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Determination of the basic motor skills and its relationship to BMI and physical activity level in preschooler

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ABSTRACT

It has been widely accepted that physical activity has a positive effect on and to contributes physical and mental health in every period of human life, especially on the development of children in early age. The basic movement skills acquired through education during this period will shape the necessary infrastructure of the child that will serve as the motor development for adulthood. Inappropriate basic movement skills in childhood results in sedentary life style which may increase the risk of certain health problems such as obesity. The aim of the study was to assess the basic motor skill development in preschool children and determine its relationship to BMI and physical activity level. A total of 1041 children (554 boys and 487 girls) aged between 4-6 years old were assessed for their basic motor skills, BMI and physical activity level. Basic motor skills were evaluated as locomotor and object oriented skills by using TGMD-2, whereas physical activity level was identified by scale. The classification for obesity was performed by using BMI which was calculated according to weight and height by using the method developed by Neyzi according to WHO. Descriptive statistic of categorical data was demonstrated as frequencies and percentages, whereas continuous variables were presented as mean ± standard deviation. Relationship was determined by using Pearson Correlation Coeeficient test at a significance level of α = .05. The mean BMI of 1041 children (with the mean age of 5.20 ± 0.45 (4-6) years) was determined as 15.70 ± 2.17 m^2/kg and the BMI percentile was 48.28 ± 29.76. Only 78.5% of the children were classified as normal weight, whereas 8.3% of the children were obese, 7.3% of them were overweight and 6% of the children were underweight. Locomotor skill scores were higher compared to oriented control motor skills, 56.26 and 45.97% respectively. Pearson Correlation Coefficient test results showed that BMI in both normal and overweight groups were correlated significantly to locomotor skills and to object oriented skills, whereas obese and underweight groups did not show any significant correlation neither to locomotor, nor to object oriented skills. Physical activity level of the the children were lower than the expected values for all items in the scale, and frequency of running (55.2%) was determined to be the highest among all activities for 7 days. Considering TGMD-2 scores, physical activity levels and BMI of preschool children, it can be concluded that physical activity preferences of children play an important role in basic motor development and is related to BMI in preschool children aged between 4-6 years in both boys and girls. Thus basic motor skills should be constructed by planned activities involving all components of motor development which can not be obtained naturally by increasing only the physical activity level in early ages.

Keywords: Early childhood, BMI, obesity, TGMD-2, physical activity level.

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INTRODUCTION

The incline in sedentary life style as a result of increased working hours spent in sitting position in many business lines reduces the physical activity of individuals. Increasing sedentary life play an important role in health

problems caused by physical activation deficiency (Bulut, 2013). It has been widely accepted that physical activity has a positive effect on contributes physical and mental health in every period of human life, especially on the development of children on early age (Edwards and Tsouros, 2006).

Preschool period constitutes the first step of education and serves as a period for creating a strong background for social, emotional, physical, language and cognitive development in children, thereby supporting also their holistic development. The basic movement skills acquired through education during this period will shape the necessary infrastructure of the child that will serve as the motor development for adulthood. Not only motor development, but also self-efficacy and self-confidence in addition to positive body perception have been gained during the childhood (Fisher et al., 2005; Olrich, 2002).

Basic motor skills should be taught actively to children and not to be assumed to be gained as a natural process by the child itself during growth and development. During the teaching process, the environment needs to be created to give the child the opportunity for practising the correct technique and thereby supporting the child with enough ammount of feedback to improve and refine the learned skills (Mukherjee et al., 2017). It has been determined that children with insufficient basic motor skill levels (Gallahue and Ozmun, 2006) are less likely to be motivated and unwilling to participate in sports activities in their adult life (Butcher and Eaton, 1989). Thus, inappropriate basic movement skills in childhood cause sedentary life style which may increase the risk of certain health problems in adulthood (Lopes et al., 2012).

