An In-Depth Analysis of Preschool Movement Environments

by

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DEDICATION

To my son.

"*Decide what to be and go be it*."

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ABSTRACT

Fundamental motor skills (FMS) are an important component of developmental trajectories of health. FMS develop in early childhood, and the current standard practice for children to learn FMS in preschools and childcare centers is an outdoor free play session. Unfortunately, children who only engage in this outdoor free play FMS environment fail to learn these skills. Conversely, children who complete FMS interventions learn these skills. The most effective FMS interventions (a) replace the standard practice of outdoor free play and (b) are implemented by motor-experts who are external to the preschool. These interventions are effective, but ultimately an unsustainable approach to FMS interventions. Hence, there is a need for sustainable FMS intervention designs that can work within the standard practice of outdoor free play and be implemented by non-motor experts.

This dissertation addressed this gap by creating, implementing, and examining the efficacy of a sustainable FMS intervention- Motor skills At Playtime (MAP). MAP was implemented by a non-motor expert during outdoor free play. The effect of MAP on changes in children FMS was examined and compared against two other FMS environments: an FMS intervention that was implemented by motor experts and replaced outdoor free play (i.e., traditional FMS intervention), or a control condition (i.e., standard practice). This dissertation also completed an in-depth examination of how child characteristics (e.g., sex, weight, and initial FMS levels) and behaviors in an FMS intervention (e.g., engagement in skill practice) related to

FMS changes after the interventions. Lastly, this dissertation compared children's performance on two FMS measures (process and product) before, after, and across the intervention.

Children from two Head Start centers served as participants. Results support that children in both MAP and traditional FMS intervention exhibited FMS gains, whereas children in the control condition did not exhibit FMS changes. Regarding child-characteristics, no sex differences were present in FMS changes in each group though there were sex differences in FMS changes between groups. Initial skill level was inversely related to changes FMS across both interventions. Regarding child-behaviors, children were more engaged in skill practice in the traditional FMS intervention, but engagement failed to predict most FMS changes. Finally, product and process measures were related before and after the intervention but did not measure change in FMS similarly.

Overall, this research supports that FMS interventions that are implemented by non-motor experts and added to the standard practice of outdoor free play (e.g., MAP) can be an effective and potentially sustainable approach to FMS interventions in this population. Further, these results support that child-characteristics and behaviors relate to intervention outcomes. These results are promising and provide a foundation for continued research on sustainable FMS interventions that can be successfully implemented by non-motor experts with a specific emphasis on the MAP intervention.

CHAPTER I. INTRODUCTION

Child development research seeks to understand the processes, constraints, and affordances of development across multiple domains: social-emotional, cognitive, physical, and motor (Payne & Isaacs, 2017). Motor development is defined as "the changes in motor behavior over the lifespan and the process(es) which underlie these changes" (Clark & Whitall, 1989, p. 194). Motor development is a broad term that includes a variety of movements such as reflexes, abilities, and skills.

The diversity of motor research and the historical creation of the motor development field from multiple areas of study (e.g., psychology, physical education, or developmental science) resulted in inconsistent terminology. This research adopts the following motor development terminology and definitions. Reflexes are involuntary movements that are the primary form of movement for young infants (Burton & Miller, 1998;). Early movement milestones are voluntary, gross motor movements that provide the foundation for skills needed to explore and interact with the environment such as rolling, sitting, crawling, creeping, reaching, and grasping (Burton & Miller, 1998). The onset of walking marks the end of early movement milestones and the transition in fundamental movement skills or fundamental motor skills (FMS; Burton & Miller, 1998). FMS are gross motor skills that serve as the building blocks for more sport or context-specific skills. FMS preferred pattern of behavior are phylogenetic (e.g., exhibited across multiple people in a population); however, not all individuals will reach the mature pattern

(Clark & Metcalfe, 2002; Logan, Robinson, Wilson, & Lucas, 2011; Wick et al., 2017). FMS should develop between 3-10 years of age and divide into two categories: locomotor (ability to transport the body through space such as running, jumping, skipping, etc;) or ball FMS (ability to manipulate or transport objects through space such as throwing, catching, or kicking; Ulrich, 2018).

FMS are translatable into sport or context-specific skills such as passing a soccer ball or serving a tennis ball. These sport or context-specific skills (soccer pass or tennis serve) are ontogenetic skills or skills that are unique to an individual (Burton & Miller, 1998; Payne & Isaacs, 2017). Each mover will develop an independent sport or context-specific skill repertoire in response to their own movement needs and engagement (Clark & Metcalfe, 2002). Lastly, an individual's motor abilities are characteristics underlying movement that may influence how early motor milestones, FMS, or sport-specific skills are performed such as balance, agility, and coordination (Burton & Miller, 1998).

Establishing competency in FMS is an essential aspect of healthy, holistic development (Stodden et al., 2008; Payne & Isaacs, 2017) and is a critical component for promoting positive developmental trajectories of health (Robinson et al., 2015b; Stodden et al., 2008). Failure to gain adequate FMS competence may inhibit a child's engagement in more translational skills or sport or context-specific skill associated with lifelong physical activity (Perkins, Jacobs, Barber, & Eccles, 2004; Seefeldt, 1980; Stodden et al., 2008). FMS in childhood is positively related to several health behaviors such as physical activity (Cohen, Morgan, Plotnikoff, Barnett, & Lubans, 2015; Figueroa & An, 2017; Foweather et al., 2015; Holfelder & Schott, 2014; Logan, Webster, Getchell, Pfeiffer, & Robinson, 2015), physical fitness (Cattuzzo et al., 2016; Cohen et al., 2015; Stodden, Gao, Goodway, & Langendorfer, 2014; Stodden, Langendorfer, & Roberton, 2007; Utesch, Bardid, Büsch, & Strauss, 2019), and inversely related to weight status (Cheng et al., 2016; D'Hondt et al., 2013; D'hondt et al., 2011; Henrique et al., 2016; O'Brien, Belton, & Issartel, 2016). FMS are also positively related to children's cognitive, social, and language development (Cameron, Cottone, Murrah, & Grissmer, 2016; Haapala, 2013; Iverson, 2010; McClelland & Cameron, 2019; van der Fels et al., 2015).

Movements, including FMS, emerge out of an interaction between an individual and the environment (Fowler & Turvey, 1978; Newell, 1986). This ecological perspective to movement (Fowler & Turvey, 1978) is vital in understanding how specially designed learning environments can elicit FMS change and learning. Movements (e.g., FMS) emerge from the interaction of three constraints- individual, task, and environment (Newell, 1986). Each type of constraint plays a vital role in how a child approaches and completes FMS. Individual constraints are child-level characteristics such as anthropometrics, motivation, or pre-existing FMS skills (Newell, 1986). Task and environmental constraints are external to the child and include specifics of the motor task (i.e., the goal of the task, rules of the task, and equipment needed for the task) or where the motor task is performed (e.g., indoors/outdoors, with or without peers, etc; Newell, 1986). The constraints-based approach to movement is important and provides a context for FMS development, performance at a single-time point, and instruction/interventions.

FMS start developing after the onset of independent walking (12-18 months) and need to be learned before a child can progress into more sport or context-specific skills (Burton & Miller, 1998; Clark & Metcalfe, 2002). Based on this developmental timeline, early childhood (ages 3-7 yrs), and particularly the preschool years (ages 3-5 yrs), is a critical period for FMS development and learning (Clark, 2005; Clark & Metcalfe, 2002). Several organizations including the National Academy of Medicine, National Association for the Education of Young Children

(Copple & Bredekamp, 2009), and National Association for Sport and Physical Education (2009) recognize the importance of learning FMS during the preschool years. Preschools must provide children with opportunities to engage in a variety of gross (e.g., FMS) and fine motor activities to meet accreditation standards (Copple & Bredekamp, 2009). Most preschools meet their gross motor accreditation requirements with an outdoor free play session (i.e., standard practice). These sessions are an unstructured and uninstructed segment of the school day where children have access to large play equipment and open spaces. Unfortunately, the literature shows that children who only participate in outdoor free play fail to learn FMS (Logan et al., 2011; Wick et al., 2017) supporting that FMS must be, "taught, practiced, and reinforced" (Robinson, 2011, p. 533).

Children's failure to learn FMS while engaging in outdoor free play (i.e., standard practice) is a serious concern from a public health and child development perspective because of the importance of FMS in establishing positive developmental trajectories of health (Robinson et al., 2015b; Stodden et al., 2008). Researchers attempt to address this concern by designing and implementing FMS interventions to elicit positive changes or FMS learning in early childhood (Logan et al., 2011; Palmer, Chinn, & Robinson, 2017; Tompsett, Sanders, Taylor, & Cobley, 2017; Veldman, Jones, & Okely, 2016; Wick et al., 2017). A 2017 meta-analysis supports that FMS interventions are effective at improving total FMS, as well as both locomotor and ball FMS (Wick et al., 2017). Interventions use a wide variety of pedagogical approaches to teach FMS from FMS instruction to active video gaming (Tompsett et al., 2017). Personnel who deliver FMS interventions include trained specialists/researchers (Altunsöz & Goodway, 2016; Robinson, Palmer, & Meehan, 2017; Robinson, Palmer, Webster, Logan, & Chinn, 2018; Robinson, Veldman, Palmer, & Okely, 2017; Veldman, Palmer, Okely, & Robinson, 2017), physical educators (Martin, Rudisill, & Hastie, 2009; Valentini, Pierosan, Rudisill, & Hastie, 2017), college students in education (Brian & Taunton, 2018; Robinson, Webster, Logan, Lucas, & Barber, 2012) or preschool teachers (Brian, Goodway, Logan, & Sutherland, 2017; Okely et al., 2017). Interventions also report inconsistent dosages from a few weeks to several months (for a full review, please see Wick et al., 2017). Regardless of intervention design differences, the literature demonstrates that children who participate in interventions exhibit improved FMS (Logan et al., 2011; Tompsett et al., 2017; Van Capelle, Broderick, van Doorn, Ward, & Parmenter, 2017; Wick et al., 2017). Intervention effects are seen both immediately after the intervention (Logan et al., 2011; Robinson, 2011; Robinson & Goodway, 2009; Robinson, Palmer, & Bub, 2016; Robinson, Palmer, & Meehan, 2017) as well as following retention periods (Robinson, 2011; Valentini & Rudisill, 2004b; Veldman et al., 2017). The studies with retention periods support that FMS interventions elicit FMS learning in young children (Robinson, 2011; Valentini & Rudisill, 2004b; Veldman et al., 2017).

The variety of FMS intervention designs highlights how challenging it is to create effective FMS interventions, and data support that though FMS interventions can improve FMS, not all intervention designs are equally effective. Specifically, research shows that the personnel responsible for implementing FMS interventions influences intervention outcomes with novice or non-specialized personnel (e.g., classroom teachers) delivering less-effective interventions compared with experts or trained implementers (e.g., research teams; Wick et al., 2017). It is unrealistic to expect preschools to hire an external expert, and relying on external teams to provide FMS interventions is an unsustainable approach to providing these services. External resources may not be available to all preschools, meaning that some children may receive FMS interventions while other children are not given opportunities to participate. If the external resources are university sponsored, preschools far away from universities or too small to host university studies are unlikely to receive these services. All children should have appropriate opportunities to learn FMS due to the important health and developmental implications associated with these skills. Hence, there is a need for novel and effective FMS interventions or programs that can be incorporated within the current standard practice (i.e., outdoor free play). This type of intervention approach would allow FMS interventions to be (a) more equitably distributed, and (b) sustained within the preschool setting without requiring external staff or resources.

Before designing an FMS intervention to be included in the extant standard practice, it is essential to examine how interventions create environments to elicit FMS learning. One factor to consider is what pedagogical approaches are used to create FMS interventions. A systematic review by Tompsett et al. found that FMS interventions tend to adopt one of six approaches: primarily focused on FMS acquisition, sports games, physical activity, active video games, teacher's professional development, or a multi-component approach (for a full review, please see Tompsett et al., 2017). Regardless of approach, their review found only one study that did not see significant changes from pre to posttest (Straker et al., 2015). This work contrasts with a study done by Valentini et al. (2017) that compared the effects of three movement environments with different instructional approaches: FMS intervention, exercise play, and free play control. This study found that children in the FMS intervention group were the only children to increase their FMS over time, and children in the exercise play group failed to change their skills (Valentini et al., 2017). Collectively, this work supports that FMS interventions primarily focused on FMS are an effective pedagogical approach to teach these skills.

FMS interventions utilize different personnel to implement interventions and different instructional approaches. Meta-analytic data supports that interventions that are implemented by a trained motor expert are more effective than those implemented by a non-motor expert (Wick et al., 2017). This finding has substantial practical implications as relying on an external team of motor experts to deliver FMS interventions is an unstainable approach to motor skill instruction and interventions. Further, FMS interventions often adopt one of two different instructional approaches: a student-centered (e.g., mastery or high-autonomy climates) or group-centered (e.g., low-autonomy climates) approach. A study by Robinson and Goodway compared the effects of a low-autonomy and high-autonomy ball FMS intervention (2009). This research found that children in both intervention groups equally improved their ball FMS, but children in the high-autonomy group exhibited a smaller decrease in FMS at the retention test compared with children in the low-autonomy intervention. Logan et al. reported similar findings in their 2013 study. Research in older children supports that high-autonomy climates are more effective for promoting physical activity, and children in these climates spend significantly less time on instruction leaving more time for FMS practice (Logan, Robinson, Webster, & Rudisill, 2015). A review by Palmer et al. supports using a high-autonomy approach always led to significant improvements in FMS across 12 intervention studies, but the benefits of low-autonomy approaches are mixed (2017a). Some studies see significant improvements in low-autonomy groups, whereas other studies fail to see improvement with this approach (for a full review, please see Palmer et al., 2017; Appendix A). Lastly, work by Brian and Taunton examined the effects of a student-centered (high-autonomy) vs. group-centered (low-autonomy) intervention when implemented by an expert or novice instructors (2018). Results showed that expert-led instruction always yielded better FMS outcomes compared with novice-led instruction, but that novice-led instruction was better when it was delivered using a group-centered approach instead of a student-led approach (Brian & Taunton, 2018). Cumulatively, the literature supports that child-centered, high-autonomy interventions focused on FMS instruction are an effective means of teaching FMS in early childhood, primarily when implemented by an expert instructor.

In addition to examining best practices for FMS interventions design, it is vital to examine how individual child's characteristics influence how much children (a) engage in and (b) learn from FMS interventions. The extant literature has examined how several child-level characteristics such as weight (Cheng et al., 2016; D'Hondt et al., 2013; Henrique et al., 2016; O'Brien et al., 2016) or sex (Goodway, Robinson, & Crowe, 2010; Robinson et al., 2017b; Veldman et al., 2017) influence FMS, but limited work has examined how these characteristics relate to changes in FMS across an intervention or to children's engagement in skill practice during the intervention. One study examined potential differences in changes in ball FMS between girls and boys after completing a 540-min FMS intervention (Robinson et al., 2017b). Results showed that boys outperformed the girls in the intervention at pretest and posttest, but boys and girls demonstrated equal ball FMS learning after the intervention (Robinson et al., 2017b). This work along with the model by Stodden et al. (2008) suggest that several child-level characteristics including sex, anthropometrics, initial skill competence, and perceived motor competence may be important to examine regarding FMS intervention effectiveness.

Learning is not a passive process, and learning FMS is the result of completing skill practice (Magill & Anderson, 2014). Work by Silverman and colleagues measured the number of skill attempts middle school children completed during physical education and related children's practice to skill outcomes. This research supports that engaging in whole-appropriate practice is positively related to achievement in sport-specific skills in both swimming (Silverman, 1985) and volleyball (Silverman, 1990). Conversely, engaging in whole-inappropriate practice negatively related to learning outcomes across both sports (Silverman, 1990; Silverman, Subramaniam, & Woods, 1998). The relationship between engagement in skill practice during FMS interventions and learning outcomes as well as how this engagement relates to pre-existing (e.g., at pretest) individual child-characteristics is mostly unknown. One can reasonably infer that children in FMS interventions engage in sufficient practice to learn FMS, whereas children in outdoor free play fail to engage in sufficient skill practice to induce FMS learning. However, there is limited evidence to support this inference. Only one study has examined children's behaviors during an FMS intervention (Logan, Robinson, Webster, & Barber, 2013). Logan et al. (2013) used the engagement criteria outlined by Silverman (1990; 1998) and quantified children's engagement in skill practice (e.g., task persistence) during a preschool low and high autonomy FMS intervention. Results revealed that children in both the high and low autonomy motor interventions completed the same number of skills attempts, but that more highly-skilled children completed more skill attempts than low-skilled children in both groups (Logan et al., 2013a). The findings from this study support the need to quantify children's engagement in skill practice during different movement environments and relate this practice to FMS learning.

Lastly, changes in FMS elicited through interventions are most often assessed using process measures of FMS (Logan et al., 2011; Palmer et al., 2017a; Veldman et al., 2016; Wick et al., 2017). Process measures, such as the Test of Gross Motor Development (TGMD; Ulrich, 2018), score how a skill is performed. For example, if a child were to perform a throw trial, they would be scored on the presence or absence of specific skill criteria such as a contralateral step, wind-up motion, trunk rotation, and arm follow through (Ulrich, 2018). These measures provide rich data about a child's movement pattern but fail to quantify the outcome of the movement.

Measuring FMS outcomes, or product measures, provides information such as the ball speed (mph) or throw accuracy (mean error). Both process and product measures are developmentally appropriate and sensitive measures to assess FMS competence in young children (Burton & Miller, 1998; Gallahue et al., 2012; Logan, Barnett, Goodway, & Stodden, 2017; Stodden et al., 2014; Ulrich, 2018). Work by Logan et al. supports that product and process measures of FMS are related but not interchangeable and combining product and process measures would provide a more comprehensive understanding of children's motor competence (2017). Hence, there is a need for more research that combines both product and process assessments when determining the efficacy of FMS interventions and programming.

Study Need

FMS are an essential component of a child's developmental trajectories of health (Robinson et al., 2015b; Stodden et al., 2008). Failure to learn FMS could inhibit a child's ability to learn more advanced movements and may negatively impact physical activity engagement across the lifespan (Perkins et al., 2004; Robinson et al., 2015b; Seefeldt, 1980; Stodden et al., 2008). FMS interventions are an effective means for teaching FMS during preschool, which is crucial because the current standard practice (i.e., outdoor free play) is insufficient to yield FMS gains or learning. Interventions implemented by motor development or movement experts are the most effective intervention designs, but this approach is unsustainable and limits which preschools may have access to these services. Hence, there is a need for sustainable interventions that can be implemented by non-motor experts and delivered within the standard practice at the preschool center. Secondly, little research takes an in-depth approach to examining child-level characteristics or behaviors that may relate to intervention outcomes. The purpose of this dissertation is to address these gaps in FMS intervention research (see Figure I.1).

Gap 1: There is a need to create and test effective FMS interventions that can be implemented by non-experts and within the extant standard practice of outdoor free play. This dissertation will examine the efficacy of a novel FMS intervention- Motor **s**kills At Playtime (MAP), which is designed to be added to the standard practice of outdoor free play and implemented by a non-motor expert.

RQ1. Are there group differences between children's FMS after completing one of three 1350-min FMS environments- traditional motor intervention (CHAMP), MAP, or control (standard practice)?

H1a- Children in the traditional motor intervention (CHAMP) and MAP will demonstrate greater changes in FMS (product and process) compared with children in the control group (standard practice).

H1b- Children who receive continuous FMS instruction in an FMS only environment (CHAMP) will demonstrate greater changes in FMS (product and process) compared with children who do not receive continuous feedback in an FMS and outdoor free play environment (MAP).

Gap 2: Limited research examines child-level characteristics or behaviors that relate to FMS change or learning across an intervention. This dissertation examines how child-level characteristics and behaviors relate to FMS changes across two FMS interventions.

RQ2. How do child-level characteristics at the start of the intervention relate to changes in children's FMS?

H2a- Perceived motor competence and initial skill level will positively relate to changes in FMS.

H2b- Weight (lbs) and weight status (BMI and BMI-z) will negatively relate to changes in FMS.

H2c- Sex differences will not be present in changes in children's FMS.

RQ3. What child-level characteristics are associated with engagement in behaviors related to learning *and* how does engagement in behaviors related to learning affect changes in FMS across two FMS interventions (MAP and CHAMP)?

H3a- Children in CHAMP will be more engaged in behaviors related to learning compared to children in MAP.

H3b- Perceived competence and initial skill level will positively relate to engagement.

H3c- Engagement will positively predict children's changes in FMS.

Lastly, interest is growing on FMS measurement. Both process and product measures are used to assess FMS in young children. Evidence suggests process and product assessments yield different information about FMS competency, but, no research has compared process and product measures before, after, and across a motor intervention. Understanding how process and product measures of FMS align or fail to align when measuring FMS will aid researchers and practitioners in making informed decisions when selecting motor assessments to determine the efficacy of FMS interventions or programming.

Gap 3: No research has compared process and product FMS measures across an intervention. This dissertation addressed this gap in the literature by comparing process and product FMS measures before, after, and across a high-autonomy FMS intervention.

RQ4. What are the agreement between process (e.g., TGMD) and product measures of children's FMS before, after, and across a high-autonomy FMS intervention?

H4- Product and process measures will not be equivalent in measuring children's changes across an FMS intervention.

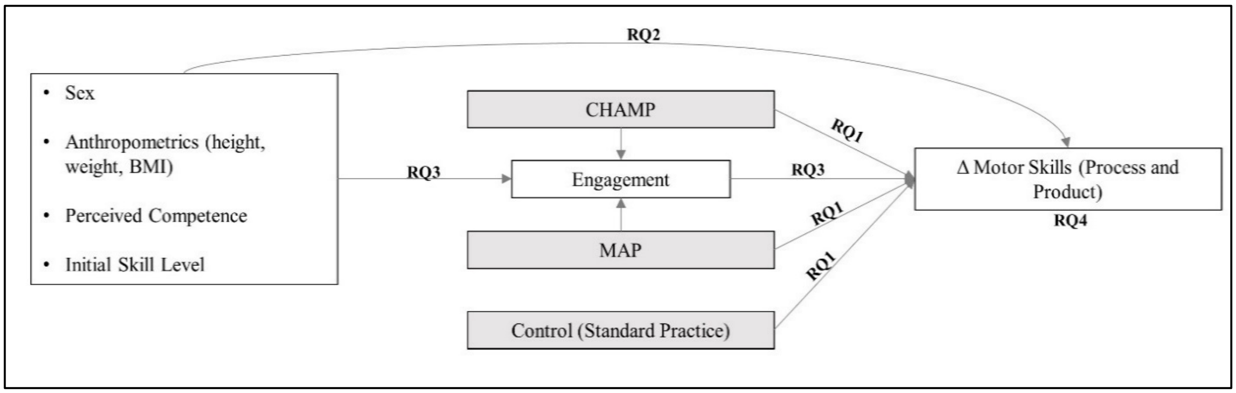


Figure I. 1 Working model of dissertation research questions.

Impact

Addressing these gaps will provide a richer understanding of FMS interventions, along with the efficacy of these FMS interventions currently missing from the literature. Results from this research can be used to create more effective and sustainable FMS interventions in preschools and early childcare centers. Results from this research will also provide much-needed insight into how different FMS assessments relate and may provide guidelines for selecting an appropriate FMS assessment.

Definition of Terms

Achievement goal theory: An educational theory that represents the way children approach, engage, and respond to educational or learning activities (Ames & Archer, 1988; Epstein, 1989).

Mastery orientation: An orientation towards learning where the learner engages in a task for the intrinsic value of learning itself and measures improvement using self-referenced standards (e.g., comparing current performance to previous performances; Ames & Archer, 1988; Epstein, 1989; Nicholls, 1989). *Note*: also known as undifferentiated or task orientation.

Performance orientation: An orientation towards learning where the learner engages in a task to prove competence or avoid failure and measures learning using norm-referenced standards (e.g., comparing current performance to performance of others; Ames & Archer, 1988; Epstein, 1989; Nicholls, 1989). *Note:* also known as differentiated or ego orientation.

Constraint: An internal or external factor that shapes movement (Newell, 1986).

Individual: Intrinsic factors that shape movement and are divided into two categories: structural (e.g., physical composition) or functional (e.g., cognitive or arousal level; Newell, 1986).

Environment: Extrinsic factors that relate to the physical environment where the movement is taking place (Newell, 1986).

Task: An external factor that relates to the goal, rules, or equipment of a movement (Newell, 1986).

Developmentally appropriate: Aligning equipment, instruction, and constraints of the activity with a child's current level of development in the social-emotional, cognitive, physical, and motor domains (Gallahue et al., 2012).

Early movement milestones: Gross motor skills that provide a foundation for fundamental motor skills. Examples include rolling, crawling, creeping, and grasping.

Ecological perspective: Approach to understanding motor behavior that situates movement is the result of the interaction between an organism and its environment (Fowler & Turvey, 1978).

Fundamental motor skills (FMS): Motor skills with phylogenetic attractor states that serve as the building blocks for more advanced or sport specific movements (Burton & Miller, 1998; Clark & Metcalfe, 2002).

Ball (skills) FMS: FMS that including propelling or manipulating objects in space (Ulrich, 2018). Examples include throwing, catching, or kicking.

Locomotor FMS: FMS that include propelling or moving the body through space (Ulrich, 2018). Examples include running, jumping, or skipping.

Fundamental motor skill (FMS) intervention: a strategically designed environment to elicit FMS practice as well as gains in performance and/or learning.

Children's Health Activity Motor Program- CHAMP: *Traditional FMS Intervention (expert-led)*. Children in this group participated in a well-established, high-autonomy FMS intervention that uses developmentally appropriate pedagogy to teach FMS to young children.

Motor skills At Playtime- MAP: *Sustainable FMS Intervention (non-expert led).* Children in this group completed a high-autonomy, low-instruction intervention that included a daily demonstration of FMS and access to the motor equipment for the same dosage as the CHAMP group during their outdoor free play (standard practice).

Control- Standard Practice: This group participated in the standard practice at the childcare center, which was a daily outdoor free play session.

Instructional approach: A descriptor of how the instruction of a movement environment is presented and implemented. For example, instruction can be student-centered (high-autonomy) or group-centered (low-autonomy).

Instructional content: The focus of the movement environment curricula. For example, the content can be focused on FMS, gross motor play, or exercise.

Motor skill: Goal specific movements that require voluntary action and can be improved through practice (Payne & Isaacs, 2017).

Ontogenetic skills: motor skills that are unique to the individual (Burton & Miller, 1998).

Phylogenetic skills: motor skills exhibited across a population (Burton & Miller, 1998).

Motor development: The change in motor behavior across the lifespan and the processes that accompany change (Clark & Whitall, 1989).

Process measure: An approach to measuring motor skills (e.g., FMS) that yields information about how the movement was completed (Haywood & Getchell, 2014).

Product measure: An approach to measuring motor skills (e.g., FMS) that yields a quantitative value about the outcome of the skill (e.g., throwing speed or hop distance; Haywood & Getchell, 2014).

Skill attempt: An execution of the skill in a manner consistent with the goal of the task (Logan et al., 2013a).

Task persistence: the amount of time a child spent in task-directed activities (Gaiter, Morgan, Jennings, Harmon, & Yarrow, 1982) and measured through skill attempts.

Sport specific skills: Ontogenetic gross motor skills that are tailed to accomplish a specific sport or complete goal (Burton & Miller, 1998; Clark & Metcalfe, 2002).

Delimitations

The delimitations of this study were:

1. All children were recruited from two preschool centers in a suburban city in the mid-western United States.
2. External personnel implemented the interventions rather than a preschool teacher.
3. The intervention implementation followed the school schedule and was implemented three or four days a week.
4. External factors that may have influenced FMS are assumed to be equal across all groups.

Limitations

The limitations of this study included:

1. The purpose of creating a new FMS intervention was to address current limitations of sustainability (i.e., adding requirements to the daily schedule and or relying on an external team of motor experts to implement programs). To that end, MAP altered two aspects of traditional FMS interventions (i.e., CHAMP): (1) implementation personnel and (2) environment (standard practice vs. intervention only). The design of this current study fails to allow for conclusions regarding how each of these factors individually

affected FMS in MAP.

2. The MAP and CHAMP interventions were implemented three of the four school days each week, meaning children in each group received the standard practice one day each week. Standard practice has been shown in the literature to be ineffective for gaining FMS (note: current results replicate these findings); therefore, children's participation in this environment one day a week should not have influenced results.
3. Due to limitations at the preschool centers, MAP was implemented at a second early childcare center, which may have introduced unaccounted for heterogeneity in the data. Centers were matched according to geographic location, school district, and socio-economic status.
4. Randomization into different intervention groups (CHAMP, MAP, or control) was done at the level of the classroom and not the level of the child.
5. Intervention daily dosage was different for the CHAMP (45 min/day, 3 days/week, 10 weeks) vs. control and MAP (30 min/day, 3 days/week, 15 weeks). Both CHAMP and MAP had equal dosage in terms of minutes (1350 min), but the dispersion of these minutes (10 vs. 15 weeks) may have influenced study findings. It is worth noting that CHAMP was arranged to be 30 min/day, but due to a change in school leadership (principals) before the start of the intervention, the dosage was altered to better fit with the revised school schedules. Previous research supports that intervention dosage in minutes does not affect intervention outcomes (Logan et al., 2011) but intervention dosage in length of implementation in months does affect outcomes (> or < 6 months, Wick et al., 2017). Though the weeks of the FMS intervention delivery were different, all interventions were below the 6-month threshold shown to be where intervention efficacy

changes (Wick et al., 2017).

6. No retention test was included in the present research design; therefore, FMS learning was not assessed.

CHAPTER II. REVIEW OF LITERATURE

This section provides a comprehensive literature review on topics most relevant to this dissertation research. The chapter begins with sections on the ecological perspective, dynamic systems theory, and Newell's constraints model. This chapter continues with a discussion of FMS interventions and an application of Newell's constraints model to FMS interventions with specific attention to high-autonomy FMS interventions and achievement goal theory. Next, this chapter includes a detailed description of the two high-autonomy interventions used in this dissertation. The chapter concludes with gaps in the extant literature and how this research addresses those gaps.

Ecological Perspective and Theoretical Framework

Motor Skills and the Ecological Perspective

Fundamental motor skills (FMS) are an essential component of developmental trajectories of health (Robinson et al., 2015b). It is a common misconception that these skills naturally emerge during child development. The notion that skills naturally emerge aligns with the maturational perspective of development. The maturational perspective states that the nervous system is the primary factor dictating the emergence of new motor behaviors; hence, as an organism's nervous system matures, it will display more advanced motor behaviors. This perspective presumes that a child's nervous system and motor skill repertoire develop in tandem

(Clark, 1995; Clark & Metcalfe, 2002; Clark & Whitall, 1989), so FMS will emerge barring abnormal development.

