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A Study on the Characteristics of 4-6 Years Old Children's GMD and Its Correlation With Social Cognitive Function

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ABSTRACT
Objective: To explore the impact of GMD on social cognitive function, and to provide evidence for the value of sports to promote children's all-round development. Methods: Two natural classes were randomly selected from the small, middle and large class. 126 children were assessed for MABC-2 and completed a questionnaire of Social Development Survey, and attention network test (ANT). The experimental results were analyzed by ANOVA and Pearson correlation. Results: There is a significant difference in the age of the fine motors of children aged 4-6 years old. There is a multi-dimensional correlation between the fine motor, balance motor, gross GMD and social development of children aged 5-6 years old. Fine motor, balance motor and attention network system are significantly related. The improvement of the executive control system helps to improve the attention network system. Conclusion: Preschool is a sensitive period for fine GMD, and GMD can improve children's sociality and attention network system.

Keywords: *4-6 years old, GMD, socialization, cognitive function, correlation.*

1. INTRODUCTION

TGMD is the study of the developmental results, internal processes and factors affecting behavioural changes of individuals who grow up with age, physical activity and coordinated motor skills throughout the life. Together with cognitive development, emotional development, social development and physical development, it promotes the overall development of people [1]. Preschool is a critical period for the rapid development of children's motor [2], sociality [3], and cognitive function [4]. Sociality is the only way for every child from biological existence to social existence [4]; Cognitive function is the brain's ability to process information from the surrounding environment. This ability is an important indicator of a person's future physical health, mental health, wealth and public safety [5], Therefore, these competencies that play an important role in lifelong development are constructed at this stage. As an important means of promoting children's health, GMD is a necessary basis for children and adolescents to participate in regular exercise [6]. Research has found that the expression of brain-derived neurotrophic factor can be increased through exercise [7]. 3-6 years old is an important developmental period in life, to study the age characteristics of different motor types, social and cognitive functions of children at this stage, and the relative influence of GMD on social cognitive ability. So as to provide evidence for the value of GMD to promote the overall development of children.

2. MATERIALS AND METHODS

2. 1. Participants

In this study, small, middle and large classes are randomly selected from a public kindergarten. Before running the test, the physician provided a detailed explanation of the research to the parents of the participants and then obtained their consent. Participants inclusion criteria: 4 years of age or older, no history of

neurological or muscular diseases, no history of falls and injuries within the last three months, and those who failed one of the above criteria were excluded from this study. 126 children took the Movement Assessment this study, the 3-year-old group included children between 3 and 4 years old who came from the bottom class in kindergarten; the 4-year-old group included children between 4 and 5 years old who came from the middle class in kindergarten; and the 5-year-old group included children between 5 and 6 years old who came from the top class in kindergarten. Basic information about the physical conditions of the participants is shown in Table 1.

Table 1. Basic Information about the Physical Conditions of the Participants

Age(year-old)	Number	Age/month	Height (cm)	Weight (kg)
4	36	53. 3±4. 8	112. 8±6. 7	19. 8±8. 0
5	33	66. 8±4. 2	123. 4±10. 2	22. 3±5. 4
6	47	74. 2±6. 0	133. 7±13. 3	23. 7±8. 4

2. 2. Apparatus and Procedures

2. 2. 1. MABC-2

MABC-2 was developed by British scholar Henderson to assess the motor coordination ability of children aged 3-16 [8]. Up to now, This set of tools has been translated into six European languages, and related studies have been carried out in different countries and regions. It has good reliability and validity, so it is a reliable evaluation tool [9]. Wuang from Taiwan and Hua Jing et al. from mainland China verified the applicability of this tool in Chinese preschoolers [10,11]. Ke of Beijing Normal University made localized revisions and established an applicable norm based on the data of 2,185 urban children aged 3-10 [12].

2.2.2 Social Development of 3-9 Years Old Children in China

The Parent Questionnaire of "Social Development of 3-9 Years Old Children in China" was compiled by Chen [13]. It is a tool specifically used to assess the level of social development of 3-9 year olds. The scale is widely used in China and has good reliability and validity. Its internal factor consistency α coefficient was Battery for Children-2 (MABC-2) and Attention Network Test (ANT) children's test; 126 children's parents filled out the Questionnaire of "Social Development of Children 3-9 Years Old in China". In between 0. 52-0. 72, and the α coefficient of the total scale is 0. 91 [14], and it has good inter-culturality [15].

