

The Construction and Grade Development of the Evaluation System of the Physical Ability Index of Preschooler

Tingting WANG (✉ 351760441@qq.com)

East China Normal University <https://orcid.org/0000-0002-5899-8622>

Zhili YAN

East China Normal University

Research

Keywords: preschooler, sports ability, physical health, evaluation system

Posted Date: May 18th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-28359/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Abstract

Purpose

Motor skills(MS), physical activity(PA) and physical fitness(PF) are important factors in preschooler's healthy growth. Thus, the aim of this study was to integrate the level of MS-PA and PF,so as to build an evaluation system of preschooler's physical activity index (PAIP). **Method:** Preschooler (n = 600) from kindergarten in Changsha, the capital city of Hunan Province in Central China were recruited, and a three-axis accelerometer (ActiGraph GT3X-BT) was used to the PA status of them, and the test of gross motor development three edition (TGMD-3) was used to the MS status of them, and national fitness test standard of China was used to PF status of them. We conducted simultaneous path modeling in AMOS to test moderation effects.

Results

Based on the measurements of MS-PA and PF-a PAIP model was built using a structural equation modeling (SEM) approach. This model combined physical fitness, physical activity and motor skills together and to reveals that the promotion of motor skills to the physical health of preschoolers has greater benefits than physical fitness and physical activity. At the same time, the evaluation index system and reference level of physical movement ability index of preschool children are developed, which provides an operational way to look forward to the development of physical health of preschool children.

Conclusions

The theoretical structure model of PAIP suggests that kindergarten administrators and physical education teachers should put the multi-directional development and types of motor skills of preschool children in the first place.

1 Introduction

In1986 the World Health Organization (WHO) reported that health is not the goal of life, but the resource of daily life, the symbol of happiness, and the pronoun of personal ability(Organization W H,1986). However, personal capability covers a wide range of sub-capability, which can be described by a word "numerous". However, among the "numerous" sub-capability, physical exercise capability is the most basic, and also an important embodiment of healthy life and work. Actually, as early as 1945, the research of famous physiologists pointed out that physical exercise capability is an important feedback index of physical health(Cureton,et al.,1945). At present, China and foreign countries are very concerned about the situation of children's physical health, and around the promotion of children's physical health has done a lot of research. It's not hard to find out after the statistics and classification of these studies, most of the researches on the promotion of children's physical health at home and abroad focus on three

aspects: the level of physical quality, the level of physical activity and the level of motor skills. Such as, Seefeldt(1979)pointed out that the reserve and development of multiple basic motor skills is the key for children (including children) to break through the threshold of "motor acquisition barrier", and then make them actively participate in the attempt of various motor modes, so as to improve their physical quality and enhance their physique. Stodden, et al.(2008)pointed out that the development of motor skills is the main potential mechanism to promote the participation in sports activities, enhance physical quality and promote physical health. Barnett, et al.(2008)pointed out that the development of children's movement skills can improve their sense of movement and actively participate in sports activities to promote the development of physical quality and overall improvement of physical fitness. Carl, et al.(2012)pointed out that the United States, Canada, the United Kingdom and other western developed countries regard the acquisition of action as the primary goal, and think that the mastery of action skills is the first element of individual development in all aspects. Vlahov, et al.(2014) reported positive correlation between the basic motor skills of preschooler and their physical fitness level. In addition, WANG, et al.(2019) reported the same conclusion. LI, et al.(2019) studied and concluded that motor skill level has a positive effect on the improvement of children's physical quality and physical fitness.

Base on this, the supporting way of physical movement ability evaluation of preschool children can be at least composed of three elements of "physical quality, physical activity and movement skills" and fed back. Therefore, we can integrate the "three elements" creatively, and use the "physical activity index of preschooler (referred to as PAIP)" to reflect the physical health level of preschool children, and establish the evaluation system and grade reference. In order to provide a basis for the kindergarten to objectively evaluate the physical exercise ability of preschool children and to look forward to the development trend of their physical health.

2 Materials And Methods

2.1 Subjects

The study was conducted between October 2019and November 2019 in Changsha, a large city Midwestern China.The sample group is small, middle and large classes in five kindergartens in Changsha City, Hunan Province. In order to ensure the accuracy of the test results, 600 preschool children aged 3–6 years were randomly selected as the subjects. However, due to the problems of test and instrument, 53 samples were lost, so the actual effective sample was 547 preschooler, 293 boys and 254 girls, and the details are as follows in Table 1. The study was approved by the Academic Research Committee of Hunan First Normal University.

Table 1
Lists the basic sample information.

Gender	Age interval				Total
	[3,4)	[4,5)	[5,6)	[6,7)	
Boy	73	71	72	77	293
Girl	64	63	65	62	254

2.2 Assessment of motor skills, physical fitness and physical activity

The level of motor skills was assessed by the test of gross motor development-3rd edition(TGMD-3). The TGMD-3 was a efficacious and credible assessment tool for assessing gross motor skill competence, which has two skill categories: LM(locomotor skill) skills and OC(object control)skills. Specifically, the LK consists of run, gallop, hop, horizontal jump, slide and skip, and then, the OC consists of two-hand strike, one-hand forehand strike, dribble, catch, kick, overhand throw and underhand throw. In order to ensure objectivity, all measurements were carried out in strict accordance with regulations and were blindly performed by two raters for each experiment under the same conditions, and the final result was expressed as the mean.

The level of physical activity was assessed by a three-axis accelerometer (ActiGraph GT3X-BT2.2.4). Of the 600 preschoolers to whom the accelerometer was proposed in the study, 36 had contraindications(catch cold or allergies to plastic) and did not consent. Of the remaining 564 participants who wore the accelerometer, 547(96.99%) had valid readable data. Participants wore the triaxial accelerometer continuously for 7 days (from Monday to Sunday)to wear the device on a waistband(in the right hip) during waking hours for 10 consecutive hours and had to be taken off for showering, swimming or bathing, and during sleep. Before data collection, parents or guardians were teach on the proper way to wear and remove the device by trained research staff. Device data were initialized, downloaded, and analyzed by using Actilife version 6.11.4-software. Accelerometer is mainly used to test the level of light physical activity(LPA), moderate physical activity(MPA), moderate-to-vigorous physical activity (MVPA)and vigorous physical activity(VPA) of preschool children. Meanwhile, We used the accelerometer cut-points for LPA, MPA, MVPA and VPA developed by Butte et al.(the details are as follows in Table 2), which has the grand classification accuracy(Buttle et al.,2013).

