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The effect of motor skill intervention on preschool aged children's ability to perform locomotor and object control skills

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The Effect of Motor Skill Intervention on Preschool Aged Children's Ability to Perform Locomotor and Object Control Skills

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Dedication Page

This work is dedicated to Gabriella Miller, whose life and commitment to childhood cancer research first instilled in me a desire to research ways to ensure a healthier future for children.

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Abstract

The development and proficiency of motor skills are a vital part of physical activity levels and overall health of children. Previous research has connected the level of physical activity participation in children to the amount of time spent physically active in adulthood[14]. The purpose of this study was to examine the effect of an object control and locomotor skill intervention on preschool-aged children's ability to produce those skills independently as assessed using the Test for Gross Motor Development-3rd Edition (TGMD-3). Participants included 19 children between the ages of 3-5 who took part in the Healthy Kids Program through the Morrison Bruce Center of James Madison University. Analysis of the data revealed statistically significant increases in proficiency in the all of the object control skills. Tossing yielded an average score of 4.07 ± 1.94 at baseline and 4.60 ± 1.84 post-intervention resulting in a p-value < 0.001. Kicking saw a slightly larger increase in proficiency from baseline to post-intervention (baseline:2.29 ± 1.33; post: 4.53 ± 1.60; $p < 0.001$). Catching showed an average score of 3.40 ± 1.34 at baseline and 3.53 ± 1.13 at post-intervention ($p<0.001$). The final object control skill tested, throwing, yielded the second greatest increase in this category (baseline: 2.60 ± 2.23; post: 3.47 ± 1.64; p = 0.0213). The locomotor skills that were taught and assessed over the 12-week study also showed significant increases in proficiency. Gallop increased from 3.33 ± 1.72 to 5.13 ± 1.60 ($p<0.001$) from baseline to post-intervention. Jumping started at an average score of 4.20 ± 2.11 at baseline and increased to 5.60 ± 2.06 at post-intervention ($p < 0.001$). Sliding (baseline: 5.60 ± 2.87; post: 7.07 ± 1.49; $p = 0.0125$), hopping (baseline: 2.47 ± 1.92; post: 3.40 ± 2.16; $p < 0.001$) and running (baseline: 3.93 ± 1.81; post: 4.93 ± 1.91; $p < 0.001$) all saw an significant increase in proficiency as well. These results indicate that a 10-week program

that meets once a week can be successful in improving motor skill proficiency among 3-5 year old children.

Chapter 1: Introduction

According to the President's Council on Fitness, Sports, and Nutrition, the prevalence of obesity in children, ages two to five years old, has doubled since the 1970's[1]. The increasing percentages of obese and overweight children can likely be partially attributed to the declining prevalence of physical activity in the daily lives of children. When energy expenditure is too low, weight gain will ensue; therefore, the more time spent being sedentary, the greater the likelihood that individuals are going to be overweight[2]. Approximately 50% of children and adolescents are not getting the recommended amount of physical activity required for optimal health[3]. Specifically, among preschool aged children, research has revealed that children in childcare programs spend the majority of their day participating in sedentary or light activities such as napping, coloring, or playing with toys rather than in activities that require gross motor movements[4]. Children who spend a majority of time being sedentary are at greater risk for developing impairments in their motor skills due to less opportunity to perform gross motor movements such as running and jumping[5]. This trend becomes a negative feedback loop because a child's motor proficiency is positively associated with the amount of time they spend in moderate-to-vigorous intensity physical activity[6]. Children with a lower proficiency in motor skills tend to have lower rates of physical activity participation, as well as experience more introversion and a lower sense of self-efficacy[7]. These physical and psychological problems that begin in sedentary children from ages two to five can possibly be avoided by helping them develop more proficient motor skills[8].