2. 2. 3 ANT

Fan et al. developed the ANT children's version in 2004, which integrated spatial cueing tasks and lateral inhibition tasks into one experiment. The former measures the efficiency of alertness and orientation systems, and the latter measures the efficiency of executive control systems. This test is simple and easy to operate, and it is a suitable version for testing the attention network system of children aged 4 and above [16]. Participants responded by using the left and right directions of the keyboard according to the orientation of the mouth of the middle of the five small fishes that appeared on the screen.

Each attempt has a random response time ranging from 400ms to 1600ms. Then there is a cue prompting time of 150ms, 450ms after the clue disappears, the target stimulus appears. The appearance time of the target stimulus is terminated by the participant's response, and the longest does not exceed 1700ms. The distance between the experimenter's eyes and the screen is about 53cm. The experiment program contains 24 exercises and 3 stages of formal tests, each with 48 exercises. Each exercise frequency randomly presents one of 12 conditions: no prompt, double prompt, center prompt, and space prompt: 4 types of clue prompts; consistent condition, inconsistent condition, and neutral condition: 3 target condition forms. After the experimenter responds, he will receive auditory and visual feedback: if the reaction is correct, the fish will spit out bubbles and hear "Woohoo!"; if the reaction is wrong, the fish will not change and hear a beep. The duration of the practice phase is about 3 minutes, each of the three phases of the formal experiment is about 5 minutes long, and the entire experiment is completed in 20-25 minutes.

2. 3 Test content and Principle

2. 3. 1 MABC-2

MABC-2 has three subtests: fine hand, positioning and grasping, and balance, including coin throwing, beading, trajectory drawing, bean bag throwing, bean

bag receiving, straight on tiptoe, standing on one leg with eyes open, and continuous jumping 8 test items [8]. According to the norm established by Ke for Chinese urban children [16], the raw scores of the test are converted into standard scores to evaluate the development of children's fine hand motors, positioning and grasping motors, balance motors and scores of gross motor development (GMD).

2.3.2 Social Development of 3-9 Years Old Children in China

The "Social Development of Children 3-9 Years Old in China" has a total of 60 questions on the test scale. The questions are scored in the form of a Likert five-point scale, from "non-conformity" to "completely conforming" as 1-5 points. The higher the value, the better the social development of children. The scale covers 15 dimensions: compliance with social rules, social cognition, will, lifestyle habits, introversion and extroversion, attachment to family members, emotional balance, self-concept, peer relationship, non-aggression, independence, honesty and justice, empathy Being helpful, competitive, and self-esteem, it fully reflects the social development of children [13].

2.3.3 ANT

When obtaining responses under different paradigm types and clue prompting conditions through ANT behavior experiments, the formula is:

The efficiency value of the alertness system = no prompt response time minus double prompt response time;

The efficiency value of the orientation system = the center prompt response time minus the space prompt response time;

The efficiency value of the execution control system = when the target is inconsistent response minus the target consistent response time.

The greater the efficiency value of the alertness and orientation system, that is, the greater the response time difference, the higher the system efficiency; the smaller the execution control system efficiency value, the smaller the response time difference, the higher the system efficiency [16].

2. 4 Statistical Analyses

The statistical software SPSS 20. 0 was used for statistical analysis of the experimental data. Analysis of age characteristics of 4-6 years old by ANOVA is about GMD (fine hand motors, positioning and grasping motors, balance motors), and Post Hoc Test LSD analysis; Through Pearson correlation, analyze the relationship between GMD and social development, and attention to the network system. P<0. 05 was used as the standard of significant difference, and P<0. 01 was used as the standard of very significant difference; 0. 5≤|r|<0. 8 was moderate correlation, and |r|≥0. 8 was high correlation.

