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Article *in* Early Childhood Education Journal · November 2015
DOI: 10.1007/s10643-015-0755-9

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Motor Skill Performance by Low SES Preschool and Typically Developing Children on the PDMS-2

Ting Liu[1] · **Chelsea Hoffmann**[1] · **Michelle Hamilton**[1]

Abstract The purpose of this study was to compare the motor skill performance of preschool children from low socioeconomic (SES) backgrounds to their age matched typically developing peers using the Peabody Developmental Motor Scales-2 (PDMS-2). Sixty-eight children (34 low SES and 34 typically developing; ages 3–5) performed the PDMS-2. Standard scores from each subtest (i.e., stationary, locomotion, object manipulation, grasping, and visual-motor integration) and three quotient scores were calculated for the children identified as low SES and typically developing children. A MANOVA was used to analyze the PDMS-2 standard score and quotient score differences between the children identified as low SES and the typically developing children. All preschool children identified as low SES scored at average or lower on total motor quotient scores. Specifically, 88.2 % of children identified as low SES were classified as average, and 11.8 % of children were in the below average performance category. The MANOVA analysis showed that children identified as low SES scored significantly lower than the typically developing children on the visual-motor integration subtest, $F(1,64) = 7.232$, $p = .009$; locomotion subtest, $F(1,64) = 11.449$, $p = .001$; and TMQ, $F(1,64) = 4.732$, $p = .033$. Children identified as low SES were significantly delayed in both fine and gross motor skill areas when compared to their typically developing age and gender matched peers. Researchers are recommended to provide comprehensive assessments for preschool children and to include motor tasks when designing early intervention programs.

Keywords Fine and gross motor skills · Peabody · Disadvantaged · Preschoolers

Introduction

The development of fine and gross motor skills begins during the critical years of early childhood. A young child's ability to move effectively in space is essential to future complex motor skill development (Bellows et al. 2013). Fine motor skills consist of tasks using small muscles such as handwriting, keyboarding, and drawing while gross motor skills require children to use large musculature to produce actions like throwing, catching, and galloping. Children's ability to perform fine and gross motor skills may affect their participation in sport, physical education classes, general education classes, and social experiences on the playground.

Mastery of these fine and gross fundamental motor skills may be imperative to a child because it forms the building blocks of future physical activity (Clark and Metcalfe 2002; Wang 2004). In fact, NASPE (2011) Active Start national guidelines explicitly recommend that preschool children should develop competence in fundamental motor skills that will serve as the building blocks for future motor skillfulness. Early fine and gross motor skill development has been found to predict later cognitive development (Hill 2010) and is related to engagement in physical activity (Stodden et al. 2008) and perceived competence (Robinson 2011). Therefore, fundamental motor skill development may influence a child's participation in physical activity, games, and sports as well as the development of social,

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Published online: 30 November 2015

cognitive, and psychological skills later in life (Brown 2010; Draper et al. 2012; Kirk and Rhodes 2011; Wang 2004). It should also be noted that acquiring these fundamental motor skills is not something that develops naturally with age and time, but rather involves instruction, practice, motivation, and encouragement (Bardid et al. 2013; Wang 2004).

Children's fundamental motor skill development promotes and facilitates interaction between their peers and their environment (Robinson et al. 2012). The absence of both fine and gross motor skills may negatively impact children's relationships with their peers as well as their participation in future physical activity. For example, Stagnitti et al. (2011) suggested that children experienced negative attitudes from their peers during active play sessions when lacking these well-developed fine and gross motor skills. These negative experiences may alter a child's view indefinitely and may result in a long-term avoidance of physical activity. Logan et al. (2011) reported that there is a strong correlation between motor skill development and physical activity participation among children. This development of motor skills has also been associated with a greater participation in physical activity as well as greater cardiovascular fitness and maintenance of a healthier body weight as an adult (Logan et al. 2011; Pope et al. 2011; Robinson et al. 2012).