Physical problems that are fostered from preschool-aged children leading sedentary lifestyles can range from immediate health risks to developing risk factors that can mature into more serious health conditions in adulthood. Inactivity and obesity in children can bring

numerous health implications that may affect a person's risk factor profile[2]. According to Iowa State University, a risk factor profile is an analysis of the presence and severity of factors of a person's health that can affect development of a chronic disease[9]. In specific reference to the development of cardiovascular disease (CVD), an individual's risk factor profile begins in the childhood and adolescent stages of life. In America, 60% of inactive and overweight children already have at least one risk factor associated with CVD[10]. There is a lack of evidence on the effect of preschool aged children's activity levels on the development of chronic diseases in adulthood, but there has been research that indicates greater amounts of physical activity among children of elementary school age results in a decreased lifetime risk of developing CVD in adulthood[2]. Furthermore, obese and overweight children in this age group face the risk of several other illnesses in adulthood because chronic diseases such as dyslipidemia, Type II diabetes mellitus, hypertension are also initiated in childhood among these individuals[2]. If inactivity results in significant weight gain, children can begin to develop these diseases even before adolescence[2]. Specifically, larger amounts of excess adiposity increases the likelihood children will develop Type II diabetes mellitus[11]. Additionally, a greater percentage of adipose tissue increases the risk of developing dyslipidemia, hypercholesterolemia, and insulin resistance at a young age[5]. A similar study conducted by Herman, et. al. found that, sedentary children who become overweight by age 7 were found to have a 6.2 times greater chance of being overweight as adults when compared to children of normal weights[12]. The same study showed that 83% of overweight children remained overweight as adults[12]. Therefore, laying the groundwork for physical activity with the development of motor skills at an early age is vital to the current health of children and their future. With the increasing rates of obesity in preschool-aged children,

professional groups have very recently begun doing more research into the development of chronic disease risk factors in children of this age group[13].

Negative mental health outcomes are also a result of inactivity among children. Studies have shown that absence of physical activity can result in a decrease in self-esteem, emotional functioning, and an increase in mental health problems[7]. Children who are less advanced in their ability to execute motor skills have a decreased sense of social competence and view themselves as inadequate in comparison to their peers. Lower levels of locomotor and ballistic skills can also result in troubles with social connections because the ability to handle objects is essential to how children play and interact with one another. If children feel as though they are unable to effectively participate in games with their peers, they may develop an apathetic perspective of physical activity. The Surgeon General's Report on physical activity published in 1996 stated that the most consistent variables that affected individuals from ages 3 to 18 years old and their involvement in physical activities included self-efficacy and perceived physical or sports competence[14]. The lower they perceived their ability to perform, the lower the likelihood children would participate in any physical activities. This relationship represents the mental side of the negative feedback loop of physical activity in which an individual has perceived low competence in motor skills can decrease the likelihood of them being physically active, with decreased time spent being active having an adverse effect on perceived motor skill competence. In a study on children ages 3.5 to 5.5 years old, poor motor coordination was also associated with higher levels of anxiety and depressive behaviors[7]. Several other studies have found this relationship between motor ability and displays of depression and anxiety in children is consistent across a larger range of ages as well. For example, Campos et al. (2000) found that mastering the early locomotor experience of crawling was crucial for the motor, cognitive,

social, academic, and emotional development of infants of about 8.5 months old[15]. Although these children are of a much younger age group than preschool children, and the motor skill being performed is less complex than those that children ages 2 to 5 would be performing, the findings indicated that poor gross motor ability in young individuals may be associated with the early development of anxiety and depression, as reported by parents. Emotional difficulties then can lead to further mental health issues in early childhood, adolescence, and adulthood because these problems often result in decreased social interactions. The inability to create strong, healthy relationships in early childhood can then result in lacking social skills and struggles with performance on cooperative tasks[16]. This behavior is typically displayed through a child's participation in solitary-passive play in which they explore objects and play on their own rather than with other children. Social reticence is also common among children with underdeveloped motor capabilities. This behavior entails a child acting as a spectator of games instead of a participant. Once proficiency in important areas of social behavior is lost, it is not likely that it will be developed later in life.