Table 2
ActiGraph GT3X-BT Physical Activity Measurement Parameter Setting List

No.	Parameter Content	Setting
1	Test Instrument	Triaxial accelerometer (ActiGraph GT3X-BT2.2.4)
2	Sampling Interval	15 seconds
3	Sampling software	Actilife version 6.11.4
4	Time of Wearing Per Day	≥ 600 minutes
5	Days of Wearing	7 days (from Monday to Sunday)
6	Different cut-point of Intensity	Butte preschoolers VM(2013)
		LPA [819, 3907)
		MPA [3907, 6111)
		VPA [6112, +∞)
Notes: LPA means light physical activity;MPA means moderate physical activity;VPA means vigorous physical activity.		

The level of physical fitness was assessed by Chinese National Fitness Test Standard for Children(referred to as CAFTC). Specifically, the CAFTC consists of a10 meter shuttle run, jump with both feet, standing long jump, throw for distance, balance beam and sit-and-reach,and to assess the level of physical fitness. In order to ensure objectivity, all measurements were carried out in strict accordance with regulations and were blindly performed by two observers for each experiment under the same conditions. Every item took at least one practice measurement and two formal measurements, and the best out of two formal tests was taken as the final result.

2.3 Statistical analysis

First, descriptive statistics were used to describe the age, sex, physical fitness, physical activity, and motor skills characteristics of the children. Second, in order to verify model, we use the standard percentage assignment method to deal with the test results dimensionless, that is, excellent (more than 90%), good (90% – 75%), general (75% – 25%), poor (25% – 10%) and very poor (less than 10%) are assigned to 5, 4, 3, 2 and 1 respectively. Through the above processing, effectively avoid the differences of the dimensions of each index, and improve the efficiency of statistical processing. Third, the Shapiro-Wilk test was wanted to judge whether data from samples was normally distributed. If normally distributed, we verified the model by using maximum likelihood methods with AMOS 24.0 software. If not, the generalized least square test was used. Fourth, we used path standardized coefficients to determine each index weight, and established the evaluation index system. Finally, the bootstrap percentile method was used to determine differences in frequencies of PAIP(at the significant level of $P < 0.05$), this is, we categorized the index as excellent(score greater than 90th percentile), good(score between 70th to 90th percentile), medium (score between 30th to 70th percentile), poor(score between 10th to 30th percentile) and very poor(score less than 10th percentile).

3 Results

3.1 Research context

On the basis of the relevant domestic and foreign literature research and the results of qualitative interviews, to integrate of Physical fitness, physical activity and motor skills, we developed the physical activity index of preschooler, and it was a health-related new indicator. Based on this background, our proposed hypothesized model illustrating causal paths linking physical fitness, physical activity and motor skills with the physical activity index of preschooler (PAIP), and the model is shown in Fig. 1. This model will be to the union of the results tested by these three indexes was taken to give a comprehensive evaluation system.

For the validation of the hypothesized model, we recruited twenty data collectors, and ten men and ten women. Meanwhile, to ensure data quality, the data collectors were trained by the principal investigators for one day on October 7, 2019. And then, The test was conducted from October 14 to November 15 2019, 1 week after the trained. On the basis of this, 20 data collectors, who were assigned to test work in 5 kindergartens, were involved. Among them, test teams in each kindergarten comprised of one team leader and three data collectors. Upon completion of data collection, data was coded and entered into SPSS24.0, and was used to establish the raw database. And then descriptive statistical analysis including frequencies was used to present the sample characteristics. Characteristics of all samples are shown in Table 3 and Table 4.

Table 3
Characteristics of Participating Boys

Index	Test items	Age interval(M \pm SD)				The annual rate of change(%)		
		[3.0, 4.0)	[4.0, 5.0)	[5.0, 6.0)	[6.0, 7.0)	3– 4 years	4– 5 years	5– 6 years
PF	10 meter shuttle run(seconds)	8.14 \pm 1.81	7.64 \pm 1.37	6.6 \pm 1.24	6.13 \pm 0.80	106.54	115.76	107.67
	jump with both feet(seconds)	6.83 \pm 2.74	6.12 \pm 2.58	4.50 \pm 1.49	4.33 \pm 0.77	111.60	136.00	103.93
	standing long jump(cm)	68.07 \pm 12.19	84.07 \pm 11.15	104.27 \pm 14.82	115.21 \pm 15.27	123.51	124.03	110.49
	throw for distance(m)	3.82 \pm 1.28	4.90 \pm 1.82	6.95 \pm 2.18	7.95 \pm 2.41	128.27	141.84	114.39
	balance beam(seconds)	9.05 \pm 3.44	6.75 \pm 3.27	4.14 \pm 1.42	2.95 \pm 1.07	134.07	163.04	140.34
	sit-and-reach(cm)	12.76 \pm 3.23	11.73 \pm 4.64	11.01 \pm 3.66	10.23 \pm 4.79	91.93	93.86	92.92
MS	run(score)	5.31 \pm 2.04	6.71 \pm 1.74	7.12 \pm 1.68	6.89 \pm 1.40	126.37	106.11	96.77
	gallop(score)	1.93 \pm 1.81	3.13 \pm 2.21	3.83 \pm 2.16	4.79 \pm 1.35	162.18	122.36	125.07
	hop(score)	1.91 \pm 2.10	3.75 \pm 1.72	4.27 \pm 1.78	5.19 \pm 1.58	196.34	113.87	121.55
	horizontal jump(score)	3.81 \pm 1.42	4.86 \pm 2.12	4.99 \pm 2.37	5.31 \pm 1.98	127.56	102.67	106.41
	slide(score)	4.13 \pm 2.60	4.89 \pm 2.58	5.52 \pm 2.65	5.77 \pm 1.97	118.40	112.88	104.53
	skip(score)	4.85 \pm 3.23	6.39 \pm 2.27	7.35 \pm 1.78	7.73 \pm 1.06	131.75	115.02	105.17
	locomotor skill(score)	21.72 \pm 5.56	28.73 \pm 5.61	34.95 \pm 5.24	38.67 \pm 3.89	132.27	121.65	110.64
	two-hand strike(score)	3.17 \pm 2.33	4.05 \pm 2.66	5.36 \pm 2.47	5.93 \pm 2.41	127.76	132.35	110.63
	one-hand forehand strike(score)	0.71 \pm 1.24	0.87 \pm 1.42	1.65 \pm 1.54	1.70 \pm 2.26	122.54	189.66	103.03