3. RESULTS AND ANALYSIS

3. 1 Age Characteristics of GMD in Children Aged 4-6

The age characteristics of 4-6 years old children's GMD are statistically analyzed (Table 2): the scores of positioning and grasping motor, balance motor, fine motor and GMD are all found in the 6-year-old group and very significantly greater than the 4-year-old group (P< 0. 01), the scores of positioning and grasping motor, balance motor and GMD of the 6-year-old group were significantly greater than those of the 5-year-old group (P＜0. 05), and the scores of balance motor and GMD of the 5-year-old group were significantly greater than the 4-year-old group (P＜0. 05); The fine motor of the 6-year-old group was very significantly greater than that of the 5-year-old group (P<0. 01), and the 5-year-old group was very significantly greater than the 4-year-old group (P<0. 01). This shows that there are age differences in the scores of positioning and grasping motors, balance motors, fine motors, and GMD of children aged 4-6 years, which increase with age, but the development of fine motors is faster.

Table 2. 4-6 years old children's GMD scores

Classification	4 /36	5/33	6/47
Positioning and grasping	10. 78±2. 29	11. 03±2. 05	12. 23±2. 20**#
Balance	8. 03±2. 51	9. 33±1. 47*	10. 36±2. 02**#
Fine Motor	8. 67±1. 93	10. 61±1. 74**	11. 98±1. 34**##
GMD	9. 06±2. 44	10. 47±2. 21*	11. 62±2. 15**#

4/36: 4 represents age, and 36 represents the number of people at that age (the same below)

Comparison of the 4 years old, *P＜0. 05,**P＜0. 01; Comparison of the 5 years old, #P＜0. 05, ##P＜0. 01

3. 2 The Correlation between GMD and Social Development of 4-6 Years old Children

From the perspective of GMD, the correlation between GMD and social development of children aged 4-6 years (Table 3) shows that positioning and grasping motors and compliance with social rules are moderately correlated in the 5-year-old group (P<0. 05) , the correlation coefficient was 0. 5≤|r|＜0. 8; In the 6-year-old group, there is a high degree of positive correlation (P<0. 01), and the correlation coefficient |r|>0. 8. The total score of honesty and fairness and social development between 5-6 years old and the 6-year-old

group's aggressiveness, independence, empathy and helping others were moderately positively correlated (P<0. 05), and the correlation coefficient was 0. 5≤ |r|<0. 8. Balance motors were highly positively correlated with the compliance with social rules, aggressiveness, honesty and fairness, empathy and helping others, and sociological development total scores of 6-year-old children's (P<0. 01), the correlation coefficient was |r|>0. 8; moderately correlated with the social rules, introversion, aggressiveness, and social development total scores of 5-year-old children's , as well as the 6-year-old group's social cognition, introversion, attachment to family members, and peer relationships (P<0. 05), the correlation coefficient was 0. 5≤|r|＜0. 8. Hand fine motors were moderately correlated with internal and external tropism in the 6-year-old group (P ＜ 0. 05), and the correlation coefficient was 0. 5≤|r|＜0. 8. The total score of GMD was highly correlated with the compliance with social rules of 6-year-old children ' s (P ＜ 0. 01), the correlation coefficient was |r|＞0. 8; moderately related with the compliance with social rules, aggressiveness, aggressiveness, and total social development of 5-year-old children, as well as with the introversion, aggressiveness, honesty and fairness, empathy and helping, and total social development of 6-year-old children(P<0. 05), the correlation coefficient was 0. 5 ≤|r|<0. 8. From the perspective of age group, the high correlation between children's motor development and social development mostly existed in the 5-6 year-old group, especially the 6-year-old group. Analyzed from the perspective of social development, GMD was mainly correlated with compliance with social rules, aggressiveness, empathy and help, honesty and fairness, and there was a high degree of positive correlation (P<0. 05), and the correlation coefficient was |r|≥0. 50. There was a moderate positive correlation between the score of GMD and the total social development in the 5-6 year old group (P<0. 05), and the correlation coefficient was 0. 5≤|r|<0. 8.

