that the experimental and control groups participate in moderate or high-intensity physical activities.

Data Analysis

Data analysis was conducted based on the research questions presented. In this study, a multivariate analysis of variance was employed for each research question. Before the data analysis, exploratory data analysis and the examination of inferred statistical hypotheses were performed. This analysis and review aim to ensure that the data obtained are error-free and satisfy the assumptions of inferential statistics. Before the analysis procedure, exploratory data analysis is performed to ensure that the basic assumptions for data analysis using MANOVA and MANCOVA statistical tests are met. The statistical analysis requires validation of various assumptions, including adequate sample size, multivariate normal distribution, presence of outliers, linear relationships, regression homogeneity, issues of multicollinearity and singularity, and consistent variance-covariance matrices.

Discussion

Developmental Level of Motor Coordination in four-year-olds

The average hand dexterity (MD) (M=9.66, SD= 0.94), average aiming and capturing (A&C) (M=11.64, SD=1.27), average balance (Bal) (M=9.68, SD= 0.82), and average total test score (M=10.47) of the subjects in this group SD=1.26) See Figure 4.

N represents number of subjects;MD represents manual dexterity;A&C represents aiming & catching;bal represents balance;TTS represents total test score.

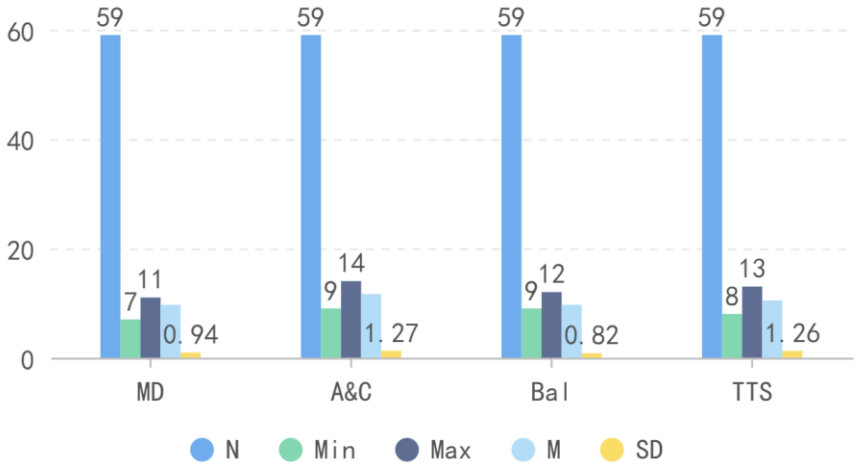

Figure 4 Four Years Old Developmental Level of Motor Coordination

Developmental Level of Motor Coordination in five-year-olds

The average hand dexterity (MD) (M=6.75, SD=1.63), average aiming and capturing (A&C) (M=9.27, SD=1.76), average balance (Bal) (M=8.54, SD=1.16), and average total test score (TTS) (M=9.78) of the subjects in this group SD=2.01) See Figure 5.

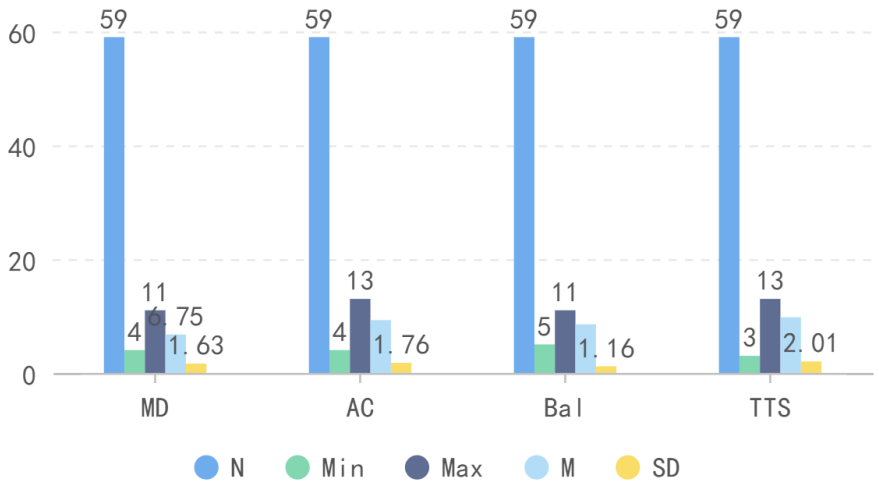

Figure 5 Fiver Years Old Developmental Level of Motor Coordination

Developmental Level of Motor Coordination in six-year-olds

The average hand dexterity (MD) (M=10.32, SD=1.09), average aiming and capturing (A&C) (M=12.39, SD=1.07), average balance (Bal) (M=10.07, SD=1.38), and average total test score (TTS) (M=11.27) of the subjects in this group SD=1.45) See Figure 6.