Notes: PF means physical fitness; MS means motor skills; PA means physical activity; LPA means light physical activity;MPA means moderate physical activity;VPA means vigorous physical activity.

	dribble(score)	0.82 ± 1.97	1.89 ± 2.03	3.33 ± 2.16	4.66 ± 2.06	230.49	176.19	139.94
	catch(score)	1.93 ± 1.30	2.95 ± 1.62	3.42 ± 1.58	3.93 ± 1.46	152.85	115.93	114.91
	kick(score)	3.07 ± 2.23	4.03 ± 2.06	5.37 ± 2.41	5.96 ± 2.44	131.27	133.25	110.99
	overhand throw(score)	2.25 ± 1.89	3.39 ± 2.31	4.41 ± 2.00	4.61 ± 2.39	150.67	130.09	104.54
	underhand throw(score)	1.66 ± 1.58	2.75 ± 1.76	3.32 ± 1.89	3.79 ± 2.08	165.66	120.73	114.16
	object control(score)	13.71 ± 5.87	19.97 ± 7.00	26.85 ± 6.33	30.55 ± 6.78	145.66	134.45	113.78
PA	LPA(minutes)	271.9 ± 31.5	278.5 ± 39.1	289.6 ± 36.5	309.5 ± 34.1	102.43	103.99	106.87
	MPA(minutes)	50.1 ± 10.5	56.3 ± 13.1	68.6 ± 12.2	75.9 ± 11.4	112.38	121.85	110.64
	VPA(minutes)	19.6 ± 9.8	25.1 ± 12.2	30.2 ± 11.4	33.5 ± 10.7	128.06	120.32	110.93
Notes: PF means physical fitness; MS means motor skills; PA means physical activity; LPA means light physical activity;MPA means moderate physical activity;VPA means vigorous physical activity.								

Table 4
Characteristics of Participating Girls

Index	Test items	Age interval(M \pm SD)				The annual rate of change(%)		
		[3.0, 4.0)	[4.0, 5.0)	[5.0, 6.0)	[6.0, 7.0)	3– 4 years	4– 5 years	5– 6 years
PF	10 meter shuttle run(seconds)	9.05 \pm 1.45	8.80 \pm 1.12	7.86 \pm 1.77	7.26 \pm 0.67	102.84	111.96	108.26
	jump with both feet(seconds)	9.46 \pm 2.33	6.42 \pm 2.23	4.71 \pm 0.79	4.60 \pm 0.70	147.35	136.31	102.39
	standing long jump(cm)	61.67 \pm 10.89	76.01 \pm 12.35	97.13 \pm 16.05	102.18 \pm 13.38	123.25	127.79	105.20
	throw for distance(m)	3.12 \pm 1.01	3.92 \pm 1.47	4.82 \pm 1.94	5.92 \pm 1.99	125.64	122.96	122.82
	balance beam(seconds)	11.28 \pm 3.71	6.43 \pm 3.33	4.18 \pm 1.21	3.07 \pm 1.09	175.43	153.83	136.16
	sit-and-reach(cm)	12.17 \pm 3.65	15.13 \pm 4.62	15.47 \pm 5.19	16.96 \pm 4.63	124.32	102.25	109.63
MS	run(score)	5.03 \pm 2.33	6.51 \pm 1.67	6.79 \pm 1.65	6.81 \pm 1.22	129.42	104.30	100.29
	gallop(score)	1.61 \pm 1.84	2.73 \pm 2.06	3.19 \pm 2.28	3.96 \pm 2.15	169.57	116.85	124.14
	hop(score)	1.67 \pm 2.05	3.19 \pm 2.13	4.09 \pm 1.91	5.14 \pm 2.12	191.02	128.21	125.67
	horizontal jump(score)	3.20 \pm 1.99	4.17 \pm 2.08	4.48 \pm 1.73	5.11 \pm 1.86	130.31	107.43	114.06
	slide(score)	2.95 \pm 2.83	4.48 \pm 2.83	5.06 \pm 2.50	5.45 \pm 2.81	151.86	112.95	107.71
	skip(score)	4.68 \pm 3.24	6.34 \pm 2.19	7.44 \pm 1.35	7.53 \pm 1.20	135.47	117.35	101.21
	locomotor skill(score)	20.46 \pm 6.28	26.91 \pm 5.36	31.05 \pm 4.24	32.99 \pm 4.14	131.52	115.38	106.25
	two-hand strike(score)	2.12 \pm 2.33	3.93 \pm 2.45	4.64 \pm 2.25	5.68 \pm 2.28	185.38	118.07	122.41
	one-hand forehand strike(score)	0.34 \pm 0.87	0.51 \pm 0.99	1.27 \pm 1.75	1.75 \pm 1.77	150.00	249.02	137.80

Notes: PF means physical fitness; MS means motor skills; PA means physical activity; LPA means light physical activity;MPA means moderate physical activity;VPA means vigorous physical activity.

	dribble(score)	0.78 ± 1.85	2.50 ± 2.13	3.87 ± 2.20	4.43 ± 1.88	320.51	154.80	114.47
	catch(score)	2.68 ± 1.63	2.67 ± 1.99	3.49 ± 1.60	4.23 ± 1.25	99.63	130.71	121.20
	kick(score)	2.12 ± 2.13	3.63 ± 2.25	4.41 ± 2.05	5.68 ± 2.18	171.23	121.49	128.80
	overhand throw(score)	1.71 ± 1.56	2.62 ± 1.62	3.79 ± 1.94	4.34 ± 1.81	153.22	144.66	114.51
	underhand throw(score)	1.23 ± 1.28	1.75 ± 1.69	2.57 ± 1.59	3.24 ± 1.72	142.28	146.86	126.07
	object control(score)	12.98 ± 5.96	17.93 ± 5.99	22.28 ± 6.47	24.35 ± 6.03	138.14	124.26	109.29
PA	LPA(minutes)	262.9 ± 36.0	270.2 ± 40.3	281.9 ± 38.1	293.0 ± 37.9	102.78	104.33	103.94
	MPA(minutes)	41.2 ± 10.9	49.8 ± 12.2	55.1 ± 11.5	66.0 ± 11.5	120.87	110.64	119.78
	VPA(minutes)	15.6 ± 6.0	19.6 ± 6.7	23.1 ± 6.3	26.4 ± 6.3	125.64	117.86	114.29
Notes: PF means physical fitness; MS means motor skills; PA means physical activity; LPA means light physical activity;MPA means moderate physical activity;VPA means vigorous physical activity.								