Inactivity in young children poses several other risks due to the negative behaviors that are typically associated with sedentary lifestyles. For example, consuming non-nourishing diets is common among children who are not participating in regular physical activities[17]. Although directionality cannot be assumed in this diet and physical activity relationship, inactive individuals are more likely to consume foods with higher fat content, specifically those high in saturated fat[10]. . Research has shown that few preschool children eat the prescribed amount of vegetables[18]. As a result of this finding, some preschools and child-care programs have begun teaching the importance of balanced, nutritional meals and the positive affects of physical activity together.

Leading inactive lifestyles as children is highly correlated with remaining inactive as an adult because sedentary behaviors become engrained into individuals' daily routines[10]. Studies have shown that children who feel incompetent in their ability to perform motor skills are significantly less likely to be physically active or ever become active later in life[19]. This relationship grows stronger as children progress through school and social comparison begins to play a role in their feelings of self-efficacy. In addition, there is a correlation between physical activity habits of children and well-being in adulthood[14]. Thus, it is vital to educate children on how to be physically active and lead lives full of movement at an early age. Recently, several associations have published guidelines for physical activity of young children. For example, the American College of Sports and Medicine recommends children and youth get 60 minutes or more of moderate to vigorous physical activity, at least five days a week[20]. The National Association for Sport and Physical Education recommends 120 minutes of physical activity daily[20]. Other research organizations have simply emphasized the importance of limiting inactivity in youth[14]. Regardless of the differing recommendations, as stated previously, the majority of children do not meet any of these suggestions for physical activity[3]. Children in childcare programs, for example, were found to spend less than 10% of their time each hour participating in moderate to vigorous activity[4]. This lack of sufficient time spent being active could be a result of preschools' failure in allotting significant amounts of time for physical activity for their students, resulting in about half to three-fourths of their days being spent sedentary[8].

Spending time to thoroughly educate preschool aged children (ages 2-5 years old) on gross motor and locomotive skills may help them in their ability to perform such skills. In a study done on the effect of using a cognitive-behavioral technique to teach preschool aged

children motor skills, it was found that teaching gross motor skills, while emphasizing the children's perceptions of their mastery and competence, resulted in a statistically significant increase in the amount of time those children spent in vigorous physical activity[8]. Thus, it can be concluded that as children feel more confident in their ability to execute certain movements, they are more likely to perform the skills on their own. In another study conducted by Krombholz et al., the effect of daily, child-centered physical activity presented by trained staff members on motor performance and body mass index of preschoolers was observed over a 20-month period[21]. At the beginning of the study, the children who were classified as "high weight" displayed inferior motor skills when compared to those of the "middle" and "low" weight children. At the end of the study, the children who received the physical activity intervention showed significant increases in motor performance in comparison to the control group. The improvements were even greater in children who were categorized as high weight initially. Furthermore, when comparing the amount of physical activity children get in Montessori preschools and traditional preschools, it was found that children enrolled in the former received a significantly greater amount of physical activity. Montessori school curriculum is based on independence and provides a larger variety of physical activity options, as well as a greater frequency of activity[22]. A study conducted in Australia found that some teachers and childcare providers did not think physical activity should be taught; rather, it should consist of unstructured play[18]. This finding may explain the variance in physical education provided at differing types of schools. The more vital finding from comparing Montessori to traditional preschools, however, was that the children who received more time to participate in physical education and activities at school also partook in more physical activity outside of school[22]. This information suggests that structuring preschoolers' days to include significant blocks of time for being active can result in less

sedentarism and more physical activity on their own. The next step in increasing physical activity among preschool-aged children would be to take time to teach these children the accurate technique to perform motor skills to ensure they are able to perform those skills correctly.

The most efficient manner in which to begin educating young children on the importance of physical activity and the proper ways to carry out certain motor movements is greatly debated. There is controversy because the influences on children's physical activity levels and willingness to learn motor skills has to first be determined in order to then be able to target those determinants and use them to help promote motor skills education[14]. It has been determined that elements of a child's perception of themselves and their capabilities play a role in their development of motor coordination, but other factors could possibly have an affect as well[14]. For instance, in a meta-analysis conducted on correlates of physical activity, it was found that the viewpoint of a child's parent on physical activity along with the parent's level of motor skills can greatly impact the child's development of motor coordination[14].