School-based physical education programs play an important role in the development of basic movement skills (Okely and Booth, 2004). The importance of making appropriate applications for the development of the child during the lessons has been emphasized with several valuable studies in literature (Martin et al., 2009; Robinson et al., 2009; Valentini and Rudisill, 2004; Valentini et al., 1999). Developmental characteristics of the child ought to be taken into account by teachers while planning their lessons and level of maturity need to be considered as well. Moreover, the teachers are encouraged to apply new teaching techniques such as auditory, visual and kinesthetic in order to fullfill requriements of students learning needs (Sze, 2009). Diverse needs of learners in the educational environment can be supported with technological support and arrangements by using verbal and visual materials in addition to organizing the learning environment physically to support educational objectives (Bulca et al., 2020). Basic motor skills are defined as a series of basic movements and skills that provide the basic for achieving high order motor competency to maintain normal development, health and athletic excellence, involving a child's ability to use various body parts in an organized way (Gallague and Ozmun, 2006; Haywood and Getchell, 2003; Lloyd et al., 2015, Lloyd et al., 2016; Payne and Isaacs, 2012).

Basic motor skills are classified in two categories as the locomotor skills such as walking, running, jumping, sliding, jumping and jumping, and the manipulative/object oriented skills such throwing, catching, hitting, jumping, kicking, pulling and pushing that are needed for object orientation (Barnett et al., 2009; Burton and Miller, 1998; Cools et al., 2009). Both locomotor and object oriented skills, which develops predominantly in preschool years, are highly required during spesific movements in sport and complex skills used in sport and sport games (Cools et al., 2009; Stodden et al., 2008) and are therefore accepted to play a very important role in becoming an elite athlete or participating in a physically active lifestyle in adulthood (Lubans et al., 2010; Seefeldt et al., 1980).

Qualification in basic motor development during childhood plays a critical role in maintaining physical activity (Lubans et al., 2010; Logan et al., 2015), achieving a high physical fitness (Cattuzzo, 2016), developing more complex motor skills in older age (Robinson et al., 2015; Stodden et al., 2008) and thereby preventing obesity in adulthood (Barnett et al., 2016; D'Hondt et al., 2013; D'Hondt et al., 2014). Despite its great importance, it has been recognized that children are not able to gain basic motor skills at required level during early age because of the challenges that we are faced to in the 21st century and the accelerated change in daily life as a result of growing technology (Bryant et al., 2014; Erwin and Castelli, 2008; Hardy et al., 2013). Therefore, mutual interaction between biological and physiological statement of the child and the environment should be established such that it favors dynamic developmental perception and being active whenever possible throughout the day (Gabbard, 2009). This may prepare children to participate in a wide and complex set of physical activities that induce adaptive neuro-motor development for long duration and thereby develops basic motor skills continuously (Barnett et al., 2009; Williams et al., 2008).

Growth and development of an infant has been evaluated almost exclusively as motor development (Berk, 2012). However, as soon as a child can reach, grasp and walk, more attention has been paid to cognitive, social, and emotional development and related aspects, thus the development of complex movement skills is unlikely to be assessed definitely or correctly and has not been of interest. Motor development is mainly taken into account only when there some dysfunctions or inefficient movements has been recognized or behavioral problems of child has been noticed and observed (Davies, 2003).

The preschool education includes children aged between three to six years (Eurydice, 2002), which is a sensitive and important period for the development of basic motor development (Gallahue and Donnely, 2003). Since most preschool children are naturally curious, love

to play and explore, it is very effective and easy to develop basic motor skills during the preschool education (Cools et al., 2009; Robinson et al., 2015; Stodden et al., 2008) stated that there is a bidirectional interaction between basic motor skills and physical activity which in turn creates the relationship between the comprehension ability of high level motor skills and physical fitness in later sport activities (Cattuzzo, 2016). However, the importance of establishing basic motor skills and its relationship with physical activity level and BMI has not been studied extensively during preschool period (Robinson et al., 2015). The aim of the study was to determine the basic motor skills and its relationship to physical activity level and BMI in preschool children aged between 4 to 6 years old.

MATERIALS AND METHOD

Participants

A total of 1800 students (aged between 4 and 6 years) of kindergartens affiliated to the national education directorate were enrolled in the cross-sectional study after the official permission of Çorum Provincial Directorate of National Education and the approval of the study by the board of the ethical commitee of the Hitit University (2019-127 28.03.2019). A total of 1041 participants were included, 554 (53.2%) boys, 487 (46.8%) girls, after receiving the written consent signed by their families before measurements and assessment performed at the sport hall of Hitit University.