3.2 Age variation in PA, PF and MS among preschool boys

Table 3 presents PA characteristics, PF characteristics and MS characteristics of preschool boys in this study's sample. (1)The aspects of Physical fitness in boys. 10 meter shuttle run, jump with both feet, standing long jump, throw for distance, sit-and-reach and balance beam, designated as the most valid measure of the physical of health status(General Administration of Sport of China,2014). Among these items, besides the sit-and-reach, all of the other items increased with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was standing long jump, balance beam, throw for distance, jump with both feet and 10 meter shuttle run, and the average annual growth rate was135.51%, 134.07%, 128.27% and 111.60%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was balance beam, throw for distance, jump with both feet, standing long jump and 10 meter shuttle run, and the average annual growth rate was163.04%, 141.84%, 136.00%, 124.03% and 115.76%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was balance beam, throw for distance, standing long jump, 10 meter shuttle run and jump with both feet, and the average annual growth rate was140.34%, 114.39%, 110.49%, 107.67% and 103.93%, respectively. By comparison, the tested results of sit-and-reach decreased with age. From 3 to 4 years old, from 4 to 5 years old and from 5 to 6 years old, the average annual percent declines was91.93%, 93.86% and 92.92%, respectively. As evident from these data, preschool boys between the age of 3 and 6, standing long jump and jump

with both feet were to some degree representative lower extremity strength, and with a rapid growth begins at around 4 years of age. Throw for distance was to some degree representative upper extremity strength, and with a rapid growth begins at around 4 years of age. 10 meter shuttle run was to some degree representative speed and agility, and with a rapid growth begins at around 4 years of age. Balance beam was to some degree representative coordination, and with a rapid growth begins at around 4 years of age. However, sit-and-reach was to some degree representative flexibility, and with a rapid growth begins at around 4 years of age. As evident from these data, besides flexibility, the age of 3–6 is a critical period for the development of boys' physical fitness, such as strength, speed, balance, sensitivity and coordination. It can be seen that the critical period for boys' flexibility exercise intervention was the age of 3–6, and our preschool physical education teachers and school physical activity leaders should seize this critical period.

(2) The aspects of motor skills in boys. run, gallop, hop, horizontal jump, slide and skip, designated as the valid measure of the locomotor skill of status (Pauli, et al., 2017), and all of the items test scores increased with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was hop, gallop, skip, horizontal jump, run and slide, and the average annual growth rate was 196.34%, 162.18%, 131.75%, 127.56%, 126.37% and 118.40%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was gallop, skip, hop, slide, run and horizontal jump, and the average annual growth rate was 122.36%, 115.02%, 113.87%, 112.88%, 106.11% and 102.67%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was gallop, hop, horizontal jump, skip, slide and run, and the average annual growth rate was 125.07%, 121.55%, 106.41%, 105.17%, 104.53% and 96.77%, respectively. As evident from these data, the scores of run, gallop, hop, horizontal jump, slide and skip had an overall the average annual growth rate of over 100.00% from 3 to 6 years old, with the highest growth rate at boy age 3–4. Thus it can be seen that the locomotor skill experienced a rapid growth at the stages in from 3 to 4 years old. Meanwhile, two-hand strike, one-hand forehand strike, dribble, catch, kick, overhand throw and underhand throw, designated as the valid measure of the object control of status, and all of the items test scores increased with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was dribble, underhand throw, catch, overhand throw, kick, two-hand strike and one-hand forehand strike, and the average annual growth rate was 230.49%, 165.66%, 152.85%, 150.67%, 131.27%, 127.76% and 122.54%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was one-hand forehand strike, dribble, kick, two-hand strike, overhand throw, underhand throw and catch, and the average annual growth rate was 189.66%, 176.19%, 133.25%, 132.35%, 130.09%, 120.73% and 115.93%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was dribble, catch, overhand throw, kick, two-hand strike, overhand throw and one-hand forehand strike, and the average annual growth rate was 139.94%, 114.91%, 114.16%, 110.99%, 110.63%, 104.54% and 103.03%, respectively. As evident from these data, the scores of items overall the average annual growth rate of over 100.00% from 3 to 6 years old, with the highest growth rate at boy age 3–4. Thus it can be seen that the object control experienced a rapid growth at the stages in from 3 to 4 years old.

(3) The aspects of physical activity in boys. LPA, MPA and VPA are three kinds of daily activities. These three activities constitute the physical activities of boys in the day, which can be said to provide more comprehensive feedback on the physical health level of boys (Biddle, et al., 2004). Among the three physical activities, MVPA and VPA had a greater effect on health promotion than LPA (Leppänen, et al., 2016&2017), with an annual growth rate of 114.96% and 119.77% was respectively. From these data, it can be concluded that LPA will increase with age, while MVPA and VPA will decrease with age. Taking this result into consideration, the conclusion that MVPA is beneficial to the physical and mental health of young children (Gordon et al., 2013). We can boldly infer that the decline in the physical health of adolescents is due to insufficient daily MVPA in preschool children. This reminds the kindergarten sports teachers or managers to strengthen the MVAP arrangement of preschool boys, and reasonably set the sports methods and game activities that can reflect the behavior of MVAP.