The maturational perspective was responsible for a rise in the interest of studying motor development at the turn of the 20th century. Researchers soon realized that maturation alone is insufficient to cause the emergence of new motor skills. In her landmark study, Myrtle McGraw discovered that providing one identical twin with a motor rich environment resulted in the emergence and mastery of a variety of motor skills (e.g., swimming, skating, sliding) whereas the twin who did not receive a motor rich environment failed to learn these new skills (McGraw, 1935). More recent research supports McGraw's findings and shows that FMS fail to develop in the absence of instruction (e.g., FMS interventions; Logan et al., 2011; Wick et al., 2017). This literature supports FMS are learned when children engaging in environments rich with motor instruction and opportunities for skill practice (for review, please see Logan et al., 2011; Palmer et al., 2017a; Tompsett et al., 2017; Veldman et al., 2016; Wick et al., 2017).

The perspective that posits movement emerges as an interaction between an individual and the environment is called an *Ecological Perspective* (Fowler & Turvey, 1978; Haywood & Getchell, 2014). The ecological perspective is central to FMS intervention research, which seeks to create and implement instructional environments to elicit FMS learning. This dissertation research is situated within the ecological perspective.

Newell's Constraints Model

One model commonly applied to the dynamic system's theory is Newell's constraints model. This model states that movement emerges with respect to three different constraints: individual, task, and environment (Newell, 1986, see Figure II.1). It is important to re-emphasize constraints are not negative, but rather are factors that limit or shape a movement. Individual constraints relate to the growth, development, and physiological state of the performer; task constraints relate to the purpose and specifics of the motor task; environmental constraints relate to the location of where the motor task is performed. The work of Kelso and Thelen provides excellent examples of how constraints work to shape the performance of a movement. In the Kelso's finger tapping experiment, the task constraint of tapping rate determined the motor performance of synchronized or alternating finger tapping (Kelso, 1984; Kelso, 1981). In Thelen's stepping reflex experiment, the individual constraint of the weight of the legs or environmental constraint of land vs. water determined the motor performance of the stepping reflex (Thelen & Fisher, 1982).

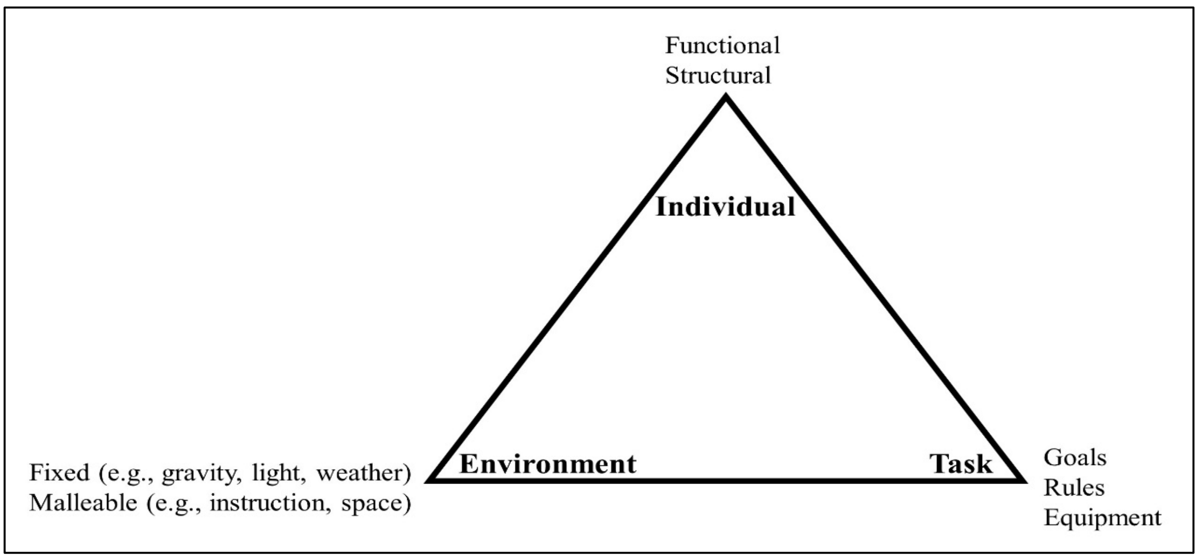


Figure II. 1. Newell's constraints model. Adapted from Newell (1986).

Both Kelso and Thelen's work demonstrates how manipulating constraints can alter motor performance. A constraints-based approach to movement is vital to interventions, treatment, or therapies where researchers or practitioners strive to elicit or teach a preferred movement pattern. Specific to this dissertation research, using a constraints-based approach is an appropriate pedagogical approach to teach FMS (Clark, 1995; Renshaw, Chow, Davids, &

Hammond, 2010). To effectively use this approach, it is vital to have an understanding of what a constraint is and how constraints can be manipulated to elicit the desired FMS. The following sections provide a more detailed description of each type of constraint with a specific emphasis on how constraints shape the FMS of infants and children. Newell’s constraints model and its application to FMS interventions and the present dissertation research are presented later in the chapter.

Individual Constraints.

Individual constraints are intrinsic to the organism performing the movement. These constraints are divided into two categories: structural or functional (Newell, 1986). Structural constraints pertain to the physical structure of the individual’s body and include factors such as height, weight, or limb length. Some structural constraints change with growth but are relatively stable once physical growth is complete (e.g., limb length or height) whereas other structural constraints will not change across time (e.g., sex). Functional constraints are intrinsic constraints that relate to an individual’s arousal or mental state and include items such as motivation, fear, or enjoyment. Functional constraints are typically fluid and can change rapidly; however, repeated negative or positive movement experiences can cause functional constraints to become more fixed (Gernigon, Fleurance, & Reine, 2000; Rudisill, 1989). For example, a child who experiences repeated success of motor task may have increased motivation to engage in that motor behavior in the future (Rudisill, 1989).

Individual constraints and motor skills. Both structural and functional individual constraints shape FMS performance. Research demonstrates how infants’ structural constraints of the musculoskeletal system influence how they walk on an infant treadmill (Ulrich, Jensen, & Thelen, 1991). Other work by Adolph and Anthony found that changing infants’ weight by adding lead weights to shoulder bags worn by the infants altered their walking patterns (Adolph & Avolio, 2000). Additional literature supports that structural constraints such as weight (Cheng et al., 2016; D'Hondt et al., 2013; D'hondt et al., 2011; Henrique et al., 2016; O'Brien et al., 2016) and sex (Goodway et al., 2010; Robinson et al., 2017b; Veldman et al., 2017) influence FMS performance of young children. For example, research has found that boys consistently outperform girls on ball FMS (Goodway, Robinson, & Crowe, 2010; Robinson et al., 2017b) even though boys and girls can learn ball FMS equally as well during an FMS intervention (Robinson et al., 2017b).

Research also shows how functional constraints such as motivation or focus of attention shape movement. A longitudinal study examined infants motivation to move by quantifying their persistence in motor tasks, activity level, and the stimulus strength required to elicit a movement (Atun-Einy, Berger, & Scher, 2013). This study found that more highly motivated infants reached motor milestones earlier than less motivated infants, and than motivation to move increased over time (Atun-Einy et al., 2013). Motivation also appears to be important for the performance of FMS. Children's catching behaviors change when tossed a ball of a preferred color, suggesting enjoyment or autonomy are functional constraints related to FMS performance (Isaacs, 1980).

Focus of attention also influences FMS performance. During the execution of a motor task, attention may be focused *externally*— attending to the outcome of the movement, or *internally*— attending to the pattern of the movement itself (McNevin, Shea, & Wulf, 2003; Porter, Wu, & Partridge, 2010). For example, when executing a jump, individuals may concentrate on how far they can jump by targeting a specific distance off of the board in front of themselves (i.e., external focus) or may focus on pushing through their feet to launch their body as forcefully as possible (i.e., internal focus). An external focus of attention is associated with improved FMS and sport-specific performance in both adults and children (Chiviacowsky, Wulf, & Ávila, 2013; Wulf, 2013). Twelve-year-old gymnasts who adopted an external focus of attention demonstrated improved quality and height of a maximum vertical jump with a 180-degree turn as compared to an internal and neutral focus of attention (Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015). Focusing attention externally also led to faster movement times on a balance task (Flores, Schild, & Chiviacowsky, 2015) as well as improved accuracy of a tennis forearm stroke at both a retention and transfer test (Hadler, Chiviacowsky, Wulf, & Schild, 2014). Work also supports that adopting an external focus of attention leads to greater ball FMS performance (Palmer, Matsuyama, Irwin, Porter, & Robinson, 2017b). Therefore, individual constraints (structural and functional) have implications for FMS performance, change, and learning.

Task Constraints.

Task constraints are extrinsic constraints that relate to the purpose or goal of a movement (Newell, 1986). Task constraints include the goals, rules, and equipment used in the execution of a motor task. Task goals include the purpose or desired outcome from the movement (e.g., to throw the ball and hit the target; dribble the ball continuously five times). Task rules include explicit guidelines that must be followed to achieve the task purpose/goal (e.g., the ball in soccer cannot be propelled through space using the hands except by the goalkeeper). Equipment, also referred to as “machines,” are the objects used in a motor task. For example, the equipment needed to strike the ball in a game of baseball includes a bat and ball. All three task constraints-goal, rules, and equipment, work together to shape the movement.

Task constraints and motor skills. Task constraints are frequently manipulated by researchers, practitioners, and therapists to elicit desired movement patterns. While the present work focuses on how task constraints are manipulated in the context of FMS, task constraints are used and manipulated in a variety of motor research such as stroke rehabilitation (Taub, Uswatte, & Pidikiti, 1999; Wolf, Blanton, Baer, Breshears, & Butler, 2002), physical therapy (Bayona, Bitensky, Salter, & Teasell, 2005; Salem & Godwin, 2009), and motor learning (Braun, Aertsen, Wolpert, & Mehring, 2009; Krakauer, 2009).

The literature on FMS supports that the goals, rules, and equipment of the task all shape FMS performance. Comparing different FMS assessments provides a prime example of how the goals of the task affect FMS performance. Some measures examine how the skill is performed (process measures), whereas others examine the outcome of the skill (product measures; e.g., throwing speed, kicking speed, jumping distance, etc.). The goal of a movement is different when performing a process versus product assessments, and the alteration of the task goal may change performance. For example, throwing for accuracy may induce an ipsilateral step, whereas throwing for process scores may induce a contralateral step. Research supports that process and product measures yield similar but not interchangeable outcomes (Logan et al., 2017); hence, manipulating the goal of FMS performance effects execution. Similarly, the developmental literature supports that changing the size of equipment, or scaling, supports the acquisition of FMS (Buszard, Reid, Masters, & Farrow, 2016; Farrow & Reid, 2010; Timmerman et al., 2015). A review of studies that used scaled equipment found that using scaled equipment lead to greater enjoyment, engagement, self-efficacy, as well as skill performance (Buszard et al., 2016).

Though goals, rules, and equipment can be manipulated individually, they are often manipulated simultaneously. For example, researchers can change the goal of the task by manipulating the equipment. Asking children to throw a ball at larger vs. smaller targets (equipment) alters the goal of the movement (hit a large vs. small target). Researchers can take this a step further and use the altered target size (e.g., goal and equipment constraints) to produce specific learning approaches that may influence motivation and competence (e.g., individual constraints). In this example, having the children aim at a larger target may increase success and decrease failure resulting elevated competence and motivation (Capio, Poolton, Sit, Holmstrom, & Masters, 2013; Masters, van der Kamp, & Capio, 2013; Xiang, McBride, Guan, & Solmon, 2003). This type of approach to teaching FMS is called errorless learning and is just one example of an application of Newell's constraints model to an FMS learning setting.

Environmental Constraints.

Environmental constraints are extrinsic constraints that relate to the physical environment where the movement is taking place (Newell, 1986). Some environmental constraints are fixed and are out of control of the researcher (e.g., gravity or weather) whereas others are malleable (e.g., instructional climate or physical space). Environmental constraints can affect the physical space such ice on outdoor play surfaces or the room set-up of a gym or play area, but they can also affect the motivational or psychological environment through instructional climate or peer interactions. Researchers, practitioners, and athletes should be cognizant of what environments are common when performing specific motor skills and mimic these conditions during practice to elicit the best performance during games or testing conditions.

Environment constraints and motor skills. Researchers, practitioners, and therapists have partial but not full control over environmental constraints. Some external constraints, such as the weather, sunlight, or outdoor surface conditions, may be beyond what can be controlled. Other constraints such as instructional climate, physical set up of a room/gym, or the number of other people within the space are well within the control of the practitioner, and these elements should be purposefully designed and executed. Researchers and practitioners should use best practices to manipulate constraints in their control while working within constraints outside of their control. Environmental constraints remain fairly constant during the execution of a closed loop skill but change rapidly during the execution of an open loop skill (Magill & Anderson, 2014).

Research demonstrates that children who are not given environments that support motor skill development fail to develop early movement skills as well as FMS (Logan et al., 2011; Veldman, Jones, Santos, Sousa-Sá, & Okely, 2018; Wick et al., 2017). The influence of environment on motor skill development is seen in the case of extreme neglect. A case report of a female child who underwent extreme neglect from 5 months-6 years of age states that the child was unable to walk when she was discovered at age 6, but the child was able to gain some motor function when placed in a nurturing environment (Davis, 1940). Because the child missed the critical period of skill development, though she exhibited improved motor function, she was never able to reach a threshold for typical development (Davis, 1940). Another example of how environmental constraints shape movement is demonstrated by research examining the development of locomotion in typically developing infants. In her work, Karen Adolph demonstrates how infants change their locomotion based on the slope of the surface they are asked to walk on (1993). In this study, researchers found that toddlers switched to a sliding instead of a walking position when they encountered a steeper descending slope (Adolph et al., 1993). This work also provides an example of how development interacts with environmental constraints to shape movement.

Summary

The previous sections describe the perspective and model used in the present dissertation research. By adopting an ecological perspective to the development of FMS, this work supports that motor skills, including FMS, emerge due to the interaction between an individual and the environment. Newell's constraints model states that movement emerges with regards to three constraints- individual, task, and environment. The present work is situated in this framework and using Newell's constraints model to guide the intervention design.

FMS Interventions

Creating and implementing developmentally appropriate interventions to promote FMS in young children is an important scholarly and public health pursuit (Barnett et al., 2016). Implementing FMS interventions during early childhood is ideal because this aligns with the critical period for skill development. FMS are the building blocks for more advanced movement (Gallahue et al., 2012) and should develop in childhood (i.e., 3-11 years; Clark & Metcalfe, 2002). Unfortunately, data show that children who are just provided standard practice opportunities for learning FMS in preschoolers (e.g., outdoor free play) fail to learn FMS during this critical developmental window (Logan et al., 2011).

FMS interventions are an effective means for teaching FMS in preschool (Logan et al., 2011; Wick et al., 2017). FMS intervention strategies vary widely regarding populations, dosage, implementation personnel, and pedagogical approaches. FMS interventions have been used in typically developing preschoolers (Birnbaum, Geyer, Kirchberg, Manios, & Koletzko, 2017; Deli, Bakle, & Zachopoulou, 2006; Goodway, Crowe, & Ward, 2003; Iivonen, Sääkslahti, & Nissinen, 2011; Mulvey, Taunton, Pennell, & Brian, 2018; Robinson et al., 2017a; Robinson et al., 2017b; Robinson et al., 2012; Veldman et al., 2017; Wang, 2004), typically developing elementary students (Bardid et al., 2017; Logan et al., 2015a; Palmer, Chinn, & Robinson, 2019; Robinson et al., 2018), children at-risk/disadvantaged backgrounds (Altunsöz & Goodway, 2016; Bellows, Davies, Anderson, & Kennedy, 2013; Draper, Achmat, Forbes, & Lambert, 2012; Goodway & Branta, 2003; Goodway et al., 2010; Goodway & Rudisill, 1996; Hamilton, Goodway, & Haubenstricker, 1999; Robinson & Goodway, 2009; Robinson, Palmer, & Bub, 2016), as well as children with disabilities (Valentini et al., 2017; Valentini & Rudisill, 2004a). Interventions range in dosage from a few weeks (Bellows et al., 2013; Deli et al., 2006; Palmer, Matsuyama, & Robinson, 2017; Robinson & Goodway, 2009; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b; Veldman et al., 2017; Wang, 2004) to over six months (Bardid et al., 2017; Birnbaum et al., 2017; Iivonen et al., 2011). Some interventions are designed specifically for implementation during the school day or physical education class time (Goodway & Branta, 2003; Goodway & Rudisill, 1996; Iivonen et al., 2011) whereas others are a part of a more extensive community-based intervention approach (Bardid et al., 2017; Birnbaum et al., 2017). Lastly, interventions are implemented by trained research personnel (Altunsöz & Goodway, 2016; Goodway & Branta, 2003; Goodway & Rudisill, 1996; Robinson, 2011; Robinson & Goodway, 2009; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b; Veldman et al., 2017), physical education or classroom teachers (Bellows et al., 2013; Brian et al., 2017; Deli et al., 2006; Goodway et al., 2003; Okely et al., 2017; Wang, 2004), parents (Hamilton et al., 1999), coaches (Draper et al., 2012), or community program leaders (Bardid et al., 2017; Birnbaum et al., 2017).

The extant literature on FMS interventions is burgeoning. As FMS intervention research continues to expand, research groups have started compiling the literature in the form of systematic reviews and meta-analyses. These reviews and meta-analyses allow for a deeper and unique understanding of the effectiveness of these interventions. All the systematic reviews and meta-analyses of FMS interventions support these interventions are an effective approach to teaching FMS (Altunsöz, 2016; Logan et al., 2011; Palmer, Chinn, & Robinson, 2019; Tompsett et al., 2017; Van Capelle et al., 2017; Veldman et al., 2016; Wick et al., 2017). A meta-analyses by Wick et al. (2017) compiled the results from 30-intervention studies in preschool-aged children and found that FMS interventions have significant positive effect on total (SMD = 0.46; 95% CI 0.28, 0.65), ball (SMD = 1.36; 95% CI 0.80, 1.91) and locomotor FMS (SMD = 0.94; 95% IC 0.59, 1.30). A similar pattern of results with smaller overall effect sizes was seen by Van Capelle et al. (2017) who examined the effects of teacher-led preschool interventions. Their results showed a significant positive effect on total (SMD = 0.13; 95% CI 0.03, 0.22), ball (SM = 0.47; 95% CI 0.15, 0.80) and locomotor FMS (SMD = 0.44; 95% IC 0.16, 0.73; Van Capelle et al., 2017). These results endorse an early review done by Logan et al. (2011) which found that FMS interventions had a positive impact on both locomotor ($d = 0.45$; 95% CI 0.20, 0.70) and ball FMS ($d = 0.41$; 95% CI 0.27, 0.55) in preschool and school-aged children.

These reviews provide new and insight into the world of FMS interventions. The meta-analysis by Wick et al. included 30 intervention studies and conducted subgroup analyses to examine how intervention duration (i.e., ≥ or < 6 months intervention dosage), implementation personnel (i.e., school teachers or specialized intervention personnel), and intervention quality impacted FMS (2017). Authors found that studies with a shorter duration (< 6 months) had a larger effect than studies with longer durations (≥ 6 months; weight mean $SDM_{between} = 1.43$, 95% CI 0.49, 2.38). They also reported that interventions implemented by trained personnel were more effective than interventions implemented by classroom teachers (weight mean $SDM_{between}$ =

1.46, 95% CI 0.52, 2.40). Interestingly, the authors did not find a difference in intervention effectiveness according to intervention quality.

A systematic review by Tompsett et al. examined how different pedagogical approaches in FMS interventions affected both motor and various health outcomes. Authors found that FMS interventions tend to adopt one of six approaches: primarily focused on FMS learning, sports games, physical activity, active video games, teacher's professional development, or a multi-component approach (for a full review, please see Tompsett et al., 2017). Regardless of approach, their review found only one study that did not see significant changes in FMS from pre to posttest (Straker et al., 2015). This paper did not include any meta-analyses making it challenging to determine which pedagogical approach is most appropriate for FMS interventions. Moreover, categorizing all FMS interventions that were fully focused on FMS learning into a single group fails to account for all the different theoretical or philosophical approaches adopted in the design and implementation of different interventions. The literature on FMS interventions incorporates a variety of approaches including interventions developed from a preschool physical education curriculum (Drummer, Connor-Kuntz, & Goodway, 1997; Goodway & Branta, 2003; Goodway & Rudisill, 1996; Iivonen et al., 2011), dance curriculum (Deli et al., 2006; Wang, 2004), grounded in motor theories (Altunsöz & Goodway, 2016; Brian et al., 2017), and grounded in education theories (Johnson, Rudisill, Sassi, Wadsworth, & Hastie, 2017; Logan, Robinson, Webster, Wadsworth, et al., 2013; Palmer et al., 2017c; Robinson & Goodway, 2009; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b; Taunton, Brian, & True, 2017; Veldman et al., 2017).

Learning is not a passive process but requires active participation and engagement with the subject material. Motor skill learning is the permanent changes in motor skill performance, and it results from repeated skill practice (Magill & Anderson, 2014). The physical education literature supports that completing whole-appropriate practice is positively related to learning sport outcomes, but engaging in whole-inappropriate practice is negatively related to sport outcomes (Silverman, 1985). However, limited empirical evidence exists regarding children's engagement in behaviors related to learning during FMS interventions and how this engagement relates to changes in FMS. One study examined how much skill practice (i.e., task persistence as measured through skill attempts) children (n = 25) completed in both a high- and low-autonomy FMS intervention (Logan et al., 2013a). Results revealed no differences in skill attempts by intervention climate but reported that high-skilled children completed more skill attempts than low-skilled children (Logan et al., 2013a). There is a need for research to examine how children engage in behaviors associated with learning (i.e., skill practice) during FMS interventions and how this engagement relates to changes in children's skills. Moreover, there is a need to examine how child-level characteristics before the start of an intervention relate to how children engage in the intervention.

Newell's Constraints Model and FMS Interventions

FMS interventions are engineered movement environments designed to elicit gains and learning in young children's FMS. As discussed earlier in this chapter, creating movement environments to yield the desired motor outcome or motor learning aligns with an ecological perspective of movement and can be done using dynamic systems theory as applied through Newell's constraints model. The purpose of this section is to give a more detailed description of how Newell's constraints model is applied to FMS interventions. Each of the three constraints in Newell's model and how FMS interventions manipulate or change each constraint are discussed. Due to the interaction among the three constraints, it is essential to note that examples may or may not be mutually exclusive to one constraint. For example, creating a high-autonomy motor intervention climate is done by simultaneously manipulating environmental (instruction, space layout), task (equipment, multiple levels of difficulty) and individual (peer-to-peer interactions, motivation) constraints.

Individual constraints and FMS interventions. There is a growing body of literature on individual constraints and FMS. Common structural constraints examined include weight (D'Hondt et al., 2013; D'hondt et al., 2011; Henrique et al., 2016) and sex (Goodway et al., 2010; Robinson et al., 2017b); common functional constraints examined include perceived competence (Goodway & Rudisill, 1996; Logan et al., 2013a; Robinson, 2011; Robinson, Rudisill, & Goodway, 2009; Rudisill, 1989; True, Brian, Goodway, & Stodden, 2017), motivation (Atun-Einy et al., 2013; Hastie, Rudisill, Boyd, & Johnson, 2019; Xiang et al., 2003), executive functioning (McClelland & Cameron, 2019; Mulvey et al., 2018), and self-regulation (Robinson et al., 2016). Research in this area mostly examines how FMS interventions influence individual constraints (e.g., child-level characteristics). For example, work by Robinson demonstrates how completing a 540-min high-autonomy FMS intervention increased children's perceived motor competence whereas completing a 540-min low-autonomy intervention did not change children's perceived competence (note: this work intersects with environmental constraints; Robinson et al., 2009). Additional work reports that FMS interventions support the maintenance of self-regulation (Robinson et al., 2016), the development of executive functions (Mulvey et al., 2018), and a decrease in anthropometrics (e.g., weight status or waist circumference; Barnett, Zask, Rose, Hughes, & Adams, 2015).

Limited research also examines how individual constraints influence changes in FMS across an intervention. A paper by Robinson and colleagues examined how the constraint of sex (boy or girl) affected children's learning across a ball FMS intervention (Robinson et al., 2017b). Results of this study found that girls and boys equally learned FMS over a 540-minute FMS intervention; however, the sex differences that were present at pretest remained at posttest (Robinson et al., 2017b). This work was particularly important as research consistently finds that boys outperform girls in ball FMS (Bolger et al., 2018; Butterfield, Angell, & Mason, 2012; Goodway et al., 2010; Valentini et al., 2016) and yet ball FMS are essential for future physical activity engagement (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009).

Task constraints and FMS interventions. Task constraints are frequently manipulated within FMS interventions. Manipulations of task constraints can vary widely and include items such as scaling equipment, changing the goals of the task (e.g., errorless learning tasks- discussed above), altering the rules of the task to promote learning and success (e.g., two hand vs. one-hand dribble). Personnel with strong pedagogical backgrounds teach most FMS interventions, and many studies do not specifically list out the task manipulations used. Instead, researchers often report how FMS interventions were designed based on educational or theoretical principles and how these principles were used to design motor tasks. One theory used in FMS interventions is achievement goal theory (note: the theoretical approach to FMS instruction used in this dissertation research; Bandeira, Souza, Zanella, & Valentini, 2017; Palmer et al., 2017a; Rudisill, 2016). Achievement goal theory is based on the principle that children are motivated to learn. Interventions using achievement goal theory design tasks to meet the developmental attainment of a variety of children. Designing these tasks includes manipulating all three task constraints (goals, rules, and equipment) to provide children with an FMS activity that has multiple levels of difficulty for them to choose from. For example, children may be asked to complete a throwing task and may be provided with several target sizes to aim for (goal/equipment), several balls to throw (equipment), and several lines to throw from (e.g., distances; equipment/rules). For a full review of FMS interventions that use achievement goal theory, please see Appendix A.

Environment constraints and FMS interventions. The influence of environmental constraints on FMS development is a cornerstone of FMS intervention research. As stated earlier, the Study of Jimmy and Johnny by McGraw demonstrates how the environment influences motor skill development (1935). One twin participated in a motor rich environment, whereas the other did not participate in a motor rich environment. The twin had a motor rich environment learned and mastered FMS such as jumping as well as more sport specific skills such as swimming and roller-skating (McGraw, 1935). Conversely, the twin who did not have a motor rich environment failed to learn these skills. This work clearly shows how physical environments, and the tasks therein, shape FMS in children.

The effects of specific environmental constraints and intervention efficacy have been examined. Two of the most commonly examined environmental constraints include dosage of intervention and instructional climate. The relationship between intervention dosage and changes in FMS remains unclear. A 2011 meta-analysis by Logan et al. found that the dose (i.e., minutes) of an FMS intervention was not a significant predictor of changes in FMS. These findings were further supported in another meta-analysis by Wick et al. (2017). Authors of this paper found that interventions of a longer duration (i.e., ≥ 6 months) were not as effective as shorter interventions (i.e., 1-5 months; weight means $SDM_{between}$ = 1.43, 95% CI 0.49, 2.38) A paper by Robinson, Palmer and Meehan experimentally examined the effects three different dosages in minutes of the same intervention (CHAMP) on children's FMS (2017a). Authors found that

CHAMP was equally as effective at three different intervention dosages. Hence, it appears that a dose of intervention alone is insufficient to predict children's changes in FMS.

There is a substantial body of work that examines the role of instructional climates on changes in FMS in preschool (Robinson, 2011; Robinson & Goodway, 2009; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b; Robinson et al., 2012; Veldman et al., 2017), kindergarten (Martin et al., 2009; Valentini & Rudisill, 2004a, 2004b) and elementary school settings (Logan et al., 2013b; Theeboom, De Knop, & Weiss, 1995). This work reports mixed findings. Some studies report that high-autonomy climates (e.g., child-centered) are better than low-autonomy (e.g., teacher-led) climates (Martin et al., 2009; Valentini & Rudisill, 2004a, 2004b) whereas others fail to find any differences between high- and low-autonomy environments (Robinson & Goodway, 2009). Moreover, intervention instruction often is provided by different personnel, including researchers or classroom teachers. Meta-analytic data support that interventions implemented by trained researchers are more effective than those implemented by teachers (Wick et al., 2017).

It is also important to consider the physical environment and how this environment supports or fails to support motor skill learning in children. The control condition/environment in most FMS intervention research is the standard practice provided by the preschool or early childcare center. Preschool and early childcare centers have to provide children with environments for gross motor play to meet accreditation standards (Copple & Bredekamp, 2009), and most centers choose to meet this accreditation requirement with free play time on an outdoor playground. The playground environment can vary significantly between preschools and childcare centers. Some playgrounds can include fixed equipment such as slides and swings as well as open grassy spaces, flat asphalt, and/or portable equipment such as tricycles or scooters.

While outdoor free play is an important unstructured playtime, children who only participate in this standard practice fail to learn FMS (Logan et al., 2011).

High-Autonomy FMS interventions

FMS intervention research supports that high-autonomy FMS interventions are an effective approach for teaching FMS in preschool (Bandeira et al., 2017; Palmer et al., 2017a; Rudisill, 2016). High-autonomy FMS interventions adopt a child-centered approach to FMS instruction where children are given authority to self-navigate through the intervention climate and take a lead role in their own decision making within the intervention session. Both interventions used in the current study are high-autonomy FMS interventions. The following sections describe the theory used to create high-autonomy FMS interventions in this dissertation. The section concludes with an in-depth description of each intervention- CHAMP and MAP.

Achievement goal theory. One approach for creating high-autonomy FMS interventions is grounded in achievement goal theory (Bandeira et al., 2017; Palmer et al., 2017a; Rudisill, 2016). Achievement goal theory represents the way children approach, engage, and respond to educational or learning activities (Ames, 1992, 1995; Dweck & Leggett, 1988; Nicholls, 1989). Achievement goal theory is grounded in the tenant that children are innately motivated to learn and explore their environment (White, 1959) and describes the goals and attributions that individuals adopt in learning and the subsequent effect of these goals on approaches and engagement in learning environments.

