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Motor skill interventions to improve fundamental movement skills of preschoolers with developmental delay.

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Running Head: FMS INTERVENTIONS

Motor Skill Interventions to Improve Fundamental Movement Skills of Preschoolers Identified
with Developmental Delay: A Systematic Review

Abstract

Preschoolers with developmental delay (DD) are at risk of poor fundamental movement skills (FMS), but a paucity of early FMS interventions exist. The purpose of this review was to critically appraise the existing interventions to establish direction for future trials targeting preschoolers with DD. A total of 11 studies met the inclusion criteria. Major findings were summarized based on common subtopics of overall intervention effect, locomotor skill outcomes, object-control outcomes and gender differences. Trials ranged from 8 to 24 weeks and offered 540 to 1700 minutes of instruction. The majority of trials ($n = 9$) significantly improved FMS of preschoolers with DD, with a large intervention effect ($\eta^2 = .57-.85$). This review supports the utility of interventions to improve FMS of preschoolers with DD. Future researchers are encouraged to include more robust designs, a theoretical framework, and involvement of parents and teachers in the delivery of the intervention.

Key Words: preschoolers, developmental delay, motor skill interventions, fundamental movement skills

Motor Skill Interventions to Improve Fundamental Movement Skills of Preschoolers with Developmental Delay: A Systematic Review

The early childhood years represent an important time period where the formation of fundamental physical, social, and cognitive skills is formed. Children identified with developmental delay (DD) do not form these fundamental skills at the same pace as typically developing children, and consequently, are at an even greater risk of compromised health and further delays in social, emotional and cognitive development across the lifespan (Centers for Disease Control and Prevention [CDC], 2009; Majnemer, 1998). DD refers to a non-permanent chronological delay (e.g., physical, intellectual, social) in achieving typical milestones expected at a certain age (Statistics Canada, 2001). In Canada, DD has been identified as the most common disabling condition among young children (ages 3-5). Among the nearly 20 000 children identified with a disability in Canada, 68% of those cases were because of a DD diagnosis (Centers for Disease Control and Prevention [CDC], 2009; Statistics Canada, 2001). Thus, research efforts focused on improving the social, cognitive, and physical development of young children with DD is a potential public health priority.

A key developmental aim among preschool-aged children (ages 3-5) is the development of proficient fundamental movement skills (FMS). FMS are considered the building blocks for future complex motor skills (e.g., sport-specific participation, habitual physical activity (PA)) where greater focus can be placed on the health outcomes of PA (Temple, Naylor, Rhodes, & Wharf Higgins, 2009; Timmons, Naylor, & Pfeiffer, 2007). FMS are comprised of locomotor and object control skills. Locomotor skills require the movement of the body through space and include running, hopping, jumping, skipping, galloping, sliding, and leaping (Stodden et al., 2008). Object control skills are those that require the manipulation of tangible objects and

1 include throwing, catching, bouncing, striking, kicking and rolling (Stodden et al., 2008). The
2 development of proficient FMS is not a naturally occurring process, and requires sufficient time,
3 instruction, and reinforcement by educators, parents, and health professionals to ensure children
4 are appropriately engaging in movement skills that build FMS (Stodden et al., 2008).

5 Children identified with DD lack the motor skill competency necessary to perform FMS,
6 and are at risk of poor physical, social, and emotional functioning later in life (Majnemer, 1998).
7 From a PA perspective, motor skill competence during the early childhood years (ages 3-5) has
8 demonstrated to track and predict future physical activity (PA) and sport participation (Telama,
9 Yang, Laakso, & Viikari, 1997; Telama et al., 2005). Thus, children with DD who have not
10 developed proficiency in FMS are at risk of having poor physical functioning and inactivity
11 extending across the lifespan. Therefore, children with DD especially need remediation,
12 intervention and instruction to develop competence in FMS to help promote overall daily
13 functioning, and future PA and sport participation (Stodden et al., 2008; Strong et al., 2005).