Measurements

Height and weight

Height of the participants was measured with a wall mounted stadiometer with 1 mm precision, while feet were bare and flat on the ground, heel was adjacent, knees were stretched and the dorsal part of the body touched the wall, taking care of the Frankfort plane. Body weight measurements of the participants were made bare feet and with light clothing on a scale with a sensitivity of 0.01 kg (Seca, Germany).

Body composition

BMI was firstly calculated according to the formula of dividing body weight by the length of the square (kg/m^2) described in detail elsewhere (NHLBI, 1998). Moreover, body composition was also analyzed by a dietician by using body composition analyzer (Tanita MC 780, Japan) and BMI percentiles of each child by age and gender were evaluated by a pediatric endocrinology medical doctor on the basis on the reference values acording to Neyzi standarts reference values (Neyzi et al., 2006) and classified according to the World Health Organization (WHO, 2006).

Physical activity scale

Determination of the physical activity level of students has been assessed with the Physical Activity Questionnaire that has been adapted to Turkish by Sert and Temel (2014) with an Cronbach alpha coefficient of .74 for internal consistency The 5-point Likert-type scale questionnaire consists of 9 questions that aim to measure the physical activity of the students in the last 7 days with no correct or wrong answers for questions. To the students, the form includes 21 activities such as football, gymnastics, skating, etc. which has been answeres that state the frequency of these activities such as “I have never done (1 point), 1-2 times (2 points), 3-4 times (3 points), 5-6 times (4 points), 7 times and above (5 points)”. The average score is calculated by dividing the total score by the number of activities. The ninth item is a table representing seven days of the week in which the student is asked to fill in the frequency of the activities performed last week by marking all 7 days. The total score obtained by the student is dividen by 7. The minimum score for each item in part 1 of the questionnaire is 1 and the maximum score is 5. The overall minimum score of the questionaire is 9, and the maximum score is 45. The level of physical activity is considered lower as it approaches 9, and the higher as it approaches 45 (Sert and Temel, 2014).

Test of gross motor development -2 (TGMD-2)

Basic motor skills were assessed by Test of Gross Motor Development -2 (TGMD-2) which was developed by Ulrich (2000) and adapted to Turkish by Boz and Aytar (2012). According to the adaptation of TGMD-2 to Turkish by Boz, the item “hitting a baseball” was excluded from the object control skill subtest as a result of its low validity which was found to be 0.19. For reliability of the scale, the Croanbach Alpha was found to be higher than 0.87. The re-test reliability was over 0.85 according to the variable age. According to the factor analysis, validity was measured for the factor loads of the items in the scale divided as locomotor and object oriented skill subscales.

Whereas the locomotor skill subscale evaluates the child's ability to run, gallop, jump, horizontal jump and slide, the object control motor skill subscale evaluates the ability to bounce, throw, hold, hit, and roll qualitatively. During data collection, children were recorded on video, and the three expert researchers evaluated the children by watching the video independently for analysis. The

evaluation reliability (> 90%) was determined by an independent expert. During the test, each skill was demonstrated clearly to the child before the two trials of the participant. If the child does not succeed and did not meet the criteria of the performance, it will be scored as zero, whereas each successful performance was scored as 1 point. Each skill contains three to five performance criteria, where locomotor has the total of 48 points and object control 38 points. Total scores were obtained by summation of subscale scores and convertion to normative percentile values spesific for age and gender and overall performance according to TGMD-2 guidelines (Boz and Aytar, 2012).

Statistical analysis

Statistical analysis was performed by using SPSS 22 software package (SPSS Inc., Chicago, IL, ABD). Normality of data was checked with Kolmogorov-Smirnov test. Descriptive statistics was presented as mean, standart deviation, median, min-max range; wheras categorical variables were presented as frequency and percentiles. Mann Whitney U test was used to determine the difference in TGMD - 2 scores between groups according to BMI at a significance level of $p < 0.05$. Pearson Correlation coeeficient was used to determine the relationship between BMI and TGMD-2 scores.

RESULTS

The mean age of the children was found as 5.20 ± 0.45 (4-6) years, BMI was 15.70 ± 2.17 (.00-29.83) m^2/kg and the BMI percentile was 48.28 ± 29.76 (.02-99.98). According to the classification performed by Neyzi and WHO scale, only 78.5 % of the children were evaluated in the normal development group, whereas 8.3% of the children were obese and 7.3% of them were classified as overweight. Moreover, it has been found that 6% of the children were underweight compared to their age matched peer (Table 1).