Although it is unclear whether it is environmental, social, educational, or other factors of life that have resulted in a decrease in physical activity among young children, preschool-aged children's participation in a physical activity intervention could provide significant benefits on their ability to perform motor skills and willingness to partake in daily physical activities. Nemet et al. conducted a research study to determine the effect of a multidisciplinary intervention program regarding nutrition, behavior, and physical activity on body composition, physical activity, dietary habits, fitness and lipid profiles on obese children They found that in a sample of about two dozen children, ages 6 to 8 years old, habitual physical activity increased following both a short-term (three month) and long-term (12 month) intervention program[5]. Children who

participated in the longer intervention program also showed signs of integrating the principles they learned into their daily lives. Other research has shown a positive correlation between gross motor skill scores and physical activity in children ages three and four[13]. Specifically, in a study conducted with children from ages three to five years old, it was found that with an increased level of gross motor and object skill performance came more time spent in moderate and vigorous physical activity[13]. Thus, providing preschool aged children with the opportunity to learn gross motor and object control skills can increase their competence in their ability to do so, which could increase the amount of time they spend in physical activity and decrease time spent sedentary[13]. The purpose of the current study was to investigate the changes in object control and locomotor skill proficiency that occur following a weekly intervention that educates children on the proper form used to carry out said motor skills.

Chapter 2: Methods

Study design

This research project was a 12-week study that investigated whether the 10-week curriculum of the Healthy Kids Program is effective at improving locomotor and select object control skills among preschool-aged children. Motor skills proficiency was assessed one week before and one week following the ten-week curriculum using the Test of Gross Motor Development-3[23]. Participants met weekly to learn about and practice motor skills, as well as concepts related to nutrition and general physical activity.

Participants

Participants in this study were males and females, ages three to five, who were participating in the Healthy Kids Program. Bulk emails were sent to parents in the community and upon expressing interest in the Healthy Kids Program, parents were informed of this study, which was a requirement of participating in the program. All research procedures were explained by research staff by in person. Parental informed consent was obtained prior to the first night of data collection. All study procedures were approved by the James Madison University Institutional Review Board.

Intervention

The intervention will be carried out through the a preschool program run through the Morrison Bruce Center located at James Madison University. The 10-week program aims to teach preschool-aged children the importance of healthy eating and nutrition along with educating them on how to execute certain locomotor and ballistic skills. Each week covers one specific

topic on nutrition and physical activity, including a focus on breaking down a specific motor skill. These skills are generally taught in the form of a physically active game, with participants getting specific instructions and feedback on each skill. The skills will be taught by undergraduate students of James Madison University who are majoring in Kinesiology or other related fields.

Anthropometric measurements

The participants' height and weight will be recorded in order to calculate body mass index (BMI) in kilograms per meters squared.

Motor Skills Testing

Motor skill competence was assessed on the first and last weeks of the Healthy Kids Program using the Test of Gross Motor Development-3 (TGMD-3)[23]. This assessment was designed to evaluate the participant's ability to perform locomotor skills such as running, galloping, hopping, horizontal jumping, and sliding. The TGMD-3 also determines the level of competence a participant has in performing the ballistic skills that follow: two-hand strike of a stationary ball, one-hand forehand strike of self-bounced ball, one-hand stationary dribble, two-hand catch, kicking a stationary ball, and overhand and underhand throws. This study focused on the following ball skills: kicking, underhand tossing, overhand throwing, and two-handed catching. Not all of the object control skills in the TGMD-3 were assessed in this study because it is important to focus on skills that preschool aged children would have the ability to perform and improve on. Therefore, only the skills that the participants had exposure to through the Healthy Kids Program were examined. This exclusion of skills for which they received no practice or instruction also maximizes feelings of success in the participants. The skills that this study will

be focusing on will be demonstrated by kinesiology graduate students and faculty who had been trained in the proper technique for each skill and the participants will then be given a practice trial. Following the practice, the participant were given two trials to perform the given skill. Each skill was broken down into three to five subcomponents, each of which was scored on a scale of 0 to 1. A score of 0 represents the skill components was not performed correctly and 1 means that it was done properly. The score of both trials of each subcomponent is recorded and the sum of those scores is totaled to determine an overall score for each skill. As previously stated, not all of the object control skills in the TGMD-3 were assessed, which did not affect the data because only the total score for each skill was summed, not the overall object control or total locomotor test scores. These tests were performed during the first session to record the children's baseline data and on the last session to assess changes in motor skill proficiency. In order to ensure accurate data collection, both testing sessions were videotaped for later review by senior research staff who have extensive experience in the field of Kinesiology.