3.3 Age variation in PA, PF and MS among preschool girls

Table 3 presents PA characteristics, PF characteristics and MS characteristics of preschool girls in this study's sample. (1) The aspects of Physical fitness in boys. 10 meter shuttle run, jump with both feet, standing long jump, throw for distance, sit-and-reach and balance beam, designated as the most valid measure of the physical of health status (General Administration of Sport of China, 2014). Among these items, all of items increased with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was balance beam, jump with both feet, throw for distance, sit-and-reach, standing long jump and 10 meter shuttle run, and the average annual growth rate was 175.43%, 147.35%, 125.64%, 124.32% and 102.84%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was balance beam, jump with both feet, standing long jump, throw for distance, 10 meter shuttle run and sit-and-reach, and the average annual growth rate was 153.83%, 136.31%, 127.79%, 122.96%, 111.96% and 102.25%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was balance beam, throw for distance, sit-and-reach, 10 meter shuttle run, standing long jump and jump with both feet, and the average annual growth rate was 136.16%, 122.82%, 109.63%, 108.26%, 105.20% and 102.39%, respectively. As evident from these data, preschool girls between the ages of 3 and 6, standing long jump and jump with both feet, which were to some degree representative lower extremity strength, and with a rapid growth begins at around 4 years of age. Throw for distance was to some degree representative upper extremity strength, and with a rapid growth begins at around 4 years of age. 10 meter shuttle run was to some degree representative speed and agility, and with a rapid growth begins at around 4 years of age. Balance beam was to some degree representative coordination, and with a rapid growth begins at around 4 years of age. However, sit-and-reach was to some degree representative flexibility, and with a rapid growth begins at around 4 years of age. As evident from these data, besides flexibility, the age of 3–6 is a critical period for the development of girls' physical fitness, such as strength, speed, balance, sensitivity and coordination.

(2) The aspects of motor skills in girls. Run, gallop, hop, horizontal jump, slide and skip, designated as the valid measure of the locomotor skill of status (Pauli, et al., 2017), and all of the items test scores increased

with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was hop, gallop, slide, skip, horizontal jump and run, and the average annual growth rate was 191.02%, 169.57%, 151.86%, 135.47%, 130.31% and 129.42%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was hop, skip, gallop, slide, horizontal jump and run, and the average annual growth rate was 128.21%, 117.35%, 116.85%, 112.95%, 107.43% and 104.30%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was hop, gallop, horizontal jump, slide, skip and run, and the average annual growth rate was 125.67%, 124.14%, 114.06%, 107.71%, 101.21% and 100.29%, respectively. As evident from these data, the scores of run, gallop, hop, horizontal jump, slide and skip had an overall the average annual growth rate of over 100.00% from 3 to 6 years old, with the highest growth rate at boy age 3–4. Thus it can be seen that the locomotor skill experienced a rapid growth at the stages in from 3 to 4 years old. Meanwhile, two-hand strike, one-hand forehand strike, dribble, catch, kick, overhand throw and underhand throw, designated as the valid measure of the object control of status, and all of the items test scores increased with age. Further analysis of these items test scores showed that from 3 to 4 years old, the ranking in the annual rate of change from highest to lowest was dribble, two-hand strike, kick, overhand throw, one-hand forehand strike, underhand throw and catch, and the average annual growth rate was 320.55%, 185.38%, 171.23%, 153.22%, 150.00%, 142.28% and 99.63%, respectively. From 4 to 5 years old, the ranking in the annual rate of change from highest to lowest was one-hand forehand strike, dribble, underhand throw, overhand throw, catch, kick and two-hand strike, and the average annual growth rate was 249.02%, 154.80%, 146.86%, 144.66%, 130.71%, 121.49% and 118.07%, respectively. From 5 to 6 years old, the ranking in the annual rate of change from highest to lowest was one-hand forehand strike, kick, underhand throw, two-hand strike, catch, overhand throw and dribble, and the average annual growth rate was 237.80%, 165.66%, 128.80%, 126.07%, 121.20%, 114.51% and 114.47%, respectively. As evident from these data, the scores of items overall the average annual growth rate of over 100.00% from 3 to 6 years old, with the highest growth rate at girl age 3–4. Thus it can be seen that the object control experienced a rapid growth at the stages in from 3 to 4 years old.

(3) The aspects of physical activity in girls. LPA, MPA and VPA are three kinds of daily activities. These three activities constitute the physical activities of girls in the day, which can be said to provide more comprehensive feedback on the physical health level of girls. Among the three physical activities, MVPA and VPA had a greater effect on health promotion than LPA (Leppänen, et al., 2016&2017), with an annual growth rate of 117.10% and 119.26% was respectively. From these data, it can be concluded that LPA will increase with age, while MVPA and VPA will decrease with age. Taking this result into consideration, the conclusion that MVPA is beneficial to the physical and mental health of young children (Gordon et al., 2013). We can boldly infer that the decline in the physical health of adolescents is due to insufficient daily MVPA in preschool children. This reminds the kindergarten sports teachers or managers to strengthen the MVAP arrangement of preschool girls, and reasonably set the sports methods and game activities that can reflect the behavior of MVAP.

4 Discussion

4.1 Verification of the hypothesis model of physical activity index of preschooler

According to the research background, the premise of the construction of the evaluation system is to assume that the verification of the PAIP model is established. Therefore, based on the database of boys and girls, amos24.0 software and ML method are used for path analysis. The results are shown in Fig. 2, and outside and inside of brackets are the results of male and female verification respectively. It can be seen from Fig. 2: After the path analysis by the AMOS software, the standardized path coefficient does not appear to be greater than 1, indicating that the verification is good, the parameter adaptation solution value is appropriate, and the model is established; that is: the assumed structural model of the PAIP theory is established and can reflect the internal structured characteristics of physical performance index of pre-school boys and girls. Further from the details: (1) For boys, in the four dimensions of PA, PF, LS and OC, the path coefficient is 0.45, 0.71, 0.64 and 0.62, respectively. After the conversion of the contribution rate, the percentage of PA, PF, LS and OC in the body movement ability index of boys was 18.59%, 29.34%, 26.45% and 25.62%, respectively. It is not difficult to find out from these data that the cumulative contribution rate of the boy's movement skill level to his body movement ability index is as high as 52.07%. It shows that the mastery or reserve of motor skill has greater benefits than physical quality and physical activity in promoting the boy's physical health. (2) For girls, in the four dimensions of PA, PF, LS and OC, the path coefficient is 0.46, 0.59, 0.73 and 0.63, respectively. Similarly, after the conversion of the contribution rate, the percentage of PA, PF, LS and OC in the body movement ability index of girls was 19.09%, 24.48%, 30.29% and 26.14%, respectively. It is not difficult to find out from these data that the cumulative contribution rate of the girl's movement skill level to his body movement ability index is as high as 56.43%. It shows that the mastery or reserve of motor skill has greater benefits than physical quality and physical activity in promoting the girl's physical health.