3. 3 Correlation between 4-6 Years old Children's GMD and Attention Network System

Note that the network system includes three subsystems of alertness, orientation, and execution control. From the perspective of GMD, the correlation between various types of GMD of children aged 4-6 and the three network subsystems (Table 4): positioning and grasping motors The balance motor and the alertness, orientation and executive control system of children in the 5-6 year old group were moderately correlated (P＜ 0. 05), and the correlation coefficient was 0. 5≤|r|＜0. 8. The fine hand motors are moderately correlated with the alertness and executive control system of children aged 4-5 years and the orientation system of children aged 5-6 years (P＜0. 05), the correlation coefficient was 0. 5≤|r|＜0. 8, The fine hand motors are highly correlated with the alertness and executive control system of children in the 6-year-old group (P＜0. 01), and the correlation coefficient |r|≥0. 8. The score of GMD was moderately correlated with the alert system and orientation system of children in the 5-6 year old group, and the executive control system of the 4-5 year old children (P＜0. 05), and the correlation coefficient was 0. 5≤|r|＜0. 8, The score of GMD was highly correlated with the executive control system of the 6-year-old group (P＜0. 01), and the correlation coefficient |r|≥0. 8. From the perspective of age groups, the middle-high correlation between GMD and alertness system as well as orientation system was mainly presented in the 5-6 years old stage; the high correlation between GMD and executive control system was mainly shown in the 4-6 years old stage. Analyzed from the perspective of attention network system, the correlation between 4-6 years old children's GMD and attention network system showed an overall increasing trend with age, especially with the alert system and executive control system basically showing a middle and high correlation (Figure 1).

Table 3. Correlation coefficients between GMD and social development of 4-6 years old children

Classification	Positioning and grasping			Balance			Fine Motor			GMD		
	4 /36	5/33	6/47	4 /36	5/33	6/47	4 /36	5/33	6/47	4 /36	5/33	6/47
Obey social rules	0. 026	0. 781*	0. 824**	0. 031	0. 521*	0. 825*	0. 024	0. 228	0. 237	0. 004	0. 685*	0. 808**
Social cognition	0. 204	0. 184	0. 289	0. 058	0. 104	0. 55*	0	0. 134	0. 393	0. 248	0. 233	0. 283
will	0. 233	0. 131	0. 372	0. 026	0. 352	0. 215	0. 18	0. 141	0. 287	0. 223	0. 336	0. 199
living habit	0. 091	0. 001	0. 391	0. 096	0. 025	0. 415	0. 17	0. 123	0. 134	0. 087	0. 054	0. 376
Introverted	0. 183	0. 141	0. 487	0. 039	0. 56*	0. 58*	0. 074	0. 306	0. 687*	0. 104	0. 403	0. 633*
Attachment to family	0. 235	0. 124	0. 48	0. 111	0. 043	0. 558*	0. 008	0. 034	0. 064	0. 185	0. 239	0. 433
Emotional balance	0. 133	0. 016	0. 314	0. 006	0. 041	0. 463	0. 039	0. 119	0. 382	0. 074	0. 077	0. 309
Self-concept	0. 213	0. 087	0. 176	0. 107	0. 168	0. 023	0. 13	0. 188	0. 217	0. 214	0. 146	0. 016
Companionship	0. 113	0. 074	0. 36	0. 036	0. 293	0. 701*	0. 092	0. 164	0. 32	0. 017	0. 242	0. 421
Aggressive	0. 167	0. 287	0. 711*	0. 018	0. 552*	0. 845**	0. 173	0. 18	0. 147	0. 139	0. 588*	0. 732*
Independence	0. 059	0. 134	0. 545*	0. 083	0. 266	0. 416	0. 114	0. 158	0	0. 041	0. 33	0. 412
Honest and fair	0. 095	0. 542*	0. 625*	0. 014	0. 31	0. 810*	0. 116	0. 223	0. 114	0. 114	0. 122	0. 623*
Empathy and helping	0. 26	0. 385	0. 588*	0. 187	0. 412	0. 882**	0. 039	0. 302	0. 042	0. 241	0. 177	0. 671*
Ambition	0. 001	0. 351	0. 261	0. 166	0. 358	0. 085	0. 09	0. 305	0. 092	0. 152	0. 525*	0. 029
Self-esteem	0. 072	0. 474	0. 306	0. 208	0. 243	0. 039	0. 161	0. 031	0. 312	0. 193	0. 251	0. 184
Total Social Development	0. 148	0. 548*	0. 778*	0. 045	0. 512*	0. 831**	0. 087	0. 224	0. 222	0. 147	0. 519*	0. 678*