Statistical analysis

Paired *t*-tests will be used to assess whether the participants showed change in their motor skill proficiency over the course of the intervention. Descriptive analysis on each participant's anthropometric data were reported.

Chapter 3: Results

Fifteen subjects had complete data for both pre- and post-intervention time points and were included in the final analyses for this study. For one subject, only one trial of the baseline examination for running was completed. This datum was corrected by doubling the score in order to allow the same TGMD-3 scoring scale to be used. On average, from baseline to post-intervention, the subjects showed a significant increase in height (baseline: 103.29 cm ± 5.31; post 105.19 cm ± 5.43; $p< 0.001$) and weight (baseline: 17.56 kg ± 1.77; post: 18.37 kg ± 1.71; $p<0.001$).

On average, subjects exhibited a significant improvement in ability to perform each of the included locomotor skills (Table 1) and object control motor skills (Table 2). However, there was significant variation at the individual level, with scores improving, declining, and remaining consistent on each skill, with at least one participant showing declines on the post evaluation for all skills except gallop and kick (Table 3).

Chapter 4: Discussion

Over the course of the 12-week intervention, there was a significant improvement in mean scores for all of the locomotor and object control motor skills that were examined. These findings are consistent with other similar experiments that have been conducted. For example, an investigation done with 60 toddlers using the TGMD-2 found that a motor skill intervention resulted in significantly greater improvements in motor skills when compared to the control group[24]. However, the intervention provided in the experiment described above consisted of 10-minute sessions, daily, for 8 weeks. The current findings show that an intervention that meets once weekly can possibly provide significant improvements in children's motor skill abilities. In another 20-month long study conducted by Krombholz et al., it was found that children who participated in a daily child-centered physical activity program focused on motor skill performance yielded a significant increase in motor performance in comparison to the control group who received no intervention[21]. Unlike this research results from the present study indicate that improvements in motor skills proficiency can be achieved in a shorter time frame (10 weeks), with only weekly interaction.

There was no control group in this experiment (i.e., a group who did not receive the intervention), so it is difficult to account for natural maturation of motor skills due to age and body mass developments. However, in a study done by Freitas et al., it was determined that only a maximum of 7.0% and 9.0% of variance in motor skills could be attributed to body mass and chronological age changes, respectively, in children ages 7-10[25]. Although this age range is different than the one observed in this study, children between ages 2 to 10 years old grow at a similar and steady pace so it is viable to apply these percentages to this study[26].

Analysis of the data revealed a trend in which proficiency in the selected object control skills saw little improvement, excluding kicking. Specifically tossing and catching saw the greatest number of participants decrease in proficiency while throwing had an equal number of participants plateau as did improve. This trend is intriguing considering that one or less participants scored maximum points in each of the object control skills at baseline, indicating that they had sufficient room to improve. On the other hand, the locomotor skills showed a trend in which no more than 3 participants regressed in motor skill proficiency. Twelve of the 15 participants saw an increase in proficiency in performing the gallop and ten saw an improvement in jumping. Sliding yielded the fewest number of participants increasing in proficiency however this may be because six of the participants had maximum scores in this locomotor skill at baseline. The variance seen between the changes in proficiency among the participants could be as a result of several factors. One of which could be the possibility of some participants practicing the skills outside of the program. Several participants would come to the program every week and would demonstrate how they had been working on a particular skill over the weekend. This extra practice could explain why some participants saw a greater increase in proficiency. Furthermore, different skills vary in the natural maturation progression, meaning that children may demonstrate proficiency in them at a certain age. For example, our data showed that seven participants plateaued in the quality of performance of throwing. This could be the result of 60% of preschool-aged boys and girls not typically demonstrating proficiency in throwing until about five and a half and eight years old, respectively[27]. As stated above, catching yielded a large number of participants decreasing in proficiency. Similar to the case with throwing, the majority of boys do not show proficiency in this skill until seven years old and require an intervention at six and a half. Sixty percent of girls do not reach quality performance