Achievement Goal Theory originated in work conducted simultaneously but separately by three researchers — Carol Dweck, John Nicholls, and Carole Ames. The culmination of this work resulted in a 2-goal theory that states that individuals adopt one of two orientations in learning tasks: *mastery orientation* (also called task or undifferentiated) or *performance* *orientation* (also called ego or differentiated). Individuals who adopt a mastery orientation engage in a task for the intrinsic value of learning itself and measure improvement using self-referenced standards (e.g., comparing current performance to previous performances). Conversely, individuals who adopt a performance orientation engage in a task to prove competence or avoid failure and measure learning using norm-referenced standards (e.g., comparing current performance to performance of others). Adopting a mastery approach has been linked with positive educational and achievement outcomes such as: more effort contributes to success (Ames & Archer, 1988; Nicholls, Patashnick, & Nolen, 1985), intrinsic interest and time on learning activities (Butler, 1987; Meece, Blumenfeld, & Hoyle, 1988; Stipek & Kowalski, 1989), positive attitudes toward learning (Ames & Archer, 1988; Meece et al., 1988), and persistence in the face of difficulty (Elliott & Dweck, 1988).

Creating Mastery Climates. Work by Ames supports learning environments can be constructed to encourage students to adopt a mastery orientation (Ames, 1992). These environments are high-autonomy, where the children have the ability to self-select classroom options. Epstein identified six classroom or learning structures that can be manipulated to create a high-autonomy environment-- *t*ask, *a*uthority, *r*ecognition, *g*rouping, *e*valuation and *t*ime (TARGET; see Table II.1; Epstein, 1988). Learning environments that manipulate these six TARGET structures are also referred to as "mastery motivational climates." Hence, all mastery motivational climates are high-autonomy climates, but not all high-autonomy climates are mastery motivational climates.

Table II. 1. TARGET structures used to create high-autonomy environments.

TARGET Structure	Description
Task	Design movement tasks and instructional activities
Authority	Children actively participate in the instructional process
Recognition	Identify reasons for recognition; opportunities for recognition
Grouping	Manner and frequency of children working together.
Evaluation	Standards for performance; monitoring of performance; evaluative feedback.
Time	Schedule flexibility; vary pace of learning

The TARGET structures are designed to shift the governance of the learning environment from the teacher to the student and place the responsibility for engaging in learning tasks on the children (i.e., child-centered). This type of environment encourages students to adopt a mastery orientation to learn and develop new skills, try to understand their work, improve their level of competence, and achieve a sense of mastery based on self-referenced standards. These TARGET structures provide a framework for creating an effective mastery-oriented learning environment. Note that some of these structures concern the child/teacher interactions (e.g., authority, recognition, and evaluation) and emphasize the teacher's role in facilitating learning and providing each child with individualized, self-referenced feedback. Other structures involve letting the children self-govern through the learning environment (e.g., task, time, and grouping), granting them autonomy, and allowing them to create an individualized learning experience.

An understanding of each TARGET structure provides insight into how these structures work harmoniously together to create mastery motivational or high-autonomy climates in FMS interventions. The task structure involves allowing students to engage in a variety of tasks with different levels of difficulty. When allowed to self-select tasks, most children chose moderately challenging tasks which help promote learning without discouragement due to repeated failure from a task that is too difficult or boredom from engaging in tasks that are too easy. The task structure is implemented in FMS interventions by providing children with multiple FMS activity stations (e.g., catch and run) with varying levels of difficulty in each station. The authority structure refers to allowing children to be actively involved in the decision-making processes in the classroom. The teachers' role in a mastery climate is to act as a learning facilitator, not the sole authoritative figure. This structure is implemented during FMS interventions by training instructors to facilitate not dictate children's decision-making and engagement in skill stations. Recognition refers to providing students with specific feedback and not universal praise. Feedback should be directly linked to each child's performance and highlight their own successes. In an FMS intervention, the instructor should base feedback on each child's progress/efforts and focus on each child's self-worth. The grouping structure states that children should be able to self-select with whom they engage within the classroom. Children navigate FMS stations in groups of their choosing and may work in pairs, small groups, or individually. Evaluation refers to how a teacher or educator references a child's performance. For a mastery climate, evaluation should be self-referenced (e.g., compare a child to their past performance) and should always be given in private to avoid social comparisons. This structure is particularly difficult in FMS interventions and requires instructors to give feedback on specific criteria while focusing on each child's progress. The final structure is time and refers to allowing the children to select how much time is allotted to a particular activity or task. This structure is implemented in FMS interventions by giving children the flexibility to establish their work and practice schedule.

Achievement goal theory and FMS Interventions. As achievement goal theory gained attention in educational research, motor developmentalists began to apply this theory to FMS environments. A 2017 systematic review found that all 12 studies using achievement goal theory in gross motor skill (FMS and sport-specific skills) instruction reported this theory was an appropriate and effective theoretical approach to teach these skills in young children were as non-achievement goal theory interventions showed mixed results (Palmer et al., 2017a). FMS interventions were all created by applying the six-TARGET structures to a movement setting (Palmer et al., 2017a). Achievement goal theory instruction is appropriate for a variety of populations including in children with a motor delay, with, and without disabilities (Valentini & Rudisill, 2004a), as well as for both boys and girls (Robinson et al., 2017b). Achievement goal theory interventions are implemented by a variety of personnel including motor development experts/specialists (Robinson et al., 2017b; Valentini & Rudisill, 2004a, 2004b), researchers (Logan et al., 2013a; Robinson, 2011; Robinson & Goodway, 2009), or Ph.D students (Robinson, 2011; Robinson & Goodway, 2009; Robinson et al., 2016; Robinson et al., 2017a); as well as by certified physical education teachers (Martin et al., 2009; Valentini et al., 2017), undergraduate students training to become early educators (Robinson et al., 2012), or summer camp instructors (Theeboom et al., 1995).

Several studies examining the efficacy of achievement goal theory interventions show that children who complete these interventions demonstrate motor skill learning as determined using retention tests. One study with the 6-month retention test found that children in the achievement goal theory group maintained skills across time, whereas the comparison group significantly decreased from posttest to retention (Valentini & Rudisill, 2004a). A second study with a 9-week retention test found that the achievement goal theory group and the comparison group (i.e., not achievement goal theory) were not significantly different from each other but were both significantly better than the control group at the retention test (Robinson & Goodway, 2009). Further, contradictory to Valentini & Rudisill (2004a), this study reports that both the achievement goal theory group and comparison group (i.e., not achievement goal theory) significantly decreased their motor performance from posttest to retention (Robinson & Goodway, 2009). A second study by Robinson and colleagues found that there are group differences in the rate of change from post to retention motor scores between the achievement goal theory and control groups (Robinson et al., 2017b). Authors report that both girls and boys in the achievement goal theory group had significantly greater rates of change compared with boys and girls in the control group but no difference in rates of change when compared to each other (Robinson et al., 2017b).

Conclusion. The extant literature on achievement goal theory FMS interventions supports that this approach is an appropriate and effective means of teaching FMS to young children. Further, several studies reported that children who completed an achievement goal theory intervention demonstrated motor learning by comparing pretest to retained FMS performance 9-weeks groups (Robinson & Goodway, 2009; Robinson et al., 2017b) or 6-months (Valentini & Rudisill, 2004a) after the end of the intervention. Despite these findings, this literature has several discrepancies regarding if achievement goal theory interventions are always better than non-achievement goal theory interventions (i.e., comparison groups). Some studies report that both the achievement goal theory and comparison groups improved over time (Logan et al., 2013a; Robinson & Goodway, 2009; Valentini & Rudisill, 2004a), whereas other studies report that comparison groups do not improve post-intervention (Martin et al., 2009; Valentini et al., 2017).

Further examination reveals that there were several methodological differences between the comparison conditions and interventions (both high- and low-autonomy). Comparison conditions that focused on FMS instruction also saw improvements in children's skills. The studies that failed to find improvements in the comparison intervention used a traditional, elementary physical education curriculum (Martin et al., 2009) and an exercise play intervention (Valentini et al., 2017). The exercise play intervention was somewhat modeled after the TARGET structures but created an environment focused on movement and exercise, not motor skill instruction. Moreover, of the four studies that included a control or no intervention condition (i.e., free play), only one reported improvements in the control group (Robinson et al., 2016). This improvement was small, and the rate of change in FMS was much higher in the achievement goal theory group. Collectively, these findings show that learning FMS requires developmentally appropriate, content specific instruction. This finding aligns with the growing body of literature that claims intervention and instruction are necessary for the acquisition and development of FMS (Logan et al., 2011; Wick et al., 2017).

Constraints-Based, High-Autonomy Interventions

The Children's Health Activity Motor Program (CHAMP)

The established intervention used in this dissertation research was the Children's Health Activity Motor Program: CHAMP. CHAMP is an evidence-based FMS intervention that uses achievement goal theory to design a mastery, high-autonomy climate. CHAMP was originally developed by Dr. Leah E. Robinson (note: primary chair of the dissertation committee) as ball FMS intervention in 2007 (Robinson, 2011; Robinson & Goodway, 2009; Robinson et al., 2009). In collaboration with past (Logan et al., 2013a; Logan, et al., 2015a; Logan et al., 2013b) and current Ph.D. students (Palmer, Chinn, & Robinson, 2019; Palmer et al., 2017c; Robinson et al., 2016),CHAMP has been expanded to include locomotor as well as ball FMS. CHAMP was previously published as an "high-autonomy" or "mastery climate motor skill" intervention, and the intervention was officially named CHAMP in 2016 (Robinson et al., 2016).

CHAMP combines achievement goal theory with a constraints-based approach of FMS instruction. CHAMP adheres to Epstein's TARGET structures to create a high-autonomy instructional climate (see Table II.2; Ames, 1992; Epstein, 1988, 1989). The TARGET structures can be overlaid with the three constraints from Newell's model to create a high-autonomy movement environment that supports learning FMS in a high-autonomy environment (see Fig II.2). Note that each TARGET structure does not align with a single constraint, but rather the interaction between two constraints (e.g., side of a triangle).

Table II. 2. Description of TARGET Structures in CHAMP

TARGET Structure	Description	CHAMP Implementation
Task	Design movement tasks and instructional activities	• Design activities for variety, individual challenge, and active involvement. • Provide a "slanted rope effect" (i.e., provide a challenge for students who exhibit different learning rates).
Authority	Children actively participate in the instructional process	• Involve children in decision-making. • Help children develop self-management and self-monitoring skills.
Recognition	Identify reasons for recognition; opportunities for recognition	• Recognize individual progress and improvement. • Focus on each child's self-worth. • Recognize effort not outcomes.
Grouping	Manner and frequency of children working together.	• Children will not be grouped but will be given the opportunity to move freely and independently within the environment. • Allow for individual choice in grouping.
Evaluation	Standards for performance; Monitoring of performance; Evaluative feedback.	• Use specific criteria involving individual progress, improvement, and mastery. • Involve children in self-evaluation via tasks & peer and self-check. • Make evaluation private and meaningful.
Time	Schedule flexibility; Vary pace of learning	• Help children establish work and practice schedules. • Allow children to individualize instruction.

To date, 13 peer-reviewed publications support the effectiveness of CHAMP in three geographic regions in the United States. CHAMP has been used in both preschool (Robinson, 2011; Robinson & Goodway, 2009; Robinson et al., 2017a; Robinson et al., 2009; Robinson et al., 2017b; Veldman et al., 2017) and school-age children (Logan et al., 2015a; Logan et al., 2013b). Table II.3 provides an overview of all studies that have used CHAMP to improve FMS in young children.

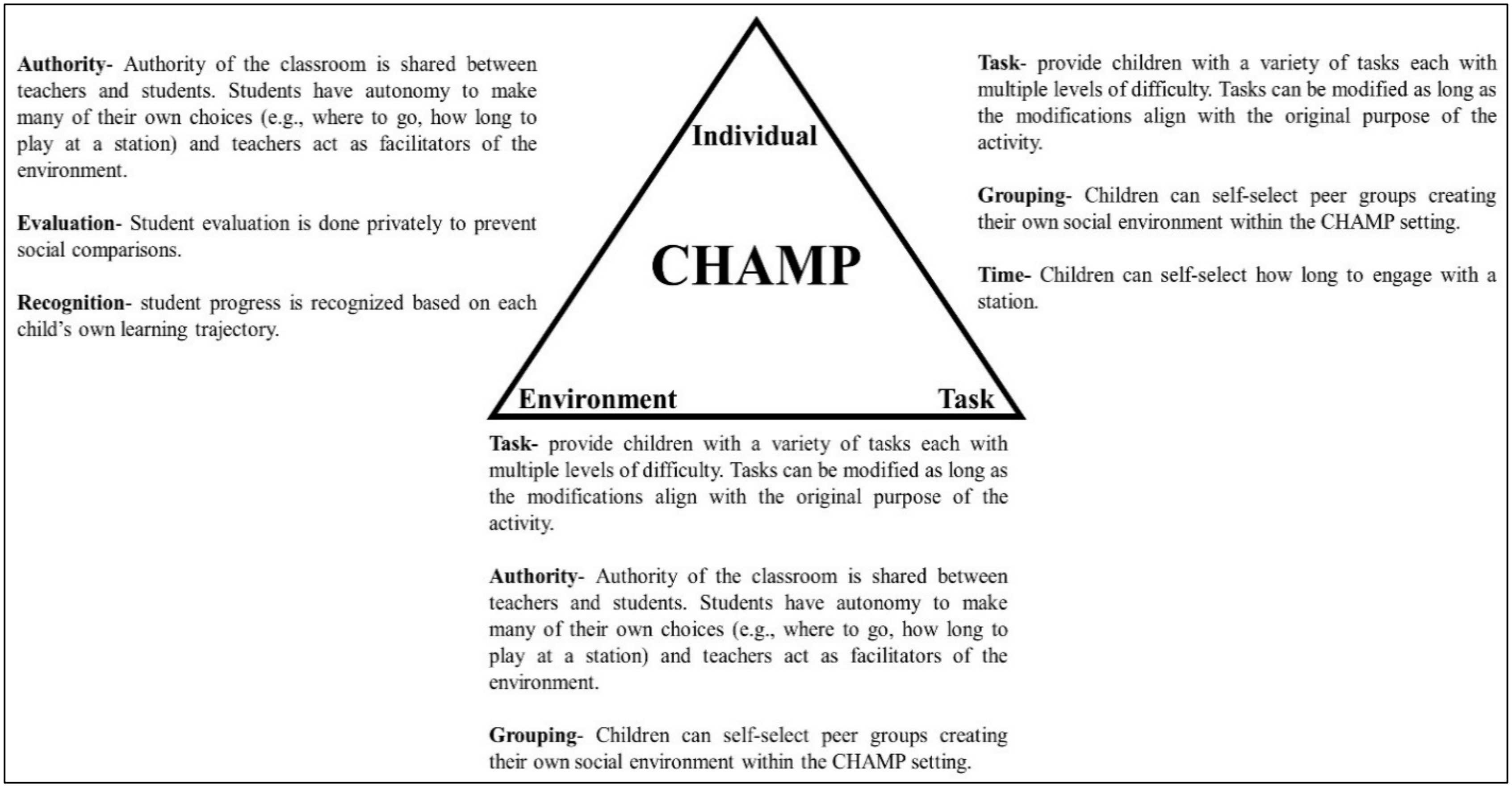


Figure II. 2. Newell's constraints model and TARGET structures in CHAMP.

Table II. 3. List of studies published using CHAMP intervention.

Year	Authors	Purpose	Outcomes	Measures	N	Groups	Dose	Results
2009	Robinson & Goodway	To examine the effect of two different instructional climates (Mastery Motivational Climate and Low Autonomy Climate) on FMS.	FMS- process (TGMD-2: Raw Scores)	TGMD-2: Raw Scores	117	3 Groups: CHAMP (*n*=39), Low Autonomy (LA, *n*=38), and Control (*n*=40)	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	Both the CHAMP and LA group significantly improved over time. The CHAMP and LA significantly lowered scores from post to retention but still scored significantly higher than the pretest.
2009	Robinson Rudisill, Goodway	To determine the effect of CHAMP and a low-autonomy climate on children's perceived motor competence.	Perceived Motor Competence	Pictorial Scale of Perceived Competence and Social Acceptance	117	3 Groups: CHAMP (*n*=39), Low Autonomy (LA, *n*=38), and Control (*n*=40)	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	Children in CHAMP significantly improved their perceived motor competence over time, but the LA group did not improve.
2011	Robinson	To see how the control group from the 2009 study was affected by MMC	FMS- process (TGMD-2: Raw Scores); Perceived Motor Competence	TGMD-2: Raw Scores; Pictorial Scale of Perceived Competence and Social Acceptance	40	Single Group	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	All children significantly improved their ball FMS and perceived motor competence over time
2012	Robinson, Webster, Logan, Lucas, & Barber	To determine if early childhood educators can effectively implement a Mastery Motivational Climate to improve FMS in young children.	FMS- process (TGMD-2: Percentiles)	TGMD-2: Percentiles	14	Single Group	22, 30 min sessions (24 min of motor) across 11 weeks. (TOTAL= 660 min; MOTOR= 528)	Significant improvement for total TGMD-2 and locomotor percentiles but not for ball FMS.
2013	Logan, Robinson, Webster & Barber	To describe children's engagement in a high and low autonomy based climate.	FMS- process (TGMD-2: Percentiles); Engagement (task persistence)	TGMD-2: Percentiles; Task Persistence	25	2 Groups: CHAMP (n=12), Low Autonomy (n=13); 2- Subgroups: High skilled and low skilled	18, 30-min sessions (24 mins of motor) over 9-weeks (TOTAL= 540 min, MOTOR = 432 min).	In both climates, children improved ball FMS and children with low skills at the pretest improved more than high-skilled children.

2014	Logan, Robinson, Webster, & Rudisill	The purpose of this study is to determine the effect of two physical education (PE) instructional climates (CHAMP, performance) on the percentage of time students spent in a) moderate-to-vigorous physical activity (MVPA) and b) management tasks during PE in 2nd-grade students	Physical Activity; Classroom Management	System for Observing Fitness Instruction Time (SOFIT)	48	2 Groups: CHAMP (n=23); Performance (n= 25) NOTE: each child also participated in the baseline control condition and served as their own control	24, 25-min sessions across 5 weeks (TOTAL=600 min); Baseline was 6, 25 min sessions across 6 days (TOTAL= 150).	Students spent an average of 36.9%, 9.9%, and 23.5% of class time in management tasks during typical PE, mastery, and performance climates, respectively. The mastery climate spent significantly less time in management compared to the performance climate and typical PE. In regards to physical activity, children engaged in significantly more MVPA during the mastery (68%) and performance (67%) climates compared to typical PE (49.7%) ($p < 0.05$).
2016	Robinson, Palmer & Bub	To determine the efficacy of CHAMP on improving FMS and self-regulation in preschoolers.	FMS- process (TGMD-2: Raw Scores); Self-regulation (Delay of Gratification)	TGMD-2: Raw Scores; Delay of Gratification-Snack Delay	113	2 Groups: CHAMP (n = 68), Control (n = 45)	40 min, 15 sessions (20-25 min of motor) across 5-weeks (TOTAL= 600 min; MOTOR = 300-375 min)	The CHAMP group significantly improved FMS over time and had greater rates of change than the control group. The control group also improved in total score over time but scored lower than the CHAMP groups at the posttest.
2016	Palmer, Matsuyama, & Robison	This study compared preschoolers' physical activity engagement during two different physical activity opportunities: outdoor free play or CHAMP.	Physical Activity-Actical Accelerometers	Actical Accelerometers	87	2 Groups: CHAMP (n=47); Control (n=40)	24, 30-min sessions (15 min of motor) across 12-weeks (TOTAL= 720 min; MOTOR= 360 min)	In total, children in CHAMP engaged in 15.5 minutes of healthier physical activity behaviors as compared with children in the outdoor free play.
2017	Veldman, Palmer, Okely, & Robinson	This study examined the immediate effects of a ball skill intervention on preschool girls and the retention of these skills after 9 weeks.	FMS- process (TGMD-2)	TGMD-2: Raw Scores	54	2 Groups: CHAMP (n = 38), Control (n = 16)	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	Girls in CHAMP improved their ball FMS and these improvements were maintained overtime.

2017	Robinson, Palmer, & Meehan	To examine the effects of three different CHAMP doses on FMS in preschoolers.	FMS- process (TGMD-2: Raw Scores)	TGMD-2: Raw Scores	131	4 Groups: Control (n=56) and 3 CHAMP groups: Dose 1; 660 min (n=27); Dose 2, 720 min (n=23); Dose 3, 900 min (n=25)	Dosages varied according to group. All groups completed 40min sessions either two or three days a week for 12-weeks.	All three groups significantly improved over the intervention, but the control group did not change. There were no differences among the three CHAMP groups at the posttest.
2017	Robinson Veldman, Palmer, & Okely	To examine the effects of CHAMP on boys' and girls' ball FMS.	FMS- process (TGMD-2: Raw Scores)	TGMD-2: Raw Scores	124	2 Groups: CHAMP (n=81), Control (n=23) 2 Subgroups: Boys and Girls	18, 30-min sessions (24 mins of motor) over 9-weeks (TOTAL= 540 min, MOTOR = 432 min).	Boys and girls in CHAMP had significantly greater positive rates of change compared to the control group. Both boys and girls in CHAMP had similar rates of change.
2018	Robinson Palmer, Webster, Logan, & Chinn	This feasibility study compared the effects of two movement programs, traditional and mastery climate (i.e., the Children's Health Activity Motor Program; CHAMP) on lesson context and children's physical activity (PA) levels.	Physical Activity; Lesson Context	System for Observing Fitness Instruction Time (SOFIT)	72	2 Groups: CHAMP (n=36); Control (n=36)	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	The findings support that participation in CHAMP elicits more MVPA in preschool-age children compared to a traditional movement program. CHAMP provided children with more class time devoted to skill practice.
2019	Palmer, Chinn, & Robinson	To examine how children's physical activity changed in CHAMP and to determine if these changes translated to the outdoor free play.	FMS (process, TGMD) and PA	TGMD-3, Accelerometers	102	2 Groups: CHAMP (n-64); Control (n=38)	40 min, 15 sessions (20-25 min of motor) across 5-weeks (TOTAL= 600 min; MOTOR = 300-375 min)	Children increased their PA in CHAMP, but no changes in PA were seen during outdoor play.

Note: LA= low autonomy, PA=physical activity

CHAMP and FMS. CHAMP has repeatedly been shown to improve FMS in young children. A randomized control trial with 117 preschoolers demonstrated that children in a CHAMP intervention (540 min) significantly improved their ball FMS over the control group (i.e., outdoor free play group) and these improvements were maintained at a 9-week retention test (Robinson & Goodway, 2009). Both the statistical effect sizes ($\eta^2 = 0.73$) and the gains in FMS were large (15th percentile to 95th percentile). In a follow-up study, CHAMP was administered to the control group, and similar improvements in ball FMS were reported (d = 2.80; Robinson, 2011). An additional randomized control trial with 131 preschoolers examined the effects of CHAMP across three different dosages (660 min; 720 min; and 900 min). Results showed that all children in CHAMP significantly improved their FMS (660 min, d=1.35; 720 min, d=1.30; and 900 min, d=1.54), and all three groups outperformed the control group at posttest (control vs. 600 min: $p < 0.01$, d =0.92; control vs. 720 min: $p < 0.001$, d =0.89; control vs. 900 min: $p < 0.001$, d = 1.21; Robinson et al., 2017a). Lastly, another randomized control trial reported on total, locomotor, and ball FMS. This study demonstrated that a 600 min CHAMP intervention was effective at improving total (d = 2.88), locomotor (d = 2.64), and ball FMS (d = 2.79). This study also reported children who completed the CHAMP intervention outperformed their peers at the posttest in total FMS (d = 1.94), locomotor (d = 2.13) and ball FMS (d = 1.59). Therefore, evidence supports the effectiveness of the CHAMP intervention for learning FMS.

CHAMP and Physical Activity. Physical activity contributes to weight status as well as cardiovascular health (Shiroma & Lee, 2010). The literature supports that physical activity behaviors during the preschool years are related to physical activity behaviors later in childhood (Jones, Hinkley, Okely, & Salmon, 2013; Telama et al., 2014) and adulthood (Telama et al., 2014). Implementing interventions that effectively improve physical activity in early childhood is an important endeavor. Data support that children are more active in CHAMP compared with outdoor free play (Logan et al., 2015a; Palmer et al., 2019; Palmer et al., 2017c; Robinson et al., 2018). One study examined physical activity engagement in 72 preschoolers using the System for Observing Fitness Instruction Time (SOFIT) and found that children in CHAMP spent less time standing (28% vs 23%, $p < 0.01$), more time walking (51% vs 27%, $p < 0.05$) and in moderate to vigorous physical activity (MVPA; 64% vs 59%, $p < 0.05$) compared to traditional early childhood movement program (Robinson et al., 2018). Similar findings are also seen with accelerometer data (Palmer et al., 2017c). This study found that children in CHAMP ($n = 87$ preschoolers) spent more time being active (3 min of light, 1.5 min of moderate, 2.5 min of vigorous physical activity) and less time being sedentary (8.5 fewer min) compared to outdoor free play($d = 1.79$; Palmer et al., 2017c) .

CHAMP and Perceived Competence. Perceived motor competence, or how well you *think* you move, appears to be an important psychosocial factor for physical activity and FMS. Current evidence suggests that perceived motor competence mediates the relationship between physical activity and FMS (Barnett, Morgan, van Beurden, & Beard, 2008; Robinson et al., 2015b; Stodden et al., 2008) and is the psychological variable most associated with physical activity in youth (Babic et al., 2014). Perceived motor competence may be particularly important during the preschool years when children are unable to accurately perceive their motor abilities and demonstrate inflated self-perceptions which may encourage children to be more active and expose them to more opportunities for FMS development (Stodden et al., 2008). Participation in a CHAMP intervention has been shown to improve perceived motor competence. A study examined the effect of CHAMP on children's perceived motor competence and found that children significantly improved their perceived motor competence after CHAMP ($\eta^2 = .44$) and reported higher perceived motor competence compared with the control group at the posttest and 9-week retention test (Robinson et al., 2009). Further, children in the control group from the original study also reported significantly higher perceived motor competence after receiving the CHAMP intervention (Robinson, 2011).

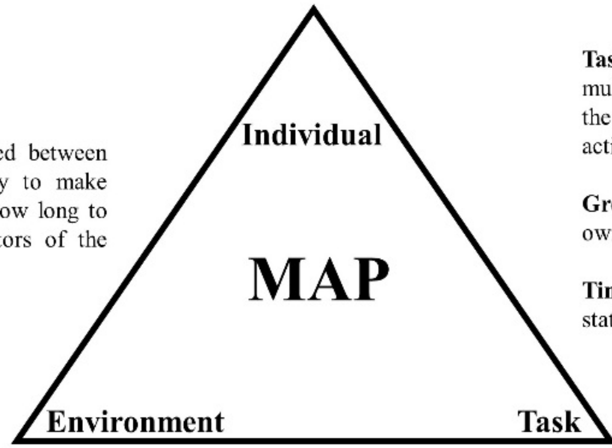
Motor skills At Playtime- MAP

The novel intervention used in this dissertation was the Motor skills At Playtime (MAP) intervention. MAP was designed to be "a roadmap to becoming a skillful mover" that could be easily implemented during established motor programming at the preschools. MAP uses a high-autonomy, low-instruction approach to teaching FMS to young children. MAP is based off Newell's constraints model and achievement goal theory and creates a low instructional, pseudo-mastery intervention by implementing four of the six TARGET structure- *t*ask, *a*uthority, *g*rouping, and *t*ime (see Table II.4, Figure II.3)

Table II. 4. Description of TARGET structures in MAP.

TARGET Structure	Description	MAP Implementation
Task	Design movement tasks	• Design FMS stations for variety, individual challenge, and active involvement. • Provide a "slanted rope effect" (i.e., provide a challenge for students who exhibit different skill abilities).
Authority	Children dictate how they engage in the environment	• Involve children in decision-making. • Help children develop self-management and self-monitoring skills. • Children receive a demonstration of skill and activity stations but are given authority to engage or not engage with skill activities.
Grouping	Manner and frequency of children working/playing together	• Children will not be grouped but will be given the opportunity to move freely and independently within the environment (i.e., standard practice).
Time	Schedule flexibility; Vary pace of learning	• Children dictate how long they want to engage in different activities, both standard practice and FMS stations.

Authority- Authority of the classroom is shared between teachers and students. Students have autonomy to make many of their own choices (e.g., where to go, how long to play at a station) and teachers act as facilitators of the environment.



Task- provide children with a variety of tasks each with multiple levels of difficulty. Tasks can be modified as long as the modifications align with the original purpose of the activity.

Grouping- Children can self-select peer groups creating their own social environment within the MAP setting.

Time- Children can self-select how long to engage with a station.

Task- provide children with a variety of tasks each with multiple levels of difficulty. Tasks can be modified as long as the modifications align with the original purpose of the activity.

Authority- Authority of the classroom is shared between teachers and students. Students have autonomy to make many of their own choices (e.g., where to go, how long to play at a station) and teachers act as facilitators of the environment.

Grouping- Children can self-select peer groups creating their own social environment within the MAP setting.

Figure II. 3. Newell's constraints model and TARGET structures in MAP.

MAP adds daily FMS activity stations and demonstrations to outdoor recess/indoor gross motor play opportunities usually provided by the preschool center. The FMS stations are designed using a constraints-based approach, and each station includes a variety of levels of difficulty. All tasks are added to the established outdoor free play session, but before the start of each session, children receive a brief (1-2 min) skill stations introduction/instruction. This introduction includes the name of each skill, a demonstration of skillful completion of that skill, and an explanation of the various levels of difficulty within each activity. Children then engage in the movement environment as they wish. They can choose to engage or not to engage in the FMS stations provided. This novel intervention approach aligns with established and well-researched intervention approaches yet is a sustainable intervention designed to work within the extant standard practice of FMS opportunities in most preschool and early childcare centers.

Comparing FMS Interventions (CHAMP vs. MAP)

CHAMP and MAP are similar in several key ways. First, both interventions are grounded in achievement goal theory and use four of the six target structures to create a high-autonomy FMS movement environment/intervention. Further, both interventions use a constraints-based approach to designing FMS activities and stations. Grounding these interventions in achievement goal theory and designing FMS stations using Newell's constraint model ensures that these environments are developmentally appropriate and use an effective approach to FMS instruction (e.g., student-centered; Palmer et al., 2017a).