14 From a public health standpoint, early intervention strategies that target FMS
15 development among children with DD can 1) help minimize and remediate existing DD
16 disorders, 2) improve overall daily functioning, 3) promote lifelong participation in health
17 promoting behaviours (e.g., PA) (Majnemer, 1998). Prior intervention efforts have focused
18 heavily on typically developing preschool-aged children or integrated samples that do not
19 differentiate between those with and without DD (Riethmuller, Jones, & Okely, 2009). Thus, our
20 understanding of the efficacy of interventions in improving motor skills of preschool children
21 with DD is limited and supports the need for a review. To our knowledge, no known systematic
22 review explicitly examining the effect of motor skill interventions on motor skill development of
23 preschool-aged children with DD has been conducted. Therefore, the purpose of this study is to

examine and critically appraise the existing literature investigating the impact of a motor skill intervention on FMS development of preschool-aged children with DD to help establish a guiding platform for future research and identify the potential research limitations and potential targets for future PA interventions among this at-risk population.

Method

Inclusion Criteria

Studies investigating the effect of a motor skill intervention on FMS scores of children identified as having DD were initially assessed for eligibility based on pre-established criteria set by both reviewers (MK, RR). The population of interest was preschool-aged children (ages 3-5) identified as having DD. Eligible studies were selected from published English peer-reviewed journal articles that examined an experimental or quasi-experimental trial and reported the effects of the intervention. Because of a limited literature, studies that also examined single case-reports that described the motor skill outcomes of motor interventions were critically appraised and included in this review.

Exclusion Criteria

Studies were excluded from this review based on pre-established criteria set by both reviewers (MK, RR). A study was excluded if it examined infant (ages < 3) or youth (ages > 6) populations since motor skill development and competency differs from that of preschool-aged children. Excluded studies were also those that 1) did not exclusively describe the gross motor outcomes of a sample of children defined as having a developmental delay (e.g., integrated sample of children with and without developmental delay) because the results may not exclusively generalize to the target population, and 2) examined gross motor skills among preschoolers identified as having a specific developmental disability (e.g., cerebral palsy,

Autism, Down Syndrome, ADHD, visual impairments) since the gross motor development of children with permanent disabilities may require unique intervention procedures (e.g., intensive physical therapy, unique instruction, adapted equipment) that differ from those used for children with DD.

Search Strategy

Based on previous recommendations (Egger, Smith, & Altman, 2001), database searches were conducted from March, 2010 to August, 2010 in 6 online databases: Academic Search Premier, ERIC, ISI Web of Knowledge, MEDLINE, SPORTDiscus, and CINAHL. The literature search strategy was developed by both authors (MK, RR), and was not restricted to year of publication or study design. Various combinations of key words were used including physical activity intervention, gross motor skills, fundamental movement skills AND intervention studies AND preschoolers AND developmental delay. To ensure saturation of the literature, manual cross-referencing of reference lists of relevant articles was also completed.

Screening

Citations, including the title and abstract, were independently screened by both authors (MK, RR). Potentially relevant and ambiguous studies were retrieved in full and judged against the pre-defined inclusion criteria. Potential studies for inclusion were compared, discussed, and agreed upon by both reviewers (RR, MK). Discrepancies were resolved through discussion until 100% consensus in all cases was reached.

Study Quality Assessment

The study quality and risk of bias of all relevant studies was assessed by both authors using a modified version of (Downs & Black, 1998) validated quality assessment tool. The assessment tool evaluates 5 areas of study quality: reporting, external validity, internal validity -