Furthermore, research has shown that children of low socioeconomic status (SES) are often behind their middle class peers when it comes to fine and gross motor skill performance and are often at greater risk for motor delays (Brown 2010; Chow and Louie 2013; Stagnitti et al. 2011). These delays may be due to a number of factors including: (a) environmental constraints that limit the available area for physical activity both indoors and outdoors; (b) task constraints such as a lack of equipment available for use during active play and insufficient funds to allow participation in recreational activities; and (c) individual constraints such as a lack of instruction on proper motor skill technique and form (Chow and Louie 2013; Goodway and Branta 2003; Pope et al. 2012; Pope et al. 2011; Stagnitti et al. 2011). Low SES has been suggested as a possible cause of fine and gross motor skill incompetence as well as lower cognitive development and ability (Draper et al. 2012). As a result of these developmental delays, children identified as low SES who lack fine and gross motor skill competency may avoid physical activity, sport participation and demonstrate lower health-related fitness and academic achievement. In contrast, well-developed fine and gross motor skills are related to better performance in the classroom as well as the likelihood that children will be active and maintain health-related fitness throughout adolescence and adulthood (Vlahov et al. 2014).

Research targeting the identification of motor delays has been previously conducted with preschool children (Logan et al. 2011; Wang 2004). For example, Cools et al. (2008) conducted a literature review to examine the different types of motor assessment tools used to evaluate preschool children. It was reported that assessment tools such as the Test of Gross Motor Development-2 (TGMD-2; Ulrich 2000), the Peabody Developmental Motor Scales-2 (PDMS-2; Folio and Fewell 2000), and the Movement Assessment Battery for Children-2 (MABC-2; Henderson et al. 2007), were effective in identifying the presence of developmental delays in preschool children (Cools et al. 2008). Similarly, Logan et al. (2011) compared the MABC-2 and TGMD-2 on their effectiveness to assess preschool children and concluded that both were effective in identifying motor delays, but that assessment choice should be tailored to the research question or clinical setting in which it was used. The findings of Logan et al. (2011) were in agreement with those found by Cools et al. (2008) that preschool children with delays in motor skill development could be effectively identified using these movement assessment tools.

Few studies on the developmental delays in fine and gross motor skills for disadvantaged and children identified as low SES have been noted. It is important to investigate motor delays in this population so that the children can improve their fine and gross motor skills early enough to fully participate in different types of physical activity and sport. In addition, limited research can be found that focuses on motor performance between low SES and typically developing preschool children (McPhillips and Black 2007). One study reported that low SES preschool children were significantly delayed in their fundamental motor skill development when compared to their age-matched middle class peers after being assessed by the MABC-2 (McPhillips and Black 2007). Stagnitti et al. (2011) assessed the fundamental motor skill performance of low SES preschool children on the PDMS-2 and found that their gross motor skill development was significantly delayed when compared to normative data.

The majority of previous studies on preschool children used the TGMD-2 which assesses a select number of gross motor skills, specifically object control and locomotor skills (e.g., Bardid et al. 2013; Chow and Louie 2013; Goodway and Branta 2003; Kirk and Rhodes 2011; Pope et al. 2011; Robinson 2011; Wang 2004). Bardid et al. (2013), for example, used TGMD-2 to assess preschool children and reported that the participants showed delays in gross motor skill performance of locomotor, object control and balance skills. Pope et al. (2011) also administered TGMD-2 to examine low SES preschool children's object control skill performance. It was found that low SES preschool children produced significantly lower performance

scores than the normative data. However, the narrow focus of TGMD-2 on object and locomotor skills may fail to give a complete evaluation of children's motor skill development, particularly in children who demonstrate motor delays in the other areas such as dynamic and static balance and/or manual dexterity.

Furthermore, fine motor skill development seems to be a neglected area for preschool children from low SES background. It has been suggested that both fine and gross motor skills are necessary for an optimal well-being and quality of life for preschool children (Cools et al. 2008; Robinson 2011). These fine motor skills are important for capturing the child's overall fundamental motor skill performance. Delays in fine motor skill development may adversely impact manual dexterity ability, thus, leading to challenges in the classroom, physical activity, and daily living. More thorough identifications and assessment instruments that target both fine and gross motor skill development should be used in this type of research (Brown 2010; Provost et al. 2007).

A comprehensive evaluation of motor proficiency is dependent upon the instrument that is chosen for assessment. The PDMS-2 is a reliable and valid assessment instrument targeting fine and gross motor skills (Folio and Fewell 2000). PDMS-2 assesses children's fundamental motor skills from birth to 5 years of age (Bellows et al. 2013; Maring and Elbaum 2007; Tripathi et al. 2008). This age range is a critical period for motor skill development and identifying the delayed areas early is key for promoting successful growth and development (Cools et al. 2008). The PDMS-2 is suggested to measure low cognitive-functioning children (Vanvuchelen et al. 2007) and it may be appropriate to evaluate the low SES population.