Based on the above analysis, PAIP assumes the establishment of a theoretical model. On one hand, it supports the construction of our next evaluation system; on the other hand, it reveals the effect of physical activity, motor skills and physical fitness on physical health. That is to say, motor skills have greater benefits to the promotion of physical health of preschool children. This suggests that kindergarten people should put the quantity and quality of children's motor skills in the first place.

4.2 Evaluation system of physical activity index of preschooler

Based on the path coefficient in the theoretical structure model of PAIP, the standardized conversion

formula(
$$W_{ij} = \frac{X_{ij}}{\sum_{i=1}^n X_{ij}}$$
) is used (Du, et al., 2015). Determine the weight of each index, and construct

the evaluation system based on the weight value, as shown in Table 5. Table 5 shows that the evaluation index system of physical movement ability index of preschool children, which consists of 4 first level indexes and 22 second level indexes. The system is constructed on the basis of PAIP theoretical model. Its biggest innovation lies in: this self-assessment system integrates the index of physical activity, physical fitness and motor skills to comprehensively examine the physical and athletic ability level of preschool boys and girls, so as to judge the future development of their physical health for kindergarten Managers, teachers and children's parents, etc., make timely interventions in physical activities. At the same time, the system's biggest breakthrough is reflected in: The overall joint evaluation is better than the previous physical fitness and physical activity, physical activity and motor skills, physical fitness and motor skills are related to each other rather than structured evaluation paradigm. And the results obtained by the joint evaluation are more comprehensive, scientific and reasonable than the related unstructured evaluation, which shows the structural characteristics of the system. In addition, from the weighting coefficients in this system, the calculation formula of physical activity index of preschool children can be obtained:

Table 5
index system of physical activity index of preschool children

Content	First-level indicators	Weight		Second-level indicators	Weight	
		Boy	Girl		Boy	Girl
PAIP-X	Physical Activity-X1	0.19	0.19	LPA-X11	0.37	0.39
				MPA-X12	0.32	0.31
				VPA-X13	0.31	0.30
	Physical Fitness-X2	0.29	0.25	10 meter shuttle run-X21	0.17	0.18
				jump with both feet-X22	0.16	0.13
				standing long jump-X23	0.17	0.18
				throw for distance- X24	0.17	0.17
				balance beam- X25	0.18	0.17
				sit-and-reach- X26	0.15	0.17
	Locomotor Skill-X3	0.26	0.30	run-X31	0.16	0.16
				gallop-X32	0.17	0.17
				hop-X33	0.17	0.17
				horizontal jump-X34	0.16	0.16
				slide-X35	0.17	0.17
				skip-X36	0.17	0.17
	Object Control Skill-X4	0.26	0.26	two-hand strike-X41	0.20	0.20
				one-hand forehand strike-X42	0.10	0.10
				dribble-X43	0.14	0.15
				catch-X44	0.12	0.09
				kick-X45	0.20	0.20
				overhand throw-X46	0.13	0.14
				underhand throw-X47	0.11	0.12

(1) Boy's calculation formula:

$$\begin{aligned}
PAIP &= 0.19X_1 + 0.29X_2 + 0.26X_3 + 0.26X_4 \\
&= 0.19(0.37X_{11} + 0.32X_{12} + 0.31X_{13}) \\
&\quad + 0.29(0.17X_{21} + 0.16X_{22} + 0.17X_{23} + 0.17X_{24} + 0.18X_{25} + 0.15X_{26}) \\
&\quad + 0.26(0.16X_{31} + 0.17X_{32} + 0.17X_{33} + 0.16X_{34} + 0.17X_{35} + 0.17X_{36}) \\
&\quad + 0.26(0.20X_{41} + 0.10X_{42} + 0.14X_{43} + 0.12X_{44} + 0.20X_{45} + 0.13X_{46} + 0.11X_{47})
\end{aligned}$$

(1) Girl's calculation formula:

$$\begin{aligned}
PAIP &= 0.19X_1 + 0.25X_2 + 0.30X_3 + 0.26X_4 \\
&= 0.19(0.39X_{11} + 0.31X_{12} + 0.30X_{13}) \\
&\quad + 0.25(0.18X_{21} + 0.13X_{22} + 0.18X_{23} + 0.17X_{24} + 0.17X_{25} + 0.17X_{26}) \\
&\quad + 0.30(0.16X_{31} + 0.17X_{32} + 0.17X_{33} + 0.16X_{34} + 0.17X_{35} + 0.17X_{36}) \\
&\quad + 0.26(0.20X_{41} + 0.10X_{42} + 0.15X_{43} + 0.09X_{44} + 0.20X_{45} + 0.14X_{46} + 0.12X_{47})
\end{aligned}$$

4.3 Development of Grade Standards for the Evaluation of Physical Activity Index of Preschooler

The database of boys and girls was substituted into the calculation formula of boys and girls respectively, and the scores of each index were calculated. Import spss24.0 for description Frequency processing in statistics module, that is, percentile method is used to evaluate the data series composed of index scores of all dimensions in five grades of excellent (10%), good (20%), medium (40%), weak (20%) and poor (10%). The self-evaluation range is obtained, and a five grade evaluation table of PAIP of preschool boys and girls is established (see Table 6). The five-level threshold range for PAIP index assessment of preschool boys and girls presented in Table 6 can be well given to kindergarten teachers, parents, etc., to understand the development of children's athletic ability in a timely manner, and provide corresponding information on their physical health in accordance with.