CHAMP and MAP also differ in two primary ways. First, CHAMP is a traditional FMS intervention in that this program *replaces* the standard practice (i.e., outdoor free play) several days each week. CHAMP takes place in a large, open indoor area provided by the preschool such as a gym or a cafeteria. The CHAMP research team sets up FMS activity stations within this space, and children in CHAMP are only given access to these stations during the CHAMP session. Conversely, MAP is *added* to the standard practice. FMS activity stations are included within the outdoor free play environment, and children can select to engage with FMS stations or to continue to participate in the traditional in the standard practice. Secondly, CHAMP is implemented by *motor experts* who provide equipment, skill demonstration, and continuous instruction during each session (e.g., recognition and evaluation TARGET structures). The instruction in CHAMP requires private student evaluation and recognition of FMS improvements based on self-referenced standards. This type of instruction means that implementers need to make quick judgments on nuanced changes in each child's FMS performance. Providing this type of instruction is a highly specialized task that requires a deep understanding of FMS, developmental sequencing, and constraints surrounding movement performance. To date, all research using this instructional approach has used motor experts as instructors (Palmer et al., 2017a). MAP does not provide children with instruction during the program itself and therefore can be implemented by a *non-motor expert* with sufficient training to provide the highly skilled FMS demonstrations at the start of each MAP session.

Creating an intervention that (1) fits within the extant standard practice and (2) can be implemented by non-experts is an important step for FMS interventions. MAP alters these two aspects of traditional FMS interventions (e.g., CHAMP) to yield a more sustainable and easily distributed FMS interventions with the potential to impact more preschooler's FMS and other health outcomes. Nonetheless, it remains unknown how altering these two aspects of FMS interventions compared with traditional FMS interventions will impact FMS gains and learning.

Conclusion

The execution of FMS is the result of the individual, task, and environmental constraints surrounding movement (Newell, 1986). FMS interventions manipulate these three constraints to design movement environments that elicit gains and learning of FMS (Logan et al., 2011; Wick et al., 2017). FMS interventions are often implemented during the preschool years (3-5yrs) as this is a critical period for the development of FMS (Clark & Metcalfe, 2002; Gallahue et al., 2012). The current standard practice for learning FMS in preschools or early childcare centers is an unstructured, outdoor free play session and this session is ineffective for teaching FMS to young children (Logan et al., 2011; Wick et al., 2017). The literature consistently shows that children who complete FMS interventions demonstrate FMS learning (Altunsöz, 2016; Logan et al., 2011; Palmer et al.; Tompsett et al., 2017; Wick et al., 2017). The literature supports that interventions that are (a) child-centered, (b) high-autonomy, and (c) focus on FMS instruction are an effective means to promote FMS learning in preschool. One highly researched and effective intervention is the CHAMP program. CHAMP uses both achievement goal theory and Newell's constraints model to create a high-autonomy FMS intervention that uses a constraints-based approach to motor skill instruction. Research supports that CHAMP improves FMS, physical activity, and perceived motor competence in young children (see Table II.3 for a complete review). Currently, CHAMP is implemented by a trained research staff member, and this approach is not feasible for long-term sustainability or dispersion of interventions. This dissertation research created a second FMS intervention- MAP. MAP is a high-autonomy, pseudo-mastery intervention that works within the extant standard practice (i.e., outdoor free play) to teach FMS to young children making MAP a potentially sustainable and easily distributed FMS intervention.

Gaps in the Literature

In this section, Newell's constraints model is used to outline current gaps in the literature on FMS interventions and outlines how this dissertation addresses these gaps (see Table II.5).

Individual Constraints

Research Gaps. Only a limited number of studies examine how individual constraints other than sex relate to changes in FMS after children complete an FMS intervention. <u>This dissertation addresses this gap in the literature by examining how individual constraints at pretest relate to changes in FMS after children complete a 1350-min FMS environment (intervention or control). Individual constraints examined include sex, perceived motor competence, anthropometrics (height, weight, body composition), and initial skill competence.</u>

Dissertation Impact. Unveiling the relationship between individual constraints and outcomes is an important step in designing more time and cost-effective FMS interventions. In particular, if specific child-level characteristics (e.g., individual constraints) are closely associated with outcomes, research and practitioners can use pretest or baseline information to predict which children will benefit the most from interventions and provide other children with additional supports or movement opportunities to enhance their FMS competency.

Task Constraints

Research Gaps. The three gaps in the literature on the task constraints and FMS are: (1) does providing FMS stations within the standard practice (e.g., outdoor free play setting) improve children's FMS (i.e., MAP) (2) how do children engage in FMS stations provided during a high-autonomy FMS interventions and what child-level characteristics (i.e., individual constraints) relate to this engagement, and (3) how do motor measures with different task goals (i.e., process and product FMS measures) relate before, after, and across an intervention. <u>This</u>

dissertation addresses these gaps in the literature by (1) creating a novel intervention (MAP) where children receive FMS stations during the extant standard practice (outdoor free play); (2) quantifying children's engagement in MAP and CHAMP and examining potential relationships between their engagement and changes in FMS as well as child-level characteristics (e.g., individual constraints) at the start of the intervention; and (3) examining the relationship between process and product motor skill measures before, after, and across a high-autonomy FMS intervention.

Dissertation Impact. This research was the first study to examine how MAP, an intervention designed to work within the extant standard practice, influences FMS in young children. This work will also be one of the first studies to examine how child-level characteristics (individual constraints) intersect with child-level behaviors (engagement with task constraints). Results from this work will provide a more thorough understanding of why the design of achievement goal theory interventions are effective as well as inform what tasks could be included in more sustainable and cost-effective FMS interventions. This work will also be one of the first to compare how process and product motor skill assessments measure changes in children's skills after completing an FMS intervention.

Environmental Constraints

Research Gaps. There is a need to design effective, evidence-based interventions that can be incorporated into current gross motor programming (i.e., standard practice) at preschool and early child-care centers. This dissertation addressed this gap in the literature by creating a novel intervention- MAP. MAP is a high-autonomy, low-instruction intervention where children received skill demonstrations and FMS stations added to the standard practice. Children's FMS were examined before and after engaging in this intervention and compared with (1) standard practice (i.e., outdoor free play) and (2) and established, high-autonomy FMS intervention (CHAMP).

Dissertation Impact. Creating a novel FMS intervention that fits within the current standard practice (MAP) may allow for a more sustainable and more easily distributed approach to teaching FMS to young children. Results from this study could be used to design effective curricula that could be easily added to outdoor free play and implemented by non-trained personnel to teach FMS and support the health of young children.

Table II. 5. List of gaps in the literature and how this dissertation research addressed those gaps.

	Gaps	Dissertation Research	Research Question
Individual	How do individual constraints at pretest (i.e., child-level characteristics) influences changes in children's FMS across different FMS interventions?	Measures individual constraints (sex, perceived competence, anthropometrics, initial skill competence) before the start of the intervention and relates these to changes in FMS.	RQ2- How do child-level characteristics at the start of the intervention relate to changes in children's FMS?
Task	How does exposure to FMS tasks affect changes in FMS? How do children engage in FMS tasks? How do measures of FMS with different skill goals (i.e., process vs. product measures) relate before after and across and intervention?	Creates a novel FMS intervention (MAP) where motor tasks are added to the extant standard practice. Quantifies children's engagement in FMS tasks and relates engagement to (1) changes in FMS, and (2) child-level characteristics at pretest. Assesses process and product measures at both pretest and posttest and compare children's performance on these measures before, after, and across and intervention.	RQ1- Are there group differences between children's FMS (product and process) after completing one of three 1350-min FMS environments- CHAMP, MAP, control (standard practice). RQ3-What child-level characteristics are associated with engagement in behaviors related to learning AND how does engagement in behaviors related to learning affect changes in motor skill across two FMS interventions? RQ4- What are the agreement between process (e.g., TGMD) and product measures of children's FMS before, after, and across an FMS intervention?
Environment	How does a novel FMS intervention that is added to the extant standard practice (i.e., MAP intervention; see task #1) affect FMS? How does MAP compare with (1) an established FMS intervention (CHAMP), and (2) extant standard practice (outdoor free play)?	Creates a novel FMS intervention (MAP) where motor tasks are added to the extant standard practice and compare this environment to (1) a well-established FMS intervention, CHAMP and (2) a standard practice - outdoor free play.	RQ1- Are there group differences between children's FMS (product and process) after completing one of three 1350-min FMS environments- CHAMP, MAP, control (standard practice).

CHAPTER III. METHODS

The purpose of this dissertation was to: (a) determine the efficacy of a novel, child-centered high-autonomy FMS intervention- Motor skills At Playtime (MAP), compared with an established high-autonomy FMS intervention (Children's Health Activity Motor Program-CHAMP) and control condition- outdoor free play (standard practice); (b) conduct in-depth examination into which child-level characteristics and behaviors relate to changes in FMS after completing both CHAMP and MAP; (c) compare process and product FMS measures before, after, and across a high-autonomy FMS intervention. This section provides an overview of the specific methods of the study including study design, participants, variables, assessments, and research procedures concluding with a description of the data analyses and statistical procedures used to answer each research question.

Experimental Design & Timeline

This dissertation used a pre-post experimental with control design. This study took place during the 2017 – 2018 school year. Recruitment through posttest data collection was completed from September 2017 – June 2018. Data coding and cleaning was completed from June- December 2018. See Figure III.1 for full timeline details.

Figure III. 1. Timeline of dissertation research.

Setting & Participants

Power Analysis

Prior to recruitment, a power analysis was completed to determine the sample size. The original power analysis was calculated to determine the needed sample size to compare engagement behaviors and how engagement related to outcomes in two groups (CHAMP vs. MAP). Estimated effect sizes of engagement data were gathered from the only known paper to measure engagement in preschool FMS, Logan et al., 2013. The power analysis was completed using the G*Power software with an estimated power of 0.08 and significance set to $\alpha = 0.05$. This analysis yielded predicted a total sample of 46 ($N = 46$ total; 23 in each group). To guard against dropout, a 30% oversampling technique was applied, which resulted in 30 children in each group where engagement was measured.

Participants

This study took place at two, matched Head Start Centers in Ypsilanti, Michigan (School A and School B). Head Start programs are the largest federally sponsored early childhood education program in the United States. The racial composition of the students in these schools were 65.9% African American, 19.14% White, 8.82% Asian-Pacific Islander, 3.26% Latinx, 2.82% other, and .06% Native Americans. A racially diverse sample of 83 preschoolers ages 3.5-5 yrs served as participants in the present study. Children from School A were randomly assigned to either a CHAMP (*n* = 35, 18 girls; 4.5 ± 0.27 yrs; 54.3% African American, 14.3% White, 5.7% Latinx, and 25.7% other) or control group (*n* = 16, 10 girls; 4.5 ± 0.24 yrs; 56.3% African American, 6.3% White, 6.3% Latinx, and 25.0% other). Children from School B were recruited to participate in MAP (*n* = 30, 16 girls, 4.7 ± .52 yrs; 66.7% African American, 6.7% White, 3.3% Latinx, and 23.3% other) group. A second school, School B, was used to avoid contamination with a previously sponsored study at School A. Randomization into a study group (CHAMP, MAP, or control) was done at the level of the classroom.

Exclusion Criteria.

Participants were excluded if they (1) had a documented physical or mental disability or (2) were less than 3.5 years of age.

FMS Environments

Children were divided among three FMS environments- two FMS interventions (CHAMP or MAP) or a control (standard practice, outdoor free play) See Table III.1 for full comparison among FMS environments.

Children's Health Activity Motor Program- CHAMP

Children replaced their regularly scheduled standard practice (outdoor free play) session with CHAMP 3 days a week for 10 weeks (45 min/day x 30 sessions = 1350 minutes). CHAMP is grounded in achievement goal theory (Ames, 1992; Ames & Archer, 1988; Epstein, 1988) and adheres to Epstein's TARGET structures (task, authority, recognition, grouping, evaluation, and time; Epstein, 1988). CHAMP adopts a high-autonomy approach to FMS instruction that allows learners to be intrinsically driven to learn and practice new FMS skills, try to understand their work, improve their own level of competence, and achieve a sense of mastery based on self-referenced standards. Correct implementation of a CHAMP affords children: (1) autonomy to select FMS stations, (2) choice of peer interactions, (3) opportunities to make independent decisions, (4) ability to self-evaluate progress, and (5) freedom to practice FMS on a continuum of difficulty. CHAMP also uses a constraints-based approach to instruction based on Newell's constraints model. This approach allows instructors to scaffold FMS activities and tasks to promote FMS change and learning (Newell, 1986).

Each CHAMP session was 45 minutes in duration and included: (a) 2-3 minutes introduction and warm up; (b) 3-5 minutes of FMS station description; (c) 30-35 minutes FMS stations practice and independent instruction; (d) brief closing. During the station description, children were taught the key performance criteria of each FMS, provided with a demonstration of how to execute the skill with all the provided equipment, and introduced to the different levels/modifications available to fit the developmental level of the learner. The 30-35 minutes of motor skill practice was a high-autonomy time where the children self-selected how to engage within CHAMP (e.g., what station they want to go to, whom they want to play with, what level of difficulty they want to practice). Each CHAMP session consisted of 3-4 stations (minimum of one locomotor and one ball FMS) each with 3-4 levels of difficulty. Children navigated through as many stations as they want and were free to modify the station to fit their individual needs as long as their modifications included the original skill. Instructors provided children with individualized, specific feedback, and evaluation during station practice. The closing activity was brief, and children were encouraged to recall their time during the FMS stations and give brief verbal descriptions of how they participated in each activity. All CHAMP sessions were implemented by two expert instructors (one lead and one assistant each with graduate-level education in pediatric motor development) and two support staff.

Fidelity checks were completed daily to ensure that CHAMP was (a) implemented according to the TARGET structures, (b) and included high-quality instruction (see Appendix B for CHAMP fidelity record form). To be considered high-quality instruction, CHAMP implementation had to meet eight instructional elements: (1) provide clear instruction, (2) incorporate critical cue words into introduction, (3) provide visual demonstration of skill performance, (4) check for student understanding, (5) implement activity stations according to lesson plan, (6) provide specific corrective/evaluative feedback during skill practice, (7) use manual manipulation to aid in FMS learning, and (8) reinforce skill critical elements during the closing activity. A member of the support staff completed daily fidelity checks. CHAMP was implemented with 100% fidelity to TARGET structures and 98% fidelity for instruction.

Motor skills At Playtime- MAP

MAP provides a "*roadmap to becoming a skillful mover*." MAP is a high-autonomy, pseudo-mastery intervention that is added to the extant standard practice of gross motor play at preschool centers. Current standard practice is typically an outdoor free play session, and MAP is integrated into the outdoor free play setting in two ways. First, MAP adds FMS stations/equipment (e.g., bats, balls, locomotor paths, throwing targets, etc.) to the outdoor free play setting. Secondly, MAP provides children with a brief skill demonstration on how to complete FMS included in the daily lesson before the start of each outdoor free play session.

MAP utilizes select components of achievement goal theory to create a pseudo-mastery intervention. Specifically, MAP implements four of the six TARGET structures to create a high-autonomy FMS intervention- *t*ask, *a*uthority, *g*rouping, and *t*ime. It is important to emphasize that

MAP does not include two, *r*ecognition and *e*valuation, of the six TARGET structures; therefore, MAP is not a mastery-motivational climate. MAP FMS stations use a “slanted rope” effect so that children of all skill levels can actively participate in the stations. Children have the autonomy to engage in the skill stations, or they can choose to use the equipment in a different version of play in the outdoor setting. Children also have the autonomy to self-select peer groups and the amount of time they engage in different activities on the playground (e.g., FMS stations or large play structures).

The current MAP intervention was implemented 3 days a week for 15 weeks (30 min/day x 45 sessions = 1350 minutes). Skills taught in MAP matched the CHAMP intervention so that children in MAP received equal dosages in minutes of each of the fifteen FMS skills taught in CHAMP. Classroom teachers were instructed to carry on with their regular routines during outdoor free play. The only modification they made to their daily routines was gathering the children at the beginning of the session so that children could see the demonstration of the daily FMS activities. Two instructors implemented MAP. The primary instructor had a college degree in English but did not have a background in physical education or pediatric motor development. The instructor participated in a two-day, 6-hour training session on FMS instruction and MAP before the start of the intervention. The primary instructor implemented 78% of all MAP lessons. The secondary instructor was the creator of MAP and had a graduate-level education on pediatric motor development. The secondary instructor completed the remaining 22% of all MAP lessons as well as attended a session taught by the primary instructor each week to ensure MAP was being implemented correctly.

Daily fidelity checks were completed to ensure MAP was implemented according to the curriculum and that the FMS setting was high-autonomy and aligned with the four TARGET structures (see appendix B for MAP fidelity record form). Daily fidelity checks also included photographs of all FMS skill stations to ensure correct FMS station set up. Results of the fidelity checks support that MAP was implemented according to the lesson plan the majority of the time (93.2% of sessions) and that skill demonstrations included all skill elements (100% of sessions). Children used the stations for skill practice on 74.6% of sessions and used the equipment for items other than skill practice 89.8% of sessions. Teachers provided unsolicited skill instruction during 33.9% of sessions.

Control

The control group made no changes to their daily routine and continued to engage in the standard practice of a daily 30-minute unstructured free play on the center-provided outdoor play space. This space included a variety of equipment including swings, play structures, slides, open grassy area (shaded and sunny), open pavement area (shaded and sunny) and daily manipulatives (e.g., balls, chalk, scarves, etc.) added at the discretion of the classroom teachers.

Table III. 1. Comparison of all three FMS environments.

	CHAMP	MAP	Control
Achievement Goal Theory	Yes	Yes	No
TARGET Structures	T-task A-authority R- recognition G- grouping E- evaluation T- time	T- task A- authority G- grouping T- time	NA
Implementers	Motor Experts (external to the preschool)	Non-Expert (external to the preschool)	Classroom teachers
Location	Gym or Indoor Space	Standard Practice (i.e., outdoor free play)	Standard Practice (i.e., outdoor free play)
Instructional Approach	High-autonomy, student-centered	High-autonomy, student-centered	No instruction
Daily instruction	- Skill demonstration - FMS equipment - Continuous instruction/feedback	- Skill demonstration - FMS equipment	None
Dosage	1350 min 45 min/session 3 sessions/week 10 weeks	1350 min 30 min/session 3 sessions/week 15 weeks	1350 min 30 min/session 4 sessions/week 11.5 weeks

Assessments

Demographics

Date of birth, sex, and race were collected through a parental report on the IRB form.

Anthropometrics

Children's height to the nearest tenth of an inch and weight to the nearest tenth a pound were recorded using a SECA 217 stadiometer and 813 scale, respectively (Hamburg, Germany). Height and weight measures were used to calculate body mass index (BMI) and BMI was converted to a percentile score using CDC data charts. Waist circumference was measured to the nearest tenth of a centimeter using a SECA 201 (Hamburg, Germany) measuring tape. Shoes and excess clothing was removed before all anthropometric measures, and children were instructed to stand still facing straight ahead while measures were completed.

Perceived Motor Competence

Perceived motor competence was assessed using both the Digital Scale of Perceived Motor Competence (DSPMC; Robinson & Palmer, 2017) and the motor subscale of the Pictorial Scale of Perceived Competence and Social Acceptance (PSPCSA; Harter & Pike, 1984). The DSPMC is a digital-based assessment that allows individuals to view FMS in four-dimensions—height, width, depth, and time. The assessment includes twelve motor skills divided into two categories, locomotor (run, gallop, hop, leap, jump, and slide) and ball FMS (throw, catch, dribble, kick, 2-hand strike, and roll). For each skill, children are presented with two 3-6 second digital clips of an adult model performing each skill on a small touchscreen tablet (9.5 x 7.3 inches). One clip depicts an immature/unskilled performance of the FMS, whereas the other displays a mature/skillful performance of the FMS. Children were instructed to: "*Watch the following videos and touch the circle under the video where the person moves like you*." Children watch both clips, and after the initial selection, the selected circle disappears and is replaced by a smaller and larger circle. If a child touched the circle under the unskilled motor performance, they were asked, "*Are you not to good at* [insert name of skill]? [large circle] OR *Are you sort of* *good at* [insert name of skill]? [smaller circle]". If a child touched the circle under the skilled motor performance, they were asked, "*Are you pretty good at* [insert name of skill]? [smaller circle] OR *Are you really good at* [insert name of skill]" [larger circle]." Each response corresponded with a numerical value ranging from 1 (cannot do this skill) to 4 (really good at this skill). The average score for the total assessment, locomotor, and ball FMS subtests was used in the present study.

The physical subtest of the PSPCSA has been used to measure perceived motor competence in preschoolers (Crane, Naylor, Cook, & Temple, 2015; Logan et al., 2013a; Robinson, 2011; Robinson et al., 2009) and includes the skills swinging, climbing, tying shoes, running, skipping, and hopping (Harter & Pike, 1984). For each skill, children are presented with two static pictures: one of a highly skilled child and one of a less skilled child. Children are asked to look at the two pictures while listening to an administrator verbally describes each picture. Children are then asked, "*Which picture is more like you?*" After making this choice, children are again prompted to choose to what extent they can perform the skill shown. If they select the picture with the more skilled child, they are asked, "*Are you really good? or pretty good*?" If they select the picture with the child who is less skilled, they are asked, "*Are you not good or sort of good*?" This response results in a quantitative score between 1 - 4 with 4 representing the most skilled and 1 representing the least skilled. An average score across all six items was used in the present study.

Engagement

Engagement was defined as (a) the amount of time that children participated in skill practice and (b) the number of skill attempts a child completed. Previous work defines a skill attempt as "a correctly executed [practice] trial in accordance with skill criteria" (Silverman,

1985) and work in older children supports that skill attempts are positively related to sport outcomes (Silverman, 1990; Silverman et al., 1998). A skill attempt was counted as long as the child attempted to execute the skill in a manner that aligned with the original skill purpose (Logan et al., 2013a). Engagement data were collected using a momentary time-sampling technique modified from the System for Observing Fitness Instruction Time protocols (McKenzie, 2002; McKenzie, Sallis, & Nader, 1991). Children were randomly selected and observed for one minute at a time at least three times across a single session. Each observation minute included four coding intervals (10-sec observe, 5-sec record). Observations alternated between boys and girls. Researchers listened to timer available through the mobile phone app Data Timer® that gave auditory signals to observe and record. During the 5-sec record period, the research would write down if the child was or was not engaged in skill practice and if the child was engaged in skill practice, the number of skill attempts completed (see Appendix B for engagement data collection form).

Because children may not have been observed for the same total of minutes, the percentage of time ((amount of time spent in skill practice/total amount of time observed)*100) and the total number of skill attempts was used in analyses. Between 10-12 children were observed daily, and each child was observed for at least three minutes across the movement session (i.e., CHAMP or MAP). Due to the sensitive nature of video recording young children, School B (i.e., MAP site) would not allow video coding of the MAP intervention; therefore, engagement was assessed using a live data coding protocol for children in MAP but video coding for children in CHAMP. Two coders scored all task persistence measures (25% overlap) and demonstrated a >99% agreement on engagement scoring.

FMS

Two FMS measures were included- process and product. Process-oriented assessments observe and score the execution of a motor skill performance. A process-oriented assessment of the throw would score a child according to the inclusion or absence of specific skill elements such as wind up, contralateral step, weight transfer, and cross-body follow through. Product-oriented assessments score the outcome of an FMS performance. For example, a product-oriented assessment would score a child based on throwing accuracy or speed. Data support both process (Cools, De Martelaer, Samaey, & Andries, 2009; Ulrich, 2000; Ulrich & Sanford, 1985) and product (Cools et al., 2009; Stodden et al., 2014) measures are appropriate for assessing FMS in children (Mally, Battista, & Robertson, 2011; Roberton & Konczak, 2001).

Process FMS- Test of Gross Motor Development 3rd Edition

FMS were measured using the Test of Gross Motor Development-3rd Edition (TGMD-3). The TGMD-3 assesses the performance of thirteen FMS divided across two categories: ball FMS (catch, underhand throw, one-handed forearm strike, kick, overhand throw, dribble, and strike off a tee) and locomotor FMS (run, skip, gallop, slide, hop, and horizontal jump). The total (alpha = 0.93), locomotor (alpha = 0.88) and ball FMS (alpha = 0.89) all demonstrate acceptable to high reliability (Ulrich, 2018). Each of the thirteen skills on the TGMD-3 is divided into three to five specific skill criteria. Children perform one practice and two test trials of each skill and are scored based on the number of correct criteria executed. Before completing a practice trial, the children received a demonstration of a skill performance that includes all specific skill criteria. All initial skill demonstrations in the present study were digital and were administered on an electronic tablet. Using digital demonstrations is an effective approach for TGMD administration (Robinson et al., 2015a) and is advantageous because it ensures that all children receive identical visual and verbal instructions before skill performance. If a child fails to demonstrate an understanding of the FMS during their practice trials, a second live-demonstration was provided. No additional skill demonstrations were given.

Scoring of the TGMD was done by coding recorded videos. A child is awarded a score of 1 if he/she performed a criterion correctly or received a 0 if he/she was unable to perform the criterion. The number of correct skill criteria is summed, resulting in raw total motor skill and subscale scores (i.e., locomotor and ball FMS). The maximum raw score for the TGMD-3 is 100, with a higher score reflecting greater FMS performance. Raw TGMD scores were used in all analyses. The primary coder for this research had a previously established inter-rater reliability of > 95% with three experts in the field and intra-rater reliability of > 96%. To ensure the coding accuracy of the primary coder, a second, blinded, expert coder cross-coded 25% of the sample. The two coders demonstrated high inter-rater reliability (ICC = 0.88 locomotor, ICC = 0.93 ball FMS, ICC = 0.96 total).

Product FMS

A total of six product motor skill measures were assessed- catching percentage (caught balls out of five attempts), maximum throwing speed (out of five trials), maximum kicking speed (out of five trials), maximum jumping distance (out of five trials), average running speed (two trials), and average hopping speed (four trials, two each leg; see Table III.2; True et al., 2017). All measures are developmentally valid and sensitive discriminators of FMS competence (Chappell, Molina, McKibben, & Stodden, 2016; Haubenstricker, Branta, Clark, & Humphrey, 1997; Malina, 1978; Mally et al., 2011; Roberton & Konczak, 2001; Stodden et al., 2014; Stodden, Langendorfer, Fleisig, & Andrews, 2006a, 2006b; Stodden, True, Langendorfer, & Gao, 2013; Tveter & Holm, 2010; Ulrich, 2000; Ulrich, 2018). Throwing and kicking speed (miles/hour) were recorded live using a Stalker radar gun (Stalker Radar, Plano, TX). Jumping distance to the nearest tenth of a centimeter was recorded live using a metric measuring tape. Running and hopping speed (meters/sec) were calculated using video analysis software (Dartfish Team Pro6). Running speed was calculated as the average speed of two strides across two run trials. Hopping speed was calculated as the average speed to complete four consecutive hops (heel to heel) for two hop trials on each foot. If a child was unable to complete four consecutive hops, a 0 was recorded and subsequently used when calculating the hopping speed average.

Aggregate product scores were created by standardizing product measures and then summing the newly created *z*-scores (True et al., 2017). Aggregate product scores were created for total (all six measures), locomotor (jump distance, run speed, and hop speed), and ball FMS (catching percentage, throwing speed, and kicking speed). Aggregate *z*-scores, also referred to as product locomotor, product ball, product total, were used in analyses unless otherwise stated.

Table III. 2. Description of data collection procedures for product FMS measures.

Skill	Outcome	Data Collection Procedure	Scoring	Verbal Instructions
Catch	Percentage of balls caught	The child was tossed five balls- chest, head, waist, right side, left side. The number of caught balls was tallied.	Live	"Catch the ball."
Throw	Speed (mph) of throw- max	The child threw the ball at the wall five times. Throwing speed (mph) was measured using a radar gun.	Live	"Throw the ball as hard and fast as you can toward the wall."
Kick	Speed (mph) of kick- max	The child kicked the ball toward the wall five times. Kicking speed (mph) was measured using a radar gun.	Live	"Kick the ball as hard and fast as you can towards the wall."
Jump	Distance (cm)- max	The child completed five standing broad jumps. Distance (cm) was measured after each jump.	Live	"Jump as far as you can."
Run	Speed (m/s) of run trials- average	The child ran a 7m distance two times. The average speed (m/s) of the run was assessed in the lab.	Video Analysis Software	"Run as fast as you can to the cone."
Hop	Speed (m/s) of hop trials-average	The child hopped across a 7m distance four times (two times on each foot). If they were able to complete four consecutive hops, the average speed (m/s) of the hop was assessed in the lab.	Video Analysis Software	"Hop as fast as you can to the cone." AND "Big Hops!" (additional cue during skill performance)

Study Procedures

All study procedures were approved by the Institutional Review Board (HUM00135602) and all children and their parents provided assent and consent, respectively, to participate in the study. This project took place at two, matched Head Start centers in Ypsilanti, MI. All children received a 1350-minute dose of a movement environment, but due to constraints at the centers, this total dose was administered differently (i.e., 45 min session vs. 30 min sessions) for the CHAMP vs. MAP and control groups. Children in the CHAMP group replaced their outdoor free play with a 45-minute CHAMP session three days a week for 10 weeks (total 1350 minutes). Children in MAP had MAP added to their standard practice outdoor play session for three days a week for 15 weeks (total 1350 minutes). CHAMP and MAP interventions were matched so that children received equal dosage in minutes to each skill and skill equipment. Children in the control group made no changes to their daily routines. Children completed anthropometrics, perceived motor competence, and FMS measures before the start of (pretest) and following the cessation of the intervention (posttest). Engagement measures were collected weekly.

Analyses

The analyses plan for each research question is discussed in detail below. See Table III.2 for a full list of variables and analyses for each question.

Research Question 1

Are there group differences between children's FMS (product and process) after completing one of three 1350-min FMS environments- MAP, CHAMP, or control?

Statistical Analyses

Due to differences in sample sizes, data were analyzed using linear regression modeling. Changes in FMS (post-pre) for both process and product motor measures served as the outcome variables, group was the predictor variable, and sex and height were added to the model as control variables. Height was never a significant predictor of FMS change and did not account for additional variability in the data, and therefore was removed from the final series of models. Final models were fit twice, once with the control group as the reference and once with the CHAMP group as the reference to ensure comparisons among all three groups were examined. All analyses were completed in SPSS v 24 and alpha levels were set to .05 a priori.

Research Question 2

How do child-level characteristics at the start of the intervention relate to changes in children's FMS?

Statistical Analyses

A variety of statistical approaches were employed. Differences in the changes in FMS for both boys and girls in each group were examined used ANOVAs. The association between changes in FMS and pretest perceived motor competence, anthropometrics, and initial skill level were examined through correlation analyses for the total sample as well as each intervention group (e.g., CHAMP and MAP). Strength of correlations was interpreted as 0.1, small; 0.3, moderate; 0.5 large (Cohen, 2013). If needed, additional secondary analysis (e.g., linear regression or multivariate ANOVAs) were performed. All analyses were completed for both process (TGMD total, locomotor, and ball FMS) and product (total, locomotor, ball FMS) measures of FMS.