PDMS-2 assesses five motor skill categories (stationary, locomotion, object manipulation, grasping, and visual-motor integration) for preschool children. It has a larger variety than MABC-2, which covers three areas (manual dexterity, ball skills, and static and dynamic balance and TMGD-2, which only assesses gross motor skills. It offers a more extensive and complete assessment of fundamental motor skill development in early childhood, which has been shown to be valid in identifying motor delays (Tieman et al. 2005; Van Waelvelde and Peersman 2007). Another advantage to PDMS-2 is that it not only uses norm-referenced data, but it also uses criterion-referenced data so that the tool is both process and product oriented (Cools et al. 2008; Wiepert and Mercer 2002). In addition, PDMS-2 is specifically designed for younger children, while MABC-2 is designed for a wider age range resulting in less specificity (Cools et al. 2008).

It is important to investigate both fine and gross motor areas of children in order to help practitioners develop interventions that will optimize children's physical activity participation. While gross motor skills are the primary skills used to enable efficient execution of active play, competent fine motor skills allow children to be more accurate and successful in each of these areas (Cools et al. 2008; Liu and Breslin 2013). In addition, many of the studies conducted fail to provide a comprehensive profile of motor skill acquisition for children identified as low SES. PDMS-2 is more focused towards the preschool population and uses a variety of assessment categories to portray a detailed and accurate evaluation of children's fundamental motor skill development in order to design intervention programs rather than simply identifying the delays (Cools et al. 2008).

The purpose of this study was to conduct a comprehensive motor skill investigation of children identified as low SES to their age matched typically developing peers using PDMS-2. It was hypothesized that children identified as low SES would have significant motor delays on PDMS-2 when compared to the typical preschool children.

Methods

Participants

Thirty-four preschool children identified as low SES from the local school district and 34 age-matched typically developing preschool children in the same school district participated in this study. Low SES was defined as being financially disadvantaged and having limited access to facilities or environments that promote physical activity (Stagnitti et al. 2011). In addition, all children qualifying as low SES attended a prekindergarten school that provided services for young children based on low parental income as defined by eligibility for free and reduced lunch. Typically developing children were defined as being middle or high SES (Bellows et al. 2013).

All children who were typically developing attended a prekindergarten program that served middle and high SES families by charging monthly tuition. None of the typically developing children were eligible for free and reduced lunch. The age of the participants ranged from 3 to 5 years ($M = 4.3$ years). Participants' demographic information is presented in Table 1. Descriptions of all tasks were provided to the parents of the children and consent was given prior to any child's participation in the study. This study was approved by the local University Institutional Review Board.

Instrument

Peabody Developmental Movement Scales-2 (PDMS-2)

The PDMS-2 (Folio and Fewell 2000) is an assessment tool used to identify children who are significantly delayed in

Table 1 Demographic information of participants

	Mean age (years)	*N*	Gender	
			Male	Female
Head Start children	4.60	34	15	19
Typically developing children	4.58	34	13	21

their motor skill performance compared to normative data. The PDMS-2 measures both fine and gross motor skill performance in children 0–5 years of age. It evaluates different motor skill tasks with six different subtests: reflexes (for 0–11 months), stationary, locomotion, object manipulation, grasping, and visual-motor integration. Reflexes were not assessed in this study because our participants were 3–5 years of age. Each subtest produces a total raw score that is then converted to standard scores, percentiles, or age-equivalent scores. Standard scores of subtests are summed for fine, gross and overall motor skill categories to produce composite standard scores called fine motor quotients (FMQ), gross motor quotients (GMQ), or total motor quotients (TMQ). Grasping and visual-motor integration contribute to the FMQ, while object manipulation, stationary and locomotion test areas contribute to the GMQ. TMQ is the composite score of FMQ and GMQ. The PDMS-2 classifies children's motor skill performance as *very superior, superior, above average, average, below average, poor, and very poor* based on their GMQ and FMQ. Scores classified as below average, poor or very poor indicate areas in which children are scoring lower than more than 75 % of the population, suggesting developmental delays may be present (Folio and Fewell 2000).

Procedure

The PDMS-2 was administered to participants using a school gym at a local elementary school. The research assistants received thorough training prior to administering the PDMS-2. Once inter-rater reliability was established between the primary investigator and research assistants (i.e., higher than 90 % agreement), administration of the test was allowed. Participants were asked to wear appropriate attire and shoes that would permit them to comfortably perform the tasks indicated by the PDMS-2. Two research assistants worked together to assess each child. One assistant provided detailed verbal instructions and visual demonstrations, while the other was responsible for scoring the child's motor skill performance. Assistants were not informed of the research hypotheses of the study to ensure accuracy and fairness during the scoring of participants. Practice trials were provided and additional feedback was given if the child was confused or if performance errors were presented during the practice trials.