Table 6
Evaluation Criteria of PAIP

Category	Age Range	Excellent	Good	Medium	Weak	Poor
Boy	[3,4)	$[+\infty, 32.66)$	$(32.66, 31.75]$	$(31.75, 30.67]$	$(30.67, 29.60]$	$(29.60, 0]$
	[4,5)	$[+\infty, 39.26)$	$(39.26, 35.76]$	$(35.76, 32.62]$	$(32.62, 30.44]$	$(30.44, 0]$
	[5,6)	$[+\infty, 40.08)$	$(40.08, 37.56]$	$(37.56, 34.12]$	$(34.12, 32.23]$	$(32.23, 0]$
	[6,7)	$[+\infty, 43.15)$	$(43.15, 40.78]$	$(40.78, 37.35]$	$(37.35, 35.30]$	$(35.30, 0]$
Girl	[3,4)	$[+\infty, 33.40)$	$(33.40, 31.09]$	$(31.09, 28.30]$	$(28.30, 26.49]$	$(26.49, 0]$
	[4,5)	$[+\infty, 35.91)$	$(35.91, 33.65]$	$(33.65, 30.23]$	$(30.23, 27.93]$	$(27.93, 0]$
	[5,6)	$[+\infty, 37.81)$	$(37.81, 35.57]$	$(35.57, 32.45]$	$(32.45, 30.26]$	$(30.26, 0]$
	[6,7)	$[+\infty, 39.67)$	$(39.67, 37.23]$	$(37.23, 33.76]$	$(33.76, 33.01]$	$(33.01, 0]$

5 Conclusion

The age range from 3 to 5 years old is an important period for the rapid development of physical quality of boys and girls, such as strength, speed, endurance, coordination, sensitivity and balance. At the same time, the age range of 3–4 years old is the sensitive period of high-speed improvement of migration skills and manipulation skills for boys and girls. Secondly, LPA of boys and girls will increase with age, while MPA and VPA will decrease with age. In addition, the theoretical model of the index structure of physical ability Index of preschooler is established, and the PAIP theoretical structure model suggests that kindergarten managers or physical education teachers should give top priority to the multi-directional development and mastery of preschool children's motor skills. Finally, the evaluation index system and reference rating standards for physical activity index of preschool children were developed, and it provides an operative way for kindergarten managers, kindergarten teachers, etc. to evaluate the sports ability level of pre-school boys and girls and look forward to their physical health development.

Declarations

Ethics approval and consent to participate

Local ethics committee approval, parental/legal guardian consent, and child assent were obtained in all studies. Consent to participate outlined in the main methods section.

Consent for publication

Not applicable.

Availability of data and material

The datasets during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was supported by a National Social Science Fund Project Youth Study (19CTY018). Meanwhile, WANG Tingting was supported by a Jiangxi Provincial Teaching Science “The 13th Five-Year Plan” Project.

Authors' contributions

All authors contributed equally to this study. The first author conceptualized and designed the study, did analyses, drafted the initial manuscript, and reviewed and revised the manuscript. The second author was involved in drafting the manuscript and critically revising its intellectual content. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

Acknowledgements

None.

References

1. Barnett LM, Morgan PJ, Beurden EV, et al. Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *Int J Behav Nutr Phys Act.* 2008;5(1):40. <https://doi.org/10.1186/1479-5868-5-40>.
2. Butte NF, Wong WW, Lee JS, et al. Prediction of energy expenditure and physical activity in preschoolers.[J]. *Med Sci Sports Exerc.* 2013;46(6):1216–26. <https://doi.org/10.1249/MSS.0000000000000209>.
3. Biddle SJ, Gorely T, Stensel DJ. Health-enhancing physical activity and sedentary behaviour in children and adolescents. *J Sports Sci.* 2004;22(8):679–701. <https://doi.org/10.1080/02640410410001712412>.

4. Carl P. Gabbard, Pearson. (2010). Lifelong motor development: Pearson New International Edition. *Neurosci Lett*, 473(473), 141–5. <https://doi.org/10.1016/j.neulet.2010.02.040>.
5. Cureton TK, Huffman WJ, Welser L, Latham KDE(1945). Endurance of young men: analysis of endurance exercises and methods of evaluating motor fitness. *Monogr Soc Res Child Dev*, 10(1), i + iii-v + vii-xxiii + 1-267 + 269–284. <https://doi.org/10.2307/1165553>.
6. Du Dong P, Qinghua Wu Yan. Modern Comprehensive Evaluation Methods and Case Selection [M]. Beijing: Tsinghua University Press; 2015.
7. General Administration of Sport
National Constitution Monitoring Bulletin[EB
General Administration of Sport. 2014 National Constitution Monitoring Bulletin[EB/OL].2020-3-15.<http://www.sport.gov.cn/n315/n329/c216784/content.html>.
8. Gordon ES, Tucker P, Burke SM, Carron AV. Effectiveness of physical activity interventions for preschoolers: a meta-analysis. *Research Quarterly for Exercise Sport*. 2013;84(3):287–94. <https://doi.org/10.1080/02701367.2013.813894>.
9. 10.1038/ijo.2016.54
Leppänen MH, Delisle Nyström C, Henriksson P, Pomeroy J, Ruiz JR, Ortega FB, Cadenas-Sanchez C, Löf M. (2016). Physical activity intensity, sedentary behavior, body composition and physical fitness in 4-year-old children: results from the ministop trial. *International Journal of Obesity*, 2016, 40(7):1126–1133. <https://doi.org/10.1038/ijo.2016.54>.
10. Leppänen MH, Henriksson P, Delisle Nyström C, Henriksson H, Ortega FB, Pomeroy J, Ruiz JR, Cadenas-Sanchez C, Löf M. Longitudinal physical activity, body composition, and physical fitness in preschoolers. *Med Sci Sports Exerc*. 2017;49(10):49(10). <https://doi.org/10.1249/MSS.0000000000001313>. 2078–2085.
11. Jing LI, Yucui DIAO, Mengmeng SUN, Wenjuan PAN. Relationship between Fundamental Movement Skills and Physical Fitness of Children Aged 3 to 5. *China Sport Science Technology*. 2019;55(06):52–8. <https://doi.org/10.16470/j.csst.2019017>.
12. Organization WH,. Ottawa charter for health Promotion[C].Health & Welfare Canada/canadian Public Health Association,1986.
13. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest*. 2008;60(2):290–306. <https://doi.org/10.1080/00336297.2008.10483582>.
14. Seefeldt, Michael F(1979).The luscher color test: sex differences in color preference. *Perceptual Motor Skills*, 48(3), 896–8. <https://doi.org/10.2466/pms.1979.48.3.896>.
15. Vlahov E, Baghurst TM, Mwavita M. (2014). Preschool motor development predicting high school health-related physical fitness: a prospective study. *Perceptual Motor Skills*, 119(1):279–91. <https://doi.org/10.2466/10.25.PMS.119c16z8>.
16. Huan WANG, Shuiqing HU, Yichen LI, ZHENG Yingdong.(2019). Canonical Correlation of Motor Skills and Physical Fitness in Preschool Children. *China Sport Science Technology*, 55(06):46–51.