Research Question 3

What child-level characteristics are associated with engagement in behaviors related to learning *and* how does engagement in behaviors related to learning affect changes in FMS across two FMS interventions (MAP and CHAMP)?

Statistical Analyses

Group differences in engagement in behaviors related to learning were examined using *t*-tests. Correlations analyses were used to examine how engagement related to (1) pretest anthropometrics, perceived motor competence, and initial skill level and (2) changes in FMS (process and product). If appropriate, multivariate linear regression models were then fit to examine how engagement predicted FMS change.

Research Question 4

What are the agreements between process (e.g., TGMD) and product measures of children's FMS before, after, and across a high-autonomy FMS intervention?

Statistical Analyses

Evaluating the agreement between process and product measures of FMS was completed using Spearman's correlations and linear regression. Spearman's correlations compared children's ranks on both process and product FMS (total, locomotor, and ball FMS) before, after, and across (change) the intervention. Correlations used raw TGMD scores and product aggregate *z*-scores. Correlations were interpreted as 0.0-0.50 as low, 0.51 - 0.70 as moderate, 0.71 - 0.90 as high and 0.91 - 1.0 as very high (Hinkle & Wiersma, 2003). All TGMD scores and product aggregate scores were then *z*-scored so that both measures had the same metric. These *z*-scores were subsequently used in a simple regression analysis to determine the linear relationship between the two variables. Nine regression models were fit to measures all three motor outcomes (e.g., total, locomotor, and ball FMS) for each time point (pretest, posttest, change).

Table III. 3. List of variable and statistical tests by research question.

	RQ	Dependent	Independent	Control	Statistical Tests
1	Are there group differences between children's FMS (product and process) after completing one of three 1350-min FMS intervention/environments-MAP, CHAMP, or control?	FMS Δ (process & product)	Group (CHAMP; MAP; Control)	Sex	Linear Regression Models
2	How do child-level characteristics at the start of the intervention relate to changes in children's FMS?	FMS Δ (process & product)	Sex Anthropometrics Perceived Motor Competence (DSPMC, PSPCSA) Pretest FMS		ANOVAs Pearson's correlations Linear Regression Models
3	What child-level characteristics are associated with engagement in behaviors related to learning AND how does engagement in behaviors related to learning effect changes in FMS across two FMS interventions (MAP and CHAMP)?	FMS Δ (process & product) Engagement (% of time, skill attempts)	Engagement (% of time, skill attempts) Anthropometrics Perceived Motor Competence (DSPMC, PSPCSA) Pretest FMS		Pearson's correlations Linear Regression models
4	What are the agreement between process (e.g., TGMD) and product measures of children's FMS before, after, and across a high-autonomy FMS intervention?	Process FMS	Product FMS	NA	Spearman Rank Correlations Linear Regression Models

CHAPTER IV. RESULTS

The purpose of this dissertation was threefold. First, this research examined the efficacy of a novel FMS intervention that is added to the extant standard practice of outdoor free play and implemented by non-experts (MAP). Secondly, this research included an in-depth examination of child-level characteristics or behaviors that relate to changes in FMS after engaging in an FMS intervention. Lastly, there is a growing interest in FMS measures used to assess FMS in young children. This research examined how process and product FMS measures compare before, after, and across an FMS intervention. This chapter contains the analyses, results, and discussion for each research question. The format of each section will be the research question, hypothesis, and analyses plan, results with tables and figures, and an interpretation/discussion of the findings.

Data Cleaning and Software

Before any analyses, data were cleaned, and children with incomplete data or outlying data were removed. Outlying data were determined after examination of the scatterplots of the raw data and sensitivity analyses and were operationally defined as an FMS change score above or below 2.5 standard deviations from the mean. See Table IV.1 for final sample size included for all Research Questions. All data were analyzed using SPSS v 24, and alpha levels were set to 0.05 a priori.

Table IV. 1. Full list of sample size (n) for pretest, posttest, change score, and outliers by research question and group.

			TGMD			Product		
			Total	LM	BS	Total	LM	BS
RQ 1	MAP	Pre	30	30	30	29	29	30
		Post	28	28	28	28	28	28
		Change	28	28	28	27	27	28
		Outlier (± 2.5 SD)	2	1	1	0	0	0
		Included Sample	26	27	27	27	27	28
	CHAMP	Pre	35	35	35	33	33	35
		Post	33	35	33	35	35	35
		Change	33	35	33	31	33	33
		Outlier (± 2.5 SD)	2	1	1	1	0	1
		Included Sample	31	34	32	30	33	32
	Control	Pre	18	18	18	17	17	18
		Post	17	17	17	16	16	17
		Change	17	17	17	15	15	17
		Outlier (± 2.5 SD)	0	0	0	0	0	0
		Included Sample	17	17	17	15	15	17
RQ 2 & 3	MAP	Pre	30	30	30	29	29	30
		Post	28	28	28	28	28	28
		Change	28	28	28	27	27	28
		Outlier (± 2.5 SD)	2	1	1	0	0	0
		Included Sample	26	27	27	27	27	28
	CHAMP	Pre	34	34	34	32	32	34
		Post	32	34	32	34	34	34
		Change	32	34	32	30	32	32
		Outlier (± 2.5 SD)	2	1	1	1	0	1
		Included Sample	30	33	31	29	32	31
RQ 4	MSI	Pre	65	65	65	62	62	65
		Post	63	63	63	63	63	63
		Change	63	63	63	60	60	63

Research Question 1

Are there group differences between children's FMS (product and process) after completing one of three 1350-min FMS environments- MAP, CHAMP, or control?

H1a- Children in CHAMP and MAP will demonstrate greater changes in FMS (product and process) compared with children in the control group.

H1b- Children who receive continuous FMS instruction in an FMS only environment (CHAMP) will demonstrate greater changes in FMS (product and process) compared with children who do not receive continuous feedback in an FMS and outdoor free play environment (MAP).

Statistical Analyses

Due to differences in sample sizes, data were analyzed using linear regression modeling. Changes in FMS (post-pre) for both process and product motor measures served as the outcome variables, group was the predictor variable, and sex and height were added to the model as control variables. Height was never a significant predictor of FMS change and did not account for additional variability in the data, and therefore was removed from the final series of models. Final models were fit twice, once with the control group as the reference and once with the CHAMP group as the reference to ensure comparisons among all three groups were examined.

Results

Descriptive statistics. See Table IV.2, IV.3, IV.4 for all descriptive statistics for the pre, post, and change scores for each group.

Table IV. 2. Mean and standard deviation of process FMS at pretest, posttest, and change scores by group.

		TGMD											
		Total				LM				BS			
		n	*M*		SD	*n*	*M*		SD	*n*	*M*		SD
MAP	Pre	26	26.50	±	9.03	27	14.37	±	7.64	27	12.78	±	4.16
	Post	26	36.12	±	8.92	27	19.30	±	5.94	27	17.37	±	6.10
	Change	26	9.62	±	8.04	27	4.93	±	5.85	27	4.59	±	4.46
CHAMP	Pre	31	31.42	±	12.54	34	14.79	±	6.27	32	16.25	±	7.38
	Post	31	43.39	±	12.13	34	19.29	±	6.93	32	23.91	±	7.98
	Change	31	11.97	±	10.04	34	4.50	±	6.65	32	7.66	±	6.01
Control	Pre	18	29.83	±	11.16	18	13.89	±	5.65	18	15.94	±	7.20
	Post	17	31.18	±	8.55	17	14.53	±	4.17	17	16.65	±	6.32
	Change	17	0.71	±	6.94	17	0.24	±	5.17	17	0.47	±	4.90

Note: LM = locomotor, BS = ball skills.

Table IV. 3. Mean and standard deviation of product z-scores FMS at pretest, posttest, and change scores by group.

		Product											
		Total				LM				BS			
		n	*M*		SD	*n*	*M*		SD	*n*	*M*		SD
MAP	Pre	27	-0.41	±	3.24	27	-0.06	±	2.23	28	-0.34	±	1.55
	Post	28	0.72	±	3.42	28	0.91	±	2.05	28	-0.20	±	1.81
	Change	27	1.13	±	1.96	27	0.96	±	1.82	28	0.14	±	1.33
CHAMP	Pre	30	1.62	±	4.50	33	0.86	±	2.57	32	0.46	±	2.28
	Post	32	1.11	±	3.68	35	-0.05	±	2.26	32	0.94	±	2.16
	Change	30	-0.43	±	2.18	33	-0.90	±	1.61	32	0.48	±	1.41
Control	Pre	17	-1.14	±	3.25	17	-0.83	±	1.77	18	-0.49	±	1.96
	Post	16	-1.92	±	4.21	16	-1.45	±	2.20	17	-0.30	±	2.36
	Change	15	-0.83	±	2.09	15	-0.62	±	1.36	17	0.13	±	1.48

Note: LM = locomotor, BS = ball skills.

Table IV. 4. Mean and standard deviation for product skills for each group at pretest, posttest, and change.

			LM									BS								
			Jump (cm)			Run (m/s)			Hop (m/s)			Catch (%)			Throw (mph)			Kick (mph)		
		n	*M*		SD	*M*		SD	*M*		SD	*M*		SD	*M*		SD	*M*		SD
MAP	Pre	30	71.79	±	30.71	3.39	±	0.53	0.56	±	0.73	14.00	±	19.76	18.53	±	3.40	16.53	±	3.35
	Post	28	90.93	±	22.07	3.77	±	0.50	0.96	±	0.67	17.86	±	19.12	20.86	±	3.37	18.46	±	3.38
	Change	27	15.82	±	17.70	0.31	±	0.77	0.40	±	0.67	3.57	±	24.38	2.36	±	2.50	1.93	±	3.04
CHAMP	Pre	34	76.76	±	28.19	3.78	±	0.69	0.82	±	0.67	21.18	±	21.99	20.21	±	4.34	16.35	±	3.69
	Post	34	92.99	±	21.56	3.47	±	0.48	0.73	±	0.53	23.53	±	19.98	21.68	±	7.09	19.12	±	6.13
	Change	34	16.24	±	25.72	-0.29	±	0.48	-0.10	±	0.52	2.353	±	18.92	1.47	±	5.74	2.76	±	5.37
Control	Pre	18	55.66	±	28.70	3.27	±	0.51	0.53	±	0.61	20.00	±	25.67	17.44	±	28.70	15.22	±	3.62
	Post	17	67.66	±	24.67	3.25	±	0.52	0.71	±	0.54	18.82	±	21.76	21.06	±	5.47	17.59	±	3.14
	Change	17	11.17	±	26.94	-0.06	±	0.65	0.19	±	0.46	-2.35	±	15.62	3.65	±	4.65	2.29	±	2.52

Note: LM= locomotor, BS= ball skills.

Total FMS. Results revealed that, controlling for sex, children in both MAP (B = 9.03, $p < 0.01$) and CHAMP (B = 11.44, $p < 0.001$) had greater TGMD-total change scores compared with children in the control group (see Table IV.4). Children in MAP had greater total product change scores compared with both the CHAMP (B = 1.55, $p < 0.01$) and control group (B = 2.0, $p < 0.01$; see Table IV.5) controlling for sex.

Table IV. 5. Linear regression for total process and product FMS.

	TGMD-Total Δ				Product(z)-Total Δ			
	(B)	*p*	(B)	*p*	(B)	*p*	(B)	*p*
n	74				72			
Intercept	1.10	0.63	12.54	<0.001	-0.80	0.16	-0.36	0.43
MAP	9.03	0.002	-2.41	0.31	2.00	0.005	1.55	0.007
CHAMP	11.44	<0.001			0.44	0.52		
Control			-11.44	<0.001			-0.44	0.52
Sex	-1.12	0.59	-1.12	0.59	-0.14	0.79	-0.14	0.79
Adjusted R^2				0.18				0.11

Note: Δ = change.

Locomotor FMS. Controlling for sex, children in both MAP (B = 4.80, $p < 0.05$) and CHAMP (B = 4.44, $p < 0.05$) had greater TGMD-locomotor change scores compared with children in the control group (see Table IV.6). Children in MAP also had greater product locomotor change scores compared with children in CHAMP (B = 1.80, $p < 0.001$) and control group (B = 1.67, $p < 0.01$). Further analysis revealed that compared with CHAMP, children in MAP had greater change in both hop (B = 0.49, $p < 0.001$) and run speed (B = 0.59, $p < 0.001$; see Table IV.7).

Follow up examination found that at pretest, children in CHAMP completed 50% (68 out of 136) of all hop trials (e.g., children exhibited 4 consecutive hops during 50% of trials) and children in MAP only completed 39% (48 out of 124) of hop trials. At the posttest children in CHAMP completed 49% (66 out of 136) of all hop trials and children in MAP completed 61% (76 out of 124) of all hop trials.

Table IV. 6. Linear regression for locomotor process and product FMS.

	TGMD-LM Δ				Product(z)-LM Δ			
	(B)	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***
n	78				75			
Intercept	0.64	0.68	5.08	<0.001	-0.48	0.27	-0.65	0.06
MAP	4.80	0.01	0.36	0.82	1.67	0.002	1.84	<0.001
CHAMP	4.44	0.02			-0.17	0.75		
Control			-4.44	0.02			0.17	0.75
Sex	-1.16	0.41	-1.16	0.41	-0.53	0.18	-0.53	0.18
Adjusted R^2				0.06				0.21

Note: LM = locomotor; Δ = change.

Table IV. 7. Linear regression for individual product locomotor FMS.

	Jump Distance (cm) Δ				Hop Speed (m/s) Δ				Run Speed (m/s) Δ			
	(B)	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***
n	79				77				76			
Intercept	12.00	0.05	16.76	0.001	0.24	0.11	-0.01	0.90	-0.01	0.94	-0.22	0.10
MAP	4.86	0.51	0.10	0.99	0.23	0.19	0.49	0.001	0.39	0.05	0.59	<0.001
CHAMP	4.76	0.50			-0.25	0.15			-0.20	0.30		
Control			-4.76	0.50			0.25	0.15			0.20	0.30
Sex	-2.35	0.66	-2.35	0.66	-0.17	0.21	-0.17	0.21	-0.15	0.30	-0.15	0.30
Adjusted R^2				0.03				0.12				0.14

Note: Δ = change.

Ball FMS. Children in both MAP (B = 4.07, $p < 0.05$) and CHAMP (B = 7.12, $p < 0.001$) and had greater TGMD-ball skill change scores compared with the control group (see Table R6). Children in CHAMP also had greater TGMD-ball skill change scores compared with children in MAP (B = 3.06, $p < 0.05$; see Table IV.8). Further analysis revealed that children in MAP had lower changes in kick speed compared with children in CHAMP (B = -1.86, $p < 0.05$; see Table IV.8). There was also a significant sex difference where boys had greater changes in throwing speed compared with girls (B = 2.10, $p < 0.01$; see Table IV.9).

Table IV. 8. Linear regression for process and product ball FMS.

	TGMD-BS Δ				Product(z)-BS Δ			
	(B)	*p*	**(B)**	*p*	**(B)**	*p*	**(B)**	*p*
n	76				77			
Intercept	0.32	0.81	7.44	<0.001	-0.04	0.91	0.24	0.42
MAP	4.07	0.02	-3.06	0.03	-0.05	0.91	-0.33	0.37
CHAMP	7.12	<0.001			0.28	0.51		
Control			-7.12	<0.001			-0.28	0.51
Sex	0.43	0.73	0.43	0.73	0.49	0.13	0.49	0.13
Adjusted R^2				0.19				0.01

Note: BS = ball skills; Δ = change.

Table IV. 9. Linear regression for individual product ball FMS.

	Catch Percentage Δ				Throw Speed (mph) Δ				Kick Speed (mph) Δ			
	(B)	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***	**(B)**	***p***
N	77				77		77.00		77			
Intercept	-1.56	0.77	4.29	0.33	2.91	<0.001	1.64	0.02	2.03	0.01	3.44	<0.001
MAP	6.17	0.34	0.37	0.95	-1.52	0.12	-0.26	0.75	-0.45	0.64	-1.86	0.02
CHAMP	5.81	0.36			-1.27	0.18			1.41	0.13		
Control			-5.81	0.36			1.27	0.18			-1.41	0.13
Sex	-2.25	0.64	-2.25	0.64	2.10	0.01	2.10	0.01	0.75	0.29	0.75	0.29
Adjusted R^2				-0.02				0.09				0.05

Note: Δ = change.

Discussion

The purpose of this research question was to evaluate the efficacy of a non-expert led FMS intervention that was added to the standard practice, MAP, and compare this intervention to an established FMS intervention, CHAMP, and a control/standard practice condition. These results partially support the initial hypotheses. As expected, children in MAP exhibited better improvements in FMS compared with the control group, and children in MAP did not exhibit as great of gains in ball FMS compared with CHAMP. Unexpected were the findings that children in MAP exhibited greater improvements in total and locomotor product scores compared with CHAMP.

The results indicate that children who completed an FMS intervention (MAP or CHAMP) demonstrated greater gains in FMS compared with children in the control group aligns with the literature on FMS interventions compared with outdoor free play (Brian et al., 2017; Logan et al., 2011; Robinson & Goodway, 2009; Robinson et al., 2016; Taunton et al., 2017). MAP and CHAMP are both high-autonomy FMS interventions where children are given equipment, opportunities, and examples to engage in FMS practice. Both interventions use tenants of achievement goal theory to create a high-autonomy intervention. This approach is an effective tool to create interventions that improve children's FMS (Bandeira et al., 2017; Palmer et al., 2017a). This study adds and expands on the achievement goal theory FMS intervention literature. This study replicated previous research, which supports CHAMP is effective for teaching FMS in preschool (Palmer et al., 2019; Robinson et al., 2017a; Robinson et al., 2017b) and that CHAMP improves skills more than control conditions (Palmer et al., 2019; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b).

This study adds to the extant literature by being the first to examine the efficacy of a newly created FMS intervention, MAP. MAP was specifically designed to be a sustainable, high-autonomy intervention that can be implemented by non-motor experts within the extant standard practice. These findings support that MAP is effective for improving some FMS (i.e., all process and product total and locomotor) compared to the current standard practice. This is one of the first studies to show that a non-expert led, high-autonomy intervention is effective for improving children's motor skills. This finding is important and has implications for FMS intervention feasibility, sustainability, and distribution.

Children in MAP improved equally as well to children in CHAMP in locomotor process and more in aggregate product locomotor as well as run and hop speed compared with children in both the control and CHAMP. There were no differences between the control and CHAMP children regarding changes in product locomotor scores. This finding was unexpected as most intervention research supports that FMS interventions improve FMS more than control conditions (Palmer et al., 2019; Robinson et al., 2016; Robinson et al., 2017a; Robinson et al., 2017b). However, the majority of FMS research examines changes in FMS using process and not product measures.

It is unclear why a difference was seen between process and product measures of locomotor FMS. It is possible that the outdoor playground environment may help children develop underlying factors (balance and strength) associated with locomotor outcomes (speed) but not necessarily mechanics of skill performance. This suggestion is supported by MAP children's improvement in the hop. The hop score calculated in the present study was calculated based on the average speed of four consecutive hops during a single trial. A trial where a child could not complete four consecutive hops was scored as a zero which was subsequently used when calculating the average hop speed. Children in MAP improved from only completing 39% of hop trials at the pretest to completing 61% of hop trials at the posttest. Children in CHAMP completed roughly the same number of hop trials at pre and posttest (50% vs. 49%). This means that there were more values included in the averages at posttest for the children in MAP than in CHAMP; hence, the changes in hop speed in MAP could be due to children in MAP's ability to demonstrate four consecutive hops and not necessarily speed of the consecutive hops. The MAP intervention and playground environment appear to help improve the number of consecutive hops a child could complete which supports this environment aids in the development of the underlying motor abilities associated with hoping performance such as leg strength, balance, and coordination.

The difference in findings across process and product measures of locomotor FMS aligns with and adds to the literature on FMS assessment. Previous research in this area demonstrates that product and process FMS measures yield similar but not interchangeable information on FMS performance (Logan et al., 2017). In this study, Logan et al. compared children's performance on two process (Test of Gross Motor Development, Gest Skilled Get Active) and product measures (2017). Results showed the measures moderately correlated with each other. Hence, finding that different FMS measures reveal different insights into intervention effects is not surprising and aligns with what is known about product and process FMS measures. More research on FMS measurement and how product and process measures align before and after interventions is needed.

Though MAP did improve some FMS equally to or better than CHAMP, it did not improve all FMS as well as CHAMP. Specifically, MAP did not improve ball FMS as well as CHAMP. Children in both MAP and CHAMP had equal opportunities to engage in ball skill practice, but children in CHAMP received continual feedback, instruction, and monitoring of personal progress whereas children in MAP only received a skill demonstration at the start of each session. Further, the MAP environment allowed children to select between FMS stations or activities on the playground, whereas the CHAMP environment only included FMS stations. Literature supports that in traditional FMS interventions, novice instructors are more effective at teaching ball FMS compared with locomotor FMS and are more effective when using a group-centered rather than student-center (e.g., high-autonomy) approach (Brian & Taunton, 2018). These findings only partially align with this work. MAP, which was instructed by a novice and non-motor expert, demonstrated more beneficial effects for locomotor not ball FMS. The MAP intervention was high-autonomy and did not include direct instruction, unlike the intervention used by Brian and Taunton (2018). The difference in findings between these studies supports that demonstration and opportunity alone are not as effective to teach ball FMS but providing children with continuous instruction or feedback in an FMS environment supports gains in these skills. Improving ball FMS is important from a health perspective as ball FMS in early childhood (i.e., 6 yrs) are associated with physical activity in adolescence (Barnett et al., 2009). Continued work is needed to create effective ball FMS interventions that can be implemented within the standard practice of outdoor free play.

The pattern of findings between the type of FMS (locomotor or ball FMS) in each FMS intervention group (CHAMP vs MAP) is interesting. Overall, both FMS interventions were effective for improving process locomotor FMS. CHAMP was more effective for process ball FMS compared with MAP, and MAP was more effective for improving product locomotor skills compared with CHAMP. Though it is unclear why FMS changes differed between interventions, it is possible these differences are present because of how locomotor and ball skills interacted with the instructional elements of MAP and CHAMP. Specifically, the continued, explicit instruction provided in CHAMP may be particularly important for aiding children in learning skills that require higher cognitive structures (e.g., ball skills) but not as important for, and may even interfere with the performance of, skills that are more automatic and rely more heavily on sub-cortical brain structures (e.g., locomotor skills). The importance of instruction on children's ball skill performance is supported in the literature. For example, children's ball skill performance is altered based on verbal instructions provided during skill performance such that directing children to have an external focus of attention improves their performance compared with a neutral focus of attention (Palmer et al., 2017c). Additional work shows that guided practice of overhand throwing elicits gains in throwing performance (Johnson, Rudisill, Hasitie, & Sassi, 2019). The continued instruction in the CHAMP environment may be appropriate to teach children ball skills, whereas the limited instruction and unstructured movement exploration in the MAP environment are appropriate for children to learn locomotor skills.

This is the first study to examine the effects of a high-autonomy intervention implemented by non-motor experts during the standard practice of outdoor free play, MAP, on children's FMS. This research supports that MAP is an effective, non-motor expert-led, FMS intervention that elicits positive gains in FMS using both process and product measures. MAP appears to be a useful approach to improve FMS, but additional, more structured, environments with more skill instruction such as CHAMP may be necessary to induce gains in ball FMS. Future work should try supplementing MAP with CHAMP to elicit gains in both locomotor and ball FMS. There were several strengths in the current study design. First, this study compared a non-expert led FMS intervention, MAP, against an established FMS intervention (CHAMP) and standard practice (control, outdoor free play). Comparing the effects of MAP against both these conditions allows for comparison against the standard practice as well as a well-established intervention. Secondly, this study included both process and product measures of FMS. Including both types of measures provided a more robust understanding of intervention effects on FMS.

This study also included several weaknesses, and some of these weaknesses were unavoidable due to the demands of the research sites. MAP was implemented in a different center than the CHAMP and control groups. The centers were matched as best as possible, but nonetheless, introducing a second research site may have introduced some unaccounted for heterogeneity in the data. Future work should replicate this study with all three groups created at a single center. This study was also limited in that external personnel delivered MAP. One of the goals of MAP is to be a sustainable FMS intervention that can be implemented by the staff available at the preschool center. Though this study did use an external team to implement the intervention, the primary person in charge of delivering MAP was not a motor development nor physical education expert which supports that MAP can be successfully and effectively implemented by a non-motor expert. The success of MAP as delivered by a non-movement expert is promising, and future work should be done to continue to develop MAP curriculum so it can be delivered within the personnel and resources already available at preschools or early child care centers.

Research Question 2

How do child-level characteristics at the start of an FMS intervention (MAP or CHAMP) relate to changes in children's FMS?

H2a- Perceived motor competence will positively relate to changes in FMS after both MAP and CHAMP.

H2b- Weight (lbs), weight status (BMI and BMI-z), and initial skill level will inversely relate to changes in FMS after both MAP and CHAMP.

H2c- Sex differences will not be present in children's FMS changes after both MAP and CHAMP.

Statistical Analyses

A variety of statistical approaches were employed. Differences in the changes in FMS for both boys and girls in each group were examined used ANOVAs. The association between changes in FMS and pretest perceived motor competence, anthropometrics, and skill level were examined through correlation analyses for the total sample as well as each intervention group (e.g., CHAMP and MAP). Strength of correlations were interpreted as 0.1, small; 0.3, moderate; 0.5 large (Cohen, 2013). If needed, additional secondary analysis (e.g., linear regression or multivariate ANOVAs) were performed. All analyses were completed for both process (TGMD total, locomotor, and ball FMS) and product (total, locomotor, ball FMS) measures of FMS.

Results

Sex. ANOVAs revealed there were between-group differences in regards to product total change ($F(3,53) = 2.80$, $p < 0.05$) and product locomotor change ($F(3,55) = 6.88$, $p < 0.01$). Tukey post hoc tests did not find any significant differences between groups for total product change, but revealed that boys ($M_{diff} = -2.07$, $p < 0.05$) and girls ($M_{diff} = 2.55$, $p < 0.01$) in MAP had greater locomotor product changes scores compared with boys in CHAMP (see Table IV.10).

There were no between group differences for TGMD-total ($F(3,52) = 1.02$, $p = 0.39$), TGMD-locomotor ($F(3,56) = 1.37$, $p = 0.263$), TGMD-ball skills change ($F(3,54) = 1.86$, $p = 0.148$), nor product ball skills change ($F(3,56) = 0.83$, $p = 0.48$). See Table IV.10 for full list of descriptive statistics.

Table IV. 10. Mean and standard deviation of process and product FMS for boys and girls in CHAMP and MAP.

		Motor Skill Δ Score											
		n	**Total Δ**			***n***	**LM Δ**			***n***	**BS Δ**		
Process (TGMD)	MAP boys	12	9.17	±	8.99	12	4.17	±	5.65	13	5.23	±	6.08
	MAP girls	14	10.00	±	7.45	15	5.53	±	6.13	14	4.00	±	2.18
	CHAMP boys	16	10.38	±	9.61	17	2.71	±	5.45	16	8.06	±	6.57
	CHAMP girls	14	14.71	±	10.09	16	6.88	±	7.23	15	7.60	±	5.59
Product	MAP boys	12	0.77	±	2.16	12	0.69	±	2.05	13	0.01	±	1.70
	MAP girls	15	1.42	±	1.8	15	1.17	±	1.65	15	0.25	±	0.97
	CHAMP boys	15	-0.66	±	2.55	16	-1.38	±	1.72	16	0.67	±	1.63
	CHAMP girls	15	-0.75	±	3.09	16	-0.32	±	1.34	16	-0.29	±	2.44

Note: Δ = change, LM = locomotor, BS = ball skills.

Anthropometrics. See Table IV.11 for full descriptive statistics of anthropometrics. Results of the correlation analyses revealed a small-to-moderate positive relationship between BMI and changes in TGMD-total change ($r(54) = .30$, $p < 0.05$) as well as weight and TGMD-ball skills change ($r(56) = 0.28$, $p < 0.05$) for all children. Children in CHAMP also had moderate, positive relationships between TGMD-locomotor change and both waist circumference ($r(31) = 0.39$, $p < 0.05$) and BMI ($r(31) = 0.38$, $p < 0.05$). There were no significant correlations between anthropometrics and changes in product FMS (see Table IV.12).

Table IV. 11. Mean and standard deviations for anthropometrics for each group at pretest and posttest.

		Height (cm)		Weight (lbs)		WC (cm)		BMI		BMI %	
		M	SD	*M*	SD	*M*	SD	*M*	SD	*M*	SD
MAP	Pre	107.02	± 4.91	40.94	± 5.98	56.26	± 5.26	16.18	± 1.87	60.33	± 32.00
	Post	110.22	± 4.82	42.88	± 6.20	54.43	± 3.95	15.03	± 1.61	39.00	± 32.75
CHAMP	Pre	107.08	± 3.65	41.67	± 4.53	54.63	± 3.73	16.49	± 1.63	67.62	± 22.72
	Post	110.31	± 3.83	43.33	± 5.11	55.48	± 3.83	16.12	± 1.46	62.96	± 22.07
Control	Pre	105.65	± 4.97	39.57	± 6.20	54.08	± 3.98	16.00	± 1.59	60.77	± 33.68
	Post	107.61	± 5.66	41.11	± 6.84	54.43	± 4.29	16.01	± 1.68	62.78	± 32.39

Note: WC= Waist circumference; BMI= Body Mass Index; BMI %= Body Mass Index Percentile

Table IV. 12. Correlations for anthropometric measures and changes in product and process FMS.

			n	Height (in)	Weight (lbs)	Waist Circ.	BMI	BMI %
Process- TGMD	Total Δ	Total	56	-0.05	0.2	0.11	0.30*	0.25†
		MAP	26	-0.04	0.10	-0.03	0.16	0.21
		CHAMP	30	-0.08	0.27	0.29	0.35†	0.28
	LM Δ	Total	60	-0.23†	0.04	0.15	0.22†	0.13
		MAP	27	-0.19	-0.11	-0.1	0.02	0.02
		CHAMP	33	-0.27	0.18	0.39*	0.38*	0.26
	BS Δ	Total	58	0.18	0.28*	0.03	0.19	0.26†
		MAP	27	0.14	0.34†	0.18	0.31	0.42*
		CHAMP	31	0.19	0.20	0.02	0.08	0.08
Product	Total Δ	Total	57	-0.1	0.01	0.05	0.08	0.12
		MAP	27	0.04	0.14	-0.48	0.22	0.27
		CHAMP	30	-0.11	0.00	-0.04	0.07	0.13
	LM Δ	Total	59	-0.24†	-0.05	0.13	0.11	0.13
		MAP	27	-0.35†	-0.3	0.01	0.14	0.26
		CHAMP	32	-0.14	0.01	0.01	0.11	0.10
	BS Δ	Total	60	0.10	0.06	-0.09	-0.01	0.04
		MAP	28	0.34†	0.19	-0.11	-0.02	-0.02
		CHAMP	32	-0.06	-0.03	-0.09	-0.01	0.10

Note: Δ = change, LM = locomotor, BS = ball skills; †, $p < 0.10$; *, $p < 0.05$

Perceived Motor Competence. See Table IV.13 for full descriptive statistics of anthropometrics. Regarding perceived motor competence, there was only one inverse relationship between the ball FMS subscale of the DSPMC and TGMD-total change for all children ($r(54) = -0.28$, $p < 0.05$). No other significant relationships between perceived competence and changes in FMS were revealed (see Table IV.14).