risk of bias, internal validity - confounders, and power. A 27-item checklist that includes a
 yes/no response assesses the quality of each category; reporting = 10-items, external validity = 3-
 items, internal validity – bias = 7-items, internal validity – confounding = 6-items, power = 1-
 item (Downs & Black, 1998). All studies were initially scored out of a maximum of 27 (See
 Appendix A). Based on pre-determined criteria set by both reviewers (MK, RR) the overall
 quality of the study was then determined based on the maximum score out of 5 to coincide with
 the 5 quality categories. For *reporting quality*, studies that scored a minimum of 8 out of 10 were
 coded as 1; studies scoring less than 8 were coded as 0. For *external validity quality*, a minimum
 score of 2 out of 3 was coded as 1; less than 2 was coded as 0. For *Internal Validity – Bias*
Quality, studies that scored a minimum of 5 out of 7 were coded as 1; studies that scored less
 than 5 were coded as 0. For *Internal Validity – Confounding Quality*, studies that scored a
 minimum of 5 out of 6 were coded as 1; studies that scored less than 5 were coded as 0. For
Power, studies that scored 1 out of 1 were coded as 1; studies that scored 0 were coded as 0.
 Both authors independently coded and assessed the overall study quality. Discrepancies were
 resolved through discussion until 100% agreement in all cases was reached. High quality studies
 were those that scored five, moderate quality studies scored three to four, and low quality studies
 were those that scored two or less (See Appendix A). The overall quality of the studies was
 reported to describe the general state of the research on the topic. Because of the limited research
 available, all studies, regardless of quality rating, were included in this review to help establish
 current limitations and future methodological recommendations for future interventions.

Data Abstraction and Analysis

A 10-item data abstraction form that included the authors, year, study design,
 participants, developmental delay measurement tool, intervention length, intervention approach,

intervention setting, gross motor outcome measure, results, and study quality was used to abstract the data (See Table 1). Subtopics and themes were identified and categorized based pre-established criteria set by both reviewers that followed previous recommendations (Sallis, Prochaska, & Taylor, 2000). Due to the limited number of studies that passed the inclusion criteria, the major findings were highlighted if they were present in a minimum of two independent studies. Each study was initially scanned to identify what themes were present across all studies. The study characteristics, intervention design characteristics, overall intervention effect, locomotor skill outcomes, object control skill outcomes, and gender differences were discussed.

The major findings from each study including the subtopics and emerging themes are discussed and synthesized in a narrative review with particular focus on whether the intervention was effective in changing gross motor scores. The qualitative appraisal included the overall intervention effect, locomotor skill outcomes, object control outcomes, and gender differences. The quantitative appraisal of studies included discussing and summarizing the necessary statistical information that was available. Reporting decisions were based on 1) significant/null findings ($p < .05$) and 2) at least a small effect size ($\eta^2 = .009$) using standardized predetermined criteria (Cohen, 1992). Homogeneity across study methods and measures was inadequate to perform a meta-analysis (Hunter & Schmidt, 2004).

Results

Overall, 30 potentially relevant records were retrieved from the database search. Based on the inclusion criteria, 24 potentially relevant abstracts and full-text articles were obtained and reviewed. Overall, 11 articles examining 11 independent samples passed the eligibility criteria and were included in this review (See Figure 1).

Study Characteristics

Table 2 presents a detailed summary of the intervention studies. In terms of quality rating, only one study was identified as being of high quality (Robinson & Goodway, 2009), three studies were identified as moderate quality (Goodway & Branta, 2003; Goodway, Crowe, & Ward, 2003; Valentini & Rudisill, 2004) and the remaining seven studies were scored as low quality (Apache, 2005; Buccieri, 2003; DeGangi, Wietlisbach, & Scheiner, 1993; Hamilton, Goodway, & Haubenstricker, 1999; Jenkins, Fewell, & Harris, 1983; Young & Lewis, 1998; Zittle & McCubbin, 1996). Overall, the studies represented a total of 395 participants (211 male and 184 female). Sample sizes ranged from 1 to 117 preschool children with a mean sample size of 36. Developmental delays were most commonly assessed by prevalence of low test scores (e.g., at or below 30th percentile) on the Test of Gross Motor Development (TGMD) ($n = 5$), followed by prevalence of low test scores (e.g., 2-standard deviations below the mean, 1st percentile) on the Peabody Developmental Gross Motor Scale (PDGMS) ($n = 4$), and predefined US state specific criteria ($n = 2$), Motor skill outcomes of preschool children were measured using the Test of Gross Motor Development (TGMD) ($n = 6$), Peabody Developmental Gross Motor Scale (PDGMS) ($n = 4$), and a study-created measure ($n = 1$).