The TGMD-2 scores of preschool students were assessed and the total mean score was evaluated as 43.45 ± 3.91 (31 to 59) points out of the highest 86 points. The object oriented motor skill mean score was slightly lower than the locomotor skill mean score, 21.38 ± 2.01 (8-25) and 22.07 ± 3.23 (16 to 36) respectively (Table 1).

As expected, the frequency of running (55.2%) was determined to be the highest among all activities for 7 days, whereas the lowest frequency was determined for playing tennis/table tennis (1.4%). Moreover, results showed that the most prefered physical activities were running (55.2%), playing chess games (44.4%), dancing (24.7%), cycling (24.4%), playing bounce games like boom (21.7%) and traditional games like “My hand is on yours” (20.9%). On the other hand, children have never done activities like taekwondo, karate, judo (88.7%), playing tennis, table tennis (86%), skate boarding (85.1%), swimming (79.5%), skating (77.2%), playing volleyball (72.7%). None of the activities have been performed over 20% for at least 3-4 times a week, only two activities which are playing bounce games like boom (32.4%) and traditional games like “My hand is on yours” (34.2%) are performed 1-2 times a week. All results have been presented as number of students and percentage values according to their frquencies in detail in Table 2.

Table 1. Descriptive statistics of the cohort sample (n = 68).

	f (Per)	Mean ± SD (min-max)
Age		5.20 ± 0.45 (4-6)
Gender		
Girl	487(46.8%)	
Boy	554 (53.2%)	
Height (cm)		111.14 ± 5.96 (93.50-130.50)
Weight (kg)		19.67 ± 3.95 (10.9-42)
BMI (kg/cm^2)		15.70 ± 2.17 (.00-29.83)
BMI percentil		48.28 ± 29.67 (.02-99.98)
Weight status		
Obese	86 (8.3%)	
Overweight	76 (7.3%)	
Normal	817 (78.5%)	
Underweight	62 (6%)	
TGDM-2		43.45 ± 3.91 (31-59)
Locomotor		22.07 ± 3.23 (16-36)
Object control		21.38 ± 2.01 (8-25)

Table 2. Descriptive statistics of the physical activity level of preschool students.

	Never do	1-2 times do	3-4 times do	5-6 times do	7 and above times do
	f (Per)	f (Per)	f (Per)	f (Per)	f (Per)
Playing bounce games like boom	222 (21.3%)	337 (32.4%)	181 (17.4%)	75 (7.2%)	226 (21.7%)
Skating	804 (77.2%)	128 (12.3%)	33 (3.2%)	18 (1.7%)	58 (5.6%)
Traditional games (etc My hand on your)	194 (18.6%)	356 (34.2%)	154 (14.8%)	119 (11.4%)	218 (20.9%)
Playing chess games	39 (3.7%)	193 (18.5%)	172 (16.5%)	172 (16.5%)	462 (44.4%)
Walking for exercise	396 (38.1%)	256 (24.6%)	124 (11.9%)	97 (9.3%)	168 (16.1%)
Cycling	426 (40.9%)	204 (19.6%)	87 (8.4%)	70 (6.7%)	254 (24.4%)
Run	34 (3.3%)	148 (14.2%)	113 (10.9%)	171 (16.4%)	575 (55.2%)
Dancing	242 (23.3%)	229 (22%)	200 (19.2%)	113 (10.9%)	257 (24.7%)
Swim	828 (79.5%)	82 (7.9%)	30 (2.9%)	10 (1%)	90 (8.6%)
Playing football	503 (48.3%)	199 (19.1%)	110 (10.6%)	54 (5.2%)	175 (16.8%)
Playing folk dances	628 (6.3%)	181 (17.4%)	72 (6.9%)	58 (5.6%)	102 (9.8%)
Playing tennis, table tennis	891 (86%)	100 (9.6%)	20 (1.9%)	15 (1.4%)	15 (1.4%)
Skate boarding	886 (85.1%)	78 (7.5%)	30 (2.9%)	16 (1.5%)	31 (3%)
Playing volleyball	757 (72.7%)	148 (14.2%)	66 (6.3%)	27 (2.6%)	43 (4.1%)
Playing basketball	655 (62.5%)	197 (18.9%)	86 (8.3%)	29 (2.8%)	74 (7.1%)
Doing sports like taekwondo, karate, judo	923 (88.7%)	56 (5.4%)	13 (1.2%)	10 (1%)	39 (3.7%)
Scooters ride	602 (57.4%)	184 (17.7%)	72 (6.9%)	21 (2%)	163 (15.7%)
Doing gymnastics	597 (57.4%)	228 (21.9%)	107 (10.3%)	40 (3.8%)	69 (6.6%)
Playing with pets	453 (43.5%)	270 (25.9%)	77 (7.4%)	69 (6.6%)	172 (16.5%)
Jump on the trampoline	634 (60.9%)	184 (17.7%)	75 (7.2%)	37 (3.6%)	111 (10.7%)
Doing other sports, games or activities	226 (21.7%)	295 (28.3%)	203 (19.5%)	114 (11%)	203 (19.5%)