Table IV. 13. Mean and standard deviation for perceived motor competence for each group at pretest and posttest.

		DSPMC							
		LM		BS		Total		PSPCSA	
		M	SD	*M*	SD	*M*	SD	*M*	SD
MAP	Pre	2.67	0.39	2.69	0.42	2.68	0.26	3.27	0.70
	Post	2.89	0.56	2.67	0.61	2.78	0.48	3.25	0.51
CHAMP	Pre	3.00	0.45	2.75	0.47	2.88	0.38	3.22	0.56
	Post	3.08	0.47	3.02	0.51	3.05	0.38	3.19	0.72
Control	Pre	2.71	0.30	2.89	0.47	2.80	0.34	3.05	0.54
	Post	2.85	0.53	2.92	0.47	2.88	0.42	3.26	0.46

NOTE: DSPMC = Digital Scale of Perceived Motor Competence; LM = locomotor; BS = ball skills PSPCSA = Pictorial Scale of Perceived Competence and Social Acceptance

Table IV. 14. Correlations for perceived motor competence and changes in product and process FMS.

				DSPMC			
			n	Total	LM	BS	PSPCSA
Process-TGMD	Total Δ	Total	56	-0.06	0.21	-0.28*	0.03
		MAP	26	-0.26	-0.02	-0.31	-0.16
		CHAMP	30	-0.01	0.28	-0.27	0.20
	LM Δ	Total	60	-0.03	0.13	-0.17	0.01
		MAP	27	-0.20	-0.08	-0.17	-0.19
		CHAMP	33	0.05	0.29	-0.17	0.16
	BS Δ	Total	58	-0.03	0.17	-0.21	0.04
		MAP	27	-0.25	-0.04	-0.29	-0.11
		CHAMP	31	-0.05	0.13	-0.20	0.18
Product	Total Δ	Total	57	-0.14	-0.16	-0.20	0.19
		MAP	27	-0.12	-0.27	-0.13	0.31
		CHAMP	30	-0.12	-0.05	-0.14	0.14
	LM Δ	Total	59	-0.17	-0.15	-0.10	0.14
		MAP	27	0.31	-0.08	0.09	0.08
		CHAMP	32	-0.11	0.08	-0.25	0.24
	BS Δ	Total	60	-0.09	-0.04	-0.09	0.13
		MAP	28	-0.15	0.08	-0.27	0.35†
		CHAMP	32	-0.07	-0.11	-0.01	-0.01

Note: Δ = change; LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$.

Initial Skill Level.

Correlations. There were moderate-to-large inverse relationships between TGMD-total change and initial TGMD-total and TGMD-locomotor for all the children ($r(54) = -0.39$, $p < 0.01$; $r(54) = -0.48$, $p < 0.001$; respectively), CHAMP ($r(28) = -0.43$, $p < 0.05$; $r(28) = -0.38$, $p <$

0.05; respectively), and MAP ($r(24) = -0.46$, $p < 0.05$; $r(24) = -0.66$, $p < 0.001$; respectively). There were also inverse relationships between TGMD-locomotor change and initial TGMD-total ($r(58) = -0.28$, $p < 0.05$) and TGMD-locomotor ($r(58) = -0.51$, $p < 0.001$) for all the children. Further, children in both CHAMP and MAP had moderate-to-large inverse relationships between TGMD-locomotor change and initial TGMD-locomotor ($r(31) = -0.40$, $p < 0.05$; $r(25) = -0.64$, $p < 0.001$; respectively). Lastly, there were small-to-moderate inverse relationships between TGMD-ball skills change and initial total ($r(56) = -0.27$, $p < 0.05$) and locomotor ($r(56) = -0.26$, $p < 0.05$) for all the children as well as between TGMD-ball skills change and initial TGMD-total ($r(29) = -0.38$, $p < 0.05$) for children in CHAMP (see Table IV.15).

In regards to product skills, there were moderate inverse relationships between product total changes and initial product total and locomotor for all the children ($r(55) = -0.44$, $p < 0.01$; $r(55) = -0.45$, $p < 0.01$; respectively) as well as children in CHAMP ($r(28) = -0.49$, $p < 0.01$; $r(28) = -0.48$, $p < 0.01$; respectively). There were moderate inverse relationships between product locomotor change and initial product locomotor for all the children ($r(57) = -0.48$, $p < 0.001$), CHAMP ($r(30) = -0.44$, $p < 0.05$), and MAP ($r(25) = -0.48$, $p < 0.05$). Lastly, product ball skills change was inversely related to initial product total, locomotor, and ball skills for all the children ($r(58) = -0.52$, $p < 0.001$; $r(58) = -0.28$, $p < 0.05$; $r(58) = -0.45$, $p < 0.001$; respectively) and children in CHAMP ($r(30) = -0.69$, $p < 0.001$; $r(30) = -.40$, $p < 0.05$; $r(30) = -0.55$, $p < 0.01$; respectively, see Table IV.15).

Table IV. 15. Correlations for initial skill level and changes in product and process FMS.

				Initial Skill Level		
			n	**Total**	**LM**	**BS**
Process-TGMD	Total Δ	Total	56	-0.39**	-0.48***	-0.10
		MAP	26	-0.46*	-0.66***	0.04
		CHAMP	30	-0.43*	-0.38*	-0.28
	LM Δ	Total	60	-0.28*	-0.51***	0.10
		MAP	27	-0.26	-0.64***	0.29
		CHAMP	33	-0.30†	-0.40*	-0.05
	BS Δ	Total	58	-0.27*	-0.26*	-0.13
		MAP	27	-0.21	-0.28	0.00
		CHAMP	31	-0.38*	-0.26	-0.31†
Product	Total Δ	Total	57	-0.44**	-0.45**	-0.16
		MAP	27	-0.17	-0.26	0.11
		CHAMP	30	-0.49**	-0.48**	-0.27
	LM Δ	Total	59	-0.18	-0.48***	0.16
		MAP	27	-0.24	-0.48*	0.3
		CHAMP	32	-0.08	-0.44*	0.15
	BS Δ	Total	60	-0.52***	-0.28*	-0.45***
		MAP	28	-0.02	0.14	-0.21
		CHAMP	32	-0.69***	-0.40*	-0.55**

Note: Δ = change; LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$; **, $p < 0.01$, ***, $p < 0.001$.

Multivariate ANOVA. Due to the pattern of inverse relationships between initial skill and changes in FMS, secondary analyses were conducted to examine how the initial skill level influenced changes in FMS after completing an FMS intervention (MAP or CHAMP). Children were divided into three skill level groups based on their initial FMS (process and product) levels- high (top 33.33%), average (middle 33.33%) and low (bottom 33.34%). A 3 (skill level group) x 2 (CHAMP or MAP) ANOVAs with post hoc Tukey (skill level) or *t*-tests (CHAMP vs. MAP) was used to examine within and between-group changes in FMS across the intervention. See Table IV.16 for descriptive statistics of motor skill change for each group.

Table IV. 16. Mean and standard deviation for changes in product and process FMS according to initial skill level group.

			TGMD Δ								Product Δ							
			n	**MAP**			***n***	**CHAMP**			***n***	**MAP**			***n***	**CHAMP**		
Initial skill	Total	Low	10	11.00	±	6.85	7	15.00	±	11.72	10	1.68	±	1.79	7	-0.44	±	1.59
		Avg	9	13.89	±	5.46	12	13.25	±	8.45	9	0.93	±	2.37	11	-0.48	±	3.60
		High	7	2.14	±	7.97	11	9.82	±	10.53	8	0.67	±	1.72	12	-1.07	±	2.65
	LM	Low	10	8.70	±	6.62	8	8.50	±	6.59	10	1.16	±	2.23	7	-1.03	±	0.71
		Avg	8	5.00	±	5.06	14	4.57	±	6.12	8	1.34	±	1.42	14	-0.20	±	1.56
		High	9	0.67	±	5.37	11	2.18	±	6.52	9	0.39	±	1.67	11	-1.51	±	1.88
	BS	Low	10	4.10	±	2.08	9	9.33	±	5.27	10	-0.01	±	0.67	9	0.45	±	1.26
		Avg	12	4.70	±	4.36	9	8.22	±	5.29	12	0.36	±	1.29	9	0.66	±	1.60
		High	5	5.40	±	8.11	13	6.54	±	7.05	6	-0.05	±	2.23	14	-0.28	±	2.74

Note: Δ = change; LM = locomotor; BS = ball skills

There was a significant main effect for skill level group ($F(2,56) = 4.21$, $p < 0.05$) for TGMD-total change. Post hoc analysis did not reveal a significant difference among the skill level groups, but there was a trend towards significance were children who had average initial skill exhibited greater TGMD-total change compared with children who had high skills ($M_{diff} = 6.69$, $p = 0.052$; see Fig IV.1 and Table IV.16). There was also a significant main effect of skill level group ($F(2, 60) = 7.23$; $p < 0.01$) for TGMD-locomotor changes. Post hoc analyses revealed that children with initial low TGMD-locomotor had greater changes than children with initial high TGMD-locomotor ($M_{diff} = 7.11$, $p < 0.01$). The analyses for TGMD-ball skills revealed a significant main effect of movement group ($F(1, 58) = 4.83$, $p < 0.05$). Post hoc *t*-tests showed that children in CHAMP had significantly greater TGMD-ball skills change compared with children in MAP ($t(56) = 2.3$, $p < 0.05$).

In regards to product FMS, there was a significant main effect of group ($F(1,57) = 6.87$, $p < 0.05$) for product total change. Post hoc *t*-tests revealed that children in MAP had greater product total changes compared with children in CHAMP ($t(55) = 2.86$, $p < 0.01$). Similarly, there was a significant main effect of group ($F(1, 59) = 17.54$, $p < 0.001$) for product locomotor change. Post hoc *t*-tests revealed that children in MAP had greater product locomotor change compared with children in CHAMP ($t(57) = 4.05$, $p < 0.001$). See Figure IV.2 and Table IV.16.

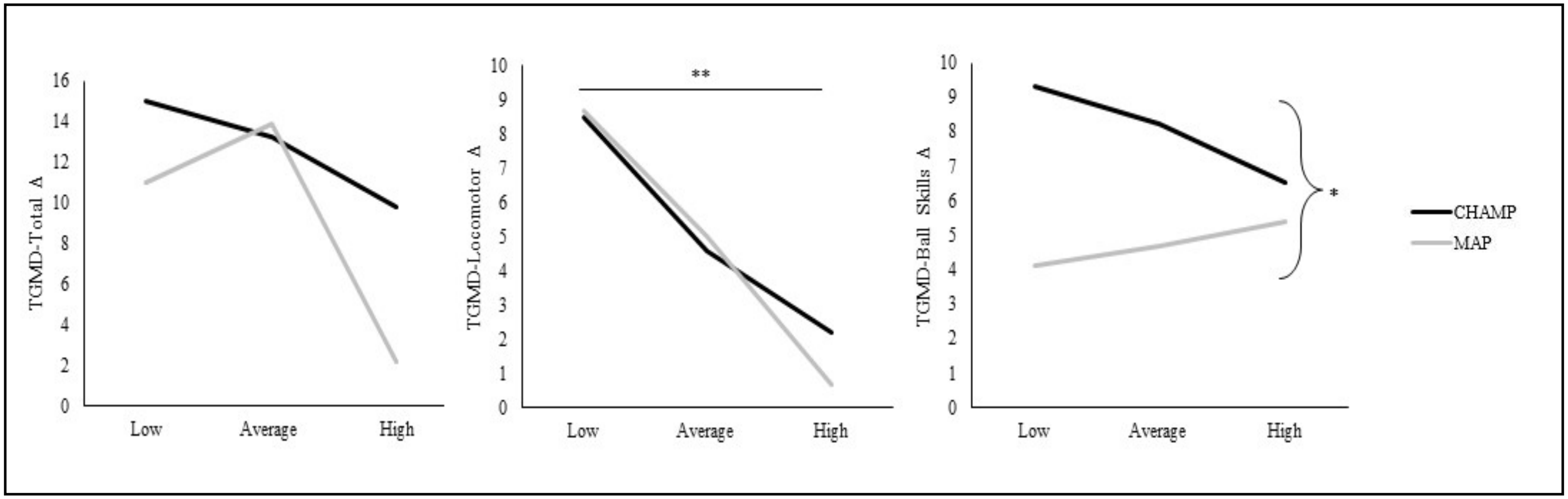


Figure IV. 1. Process motor skill changes for low, average, and high initial skill groups in CHAMP and MAP.

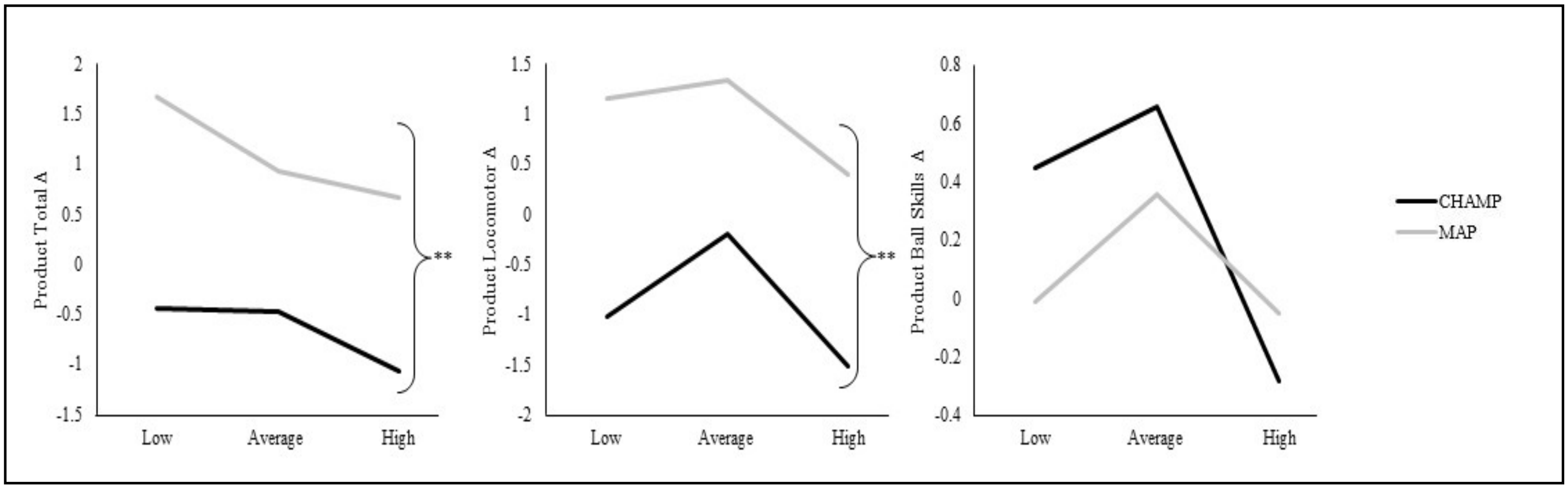


Figure IV. 2. Changes in process FMS for low, average, and high initial skill level groups in CHAMP and comparison.

Discussion

The purpose of this research question was to examine how child-level characteristics at pretest related to changes in FMS across an FMS intervention. Child-level characteristics examined included sex, anthropometrics, perceived competence, and initial skill level.

Results of this study partially supported the initial hypothesis. As hypothesized, there were no differences in process FMS changes between boys and girls across both groups. Further, both boys and girls in each group (CHAMP and MAP) exhibited equal changes in both process and product FMS. These findings align with previous research that found that boys and girls in a CHAMP intervention exhibited the same changes in ball FMS across the intervention (Robinson et al., 2017b). Hence, it appears that both the CHAMP and MAP intervention are equally as effective for boys and girls in the programs. There were, however, differences between girls and boys in MAP compared with boys in CHAMP. Both boys and girls in MAP had greater changes in product-locomotor compared with boys in CHAMP. This is finding was unexpected as the CHAMP intervention provides instruction on locomotor FMS compared with MAP, which does not provide locomotor instruction.

Further, results found that the CHAMP intervention elicited gains in ball FMS whereas MAP did not. These results suggest that instruction is important for eliciting change in ball FMS and the outdoor play space is important and beneficial for locomotor FMS and may be a particularly important space for boys to practice these skills. Though data collection was not conducted on the playground for this research question, anecdotal observations by members of the research team support that there were few ball FMS completed on the playground, and boys on the playground engaged in a variety of locomotion and often played chase or tag games with friends. Indeed, other observational research on playground supports these environments lend themselves to practice more locomotor compared with ball FMS games and skills (Adams, Veitch, & Barnett, 2018).

Contrary to the original hypothesis, weight, waist circumference, and BMI were positively related to several FMS outcomes. Interestingly, these relationships were different between the two interventions as well as between process and product FMS measures. For all children, regardless of intervention, weight positively related to changes in TGMD-ball skills and BMI to TGMD-total. Children in CHAMP also had a positive relationship between change in TGMD-locomotor and waist circumference and BMI. Lastly, there were no relationships between any anthropometrics at pretest and changes in product FMS. This is surprising as several anthropometric measures (e.g., height or weight) have been implicated as important for FMS (D'Hondt et al., 2013; D'hondt et al., 2011; Gentier et al., 2013; O'Brien et al., 2016).

Contrary to the initial hypothesis, perceived motor competence was inversely related to changes in children's process or product FMS. Perceived motor competence findings should be interpreted with caution due to the small strength of this correlation and that no other relationships between perceived motor competence and changes in FMS were found. The data also showed that different measures of perceived motor competence might have different relationships with changes in FMS after completing FMS interventions. The DSPMC was primarily inversely related to changes in FMS, whereas the PSPCSA was primarily positively related to changes in FMS. Both the DSPMC and PSPCSA are validated in this population (Harter & Pike, 1984; Robinson & Palmer, in review), but the differences in their relationship with FMS changes may be due to the skills included on each scale. The DSPMC includes both locomotor and ball FMS skills (note, 10 of the same skill as on the TGMD-3) whereas the PSPCSA includes FMS (hop, run, skip), play skills (swing, climb) and fine motor skill (tying shoes). Other work that compares the DSPMC and the PSPCSA to FMS at a single time point has found that the DSPMC more closely relate to FMS than the PSPCSA (Robinson & Palmer, in review). These findings add to the extant literature on perceived motor competence and how different measures of perceived motor competence may yield unique insight into this construct. More research on perceived motor competence and how different measures of perceived competence relate to motor outcomes is needed.

The results on initial skill level aligned with the original hypotheses. There was a repeated pattern of inverse correlations between children's initial total and locomotor FMS and their changes in FMS after an intervention (both MAP and CHAMP). This finding was particularly evident in children's initial locomotor FMS and changes in both process and product skills. These results support that children with higher locomotor FMS at the start of an intervention may demonstrate lower gains in locomotor and ball skills. When children were categorized into three groups (low, average, high) based on initial skill level, results reiterated the correlational findings in that the children with low initial locomotor FMS gained more than children with high initial skills. Collectively, these results support that pretest locomotor FMS may be a good indicator of which children will gain the most from intervention and researchers and practitioners may want to provide additional support and encouragement for children with better locomotor FMS at pretest to keep these children engaged and learning from FMS interventions.

Interestingly, initial ball FMS only inversely related to changes in product ball FMS for the total (MAP and CHAMP) and CHAMP groups, and initial ball FMS did not relate to changes in children's process TGMD-ball skills. The data revealed a trend where initial TGMD-ball skill inversely related to changes in ball FMS for the CHAMP group but not the children in MAP. It is likely that the correlation between initial ball FMS and ball FMS changes would have been significant if the analysis had additional power. The difference in pattern between initial and changes in ball FMS in different intervention settings (MAP vs. CHAMP) may be because children in MAP had smaller gains in TGMD-ball skills compared with children in CHAMP. The finding that MAP is not as effective for improving TGMD-ball skills aligns with the results from Research Question 1. These results show that all children, regardless of initial skill level, have an equal opportunity to learn ball FMS in an FMS intervention but that FMS interventions need to include continuous instruction and feedback to be effective for improving these skills. More research is needed to determine potential child-level characteristics at pretest that could be used to predict children's changes in ball FMS.

This study was one of the first to examine how child-level characteristics at pretest relate to changes in children's FMS across an intervention. These findings add to the literature on FMS interventions and have practical implications for researchers and practitioners. These results support that a children's initial locomotor FMS may be inversely related to their gains in FMS across an intervention. Researcher and practitioners may use locomotor screening tests to see which children might benefit the most from FMS intervention in early childhood. Moreover, children who enter an intervention with high locomotor FMS may need more encouragement or additional supports to continue to develop and master FMS skills. These results also support that the outdoor play environment may be an important place for young children to learn locomotor FMS, especially for boys, but even adding ball FMS activities to the outdoor setting (i.e., MAP intervention) is insufficient to improve these skills. These findings support that FMS interventions should not completely replace the standard practice of outdoor free play, and FMS interventions may need to provide continual instruction and feedback for ball FMS improvements.

Even with all that this study adds to the literature, it is vital to acknowledge the limitations within the present research. First, the included sample sizes were small, so it is important to examine the effect size or strength of the correlation in addition to the statistical significance of findings. Replicating this study with a larger sample is needed. Secondly, the MAP and CHAMP interventions were implemented at different childcare centers. Though the centers were carefully matched based on geographic location and demographics of the enrolled students, it is possible that having different centers introduced unaccounted for heterogeneity in the data. Future work should include MAP and the CHAMP intervention in the same center(s).

Research Question 3

What child-level characteristics are associated with engagement in behaviors related to learning *and* how does engagement in behaviors related to learning affect changes in FMS across two FMS interventions (MAP and CHAMP)?

H3a- Children in CHAMP will be more engaged in behaviors related to learning compared to children in MAP.

H3b- Perceived competence and skill level before the start of the intervention will positively relate to engagement.

H3c- Engagement will positively relate and predict children's changes in motor skill competence.

Statistical Analyses

Group differences in engagement in behaviors related to learning were examined using *t*-tests. Correlations analyses were used to examine how engagement relates to (1) pretest anthropometrics, perceived motor competence, and initial skill level and (2) changes in FMS (process and product). If appropriate, multivariate linear regression models were then fit to examine how engagement predicted FMS change.

Results

Group differences.

Across the intervention, children in MAP were observed an average of 15.3 times for 3.3 mins/observations, and children in CHAMP were observed an average of 11.1 times for 2.4 mins/observations. Compared with children in MAP, children in CHAMP engaged in skill practice for a greater percentage of time for total ($M_{diff} = 26.34 \pm 1.8$, $t(60) = 14.59$, $p < 0.001$), locomotor ($M_{diff} = 10.49 \pm 1.53$, $t(60) = 6.87$, $p < 0.001$), and ball FMS ($M_{diff} = 14.88 \pm 1.63$, $t(60) = 9.14$, $p < 0.001$; see Table IV.14). Similarly, compared with children in MAP, children in CHAMP completed more skill attempts for total ($M_{diff} = 36.08 \pm 7.96$, $t(60) = 4.53$, $p < 0.001$), locomotor ($M_{diff} = 14.97 \pm 3.26$, $t(60) = 4.59$, $p < 0.001$), and ball FMS ($M_{diff} = 22.37 \pm 7.27$, $t(60) = 3.08$, $p < 0.01$; see Table IV.17).

Table IV.17. Mean and standard deviation for engagement (percentage of time and completed skill attempts) for CHAMP and MAP.

			CHAMP			MAP			Difference		
			M		SD	M		SD	M	SE	*t*-score
Engagement	Total	% Time	32.58	±	9.01	6.24	±	4.31	26.34	1.80	14.59***
		Skill Attempts	56.18	±	39.14	20.10	±	20.44	36.08	7.96	4.53***
	LM	% Time	15.21	±	7.01	4.72	±	4.84	10.49	1.53	6.87***
		Skill Attempts	23.32	±	16.11	8.34	±	8.16	14.97	3.26	4.59***
	BS	% Time	18.75	±	8.51	3.88	±	2.78	14.88	1.63	9.14***
		Skill Attempts	34.21	±	37.02	11.83	±	15.55	22.37	7.27	3.08**

Note: **, $p < 0.01$; ***, $p < 0.001$.

Pretest Characteristics and Engagement.

Sex. Results of the one-way ANOVAs examining sex by group differences for engagement revealed significant between group differences in percentage of time engaged in total (F(3.63) = 23.52, $p < 0.001$), locomotor (F(3,23) = 17.09, $p < 0.001$), and ball skill practice (F(3,63) = 31.41, $p < 0.001$). Post hoc Tukey analyses showed that, compared with boys and girls in MAP, boys in CHAMP spent significantly more time engaged in total ($M_{diff} = 28.56$, $p < 0.001$; $M_{diff} = 26.82$, $p < 0.001$; respectively), locomotor ($M_{diff} = 9.37$, $p < 0.001$; $M_{diff} = 8.18$, $p < 0.01$; respectively), and ball skill practice ($M_{diff} = 17.84$, $p < 0.001$; $M_{diff} = 17.07$, $p < 0.001$; respectively). Similarly, compared with boys and girls in MAP, girls in CHAMP spent significantly more time engaged in total ($M_{diff} = 25.99$, $p < 0.001$, $M_{diff} = 24.24$, $p < 0.001$; respectively), locomotor ($M_{diff} = 12.88$, $p < 0.001$; $M_{diff} = 11.68$, $p < 0.001$; respectively), and ball skill practice ($M_{diff} = 12.72$, $p < 0.001$, $M_{diff} = 11.97$, $p < 0.001$; respectively).

One-way ANOVAs examining sex by group differences for engagement as measured by skill attempts revealed there were significant between group differences in total number of completed skill attempts for total (F(3,63) = 7.12, $p < 0.05$), locomotor (F(3,63) = 8.83, $p<0.001$), and ball FMS (F(3,63) = 4.18, $p < 0.01$). Post hoc Tukey analyses showed that, compared with boys and girls in MAP, boys in CHAMP completed more total ($M_{diff} = 43.96$, $p < 0.01$; $M_{diff} = 39.22$, $p<.01$; respectively) and ball skill attempts ($M_{diff} = 31.36$, $p<.05$; $M_{diff} =30.34$, $p < 0.05$; respectively). Boys in CHAMP also competed more locomotor attempts compared with boys in MAP ($M_{diff} = 12.44$, $p < 0.05$). Girls in CHAMP completed more total skill attempts compared with boys in MAP ($M_{diff} = 33.25$, $p < 0.05$) as well as more locomotor attempts compared with both boys ($M_{diff} = 21.21$, $p < 0.001$) and girls ($M_{diff} = 17.71$, $p < 0.01$) in MAP. See Table IV.18 for full sex differences in engagement.

Table IV.18. Mean and standard deviation for engagement (percentage of time and completed skill attempts) for boys and girls in CHAMP and MAP.

			n	% Time			Skill Attempts		
				M		SD	M		SD
Total	MAP	Girls	16	7.06	±	4.82	22.31	±	24.94
		Boys	14	5.31	±	3.59	17.57	±	14.18
	CHAMP	Girls	17	31.30	±	9.45	50.82	±	38.63
		Boys	17	33.87	±	8.65	61.53	±	40.08
LM	MAP	Girls	16	5.28	±	5.66	10.00	±	10.09
		Boys	14	4.08	±	3.81	6.50	±	4.91
	CHAMP	Girls	17	16.96	±	6.04	27.71	±	17.80
		Boys	17	13.46	±	7.64	18.94	±	13.33
BS	MAP	Girls	16	4.24	±	3.27	12.31	±	18.38
		Boys	14	3.47	±	2.14	11.29	±	12.22
	CHAMP	Girls	17	16.19	±	6.30	25.76	±	29.18
		Boys	17	21.31	±	9.79	42.65	±	42.70

Note: LM= locomotor; BS= ball skills.

Anthropometrics. See table IV.11 for full descriptives of anthropometrics**.** Body mass index was inversely related to the percentage of time children in CHAMP spent engaged in ball skill practice ($r(30) = -0.37$, $p < 0.05$). There were no other significant correlations between anthropometric measures and engagement (see Table IV.19).

Table IV.19. Correlations for anthropometric measures and engagement by group.

Group			Height (in)	Weight (lbs)	Waist Circ.	BMI	BMI %
Total (N=62)	Total	% Time	-0.10	-0.05	-0.21	0.02	0.04
		Skill Attempts	-0.04	-0.10	-0.20	-0.10	-0.08
	LM	% Time	-0.12	-0.01	-0.15	0.09	0.16
		Skill Attempts	-0.11	-0.04	-0.12	0.02	0.09
	BS	% Time	0.03	-0.04	-0.21†	-0.07	-0.06
		Skill Attempts	0.01	-0.10	-0.18	-0.13	-0.13
CHAMP (n=32)	Total	% Time	-0.27	-0.32†	-0.20	-0.17	-0.23
		Skill Attempts	0.02	-0.21	-0.21	-0.25	-0.26
	LM	% Time	-0.30†	-0.13	-0.04	0.05	0.16
		Skill Attempts	-0.09	-0.10	-0.07	-0.06	0.03
	BS	% Time	0.08	-0.22	-0.25	-0.3†	-0.37*
		Skill Attempts	0.07	-0.18	-0.20	-0.24	-0.29†
Comparison (n=30)	Total	% Time	-0.24	-0.13	0.02	0.01	-0.04
		Total Skills	-0.17	-0.11	-0.01	-0.03	-0.05
	LM	% Time	-0.04	0.00	-0.05	0.04	0.05
		Total Skills	-0.24	-0.10	0.02	0.05	0.06
	BS	% Time	-0.08	-0.06	0.12	-0.03	-0.06
		Total Skills	-0.11	-0.10	0.03	-0.06	-0.10

Note: LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$.