Intervention Characteristics

Research Design

Of the eleven studies, the majority conducted non-randomized control trials ($n = 3$), followed by a quasi-experimental two-treatment intervention design ($n = 3$), a single case-report design ($n = 2$), and other experimental designs ($n = 2$). Only one study conducted a randomized control trial. Authors reported that true randomized control trials were difficult to conduct in the majority of the studies due to the educational structure and nature of the preschool setting.

For the five control trials, all studies indicated that the intervention and control groups were comprised of children identified with DD that attended a community-based preschool. Two of the studies reported that the preschool setting used for recruitment was part of the US Head Start program (Hamilton et al., 1999; Robinson & Goodway, 2009). None of the five studies indicated that the control group would be receiving the motor skill intervention following the study, but all studies reported that the control group would be receiving the typical play/recess program they were accustomed to.

Intervention Approach

The type of intervention approach used in the studies varied. Eight of the eleven interventions (72.7%) implemented an instructor-directed approach that was task-specific. Five studies (45.5%) implemented a child-directed approach where the child initiated learning, and three studies (27.3%) followed a physical/occupational therapy based approach. Overall, five studies implemented both instructor-directed and child-directed interventions to compare gross motor outcomes (Apache, 2005; DeGangi et al., 1993; Jenkins et al., 1983; Robinson & Goodway, 2009; Valentini & Rudisill, 2004). Intervention objectives were most commonly developed based on pre-established guidelines and procedures: physical therapy ($n = 4$), education curriculum guidelines ($n = 3$), TARGET ($n = 2$), I-CAN ($n = 1$). One study followed guidelines developed by the primary researcher.

Intervention Implementation

All studies described the intervention implementation procedures. The intervention trials were most commonly delivered in the school setting ($n = 7$); two studies examined an in-home intervention trial and two studies were conducted in a therapy setting. The primary researcher ($n = 4$) and therapist/specialist ($n = 3$) delivered the intervention in the majority of studies. For the

remaining four studies, the researcher/therapist worked with parents, research assistants and preschool teachers to implement the intervention. The intervention length and hours of instruction provided to participants varied. Intervention trials ranged from 8- to 24-weeks with an average duration of 13.7 weeks. The weekly frequency of instruction ranged from 1 to 4 times per week, with only one study administering the intervention program 4 times per week. Overall, the intervention trials offered between 540 to 1700 minutes of total instruction time.

Overall Efficacy of Intervention Trials

Overall, nine of the eleven (81.8%) studies reported improvements in gross motor skills among preschoolers with DD at post-intervention testing, with six studies reporting significance at the $p < .05$ level (Apache, 2005; Buccieri, 2003; DeGangi et al., 1993; Goodway & Branta, 2003; Goodway et al., 2003; Jenkins et al., 1983; Robinson & Goodway, 2009; Valentini & Rudisill, 2004; Young & Lewis, 1998). Two studies found no significant difference ($p > .05$) in motor skill scores based on the intervention condition (Jenkins et al., 1983; Zittle & McCubbin, 1996), the results may be attributed to the poor study quality. The magnitude of the intervention effect was reported in three studies and ranged from $\eta^2 = .57$ to $\eta^2 = .85$ indicating a strong/large effect of the motor skill intervention in improving gross motor skills (Apache, 2005; Goodway et al., 2003; Robinson & Goodway, 2009).

In terms of motor skill retention over time, only two studies investigated participants' motor skill competence following post-intervention measures (Robinson & Goodway, 2009; Valentini & Rudisill, 2004). The follow-up measures were conducted at 9-weeks (Robinson & Goodway, 2009) or 6-months (Valentini & Rudisill, 2004) after post- intervention testing. From post-intervention to retention, one study found significant decreases in scores from post-intervention to retention among intervention groups (Robinson & Goodway, 2009), and one

study found no significant change in motor skill scores at follow-up (Valentini & Rudisill, 2004). Both studies reported that the intervention groups had significantly higher scores than the control group at retention suggesting that the intervention is efficacious in maintaining and developing motor skills. Despite these promising findings, however, more research is needed to substantiate the findings.