Data Analysis

PDMS-2 standard scores from each subtest (stationary, locomotion, object manipulation, grasping, and visual-motor integration) and three quotient scores were calculated for each group. A 2 (group) $\times$ 2 (gender) MANOVA was used to assess PDMS-2 standard and quotient score differences between low SES preschool children and typically developing children. Results were considered significant at $p < .05$.

Results

Descriptive statistics showed that 82.4 % of the typical preschool children categorized as average or better for overall motor performance (TMQ). No delays were seen in the typical preschool children when compared to normative data from the manual. However, 100 % of the low SES preschool children had scores of average or lower on TMQ. Specifically, 88.2 % of low SES preschool children were classified as average, and 11.8 % of children were in the below average performance category. The low SES preschool children's motor delays were seen in locomotion, object manipulation, and visual-motor integration subtests. For the locomotion subtest, 8.8 % of low SES preschool children were in the above average category, 73.5 % were average, and 17.6 % fell below average. Similar results were found for both the object manipulation (14.7 % above average; 76.5 % average; 8.8 % below average) and visual motor integration (14.7 % above average; 61.8 % average; 20.6 % below average; 2.9 % poor) subtests. Descriptive data also showed that low SES preschool girls performed better than the boys on locomotion, grasping, visual, FMQ and TMQ motor areas, however, of these, only visual-motor integration and FMQ showed a significant amount of difference. The results for typically developing children showed a similar pattern in gender differences. On average, girls performed better than boys on four of the motor skill subtest (stationary, object manipulation, grasping, and visual-motor integration, while boys performed better on the locomotion subtest. Significant gender differences were only seen for the visual-motor integration scores.

A 2 (gender) $\times$ 2 (group) MANOVA was conducted to compare the standard subtest scores and quotient scores of low SES preschool children and typically developing

children. Significant main effects were found for group ($F(1,64) = 2.534$, $p = .020$) and gender($F(1,64) = 2.328$, $p = .031$). No group × gender interaction effects were found, indicating that the group differences were not related to gender. Specifically, preschool children from the low SES background scored significantly lower on the visual-motor integration subtest ($F(1,64) = 7.232$, $p = .009$), locomotion subtest ($F(1,64) = 11.449$, $p = .001$; Fig. 1), and TMQ ($F(1,64) = 4.732$, $p = .033$; Fig. 2). Significant gender differences among low SES preschoolers were seen for the visual-motor integration subtest ($F(1,64) = 5.500$, $p = .025$; Fig. 3) and FMQ scores ($F(1,64) = 4.771$, $p = .036$; Fig. 4). Significant gender differences were also seen among typical children for the visual-motor integration subtest (Fig. 5). Preschool girls outperformed the boys for both groups in this particular subtest area.

Discussion

The purpose of this study was to compare the motor skill development of preschool children from low SES background to their age matched typically developing peers using the PDMS-2. Assessment occurred in five subtest areas consisting of stationary, locomotion, object manipulation, grasping, and visual-motor integration tasks. The results from this study are supportive of the hypothesis that low SES preschool children showed significant motor delays when compared to their age-matched typical preschool children.

Data analysis revealed significant differences in low SES preschool children's performance scores on locomotion, object manipulaion, and visual-motor integration subtests, as well as their GMQ and TMQ scores when compared to the normative data. When compared to typical preschool children, significant differences were seen for locomotion, visual-motor integration and TMQ scores (Figs. 1, 2). Gender differences, although not the primary focus of this study, were also present for both groups. In general, preschool girls seem to have significantly better visual-motor integration skills when compared to their male counterparts (Figs. 3, 4, 5). The results also showed

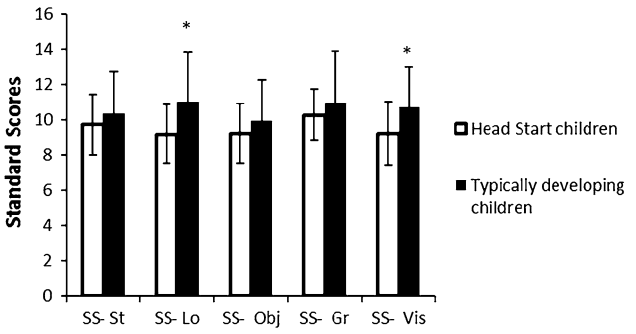

Fig. 1 Standard scores for each subtest between Head Start and typically developing groups. *Asterisk* indicates significant differences between the two groups