Perceived Competence. See Table IV.14 for full descriptives for perceived motor competence. For the total sample, perceived competence on the DSPMC positively correlated to the percentage of time ($r(60) = 0.29$, $p < 0.05$) and the number of completed ball skill attempts ($r(60) = 0.26$, $p < 0.05$). Perceived locomotor competence on the DSPMC was positively correlated to percentage of time all children spent engaged in total skill practice ($r(60) = 0.27$, $p < 0.05$) and ball skill practice ($r(60) = 0.32$, $p < 0.05$) as well as the number of ball skill attempts completed ($r(60) = 0.27$, $p < 0.05$). For children in CHAMP, perceived motor competence on the DSPMC was inversely related to the percentage of time children engaged in locomotor skill practice ($r(30) = -0.48$, $p < 0.01$). Perceived locomotor and ball skill competence on the DSPMC was inversely related to the percentage of time engaged in locomotor skill practice ($r(30) = -0.40$, $p < 0.05$; $r(30) = -0.38$, $p < 0.05$; respectively, see Table IV.20).

Table IV.20. Correlations for perceived motor competence and engagement by group.

			DSPMC			
			Total	**LM**	**BS**	**PSPCSA**
Total (N=62)	Total	% Time	0.21	0.27*	0.05	0.03
		Skill Attempts	0.22	0.21†	0.12	0.08
	LM	% Time	-0.03	0.04	-0.08	-0.05
		Skill Attempts	0.01	-0.01	0.02	0.08
	BS	% Time	0.29*	0.32*	0.13	0.08
		Skill Attempts	0.26*	0.27*	0.12	0.06
CHAMP (n=32)	Total	% Time	-0.19	-0.16	-0.15	0.13
		Skill Attempts	0.11	0.04	0.13	0.17
	LM	% Time	-0.48**	-0.40*	-0.38*	-0.13
		Skill Attempts	-0.24	-0.29†	-0.11	0.12
	BS	% Time	0.15	0.08	0.16	0.18
		Skill Attempts	0.21	0.18	0.17	0.14
Comparison (n=30)	Total	% Time	0.21	-0.02	0.28	0.16
		Skill Attempts	0.06	0.04	0.04	0.04
	LM	% Time	0.11	-0.10	0.23	0.09
		Skill Attempts	0.06	-0.16	0.22	0.14
	BS	% Time	0.09	0.12	0.01	0.23
		Skill Attempts	0.05	0.14	-0.07	-0.03

Note: LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$; **, $p < 0.01$.

Initial Skill Level. For the total sample, there was a positive relationship between initial TGMD-total and total completed skill attempts ($r(60) = 0.41$, $p < 0.01$), percentage of time engaged in ball skill practice ($r(60) = 0.36$, $p < 0.01$), and the completed ball skill attempts ($r(60) = 0.42$, $p < 0.001$). There was a positive relationship between initial TGMD-ball skills and percentage of time engaged in total skill practice ($r(60) = 0.32$, $p < 0.05$), total completed skill attempts ($r(60) = 0.34$, $p < 0.01$), percentage of time engaged in ball skill practice ($r(60) = 0.39$, $p < 0.05$), and total completed ball skill attempts ($r(60) = 0.35$, $p < 0.01$). There were also positive relationships between TGMD-locomotor and total completed skill attempts ($r(60) = 0.37$, $p < 0.01$) and ball skill attempts ($r(60) = 0.38$, $p < 0.01$; see Table IV.21).

A similar pattern was seen for product FMS measures where initial product total positively related to percentage of time children engaged in skill practice ($r(60) = 0.30$, $p < 0.05$), total number of completed skill attempts ($r(60) = 0.53$, $p < 0.001$), percentage of time engaged in ball skill practice ($r(60) = 0.52$, $p < 0.001$), and number of completed ball skill attempts ($r(60) = 0.59$, $p < 0.001$). Initial product ball skills positively related to total completed skill attempts ($r(60) = 0.43$, $p < 0.001$), percentage of time engaged in ball skill practice ($r(60) = 0.45$, $p < 0.001$), and number of completed ball skill attempts ($r(60) = 0.53$, $p < 0.001$). Initial product locomotor positively related to percentage of time engaged in total skill practice ($r(60) = 0.29$, $p < 0.05$), total number of completed skill attempts ($r(60) = 0.49$, $p < 0.001$), percentage of time engaged in ball skill practice ($r(60) = 0.45$, $p < 0.001$), and number of completed ball skill attempts ($r(60) = 0.51$, $p < 0.001$; see Table IV.21).

For children in CHAMP there was a positive relationship between TGMD-total and percentage of time engaged in total skill practice ($r(30) = 0.35$, $p < 0.05$), total number of completed skill attempts ($r(30) = .47$, $p < 0.01$), percentage of time engaged in ball skill practice ($r(30) = 0.48$, $p < 0.01$), and total number of completed ball skill attempts ($r(30) = 0.46$, $p < 0.01$). TGMD-ball skills positively related to the percentage of time children spent engaged in ball skill practice ($r(30) = 0.36$, $p < 0.05$) as well as the number of completed ball skill attempts ($r(30) = 0.33$, $p < 0.05$). TGMD-locomotor positively related to the percentage of time children engaged in skill practice ($r(30) = 0.38$, $p < 0.05$), total number of completed skill attempts ($r(30) = 0.57$, $p < 0.01$), percentage of time engaged in ball skill practice ($r(30) = 0.53$, $p < 0.01$), and the number of completed ball skill attempts ($r(30) = 0.53$, $p < 0.01$).

A similar pattern of results was seen for product motor measures where total product positively related to the total number of completed skill attempts ($r(30) = 0.58$, $p < 0.001$), percentage of time engaged in ball skill practice ($r(30) = 0.65$, $p < 0.05$), and number of completed ball skill attempts ($r(30) = 0.63$, $p < 0.001$). Product ball skills positively related to the number of completed total skill attempts ($r(30) = 0.40$, $p < 0.05$), percentage of time engaged in ball skill practice ($r(30) = 0.52$, $p < 0.01$), and number of completed ball skill attempts ($r(30) = 0.51$, $p < 0.01$). Product ball skills also inversely related to the percentage of time children engaged in locomotor skill practice ($r(30) = -0.60$, $p < 0.001$). Product locomotor positively related to percentage of time engaged in skill practice ($r(30) = 0.42$, $p < 0.05$), total number of completed skill attempts ($r(30) = 0.65$, $p < 0.001$), percentage of time engaged in ball skill practice ($r(30) = 0.65$, $p < 0.001$), and number of completed ball skill attempts ($r(30) = 0.62$, $p < 0.05$; see Table IV.21).

For children in MAP, product ball FMS positively related to the number of completed ball skill attempts ($r(28) = 0.47$, $p < 0.01$). See Table IV.201for full correlations.

Table IV.21. Correlation for initial skill level and engagement by group.

			TGMD			Product		
			Total	**LM**	**OC**	**Total**	**LM**	**OC**
Total (N=62)	Total	% Time	0.24†	0.12	0.32*	0.30*	0.29*	0.22†
		Skill Attempts	0.41**	0.37**	0.34**	0.53***	0.49***	0.43***
	LM	% Time	- 0.09	- 0.12	- 0.03	- 0.16	- 0.07	- 0.23†
		Skill Attempts	0.12	0.13	0.07	0.09	0.17	- 0.04
	BS	% Time	0.36**	0.24†	0.39**	0.52***	0.45***	0.45***
		Skill Attempts	0.42***	0.38**	0.35**	0.59***	0.51***	0.53***
MAP (n=30)	Total	% Time	- 0.14	0	- 0.33†	- 0.09	- 0.09	- 0.06
		Skill Attempts	0.18	0.25	- 0.05	0.2	0.07	0.31
	LM	% Time	- 0.24	- 0.13	- 0.32†	- 0.28	- 0.21	- 0.27
		Skill Attempts	0.01	0.11	- 0.19	- 0.18	- 0.17	- 0.11
	BS	% Time	0.01	0.06	- 0.13	0.14	0.08	0.16
		Skill Attempts	0.23	0.27	0.05	0.35†	0.18	0.47**
CHAMP (n=32)	Total	% Time	0.35*	0.38*	0.28	0.28	0.42*	0.1
		Skill Attempts	0.47**	0.57**	0.31†	0.58***	0.65***	0.40*
	LM	% Time	- 0.27	- 0.2	- 0.28	- 0.49**	- 0.28	- 0.60***
		Skill Attempts	0.07	0.19	- 0.05	0	0.2	- 0.19
	BS	% Time	0.48**	0.53**	0.36*	0.65***	0.65***	0.52**
		Skill Attempts	0.46**	0.53**	0.33**	0.63***	0.62***	0.51**

Note: LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

Motor skill changes and engagement. There was a positive correlation between the percent of time children in MAP were engaged in skill practice and in TGMD locomotor change ($r(60) = 0.40$, $p < 0.05$). There was also a positive correlation between the percent of time children were engaged in skill practice and TGMD ball skills change for all the children ($r(60) = 0.33$, $p < 0.05$). Lastly, there were inverse relationships between total product changes and the percent of time children were engaged in skill practice ($r(60) = -0.28$, $p < 0.05$) and the total number skill trials completed ($r(60) = -0.29$, $p < 0.05$; see Table IV.22).

Table IV. 22. Correlation for engagement and changes in process and product FMS by group.

			Engagement	
			% Time	Skill Attempts
Process- TGMD	Total	Total	0.16	0.10
		MAP	0.19	0.09
		CHAMP	0.00	- 0.01
	LM	Total	0.04	- 0.06
		MAP	0.40*	0.21
		CHAMP	- 0.10	- 0.15
	BS	Total	0.33*	0.19
		MAP	- 0.02	0.14
		CHAMP	0.22	- 0.08
Product	Total	Total	- 0.28*	- 0.29*
		MAP	0.17	0.02
		CHAMP	0.10	- 0.18
	LM	Total	- 0.20	- 0.16
		MAP	0.20	0.37†
		CHAMP	0.13	- 0.03
	BS	Total	0.25†	0.16
		MAP	- 0.09	0.05
		CHAMP	0.27	0.14

Note: LM = locomotor; BS = ball skills; †, $p < 0.10$; *, $p < 0.05$.

Linear regression models were fit to examine further if engagement was a significant predictor of children's changes in TGMD-ball skills and product total. Results revealed that controlling for group, percentage of time engaged in ball skill practice did not significantly predict TGMD-ball skills change (B = .23, $p = 0.07$). Conversely, percent time engaged in total skill practice predicted product total changes (B = 0.13, $p < 0.01$). This model also revealed that children in CHAMP had a lower product total change compared with children in MAP (B = -0.58, $p < 0.001$).

Discussion

The purpose of this research question was threefold: (1) to compare if children's engagement in behaviors related to learning between two FMS interventions (CHAMP and MAP), (2) to explore relationships between child-level characteristics (sex, anthropometrics, and perceived motor competence) at pretest and engagement in FMS interventions, and (3) to determine if engagement was related to and/or predicted changes in FMS after CHAMP or MAP. As expected, we found that children in CHAMP completed more FMS skill attempts and were engaged in skill practice for a greater percentage of time compared with children in MAP. This finding was seen for all children in each intervention group as well as both boys and girls in each intervention group. This finding is not surprising as MAP included skill stations alongside the normal outdoor free play activities. At the MAP center, the outdoor free play environment included large play structures, swings, bike path, sandbox, music fence, and an open grassy area. Motor skill stations were added to the environment on a veranda, and children had the option to engage in any of the above locations/activities. Conversely, the CHAMP program was implemented in a gymnasium and included three to five FMS activity stations daily. The finding that MAP did not induce many FMS skill attempts or a large percentage of time in skill engagement aligns with the literature on playgrounds and how playground environments promote or inhibit FMS learning (Adams et al., 2018).

These findings support that child-level characteristics at pretest relate to how children engage during FMS interventions. Interestingly, the relationship between pretest child-level characteristics and engagement may differ based on the intervention itself or the type of FMS (locomotor vs. ball FMS) children practice. Children in CHAMP had an inverse relationship between perceived motor competence as measured with the DSPMC and their engagement in locomotor FMS, but this relationship was not found for children in MAP. Across all children, there was a positive relationship between perceived motor competence using the DSPMC and their engagement in ball skills. When examining initial FMS, results found that children across both interventions with higher initial total and ball FMS were more engaged in all total and balls skill practice overall. When the FMS interventions were separated, this relationship was only seen for children in CHAMP. Hence, it appears that how a child thinks they move might inversely related to engagement, whereas how children actually move might encourage engagement, particularly for ball FMS. This trend appears to be particularly salient in a high-instruction environment such as CHAMP. Indeed, previous research on how children engaged in low- and high-autonomy FMS interventions found that children engaged in equal skill attempts in both interventions but children with higher initial skill competence engaged in more skill practice regardless of whether the intervention was low- or high- autonomy (Logan et al., 2013). These findings support this work and show that a child's initial skill level may be a particularly important predictor of engagement in high-autonomy FMS interventions.

Our results found that engagement, as measured as the percent of time completing skills and the total number of skill attempts a child completed only related to a few actual changes in FMS. The only significant linear regression found that children who spend more time engaged in skill practice improved their product total skills. These results were surprising as previous literature supports that children who exhibit task persistence (i.e., skill attempts) demonstrate greater learning of sport specific skills (Silverman, 1985, 1990). Silverman goes on to specify that it is not only the number of attempts a child completes but the quality of those attempts

(Silverman, 1990; Silverman et al., 1998). Below are two proposed reasons the present findings do not fully align with previous work. First, the current study did not qualitatively score the skill attempts children completed. It is possible that the children in this study were not engaging in "high quality" practice, which may have resulted in the null findings for engagement predicting FMS changes. Secondly, the coding scheme used in the present study was a 10-sec observe and 5-sec record momentary time sampling technique. This technique has previously been shown to be a reliable scoring procedure for observing child behaviors related to physical activity or classroom behaviors (SOFIT; Mahar et al., 2006; McKenzie, 2002), but this scheme may have been insufficient to capture all FMS engagement. Indeed, researchers frequently noticed that during the 10-second observe period children may not complete a skill attempt but were still engaged in "on-task" behaviors such as running to get a ball, transporting between skill stations, or interacting with peers or instructors. Future work on engagement during FMS intervention or programming may want to use a different observation protocol to capture engagement behaviors.

Our results on the relationship between engagement and changes in FMS may also be due to how engagement was operationalized and measured in the current study. Two measures of engagement were used, percent time completing skill practice and skill attempts; however, other measures of engagement could have also been included, such as time-on-task. Time-on-task is a measure that examines if a child is engaging in behaviors that align with the classroom goals. In a traditional FMS intervention (e.g., CHAMP), a child would be on-task if they were actively participating in the environment to learn FMS. Behaviors that would be considered on-task in CHAMP would include things such as retrieving a ball, interacting with instructor/peers, waiting for a turn, setting up a station to complete an activity, and practicing skills. These on-task behaviors align with the classroom goals but would not be quantified as time spent engaged in skill practice because the child was not engaged in any phase of skill execution. Unfortunately, due to the differences in the goals of the MAP and the CHAMP intervention, time-on-task was not a viable comparison of engagement between the two interventions. The outdoor free play environment of MAP means that many play behaviors would be considered "on-task" for MAP, but these same behaviors would be "off-task" for CHAMP. For example, a child in CHAMP who picked up a hula hoop being used as a ball holder and started to hula hoop would be considered off-task, but this same child and action would be considered on-task in MAP. Future work should consider examining time-on-task as a measure of engagement in a single FMS intervention.

This study was one of the first to examine how children engage in high-autonomy FMS interventions and to relate this engagement to changes in FMS across the intervention. This study also examined how child-level characteristics at pretest related to how children engaged in FMS interventions. This study has several strengths. First, it used a well-established FMS intervention, CHAMP, and newly created FMS intervention MAP. Both CHAMP and MAP are effective interventions for improving FMS in young children (see Research Questions 1 & 2) and examining if engagement related to outcomes may provide a new depth of understanding about these interventions which could help to establish best intervention practices. Secondly, weekly engagement measures were collected, which provides a more complete picture of how children engaged across an entire FMS intervention. Research reports that children in high-autonomy FMS interventions undergo multiple stages across the intervention: exploration/captivation, consolidation/consolidation, and collaboration/dedication (Hastie et al., 2019). Future work should examine if children demonstrate different engagement in the FMS intervention during each of these stages.

The current study also contains several weaknesses. As noted earlier, engagement was measured using a momentary time sampling technique and was operationalized as skill practice attempts and percentage of time children engaged in skill practice. It is possible that this measure and operational definition of engagement failed to fully capture all of the children's engagement behaviors related to learning during the intervention. Moreover, this study failed to qualitatively score children's skill practice attempts as high or low quality. Quality of skill attempts has been shown to be important to consider when examining skill attempts' relationship to movement outcomes(Silverman, 1990; Silverman et al., 1998). Future work examining children's engagement in FMS intervention should consider these limitations and may want to adopt a broader definition of engagement and include a quality rating of children's skill practice. Secondly, the MAP and CHAMP interventions were implemented at different childcare centers. Though the centers were carefully matched based on geographic location and demographics of the enrolled students, it is possible that having different centers introduced unaccounted for heterogeneity in the data. Lastly, as with all research, the results of this study represent the samples in which the data were collected. This study took place at two Head Start centers in an urban town in the Midwestern United States, and results may not be generalizable beyond this sample. Replication is a cornerstone of scientific inquiry, and this study should be replicated in diverse samples.

Research Question 4

What are the agreement between process (e.g., TGMD) and product measures of children's FMS before, after, and across an FMS intervention?

H4- Product and process measures will not be equivalent in measuring children's changes across an FMS intervention.

Statistical Analyses

Evaluating the agreement between process and product measures of motor skill was completed using Spearman's correlations and linear regression. Spearman's correlations compared children's ranks on both process and product FMS (total, locomotor, and ball FMS) before, after, and across (change, post-pre) the intervention. Correlations used raw TGMD scores and product aggregate *z*-scores. Correlations were interpreted as 0.0 - 0.50 as low, 0.51 - 0.70 as moderate, 0.71 - 0.90 as high and 0.91 - 1.0 as very high (Hinkle & Wiersma, 2003). All TGMD scores and product aggregate scores were then *z*-scored so that both measures had the same metric. These *z*-scores were subsequently used in a simple regression analysis to determine the linear relationship between the two variables. Nine regression models were fit to measures all three motor outcomes (e.g., total, locomotor, and ball FMS) at each time point (pretest, posttest, change).

Results

Spearman's Correlations. Results revealed that children's ranks on raw TGMD and product aggregate *z*-scores were moderately correlated at pretest locomotor ($r_s(61) = 0.74$, $p < 0.001$) and ball FMS ($r_s(61) = 0.55$, $p < 0.001$; see Table IV.19) as well as at posttest locomotor ($r_s(63) = 0.61$, $p < 0.001$), ball FMS, ($r_s(63) = 0.68$, $p < 0.001$) and total skills ($r_s(63) = 0.65$, $p < 0.001$). Children's ranks on raw TGMD and product aggregate *z*-scores measures were highly correlated at pretest ($r_s(61) = 0.78$, $p < 0.001$; see Table IV. 23). There were no significant correlations between children's ranks on raw process and product aggregate *z*-scores change scores (see Table IV.23).

Table IV. 23. Spearman's correlation between process (TGMD) and product measures of FMS before, after, and across the intervention.

	Pretest	Posttest	Δ
Total	0.78***	0.65***	0.19
LM	0.74***	0.61***	0.19
BS	0.55***	0.68***	0.16

Note: LM = locomotor; BS = ball skills; ***, $p < 0.001$.

Linear Regression. See Figure IV.3 for raw scatter plots. Product scores significantly predicted total (B = 0.80, $p < 0.001$), locomotor (B = 0.74, $p < 0.001$), and ball process FMS (B = 0.62, $p < 0.001$) at pretest. At posttest, product scores significantly predicted total (B = 0.68, $p < 0.001$), locomotor (B = 0.59, $p < 0.001$), and ball skill (B = 0.66, $p < 0.001$) process FMS. Product locomotor change scores significantly predicted locomotor process change scores across the intervention (B = 0.28, $p < 0.05$; See Table IV.24).

Table IV. 24. Linear regression for process and product FMS measures at pretest, posttest, and across the intervention (post-pre).

	Pretest			Posttest			Change		
	(B)	*p*	Adj R^2	(B)	*p*	Adj R^2	(B)	*p*	Adj R^2
Total	0.80	<0.001	0.62	0.68	<0.001	0.48	0.21	0.17	0.02
LM	0.74	<0.001	0.49	0.59	<0.001	0.38	0.22	0.14	0.02
BS	0.62	<0.001	0.35	0.66	<0.001	0.43	0.28	0.04	0.05

Note: LM = locomotor; BS = ball skills; Adj R^2 = adjusted R-squared

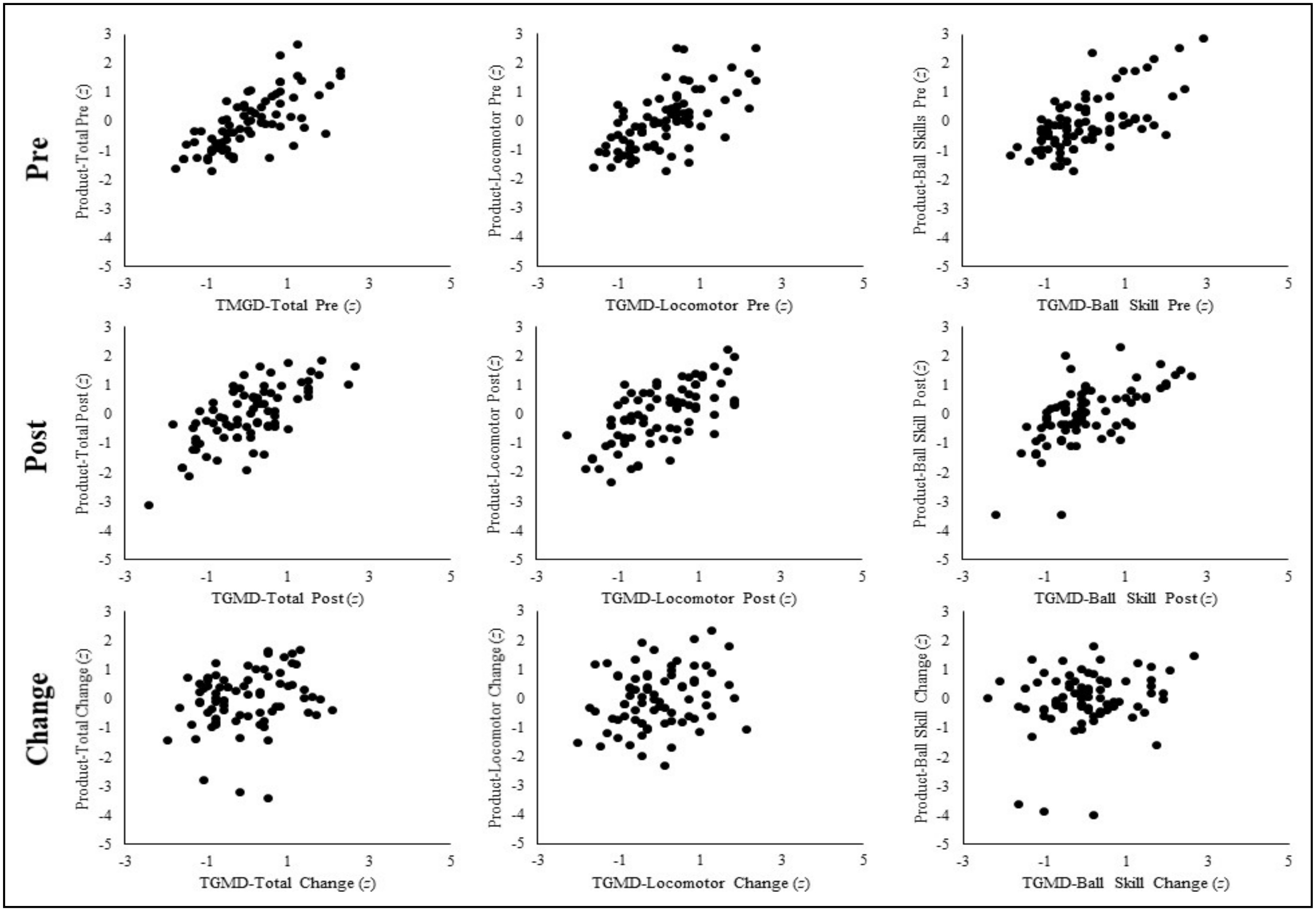


Figure IV. 3. Scatterplots for process and product FMS measures at pretest, posttest, and change scores.

Discussion

The purpose of this research question was to determine the agreement between process (i.e., TGMD) and product FMS measures before, after, and across a high-autonomy FMS intervention. Research supports that both process and product measures are valid to use in this population (Bardid, Vannozzi, Logan, Hardy, & Barnett, 2019; Cools et al., 2009; Logan et al., 2017; Roberton & Konczak, 2001) and work that examines the relationship between process and product measures shows these two assessments to be similar, yet not interchangeable (Logan et al., 2017). Results of this study align with the work of Logan et al. and found that process and product FMS measures at a single time point are similar but not identical (2017). This finding was evident in the strength of the relationships reported between process and product FMS measures at pretest and posttest. Spearman correlation and linear regression analyses found moderate to strong relationships between the measures but no value went above 0.8, meaning the two measures were highly but not very strongly related.

This study expanded on the work of Logan et al. (2017) and examined how process and product measures of FMS both evaluate changes in FMS across an intervention. Unexpectedly, there were no significant Spearman rank correlations between process and product measures for change scores meaning these children did not exhibit similar changes in FMS when measured using process versus product assessments. This finding was unexpected, particularly because children's rank on both process and product measures at the pretest and posttest were related. Similarly, when not considering child rank and just examining the relationship of the standardized scores, results also found that FMS changes on process measures did not relate to FMS changes on product measures.

There are several possible explanations for why process and product assessments did not measure FMS change similarly. First, it is possible that children develop process and product FMS elements at different time points. The process skill criteria included on the TGMD are based out of developmental sequencing, and the more mature pattern of movement should elicit the best FMS outcome (e.g., product measures); however, young children often do not have stable movement patterns. FMS development is fluid, and young children often exhibit great variability in how they accomplish the same motor task (Haywood & Getchell, 2014). The fluid developmental nature of FMS aligns with dynamic systems theory of movement which states that phase shifts, the transition to a behavior attractor, can be progressive and regressive (Kamm et al., 1990; Thelen & Smith, 1996). For example, in overhand throwing a child is working towards a behavior attractor, including a contralateral step, wind-up/follow through, and trunk rotation. Each child's progress into this behavior attractors is a unique path, and some children may willingly "sacrifice" one element of the behavior attractor for a more immediately desired outcome. If the child is motivated to throw at a certain target, they may use an ipsilateral step instead of a contralateral one, or if the child is motivated by the speed of the throw, they may use a side arm motion instead of overhead motion. In this way, it is possible that the FMS intervention in this study was helping children progress along their own individual path which may be marked by a unique pattern of changes to process and product skill elements. Adding additional assessment time points such as a retention test may help to examine learning as measured using process and product FMS. Future research on process and product FMS measures should add more time points to create a more comprehensive understanding of how process and product FMS change over time and possibly replicate this study with older children.

It is also possible that there was no relationship between children's changes in product and process FMS was due to the process and product measures used in this study. The process measure was the TGMD-3 (Ulrich, 2018). This assessment included thirteen FMS divided across two subscales: locomotor (run, gallop, hop, skip, slide, and jump) and ball FMS (overhand throw, underhand toss, catch, kick, dribble, forearm strike, and two-hand strike). Product measures included in this study were run speed, hop speed, jump distance, catching percentage, throwing speed, and kicking speed, and these six measures were grouped into locomotor (run, hop, jump) and ball FMS (catch, throw, kick) aggregate subtests. Hence, the process measures (TGMD-3) included more skills than product measures. Nonetheless, in alignment with the original purpose of this study, to examine how different FMS measures relate, the whole TGMD-3 subscales were related to product subscales. It is possible that the reason children FMS changes did not align was due to children's improvement in skills not included in both the process and product measures. Future research could compare children's changes in FMS measures that only include the same FMS.

Lastly, it is important to examine the differences between process and product measures from a developmental perspective. Children undergo rapid cognitive, language, and social development during this period. A constraints-based approach to movement shows that a child's development or change in any of these areas may impact how FMS are performed (Newell, 1986). For example, research supports that changing focus of attention impacts children's performance on the TGMD-2nd edition in as young as first graders (Palmer et al., 2017c). Additional research support that children who receive positive feedback are more motivated to learn motor skills compared with children who did not receive positive feedback (Ávila, Chiviacowsky, Wulf, & Lewthwaite, 2012). The importance of social comparison is frequently observed in instances where the child may do something "silly" during testing and then try to repeat the experience to elicit laughs from the other children in the room. For example, a child's shoe may come off during a kicking trial, which causes the other children in the testing room to laugh. The child completing the kicks may then spend the remaining kicking trials focused on kicking off their shoe instead of kicking the ball. Though the testing environment in the present research used identical verbal and visual cues at both the pretest and posttest, unaccounted for factors in the testing environment such as peer groups, administrators, time of day, or changes in other individual constraints (e.g., cognition, motivation, etc.) may may have influenced performance of process vs. product FMS measures differently.

This is one of the first studies to examine FMS before, after, and across an FMS intervention using both process and product measures. There were several strengths in this research study. First, this study used a high-autonomy FMS intervention, which is a well-established intervention approach. Using an intervention approach frequently seen in the literature expands the generalizability of the findings to other FMS interventions even though generalizability of the findings is still constrained based on the specifics of the sample (e.g., age, socioeconomic status, etc.). Secondly, for skills that were the same on both measures, verbal cues and visual demonstrations of the skill were identical during testing.

This study also has several limitations. As stated above, the process and product measures included in this study do not contain identical skills. The statistical analyses employed in this study do not allow for an understanding of equivalence between the two measures. Traditional analysis to examine agreement or equivalence between two assessments include Bland-Altman plots or equivalence testing such as the TOST methods (Bunce, 2009; Dixon et al., 2018; Giavarina, 2015). Due to the differences in metrics between the process (raw TGMD3 scores) and product (aggregate *z*-scores), it was determined more traditional analyses would not yield meaningful information. The analyses included in this paper, Spearman rank correlations and linear regression, do provide useful and meaningful information. If future work were to compare product and process assessments that included identical FMS and metrics, then equivalence testing would be an appropriate and needed next step in the literature. Lastly, this study included preschool-aged children. Children at this age demonstrate large variability in their FMS performance (Haywood & Getchell, 2014), and the relationship between product and process FMS assessments may be different in older populations.

CHAPTER V. CONCLUSIONS AND SUMMARY

This chapter provides a conclusion and summary of this dissertation research. The section begins with a summary of the background leading up to this dissertation research. The remaining section covers (a) gaps in the current literature, (b) how this dissertation addressed these gaps, (c) key findings from this research, (d) implications on the field for addressing each gap, and (e) future research in each line of inquiry. This chapter concludes with a description of the strengths and weaknesses and an overall summary of this dissertation project.