Locomotor Skill Outcomes

Locomotor skill outcomes were assessed in nine of the eleven studies (Apache, 2005; Buccieri, 2003; DeGangi et al., 1993; Goodway & Branta, 2003; Goodway et al., 2003; Jenkins et al., 1983; Valentini & Rudisill, 2004; Young & Lewis, 1998; Zittle & McCubbin, 1996). Seven of the nine studies reported significant improvements in locomotor skills following the intervention among the intervention group and treatment effects ranged from $\eta^2 = .10$ to $.85$ (Apache, 2005; Buccieri, 2003; DeGangi et al., 1993; Goodway & Branta, 2003; Goodway et al., 2003; Valentini & Rudisill, 2004; Young & Lewis, 1998). For control trials, all three studies reported that the intervention group performed significantly better on locomotor tests compared to the control group at post-intervention testing (Goodway & Branta, 2003; Goodway et al., 2003; Valentini & Rudisill, 2004). For studies comparing two treatments, both studies reported significantly higher locomotor scores for the child-initiated/directed approach compared to the instructor-directed approach (Apache, 2005; Valentini & Rudisill, 2004). Running and jumping emerged as the most common locomotor skills that saw the greatest improvement. Among the studies that reported locomotor performance norms pre- and post-intervention, locomotor performance was found to be at or above the 50th percentile following the intervention, indicating that the intervention helped preschool children with developmental delays to perform at a level

similar to typically developing preschoolers (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999).

Object Control Skills

Overall, all eleven intervention trials assessed and reported object control skill outcomes. Nine of the studies reported significant improvements in object-control skills following the intervention among treatment groups with intervention effects ranging from $\eta^2 = .002$ to $.97$ (Apache, 2005; Buccieri, 2003; DeGangi et al., 1993; Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Robinson & Goodway, 2009; Valentini & Rudisill, 2004; Young & Lewis, 1998). The interaction effect of intervention and time for object-control skills was reported in six studies and ranged from $\eta^2 = .32$ -.85, indicating a strong/large effect of the intervention on post-test scores (Apache, 2005; Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Robinson & Goodway, 2009; Valentini & Rudisill, 2004). For control trials, four of the five studies reported that the intervention group performed significantly better on locomotor tests compared to the control group at post-intervention testing (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Robinson & Goodway, 2009; Valentini & Rudisill, 2004). For studies comparing two treatments, one study found the child-initiated/directed intervention to produce significantly better object control skills than the instructor-directed intervention (Apache, 2005), and one study found no significant differences b/n treatments (Valentini & Rudisill, 2004). The strike and throw emerged as the most common object control skills that showed the greatest improvement in performance among the participants. Object-control skill performance among the intervention groups improved to a level at or above the 50th percentile following the intervention (Goodway & Branta, 2003; Goodway et al., 2003; Hamilton et al., 1999; Robinson & Goodway, 2009).

Gender Differences in Motor Skill Outcomes

Only two of the eleven studies reported and tested for differences in gross motor scores among male and female participants following the intervention (Apache, 2005; Goodway & Branta, 2003). No significant main effect or interactions were found based on gender.

Discussion

The purpose of this review was to summarize and critically appraise the existing literature pertaining to the efficacy of motor skill interventions in improving FMS of preschool-aged children identified with DD. A total of eleven studies were identified as meeting the eligibility criteria and were critically appraised in the review. Only one study met the criteria for “high quality.” None of the remaining ten studies included random assignment of participants to the intervention group or adequately controlled for potential confounders and, therefore, were rated as “moderate” or “low” quality. Overall, 81% of the studies identified significant improvements in motor skill scores following an intervention with locomotor skills showing the largest improvements. Significant gains in both locomotor (e.g., running, jumping) and object-control (e.g., throwing, catching) skills to a performance level similar to typically developing preschoolers was found among the majority of controlled intervention trials. Thus, this review provides preliminary support of the effectiveness of early motor skill interventions in improving gross motor skills among preschoolers with DD.