Figures

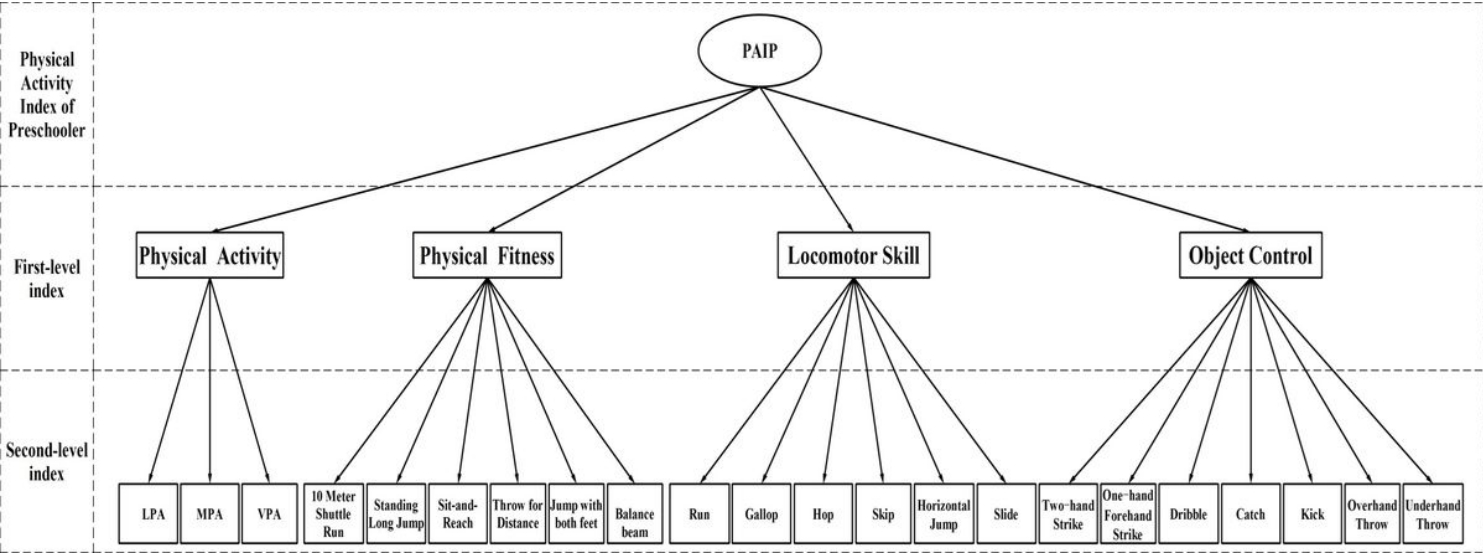


Figure 1

PAIP Hypothesis Model

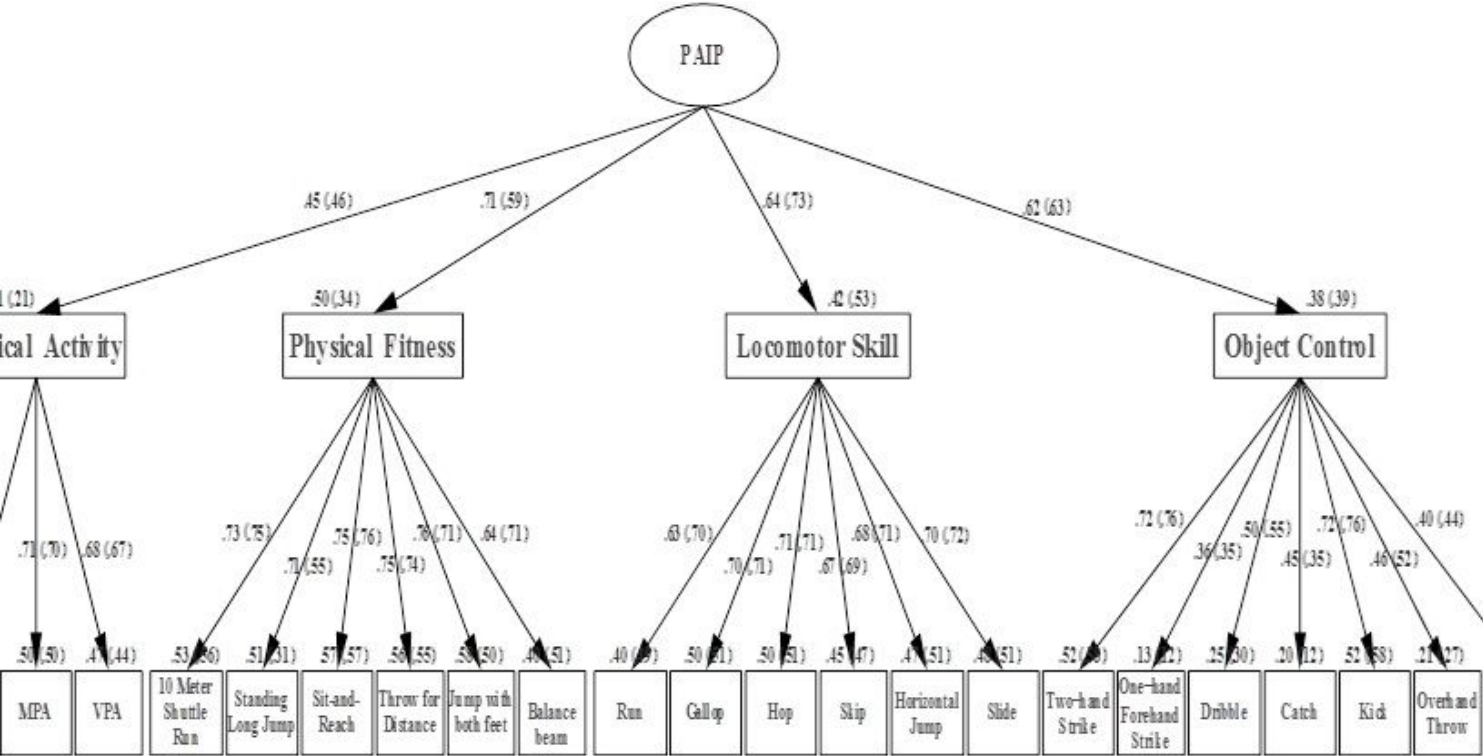


Figure 2

PAIP Theoretical Model Verification