Table 4. Correlation coefficients between 4-6 years old children's GMD and attention network system

Classification	Positioning and grasping Motor			Balance Motor			Fine Motor			GMD		
	4 /36	5/33	6/47	4 /36	5/33	6/47	4 /36	5/33	6/47	4 /36	5/33	6/47
Alertness	0. 37	0. 51*	0. 57*	0. 41	0. 53*	0. 61*	0. 54*	0. 68*	0. 80**	0. 46	0. 59*	0. 74*
Orientation	0. 4	0. 51*	0. 52*	0. 31	0. 52*	0. 53*	0. 31	0. 53*	0. 55*	0. 37	0. 52*	0. 54*
Execution Control	0. 48	0. 56*	0. 65*	0. 43	0. 57*	0. 67*	0. 53*	0. 58*	0. 87**	0. 51*	0. 57*	0. 81**

*$P<0.05$;**$P<0.01$

*P＜0. 05;**P＜0. 01

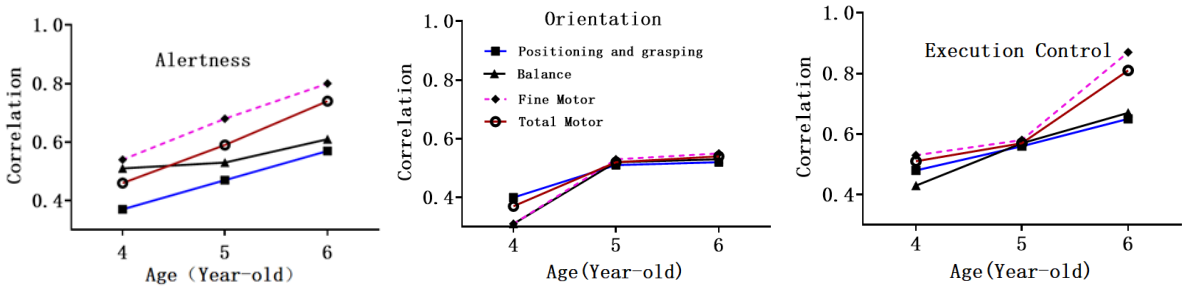

Figure 1. Change trend chart of the correlation between 4-6 years old children's GMD and attention network system

4. DISCUSSION

The level of GMD of preschool children is not only improving, but the overall level of development has obvious age characteristics, that is, the level of development is higher with age [17]. Based on previous studies, this research further classifies the types of movements and explores the characteristics of the age of the development of various types of movements. It was found that the balance movements and fine hand movements of children from 4 to 6 years old are always in development. Positioning and grasping movements begin to develop rapidly at the age of 5-6. Among them, the difference between the ages of fine hand movements is the most significant (P<0. 01) , That is, the development of fine motor is the fastest, which shows that 3-6 years old is a critical period for children's motor development, especially fine motor [18].

Sports and cognition, social and emotional relationships have always been a hot spot for researchers, especially for preschool children [19]. Bushnell et al. believe that motor is the prerequisite for the development of sensation, cognitive function, sociality and so on [20, 21]. During the process of interacting with the surrounding environment, the individual influences the development of social cognition through motor, which is the control variable for the overall development of the individual in the future. Shao's research on the correlation between gross motor development test (TGMD-2) and social development found that: operational motors and gross movements are related to social development in more dimensions than locomotor motors; andthis correlation exists in the 5-year-old group, but not in the 5-year-old group [21]. And there is no correlation between the 4-year-old group and the 5-year-old group. This study uses the MABC-2 test tool to find that children's positioning and grasping motors are highly correlated with social rules, aggression, independence, honesty and fairness, empathy and helping others, and social development total scores; balancing motors and social compliance rules, social cognition, attachment to family members, introversion and extroversion, peer relationship, aggressiveness, honesty and fairness, empathy and helping others, and social development total scores are moderately to highly correlated; fine hand motors are moderately related to introversion and introversion. And this correlation mostly exists in the 5-6 year old stage. Positioning and grasping motors belong to operational motors, which belong to the category of gross motors with balancing motors. Therefore, operational motors, balancing motors, GMD and social development are related in multiple dimensions. In Shao's research, TGMD-2 did not test the balance movement and fine hand movement, so the correlation between balance motor, fine hand motor and social development needs to be further studied on the basis of increasing the sample size [21]. In short, through the TGMD-2 or MABC-2 test tools, it can be seen that there is a multi-dimensional correlation between GMD and social development.