of catching until about six and a half years old as well[27]. The present study was conducted on children between the ages of three and five, and thus the participants were not at the peak age for some of the skills that were tested. This could explain why some individual participants did not show a significant increase in proficiency of specific object control and locomotor skills.

A larger sample size could have provided a better representation of the trends seen in this experiment. Furthermore, if a larger sample was used, the differences, if any, in biological sex may have been sufficient enough to examine. This analysis could provide any interesting perspective on how to teach different genders certain motor skills. An additional limitation of this study was that several participants had previously participated in the Healthy Kids program before. That this was not the first exposure to the intervention for some participants may impact how much improvement is seen across motor skills, although it would be expected that these skills continue to improve with additional instruction and practice. At baseline, with the exception of slide (which had six participants achieve maximum score), on any individual skill, two or fewer participants achieved a maximum score, indicating that the vast majority of participants had room to improve their motor skill competency. Furthermore, after the completion of the program, no follow-up was completed to determine if motor skill improvements were retained by the participants.

Overall, these results indicate that providing preschool-aged children with a locomotor and object control motor skill intervention that meets once weekly for 12 weeks can improve the children's ability to perform those skills on their own. Advanced proficiency in motor skills may then lead to increased time spent participating in moderate and vigorous physical activity[13]. Research has shown that the more frequently children engage in physical activity, the more confident they will become in their ability to successfully carry out the motor skills required to

be physically active, and the more likely they are to continue participating in physical activity[14]. This positive feedback loop is essential to the healthy development of children, as time spent being physically active at a young age is linked to overall health throughout a lifetime[12].

The amount of time that children spend being sedentary has been on the rise over the past several years[4]. This increase can be partially accredited to children's lack of knowledge on the correct form and manner in which to carry out many object control and locomotor skills[7,8]. As this study supports, teaching children how to perform object control and locomotor skills increases their ability to carry out those skills on their own, thus increasing their likelihood to be physically active and healthy throughout their lives. It is then appropriate to urge the implementation of motor skill educational programs in settings such as day cares in order to produce a widespread increase in motor skill proficiency in preschool-aged children

Table 1. Average combined score for two trials for select locomotor skills from the Test of Gross Motor Development – 3rd edition.

	Baseline	**Post-Intervention**	***p*-value**
Gallop	3.33 ± 1.72	5.13 ± 1.60	$p < 0.001$
Jumping	4.20 ± 2.11	5.60 ± 2.06	$p < 0.001$
Sliding	5.60 ± 2.87	7.07 ± 1.49	$p = 0.0125$
Hopping	2.47 ± 1.92	3.40 ± 2.16	$p < 0.001$
Running	3.93 ± 1.81	4.93 ± 1.91	$p < 0.001$

Table 2. Average combined score for two trials for select object control motor skills from the Test of Gross Motor Development – 3rd edition.

	Baseline	**Post**	***p*-value**
Tossing	4.07 ± 1.94	4.60 ± 1.84	$p < 0.001$
Kicking	2.29 ± 1.33	4.53 ± 1.06	$p < 0.001$
Catching	3.40 ± 1.34	3.53 ± 1.13	$p < 0.001$
Throwing	2.60 ± 2.23	3.47 ± 1.64	$p = 0.0213$

Table 3. Number of subjects whose score improved, declined or remained the same on select skills from the Test of Gross Motor Development – 3rd Edition.

	Gallop	Slide	Jump	Hop	Run	Toss	Kick	Catch	Throw
Improved	12	8	10	9	9	8	12	5	7
Same	3	5	2	3	3	2	3	4	7
Declined	0	2	3	3	3	5	0	6	1

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