Table 3. The correlation of BMI and TGDM-2 scores in preschool students.

	TGDM-2					
	Locomotor			Object Control		
	Mean ± SD (min-max)	r	P	Mean±SD (min-max)	r	p
Obese	20.79 ± 2.51(16-27)	-.137	.208	17.55 ±1.58 (14-21)	-.175	.107
Overweight	21.54 ± 2.26 (17-27)	-.318	.005*	19.86 ± 2.06 (14-23)	.557	.000*
Normal	22.19 ± 3.33 (16-36)	-.081	.020*	21.89 ± 1.50 (8-25)	-.077	.027*
Underweight	22.85 ± 3.32 (20-32)	-.076	.555	21.94 ± 1.47 (18-25)	.088	.494

* Significant at $p < .05$

Pearson Correlation Coefficient test results showed that BMI in both normal and overweight groups were correlated significantly to locomotor skills and to object oriented skills, whereas whereas obese and underweight groups did not show any significant correlation neither to locomotor, nor to object oriented skills (Table 3).

DISCUSSION

It has been accepted that BMI is correlated to physical activity level during childhood; however, the importance of basic motor skills and its contribution to health during preschool has not been studied extensively in large samples. This is the first study in literature that has been focused on physical activity level, BMI and basic motor skills in a large preschool sample in both girls and boys aged between 4-6 years. The findings of the cross-sectional study primarly showed that basic motor skills are moderately correlated to BMI for children with normal weight and overweight, whereas obese or underwieght children had lower basic motor skills than theirage matched peers. Moreover, basic motor skills were under the normal reference values in almost all children, even in those who were determined to be physically active.

According to the results of the present study, 86 (8.3%) of 1041 children were obese, 76 (7.3%) were overweight, 817 (7.5%) were normal and 62 (6.0%) of them were underweight. The results are paralel with the risk of obesity among children in the world according to the

Figure 1. Early childhood obesity.

report in 2019 of WHO,

In comparison, in South Africa the proportion of 2-5 year olds who are obese is 4.7%. In Australia, the proportion of obese 2-4 year olds is 8.7%, and in the UK, the proportion obese 4-5 year olds is 9.6% of all children (Figure 1). In this limited comparison at least, countries in the global north show higher incidences of obesity in early childhood than the global south (NHS, 2016).

Not only obese, but also underweight children BMI did not show any correlation to basic motor skills, suggesting that basic motor skill development plays a critical role for health during preschool period in both girls and boys ged between 4-6 years. This result has been supported by previous literature suggesting a strong assocciation between competence in basic motor skills and health such as proper decreased risk of obesity and improved social and cognitive skills (Lubans et al., 2010; Leonard and Hill, 2014). Basic motor skills allows the child to interact with the social and physical environment and become crucial for running, engaging in complex physical interactions with peers on the playground and for throwing-catching balls in certain games. Thus, while growing up, motor and cognitive performances interact to perform executive functions (Diamond, 2000; Roebers and Kauer, 2009).