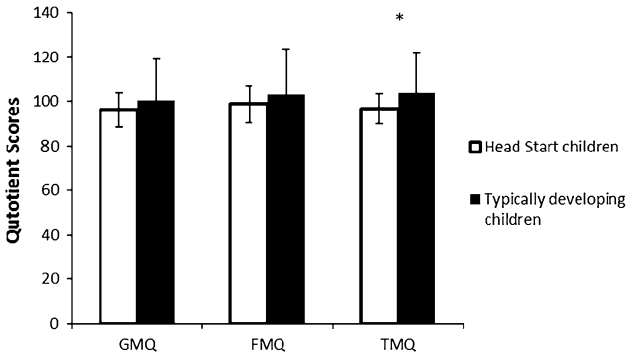

Fig. 2 Quotient scores for Head Start and typically developing groups. *Asterisk* indicates significance between the two groups

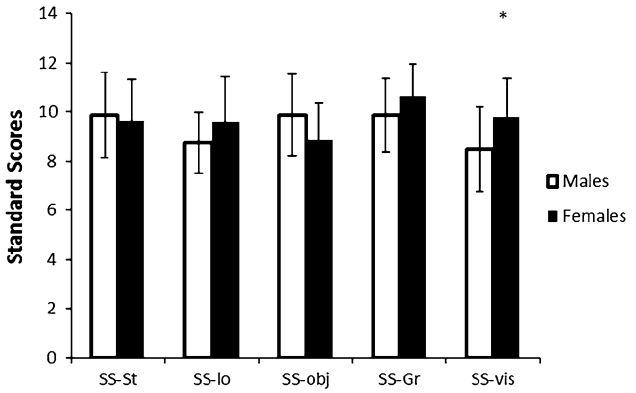

Fig. 3 Standard scores for each subtest between Head Start boys and girls. *Asterisk* indicates significant differences between the two genders

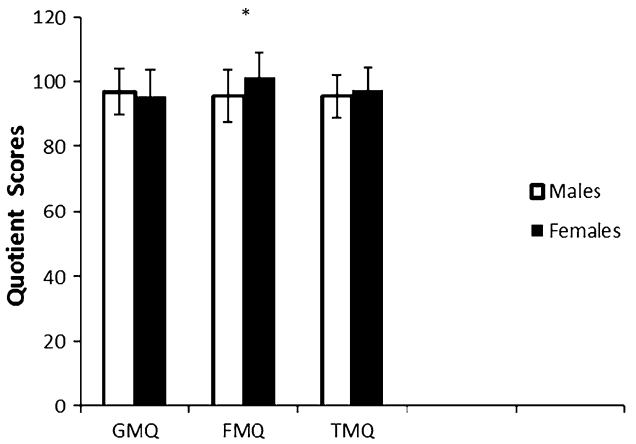

Fig. 4 Quotient scores between Head Start boys and girls. *Asterisk* indicates significant differences

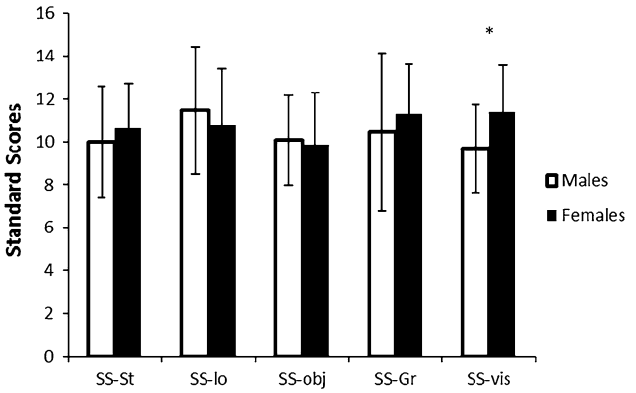

Fig. 5 Standard scores for each subtest between typical boys and girls. *Asterisk* indicates significant differences between the two genders

that low SES preschool girls had significantly higher FMQ scores than boys indicating that girls were better in fine motor skill performance as compared to boys. This finding is consistent with the literature that girls tend to be advanced in fine motor skills like handwriting and boys have an advantage in gross motor skills that require strength such as throwing, catching, running, and jumping (Kail and Cavanaugh 2014; Sinclair 1973; Thomas and Karen 1985). The possible explanation is that gender differences are related to children's physical activity experiences in early childhood. That is, boys tend to participate in more gross motor related physical activity like playing soccer, basketball and football while girls are more into fine motor skills like playing with dolls.