The findings from this review are in congruence with previous research investigating the effectiveness of motor skill interventions on gross motor development of typically developing preschool-aged children (Riethmuller et al., 2009; van Sluijs, McMin, & Griffin, 2008). In support of our findings, van Sluijs et al. (2008), identified three PA interventions that targeted children from low SES backgrounds. Of these, all three reported significant positive intervention

1 effects. Of particular importance, however, our review highlights that the intervention effect of
2 motor skill programs may be even larger and more consistent among preschoolers with DD than
3 those studies exclusively examining motor outcomes among typically developing children
4 (Riethmuller et al., 2009; van Sluijs et al., 2008). Future researchers are encouraged to
5 implement early motor skill interventions.

6 The findings from this review highlight that the setting and type of intervention approach
7 are important considerations for future FMS interventions. It appeared that the school setting was
8 the most opportune location to help improve FMS compared to home-based and therapy-based
9 settings. The school environment may provide greater opportunities for motor skill development
10 as a result of greater access to equipment and space than perhaps the child's home environment.
11 In addition, intervention approaches that emphasize child-initiated learning appeared to produce
12 the most significant gains in FMS among children identified with DD compared to instructor-
13 directed approaches. More specifically, the intervention strategies that focused developmentally
14 appropriate progressions in motor skill acquisition and tailored the session towards how the child
15 best learns and processes information appeared to have promising results. Further research
16 investigating the effectiveness of a child-centered approach towards improving and maintaining
17 FMS among children with DD is encouraged to help build the preliminary evidence. Overall, use
18 of a motor skill intervention to assist preschoolers with DD to become proficient in FMS is
19 supported by this review. Thus, targeted interventions are urgently needed to prevent habitual
20 inactivity and adverse health consequences among this at-risk population.

21 Of particular interest, only two of the studies conducted follow-up retention tests after
22 post-intervention measures. While both studies concluded that motor skill competences remained
23 significantly higher among the intervention group compared to the control group, the lack of

research examining retention effects is concerning since the overall effectiveness of an intervention is determined by the long-term follow-up effects. The findings from this review provide initial support for the efficacy of FMS interventions among children with DD, but further retention measures are urgently needed to establish robust support in this area.

Despite the strengths of motor skill interventions in improving motor skills among preschool children with developmental delays, there are inherent limitations to the studies reviewed that must be considered. First, the lack of high-quality studies (e.g., small samples, few RCT trials, poor internal validity) limits our conclusions concerning the efficacy of motor skill interventions in improving FMS among preschoolers with developmental delays. Second, despite increased emphasis on conducting theoretically sound research, few studies included in this review used previously validated intervention approaches to guide the intervention trials. Successful interventions are thought to be best implemented if they follow a theoretical framework to help identify the critical determinants of behaviour (Baranowski, Anderson, & Carmack, 1998; Rhodes & Pfaeffli, 2009). Therefore, it is expected that even greater improvements in motor skills among preschool children with DD are possible if future trials use theoretically sound frameworks to guide their intervention (e.g., Self-Determination Theory). Third, only one of the studies followed a randomized controlled trial design, and few studies attempted to conduct multi-component interventions. Prior research has established that parents, teachers, and community organizations play an important role in the physical development of young children (Stodden et al., 2008; Timmons et al., 2007; Tucker, 2008). Future intervention trials should involve parents and teachers in the direct delivery and design of the intervention, as well as attempt to include various settings (e.g., school, home, community). Overall, this review

1 supports the use of more robust designs and longitudinal RCT trials to further strengthen the
2 findings.

3 It is important that this review also be interpreted within the context of its limitations.
4 First, the literature reviewed was limited to English written journal articles, which prevents the
5 results from being generalized to studies conducted in other languages. Second, this review is
6 limited to the search terms and databases referred to in the methods section. Thus, potentially
7 relevant articles that were not identified with the key words used are missing from this review.

8 Based on the evidence included in this review, it appears that motor-skill interventions
9 aimed at increasing FMS of preschoolers with DD, particularly child-directed approaches, are
10 effective. Continued research investigating the long-term outcomes (e.g., health, physical
11 functioning) are needed to confirm the efficacy of early FMS interventions in improving overall
12 health and daily functioning from the preschool years to adolescence. Future studies aimed at
13 improving the motor skills of this at-risk population are needed to minimize and remediate their
14 DD and maximize their overall physical, social, and emotional development across the lifespan.

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