Piaget put forward the importance of motor to the improvement of cognitive ability, and early childhood experts have long emphasized the importance of GMD [22,23]. Studies have confirmed that children with delayed or uncoordinated motors are often accompanied by certain cognitive difficulties. A follow-up study found that the development level of gross and fine hand motors of preschool children has a higher positive correlation with reading performance [24]. Mafound through the MABC-2 test that the positioning and grasping motors, fine hand motors, and balance motors of children in the 4-year-old group and 5-year-old group have a positive effect on the behavioral self-regulation ability of preschool children. This study found that different types of motors have different degrees of correlation between GMD and attention network systems. The 4-6 year old children's positioning and grasping motors, balance motors are moderately correlated with the presentation of the attention network system, and are highly correlated with the presentation of fine hand motors, and the latter have more relevant dimensions. The analysis found that the level of GMD can predict the level of cognitive development, especially the level of neuro-GMD, while fine motor skills require visual tasks, cognitive tasks, hand flexibility and spatial organization skills. The ability to cooperate with multiple tasks [25], reflecting the ability of the nervous system and multi-sensory integration, can effectively treat cognitive impairment by improving the ability of hand fine motor skills [26], Therefore, the fine motor skills of the hands are significantly related to the attentional network system, which may also be the indicator that kindergarten teachers often regard the fine motor skills of the hands as the entrance preparation test [27]. The correlation between balance motor and attention network system, Wijnroks found that individual differences in posture control can accurately predict the level of early childhood cognition and attention development currently [28]. Murray found that there was a significant linear relationship between the age at which babies can stand and the working memory score of adults [29]. That is, children who can stand earlier than their peers in infancy, Working memory scores are higher at the age of 33-35, Therefore, there is a correlation between balancing motor and attention to the network system. Ren et al. found that gross motors are correlated with children's behavior and cognitive development, but the correlation between positioning and grasping motors and attention network systems needs further verification [30].

Vigilance refers to a state of alertness that an individual achieves and maintains in order to increase sensitivity to upcoming information; orientation refers

to the selection of information in sensory perception, and the shifting of attention to the stimulus to be selected or focused; executive control refers to The monitoring of expected stimuli and the resolution of conflicts in various responses. Budde et al. found that the intervention of bilateral coordinated motor helps to improve children's attention [31]. GMD is the basis for participating in daily sports activities. This study concludes that there is a correlation between GMD and the three subsystems of the attention network. A large number of studies have confirmed that exercise improves executive control functions and academic performance, Bixby et al. found that exercise can significantly improve the executive control system through the Stroop test [32]. Hillman et al. confirmed that aerobic exercise promotes executive function [33]. Van et al. found that exercise significantly improved academic performance and executive function [34]. This shows that children's GMD and executive control system are significantly related. There are relatively few studies on the correlation between children's GMD and alertness system and orientation system. Yu et al. found that table tennis can improve the attention network system of college students, especially the alertness and executive control system [35]. This study found that there is a moderate correlation between GMD and children's alertness and orientation system, which is different from Yu's results. The reason may be the difference in table tennis and GMD, or difference in the age of the research object. Therefore, correlation between GMD and the alertness and orientation system of preschool children needs further research.

5. CONCLUSION

Teachers and parents generally attach importance to children's gross motor training and ignore the development of fine motor. Preschool is a critical period for children's fine GMD. Therefore, the development of fine motor should be taken seriously. Positioning and grasping motors and balancing motors have a positive influence on social development; fine motors and balancing motors can improve attention. With the transformation of education reform and social informatization, parents and teachers should change the concept of sports education, grasp the critical period of children's GMD, and conform to the law of human growth and development, so as to promote the comprehensive and healthy development of children's mind, body and mind.

AUTHORS' CONTRIBUTIONS

Xin Hu was mainly responsible for research design, research experiment and report writing; Bobo Zong was mainly responsible for the arrangement of research experiments; Baosen Wang was mainly responsible for data collection and sorting; Yanyu Dong was mainly responsible for research design.

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