In addition, there seems to be a lack of studies that provide a comprehensive motor skill evaluation on prekindergarten children who are from low SES backgrounds. In this study we utilized the PDMS-2 as an assessment tool to identify motor skill discrepancies among low SES preschool children and typically developing children. In fact, it may be the first study of its kind to attempt to identify motor skill delays found in low SES preschoolers using the PDMS-2. Stagnitti et al. (2011) found similar results when gross motor skills were assessed on low SES preschool children using PDMS-2, however, this study did not incorporate the fine motor assessment portion in their research. Pope et al. (2011) was able to identify object control gross motor skill delays found in low SES preschool children when compared to normative data using the TGMD-2 assessment tool. Due to the lack of research in this area, more studies are needed to assess fine and gross motor skill performance among children from different SES backgrounds. It is our contention that PDMS-2 should provide a comprehensive view of children's fine and gross motor proficiency and not be limited to a narrowly defined subset of skills that is determined by feasibility alone.

It is important to note that the negative implications exist for motor delays of fine and gross skill development among preschool children with low SES background. Children lacking the development of these skills are limited to participate in many physical activities. Our participants had about 30 min each day to participate in unstructured physical activity at school. In addition, only one 30 min structured lesson of physical activity per week was offered to preschool children. NASPE recommends that preschool children ages 3-5 should engage in at least 60 min per day of structured and 60 min per day of unstructured physical activity per day to build competence in movement skills (2002). In a meta-analysis review of 39 studies, Tucker (2008) reported that 46 % of the studies demonstrated preschool children did not meet the minimal NASPE standards for physical activity.

The strengths of this study begin with the fact that it seems to be an introduction to the topic of identifying comprehensive motor skill delays in low SES preschoolers using the PDMS-2. Additionally, this study was able to identify significant motor delays found in low SES preschool children when compared to typically developing age matched peers. Previous research tends to assess either fine or gross motor skill development, but rarely assesses both simultaneously. This study was able to thoroughly assess both areas of motor skill development and successfully identify developmental delays. These identified developmental delays should be noted when creating a physical activity program for preschool children that come from low SES backgrounds. It is pertinent to the skill development of young children that programs be structured toward acquiring multiple skills that enable successful participation in physical activity, rather than simply increasing "play time" and calling it quality physical activity. At such a young age children are more likely to retain these motor skills when physical activity is offered in the form of a structured lesson. Bardid et al. (2013) explains that the development of motor skills requires planned instruction, practice, motivation, and encouragement in order for the skill development to successfully occur. The information found in this study may be useful for future research attempting to identify additional delays and for implementing interventions and training programs related to motor skill development in the delayed areas.

This study has a limitation that should be recognized. Due to the young age of our participants, they are sometimes apprehensive in a testing environment or easily distracted. Every attempt was made to make our participants comfortable with the testing environment prior to being assessed on motor skills and to eliminate potential distractions such as having the homeroom teacher accompany the participant if the child was anxious or taking the participant to a classroom if he/she was distracted in the gym.

In conclusion, the results of this study will make a significant contribution to the literature in identifying developmental delays concerning fine and gross motor skill development. These results indicate that children identified as low SES are significantly delayed in both fine and gross motor skill areas when compared to their typically developing age-matched peers. Furthermore, girls in general tended to perform better on visual-motor integration tasks than boys. This study, along with additional research of its kind, may be beneficial to creating intervention programs to improve the motor skills of children identified with motor delays. Early improvement of these developmental delays is imperative to the success of the child in classroom, playground and physical activity settings. The outcomes of this study suggest that the presence of developmental delays in this and previous findings by Pope et al. (2011) are important to policy makers, caretakers, and educators. Unfortunately, many preschool children do not receive structured physical activity lessons at the levels recommended by NASPE (2002). At present date, many states lack specific guidelines or objectives for amount of physical activity recommendations for preschool children. However, studies such as this one are beneficial in possibly identifying these areas for policy makers. In addition, preschools, child cares, and Head Start programs would benefit from developing clear curricular objectives that focus on specific gross and fine motor competencies.

Given the number of children who attend publicly funded preschool, child care, and Head Start programs on an annual basis, this finding merits further consideration. Policy makers can provide important direction to preschool children with low SES backgrounds on appropriate movement content and best practices for the development of gross and fine motor development.

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