Although children mostly use a large variability of movements while playing, and participating in physical activities throughout their lifes (Gallahue and Ozmun, 2006), findings of the present study showed that this variability has been decreased, thus only few movements dominate the physical activities, especially in metropool cities. Playing tag and running were the most prefered physical activities among 1041 children, which may serve as practice primarly for locomotor skills. Moreover, half of the children also played hopscotch at least once, but merely more than three times a week which may improve jumping skills. However, results of the cross-sectional survey showed that almost all object oriented skills are poorly involved in physical activity types among preschoolers which in turn may result in inappropriate basic movement skill development, especially in obese and underweight children. This movement repertoire

develops as a result of a combination of many factors. Findings are paralel to literature that states that experience and practise play key role in learning and motor competences, and environmental or individual limitations are the very important factors (Haywood and Getchell, 2009). The limited opportunity of children for some basic skills in an insufficient environment may lead to poor skilled children can not perform all basic movent skills at certain level, but can perform only few of them properly (Goodway and Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999). Thus, it can be suggested that basic motor skill development needs a curriculumn with an appropriate planning of all basic movement skills included at a well-balanced equilibrium for practise and equiliinadequate forms of movement and movement repertoires will be limited unless an effective curriculum is implemented.

Scientists in the field of psychomotor agree that the motor skills of the child have improved significantly in the first eight years of life (Clark, 1994; Gallahue and Ozmun, 2006; Payne and Isaacs, 2007; Roberton, 1978; Williams, 1983). However, basic motor skills do not develop naturally; movements need to be refined and mature only through learning and practice (Gabbard, 2008; Haywood and Getchell, 2009; Newell, 1984). Basic motor skills of children in the present study were 43.45 ± 3.91 (31 to 59), which is quite below the highest score that is 86 in TGMD-2. Thus, it can be argued that almost all children have gained only 50.52% of the basic motor skills. Newell (1986) stated that the differences in motor development might be caused by environmental limitations and the different tasks performed by individuals. Considering TGMD-2 sub-group seperately in the present study, locomotor skill scores were higher compared to oriented control motor skills, 56.26 and 45.97% respectively. This seems reasonable and can be explained by physical activity preferences of children determined by the cross-sectional survey where locomotor skills are practised more frequently than object oriented skills in different games and physical activities.

Motor control is used to guide the perception and processing of the environment through interactions between the brain, body and environment (Smith, 2005). Thus, perceived motor competence can provide improved opportunities for developing motor skill development, as well as the development of various perceptual, social and cognitive skills, and may also be affected by these abilities in repetitive interactive cycles (Robinson et al., 2015; Robinson, 2011; Leonard, 2016; Smith and Thelen, 2003). Hence, planned lessons are needed to improve basic motor skills in preschools where physical education teachers are not available, video or animation based lessons can serve as educational materials for technology integrated education. A study proved that 15 minutes of spesific physical activity per day for 3 days by using animated physical activity videos was effective in teching basic motor skills in preschool children. Although Turkish and Bulgarian children had lower basic motor skills than their developmental stage at the beginning of the study, the children who practised certain movements with animated videos improved significantly, whereas children playing games and doing regular activities in the control group remained same after the 8 week technology assisted exercise program (Bulca et al., 2020). Not only physical development such as basic movement skills, coordination, physical fitness, body awareness, but also cognitive development such as problem solving, creativity, imagination, conceptual development in addition to emotional development such as positive self-development, self-knowledge, empathy, coping with problems, social competence, communication has been observed in a short period of time, since development rate is at highest during preschool period.

Taken all these together, the development of real and perceived motor skills, promoting physical activity in children has clinically meaningful and reasonable benefits. Thus basic motor skills might play an important role to obtain a healthy population and therefor should be actively tauched in preschool age. Based on information in literature (Morgan et al., 2013; Logan et al., 2012; Riethmuller et al., 2009), all aspects of basic motor skills should be considered while preparing curriculum for physical education in preschools.

The program should be well balanced in locomotor and object oriented skills with increasing in complexity according to age and growth (Robinson and Goodway, 2009). Attention should be paid to integrate technology for maintaining attractive and strong intervention programs for children and teachers, as effects may decrease over time due to loss of motivation or insufficient physical stimulus. To advance in the field, more theoretical studies should examine the components of effective intervention (length and intensity of sessions, timing, duration, content, context, with or without music, technology assisted interventions and gamification). Personalized tech assisted programs may be constructed according to students age, gender, BMI scores, physical activity competence and perceived motor, thereby without neglecting the possible effects of internal and external factors such as environmental characteristics and preschool teacher qualifications. Further detailed longituidinal multi-disciplinary studies are needed to expand the knowledge in this field.

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