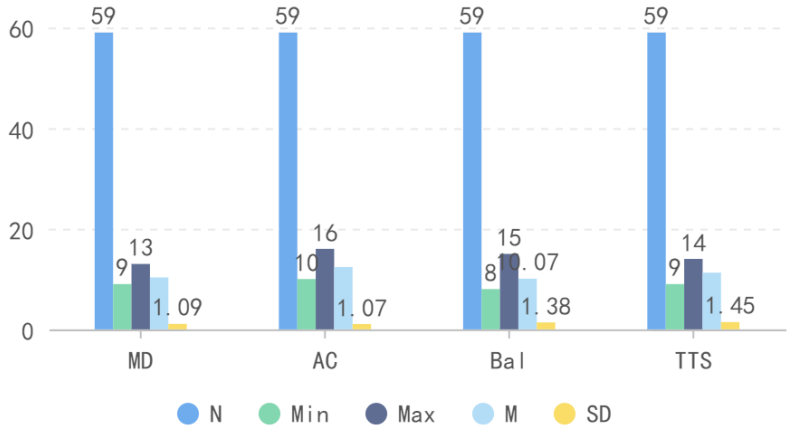

Figure 6 Six Years Old Developmental Level of Motor Coordination

Judging from the standardized scores of the sub-tests in Figure 7, the performance of the first group of children (4.01-4.11 years old) in the dependent variables of manual dexterity (MD), aiming and grasping (A&C), and balance (Bal) was at an average level. 103, and all three indicators were better than those of Group 2 (5.0-5.11 years old) but not as good as those of Group 3 (6.01-6.10 years old). The TTS scores of children in group 1 (4.01-4.11 years old) did not reach the average value, which was lower than that of children in group 3 (6.01-6.10 years old), but better than that of children in group 2 (5.0-5.11 years old).

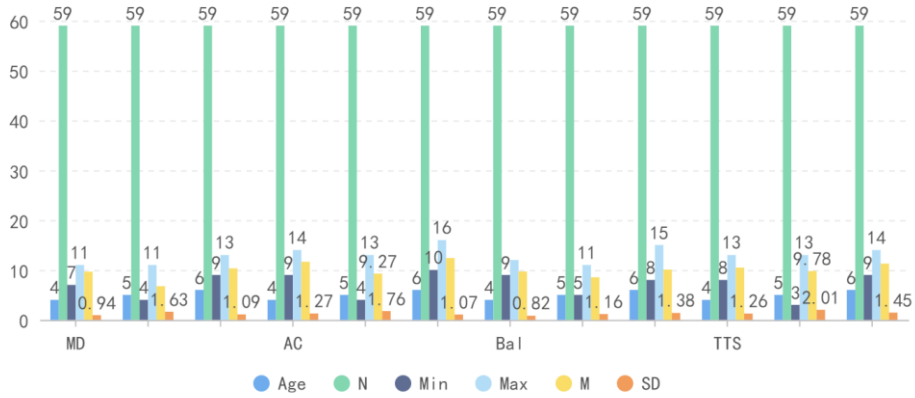

Figure 7 Six Years Old Developmental Level of Motor Coordination

Descriptive analyses of the motor coordination abilities of the three groups of children were conducted based on the conversion of TTS standard scores and percentile ranks in the MABC-2 test and the 'Traffic Light' System in the MABC-2, as shown in Figure 8.

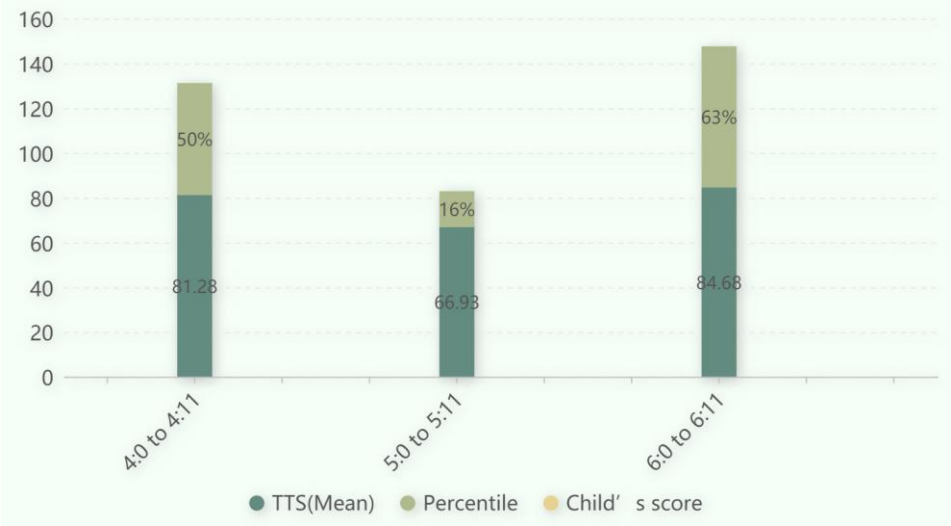

Figure 8 Six Years Old Developmental Level of Motor Coordination

Conclusion

The results indicated that the 6-year-old children had higher scores in MD, A&C, Bal and TTS than the 4-year-old and 5-year-old children, demonstrating better development of motor coordination. Meanwhile, the motor coordination development level of 5-year-old children was the weakest among the three age groups. According to the MABC-2 test score conversion table, the motor coordination percentile of 5-year-old children was the lowest among the 4-year-old, 5-year-old and 6-year-old children. In the "traffic light" system of MABC-2, the motor coordination development level was the most problematic group among the 5-year-old participants. After the intervention, active video games had a significant impact on all dependent variables (MD, A&C, Bal and TTS) of motor coordination development. The analysis showed that gender and body mass index also affected the development of motor coordination. After considering gender, body mass index and income factors, active electronic games still significantly influenced the motor coordination development of the participants. The analysis results support and prove that the active electronic game intervention program can promote the development of motor coordination in the experimental group.

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