Study Need

FMS interventions are needed. Preschools and early childcare centers meet their gross motor requirements through outdoor free play sessions, but the children who only engage in the current standard practice of outdoor free play fail to learn FMS (Logan et al., 2011; Wick et al., 2017). FMS are an essential component for developmental trajectories of health (Robinson et al., 2015b; Stodden et al., 2008), and relate to other indicators of health (e.g., weight status, physical activity engagement), cognitive (language development, early academic achievement, perceived competence) and social outcomes in childhood (Cameron et al., 2016; Figueroa & An, 2017; Henrique et al., 2016; Logan et al., 2015; Utesch et al., 2019; van der Fels et al., 2015). The critical period of FMS development is during the preschool years once a child has mastered independent locomotion but before children begin to develop a specialized motor repertoire (Burton & Miller, 1998; Clark, 2005; Clark & Metcalfe, 2002). If a child fails to acquire an adequate foundation of FMS, they may not engage in more sport specific movements (Seefeldt, 1980) and lifelong physical activity (Perkins et al., 2004; Stodden et al., 2008).

The most effective FMS interventions are implemented by trained personnel/researchers who are external teams to the preschool (Wick et al., 2017). This approach to FMS programming is effective but is not sustainable and limits how many children receive such services. There is a need to develop more sustainable and cost-effective FMS interventions. The extant literature on FMS interventions also lacks research on how child-level characteristics before the start of an intervention (i.e., at pretest) may relate to and predict changes in FMS across the intervention. Gaining a better understanding of how child-level characteristics relate to (a) behaviors within and (b) changes after an FMS intervention will aid with the future design of more time and cost-effective FMS interventions. Lastly, current measures of FMS and FMS intervention efficacy use mostly process (*how* movement is performed) related measures. Product (the *outcomes* of the movement) related measures are an emerging area of interest in motor assessment. Research supports process and product FMS measures are related but not interchangeable (Logan et al., 2017). Unfortunately, little research has compared these measures before, after, and across an FMS intervention.

The purpose of this dissertation was to: (a) determine the efficacy of a child-centered, high-autonomy FMS intervention that is implemented by non-motor experts- MAP, (b) compare MAP with an established high-autonomy, expert-led FMS intervention- CHAMP, and control condition- outdoor free play (standard practice); (c) conduct an in-depth examination into which child-level characteristics and behaviors relate to changes in FMS after completing both CHAMP and MAP; and (d) compare process and product motor skill measures before, after, and across an FMS intervention.

Gap 1- Sustainable FMS Interventions

High-autonomy FMS interventions are an effective approach for teaching FMS (Bandeira et al., 2017; Palmer et al., 2017a), but currently, most high-autonomy FMS interventions are implemented by a motor development expert (e.g., researcher) who are external to the preschool. Relying on external personnel to implement interventions is an unsustainable approach and inhibits the wide-spread distribution and implementation of effective FMS interventions. Designing effective FMS interventions that can be implemented using the resources and personnel available at preschool centers is a critical next step in the FMS intervention literature. This dissertation research addressed this gap in the literature by creating and piloting a novel FMS intervention- MAP. MAP is designed to be a roadmap or guide to help children become skillful movers. MAP is designed to be implemented by non-motor experts and can be integrated into the extant standard practice currently in place in most preschool and early childcare facilities (i.e., outdoor free play).

Key Findings

Results of the present research support that in this sample of Head Start children:

1. MAP elicited greater FMS changes in TGMD-total, TGMD-locomotor, TGMD-ball FMS, product total, and product locomotor compared with a control (standard practice) condition.
2. MAP elicited greater FMS changes in product total and product locomotor compared with CHAMP.
3. CHAMP elicited greater FMS changes in TGMD-ball skills compared with both MAP

and the control.

Implications

This research is the first to examine the efficacy of a sustainable FMS intervention that is implemented by non-motor experts during the standard practice of outdoor free play, MAP. This study (1) determined the effects of MAP, (2) compared the effects of MAP with both an established FMS intervention, CHAMP, and the current standard practice, outdoor free play. Comparing MAP to both groups allows for a greater understanding of how MAP compares to current FMS environments and practices. These results are promising and demonstrate that FMS interventions, including skill demonstration and equipment but not instruction, can be added to the extant standard practice and implemented by non-expert personnel to improve FMS in young children in Head Start Centers. This data supports that non-motor experts can implement effective high-autonomy FMS interventions (MAP); therefore, MAP may be a sustainable practice to improve FMS, especially locomotor skills, in preschool. FMS are related to health behaviors such as physical activity engagement; therefore, sustainable FMS intervention and programs may help to alleviate health disparities rooted in insufficient FMS development in children.

Future Research

Based on the current findings, future research includes:

1. Revising MAP to better improve ball FMS as well as locomotor FMS. The current MAP intervention did not improve TGMD ball skills as much as CHAMP; therefore, future iterations of MAP should address this limitation and redesign the program in a way to improve ball as well as locomotor FMS.
2. Implementing MAP by preschool staff. MAP in this project was implemented by a non-

motor expert who was an external instructor in the school. Future work should examine the efficacy of MAP when implemented by classroom teachers or staff already at the preschool center.

3. Examining the effects of MAP on additional outcomes. Specifically, the only outcome examined in the current study was motor skills. Future investigations should examine how MAP influences additional health outcomes such as physical activity or perceived motor competence.
4. Examining the effects of MAP in different populations and childcare settings.

Gap 2- Child-Level Characteristics and Intervention Efficacy

In addition to examining the efficacy of a sustainable FMS intervention, it is vital for research to examine potential child-level characteristics or behaviors that may influence FMS intervention efficacy. Movement emerges as an interaction between a mover and their environment, and three types of constraints- individual, task, and environment- surround each movement and shape how FMS are performed (Newell, 1986). Some constraints can be strategically manipulated to help elicit a specific motor pattern, and FMS interventions capitalize on the constraints-based approach to movement to build environments that elicit skillful patterns of movement. All children bring their own characteristics to the intervention, but unfortunately, there is limited research that examines how child-level characteristics relate to changes in FMS across interventions. This dissertation addressed this gap in the literature by examining how several child-level characteristics at pretest (sex, anthropometrics, perceived motor competence, and initial skill level) related to changes in children's FMS across an intervention

Key Findings

Results of the current study support that in this sample of Head Start children:

1. Boys and girls demonstrated equal changes in FMS within each FMS intervention (MAP and CHAMP).
2. Boys in CHAMP did not improve as much as boys and girls in MAP for product-locomotor FMS.
3. Anthropometrics positively related to changes in FMS for children in CHAMP.
4. Children in both groups (CHAMP and MAP) with high initial FMS, especially locomotor, demonstrate lower changes in FMS across an FMS intervention.

Implications

This research was one of the first studies to examine how child-level characteristic (e.g., individual constraints) influence changes in FMS after a high-autonomy FMS intervention. These results support that the characteristics children bring with them into the intervention setting influence how much that child receives from the intervention. In particular, these results suggest that a child's initial locomotor FMS may be a good indicator of FMS changes a child will gain across an intervention so that children with higher locomotor FMS may gain less than children with lower locomotor FMS. Hence, researchers and practitioners may want to consider using initial locomotor FMS as a screening tool to help identify children who will benefit the most from completing FMS interventions. These results also suggest that the playground is an important physical setting for children, especially boys, to learn locomotor FMS. FMS interventions should supplement time on the playground and should not completely replace outdoor free play.

Future Work

Based on the current findings, future research includes:

1. Examining additional child-level characteristics that might influence FMS changes such

as motivation or enjoyment.

2. Comparing children's posttest scores among initial FMS groups (low, average, high) to determine if children with low initial FMS demonstrate enough FMS change to "catch up" to their peers.
3. Using initial locomotor FMS as a screening tool and providing a scaled FMS intervention dosage based on initial locomotor skill scores.
4. Examine how child-level characteristics at pretest relate to FMS change in different populations and childcare settings.

Gap 3- Child-Behaviors and Intervention Efficacy

Learning FMS is not a passive process but requires engagement in repeated skill practice (Magill & Anderson, 2014). Limited research examines how children engage in skill practice during FMS interventions. Physical education literature supports that skill practice is a positive predictor of learning more sport specific motor skills such as volleyball or swimming (Silverman, 1985, 1990). Conducting more in-depth analyses of how children engage in FMS interventions and how this engagement related to FMS change outcomes was needed. A universal, one-size-fits-all, approach to FMS instruction may not be the most time and cost-effective strategy and using the information on children's engagement behaviors could be used to construct best practices for FMS interventions and programming. This dissertation was one of the few studies to examine children's engagement in skill practice during high-autonomy FMS interventions and was the first to look at engagement in MAP. This dissertation went a step further and investigated how (a) child-level characteristics were associated with engagement and (b) engagement related to changes in FMS across FMS interventions.

Key Findings

Results of the current study support that in this sample of Head Start children:

1. Children in CHAMP completed more skill practice than children in MAP.
2. Perceived locomotor competence is related to engagement in skill practice, but the direction and strength of this relationship changes based on the type of FMS (locomotor vs. ball FMS) and group (CHAMP vs. total sample). Perceived motor competence did not relate to engagement in skill practice for children in MAP.
3. Children with higher FMS at the start of an FMS intervention are more engaged than children with lower FMS.
4. Controlling for group, skill practice positively predicted changes in product total FMS.

Implications

This dissertation research is one of the few studies to examine engagement in skill practice in FMS interventions. Results support that instruction aids in children's engagement (CHAMP vs. MAP) and child-level characteristics such as initial skill level related to engagement so that higher skill children being more engaged than their less skilled peers. Overall this work did not find engagement to be a strong predictor of outcomes. This finding was unexpected but important for future research. Additional measures of engagement should be used to examine quality along with the quantity of skill practice, and additional constructs of engagement (e.g., time-on-task) should be considered.

Future Research

Based on the current findings, future research includes:

1. Including different measures of engagement, such as quality of skill practice or time-on-

task.

2. Examining if children's engagement changes across an intervention (beginning, middle, and end).
3. Adding a retention task to determine if engagement relates to FMS learning and maintenance.
4. Examining children's engagement in FMS interventions in samples from different backgrounds and childcare centers.

Gap 4- FMS Measurement and Intervention Effects

Measuring FMS is a challenging endeavor (Bardid et al., 2019; Cools et al., 2009). Research teams operationalize FMS measurement differently and using different FMS measures limits the generalizability of results. In the United States, one of the most commonly used measures of FMS is the Test of Gross Motor Development (Ulrich, 2018). This is a process-oriented, criterion-based assessment where children are scored on their ability to demonstrate predetermined skill criteria during the execution of both locomotor and ball FMS. The TGMD is a valid and reliable instrument and has been extremely valuable and important in the FMS intervention literature (Logan et al., 2011; Ulrich, 2017; Wick et al., 2017).

In contrast to the TGMD and process measures of FMS, product measures examine the outcomes of skill execution such as speed, distance, or accuracy. Product measures are also an appropriate measure of FMS in young children (Cools et al., 2009; Roberton & Konczak, 2001). Since neither process nor product measures can be considered the "gold standard" of FMS measurement, it is important to know how different FMS measurements align. Previous research supports that process and product measures are not interchangeable, but rather, each type of assessment provides a distinctively unique perspective to children's FMS competency (Logan et al., 2017). This work was done with process and product FMS measures taken at a single time point. There is a gap in the literature examining the relationship between process and product measures when to quantify changes in FMS across an intervention. This dissertation addressed this gap in the literature by collecting both process and product FMS measures before and after a high-autonomy FMS intervention and examining how these measures aligned before, after, and across (e.g., change) FMS interventions.

Key Findings

Results of the current study support that in this sample:

1. Children's ranks on process and product FMS measures were moderately correlated before and after an FMS intervention.
2. There were no significant relationships between process and product FMS change (i.e., across) measures after completing a 1350 min high-autonomy FMS intervention.

Implications

This was one of the first studies to examine the relationship between process and product FMS measures before, after, and across an FMS intervention. Previous work had compared process and product FMS at a single time point, but nothing had compared how process and product measures assess changes in FMS across and intervention. Results of this study show that process and product measures to not asses FMS change similarly. These findings are important and impactful to the field of motor development. As work in this area continues to grow, researchers need to know how these FMS measures relate. This is particularly important as FMS researchers continue to collaborate on a global scale. Comparing results from studies using different FMS measures requires a better understanding of how process and product measures evaluate FMS change. The current results also show that process and product measures are not interchangeable; therefore, new FMS measures should consider incorporating both process and product elements to create a more comprehensive measure of FMS.

Future Research

Based on the current findings, future research includes:

1. Examining changes in process and product FMS at multiple time points across and intervention (pre, mid, post, and retention).
2. Comparing how process and product FMS measures assess FMS retention after the cessation of an FMS intervention.
3. Determining equivalence between process and product FMS measures.

Results and Newell's Constraint Model

This research used a constraint-based approach to movement which states that movement emerges out of the interaction of individual, task, and environmental constraints (Newell, 1986). The current findings relate back to this model. Specifically, these results support that individual constraints at the start of an intervention (e.g., initial skill level) inversely related to how much change children exhibit across and intervention and other individual constraints (e.g., anthropometrics) positively related to FMS change in this sample. Further, boys and girls in this sample exhibited equal rates of changes in two FMS interventions supporting that sex does not appear to be an individual constraint that may limit skill change in FMS preschool interventions. This finding is particularly interesting as a substantial body of literature supports that boys outperform girls in FMS at a single time point (Butterfield et al., 2012; Goodway et al., 2010); however, the finding that boys and girls exhibit equal changes in FMS across an intervention aligns with previous intervention research (Robinson et al., 2017b, Harkavy et al., 2019) in similar populations (e.g., low income children from a racially diverse urban area). These findings support that sex differences in FMS may be due to environmental constraints such as parental encouragement, social play expectations, or opportunities and not children's learning ability. More research is needed to evaluate potential environmental constraints and how that may affect FMS performances of boys and girls.

The three FMS environments examined in this dissertation showed differences in FMS change. The MAP environment saw positive effects for all measured FMS except product-ball skills but not as much change in process (TGMD) ball skills as CHAMP. CHAMP is implemented by motor experts who provide children with continuous instruction in an FMS only environment. It is unclear how the instruction or the FMS only environment may have influenced process ball skills separately, but it is shown that the CHAMP environment elicits greater gains in FMS ball skills compared with MAP or standard practice. Lastly, this work found that the FMS task used to evaluate skill performance (i.e., process vs. product) yielded different information about children's skill levels before, after, and across an intervention. This finding aligns with task constraints in Newell's model and supports that researchers and practitioners should be aware of FMS task constraints included in FMS testing protocols.

In conclusion, these results align with and expand on Newell's constraint model for FMS performance. The findings from each research question relate back to this model and enhance understanding of how constraints (individual, task, and equipment) shape skill performance and change across two interventions (MAP and CHAMP).

Strengths & Limitations

Strengths

1. The interventions (MAP and CHAMP) used in this research both use a constraints-based approach to FMS intervention are grounded in a pre-determined educational theory (i.e.,

achievement goal theory) and motor development principles.

2. MAP is a novel intervention and was implemented by a non-motor expert within the extant standard practice within the preschool centers. This type of approach to FMS intervention increases the potential for intervention sustainability and distribution.
3. This dissertation examined children's engagement during two FMS interventions to provide a new depth of knowledge of child behaviors during interventions and how these behaviors relate to intervention outcomes.
4. FMS were assessed using both process and product measures providing a more robust assessment of FMS than seen in previous research.

Limitations

1. The purpose of creating a new FMS intervention was to address current limitations of sustainability (i.e., additional requirements to the daily schedule and or relying on an external team of motor experts to implement programs). To that end, MAP altered two aspects of traditional FMS interventions (i.e., CHAMP): (1) implementation personnel and (2) environment (standard practice vs. intervention only). The design of this current study fails to allow for conclusions regarding how each of these factors individually affected FMS in MAP.
2. The MAP and CHAMP interventions were implemented three of the four school days each week, meaning children in each group received the standard practice one day each week. Standard practice has been shown in the literature to be ineffective for gaining FMS (note: current results replicate these findings); therefore, children's participation in this environment one day a week should not have influenced results.
3. Due to limitations at the preschool centers, MAP was implemented at a second early

childcare center, which may have introduced unaccounted for heterogeneity in the data. Centers were matched according to geographic location, school district, and socio-economic status.

4. Randomization into different intervention groups (CHAMP, MAP, or control) was done at the level of the classroom and not the level of the child.
5. Intervention daily dosage was different for the CHAMP (45 min/day, 3 days/week, 10 weeks) vs. control and MAP (30 min/day, 3 days/week, 15 weeks). Both CHAMP and MAP had equal dosage in terms of minutes (1350 min), but the dispersion of these minutes (10 vs. 15 weeks) may have influenced study findings. It is worth noting that CHAMP was arranged to be 30 min/day, but due to a change in school leadership (principals) before the start of the intervention, the dosage was altered to better fit with the revised school schedules. Previous research supports that intervention dosage in minutes does not affect intervention outcomes (Logan et al., 2011) but intervention dosage in length of implementation in months does effect outcomes (> or < 6 months, Wick et al., 2017). Though the weeks of the FMS intervention delivery were different, all interventions were below the 6-month threshold shown to be where intervention efficacy changes (Wick et al., 2017).
6. No retention test was included in the present research design; therefore, FMS learning was not assessed.

Dissertation Summary

This dissertation research set out to create and pilot a high-autonomy FMS intervention that can be implemented by non-motor experts within the standard practice of outdoor free play, MAP (Motor skills At Playtime). This research revealed that the current MAP intervention was effective at improving children's total and locomotor FMS equally as well as an established FMS intervention (CHAMP), but MAP was not as effective as CHAMP for improving ball FMS. Future work is needed to continue to develop sustainable intervention approaches (e.g., non-expert led) to improve both locomotor and ball FMS in young children.

This research also included an in-depth analysis of child-level characteristics or behaviors that might relate to changes in FMS after children participate in an FMS intervention. Results support that in this sample initial skill level is inversely related to changes in children's FMS so that children with higher skills at the start of an FMS intervention have smaller gains across the intervention. Perceived motor competence, sex, and anthropometrics were not consistently related to FMS changes. This research also examined child-behaviors that may be associated with FMS change (i.e., engagement in skill practice). This research found that children in this study were more engaged in the FMS intervention with greater instruction (CHAMP > MAP), but that engagement as measured as skill attempt or percentage of time in skill practice was not a significant predictor of FMS change. This in-depth examination provides a unique insight into FMS interventions, particularly high-autonomy FMS interventions. This work provides a foundation for future research in this area as well as has applications for future interventions or motor programs designed for researcher and practitioners.

Lastly, this dissertation used both process and product FMS measures to evaluate children's FMS performance before and after and FMS intervention. Including both types of FMS measures (process and product) provides a more robust understanding of how FMS interventions and preschool gross motor environments may influence FMS change. Indeed, the current results found different patterns of change for process and product FMS skills. These results suggest that outdoor free play is an important environment to improve product FMS, particularly product locomotor for boys. Further, FMS interventions with instruction (e.g., CHAMP) appear to be the only type of environment that elicits positive changes in process ball FMS. Examining agreement between process and product FMS before, after, and across a high-autonomy FMS intervention revealed that process and product FMS relate at a single time point (e.g., pretest or posttest) but fail to agree when assessing changes in FMS across interventions. This finding is essential and stresses how different FMS measures influence study results. Future work in this area should continue to expand on these findings.

APPENDICES

APPENDIX A

Manuscript 1

Using Achievement Goal Theory in Motor Skill Instruction: A Systematic Review

Using Achievement Goal Theory in Motor Skill Instruction: A Systematic Review

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Conflict of Interest

Kara K. Palmer, Katherine Chinn, and Leah E. Robinson declare that they have no conflict of interest.

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Abstract

Background: Over the past two decades, Achievement Goal Theory (AGT) has been used as a theoretical framework to design and implement motor skill programming in young children. The purpose of this systematic review was to examine the effects of AGT in motor skill interventions and programming in children ages birth to 12 years. **Methods**: This systematic literature search was conducted using three databases - GoogleScholar, PubMED, and EBSCOHOST. Studies were included if they met the following four inclusion criteria: (1) had an intervention with a motor outcome, (2) used AGT, (3) included young children (ages birth-12 years), and (4) were written in English. Studies were rated according to methodological reporting quality. **Results**: A total of 12 studies met all inclusion criteria and were included in the sample. All studies reported that AGT motor skill interventions were effective for improving motor skills in young children. Studies varied in regard to intervention group, duration, dosage, and the personnel responsible for implementing the intervention. None of the included studies met the requirements to be considered as having high methodological quality. **Conclusions**: Based on these findings, AGT is an effective theoretical approach for designing and implementing motor skill interventions for young children.

Key Points

This systematic review synthesizes the available literature on using Achievement Goal Theory to create motor skill interventions in young children. Results provide evidence that Achievement Goal Theory-interventions elicit both immediate (post intervention) and sustained improvements in motor skills. This finding adds to the growing body of work that suggests that motor skills need to be taught using developmentally appropriate pedagogy.

Key words: *Mastery Motivational Climate, Motor Skills, Early Childhood, Intervention*

1 Introduction

Fundamental motor skills are the "building blocks" for more complex movement [1]. These skills are a key component in establishing developmental trajectories of health [2, 3] and are an important focus for a holistic approach to child development [4]. The literature on motor skills consistently demonstrates that they do not naturally emerge, but the skills need to be taught using developmentally appropriate pedagogy [5]. Therefore, creating and implementing developmentally appropriate interventions to promote motor skills in young children is an important pursuit.

Children are innately motivated to learn and explore their environment [6]. Achievement Goal Theory (AGT) describes the goals and attributions that individuals adopt in learning and the subsequent effect of these goals on approaches and engagement in learning environments. The origin of AGT comes from work conducted simultaneously but separately by three researchers — Carol Dweck, John Nicholls, and Carole Ames. The culmination of this work resulted in a theory which states that individuals adopt one of two orientations in learning tasks: *mastery orientation* (also called task or undifferentiated) or *performance orientation* (also called ego or differentiated). Individuals who adopt a mastery orientation engage in tasks for the intrinsic value of learning itself and measure improvement using self-referenced standards (e.g., comparing current performance to previous performances). Conversely, individuals who adopt a performance orientation engage tasks to prove competence or avoid failure and measure learning using norm-referenced standards (e.g., comparing current performance to performance of others). Adopting a mastery approach has been linked with positive outcomes such as learning for learning sake, increased persistence, and improved perceived competence.

Work by Ames supports that learning environments can be constructed to encourage students to adopt a mastery orientation [7]. Epstein identified six classroom or learning environment structures that can be used to help children adopt a mastery orientation-- *t*ask, *a*uthority, *r*ecognition, *g*rouping, *e*valuation and *t*ime [8]. In the literature these are commonly abbreviated as TARGET. The TARGET structures are designed to shift the governance of the learning environment from teacher to the student and place the responsibility for engaging in learning tasks on the children. Mastery oriented learners are driven to learn and develop new skills, try to understand their work, improve their level of competence, and achieve a sense of mastery based on self-referenced standards

An understanding of each TARGET structure in reference to motor skill programming will provide insight on how these structures work harmoniously together to create a mastery oriented climate. The *t*ask structure involves giving students the opportunity to engage in a variety of tasks with different levels of difficulty. When given the opportunity to self-select tasks, most children chose moderately challenging tasks which helps promote learning without discouragement due to repeated failure from a task that is too difficult, or boredom from engaging in tasks that are too easy. The *a*uthority structure refers to allowing children to be actively involved in the decision making processes in the classroom. In a mastery climate the teachers' role is to be a learning facilitator not the sole authoritative figure. *R*ecognition refers to providing students with specific feedback and not general praise. Feedback should be directly linked with children's individual performances and highlight their own personal successes. The *g*rouping structure states that children should be able to self-select with whom they engage with in the classroom. Children may choose to work in pairs, small groups, or individually. *E*valuation refers to how a teacher or educator references a child's performance. For a mastery climate, evaluation should be self-referenced (e.g., compare a child to their previous performance) and should always be given in private to avoid social comparisons. This requires instructors to give feedback on specific criteria while focusing on each individual child's progress. Lastly, the *t*ime structure refers to allowing children to select how much time they will allot to a certain activity or task. These TARGET structures provide a framework for creating an effective mastery-oriented learning environment. Note that some of these structures concern the child/teacher interactions (e.g., *a*uthority, *r*ecognition, and *e*valuation) and emphasize teacher's role to facilitate learning and provide each child with individual, self-referenced feedback. Other structures involve letting the children self-govern through the learning environment (e.g., task, time, and grouping), granting them autonomy and allowing them to create an individualized learning experience. Climates that adhere to the TARGET structures are often referred to as *High-Autonomy* or *Mastery Motivational* instructional climates.

As AGT gained notoriety in educational research, sport and motor developmentalists began to apply AGT to movement learning environments. To date, there has not been a systematic review of this body of work to determine the efficacy of using AGT interventions to improve motor outcomes in young children. The purpose of the present study is to address this gap in the literature. Specifically, this study conducts a systematic search to examine the available literature on AGT grounded interventions to improve motor outcomes in young children ages 0-12 years.

2 Methods

All methodology was consistent with guidelines in the Preferred Reporting of Items for Systematics Review and Meta-Analysis (PRISMA) [9].

2.1 Eligibility Criteria

To align with the purpose of this systematic review, all included published studies had to meet the following four inclusion criteria: (1) included an intervention with a motor outcome, (2) used an intervention grounded in AGT, (3) included young children (ages birth-12 years), and (4) were written in English.

2.2 Search Strategy and Information Sources

A systematic literature search was conducted in Fall 2016 using the following databases: GoogleScholar, PubMED, and EBSCOHOST- Family Studies Abstracts, Child Development & Adolescent Studies, PsycINFO, SPORTDiscus, PsycARTICLES. Key terms searched were divided into three categories: AGT (*Achievement Goal Theory, Mastery Motivational Climate, High Autonomy, Instructional Climate*), motor skills (*Motor skills, Fundamental Motor Skills, Gross Motor Skills*) and desired sample (*Children, Early Childhood, Pediatrics*). No date restrictions were set to ensure that all possible sources were identified. The literature searches were conducted in three phases. In the first phase, all search terms were entered simultaneously. In the second phase, each possible combination of terms were entered and searched individually. Lastly, the reference list from relevant papers [10, 11] were examined to identify additional sources.

All GoogleScholar searches were conducted using the Publish or Perish® Software [12] and search results were exported directly to excel. The remaining sources identified through PubMED, EBSCOHOST, and from review papers were added to the excel file manually. The excel file was then cleaned by three individuals (KP, CP, KC). First, all books, theses, dissertations, conference abstracts, conference programs, and encyclopedia entries were removed from the file. Secondly, all duplicates and sources not written in English were removed. The titles of each remaining source were independently reviewed and scored on relevance to the three categories:

(1) included an intervention with a motor outcome, (2) used AGT, and (3) included young children age birth-12. Two reviewers each scored half of the sources (CP, KC) and a third individual reviewed all source titles (KP). To ensure all relevant sources were identified, article abstracts were fully read if they were scored as relevant in two of the three categories. Based off the review of titles, abstracts from 42 studies were read. The lead author reviewed all abstracts and full texts (KP).

2.3 Methodological Quality

Based off similar reviews [13, 14] and in accordance with the CONSORT guidelines on reporting randomized control trials [15], the methodological quality of each study was examined using a modified 10-item assessment. Nine of the ten items were identical to previous reviews [13, 14], but one item was replaced with a more relevant quality criteria. This added criteria examined reporting quality of AGT alignment and use. For each item, studies were scored as “positive”, “negative”, or “unclear”. The number of “positives” for each study were tallied, and studies were considered to have high methodological quality when they had five or more positives for a control trial or six or more for a randomized control trial [13, 14]. The methodological quality of the final included articles was assessed by a single reviewer (KP).

-- Insert Table 1 --

2.4 Data Extraction and Synthesis

The following data were extracted and synthesized from included studies: sample size, research design, motor skill measurement, AGT alignment and use, intervention characteristics (i.e. groups, purpose, dosage, and duration), and intervention efficacy.

3 Results

3.1 Literature Search

A total of 2,731 potential sources were identified through literatures searches, and three sources were identified through reference lists of review papers. After removing duplicates and non-English sources (*n* = 1,534), a total of 1,197 sources remained. Books, theses, dissertations, conference abstracts, conference programs or encyclopedia entries were removed (*n* = 589) leaving a total of 608 sources. These source titles were screened for (1) motor skill outcome, (2) AGT use, and (3) a sample of the correct age. After this screen was completed, 42 possible sources remained. After reading all 42 abstracts, 20 papers were removed from further analysis because of the following reasons: did not include a motor assessment [16-25], children were too old [16, 18, 23, 24, 26], children were not the primary participants [27], no intervention [28], not a primary scientific source [29-33], or did not apply AGT to the intervention [34-36]. To ensure that all relevant sources were identified, papers without an abstract [37, 11], unclear motor inclusion [38], or unclear alignment with AGT [39-45] were fully read. This left a total of 22 papers that were fully read. After reading these full-texts, another 10 papers were removed from further analysis due to a lack of an intervention [11], no motor outcome [38], or did not use AGT [39-46]. This resulted in twelve papers that met the criteria for this systematic review and were included in the final analysis. Figure 1 provides the PRISMA Flowchart diagram of source inclusion and Table 2 gives a full description of all included studies.

-- Insert Table 2 & Figure 1 --

3.2 Study Characteristics

Table 2 provides a description of study characteristics. The work examining AGT and motor skill interventions is fairly recent with one study published in 1995 [47], two in 2004 [48, 49], and nine between 2009 and the present [37, 50-57]. The sample size of included studies varied from 14[50] to 131 children [56]. Children were recruited from preschools [37, 51, 50, 52, 53, 55, 56, 58], kindergartens [48, 49, 54], elementary schools [55], and summer camps [47]. All but one study [55] were completed in the United States.

3.3 Study Designs

All studies used an experimental intervention design. Two studies used a within-subjects single group design [37, 50]. Three studies included an AGT group and a non-AGT comparison group that also received some type of intervention (e.g., low autonomy group or exercise play group) [47, 48, 54]. One study included an AGT and a control group (i.e., did not receive any type of intervention) [53]. One study included three AGT groups that varied by dose as well as a control group [56]. One study included an AGT, non-AGT comparison, and control group [51]. Lastly, four studies included an AGT and comparison or control group but further subdivided these groups by initial skill level [52], presence of a disability [55, 49], or participant sex [58]. For those that included a control or non-AGT comparison group, participants were assigned to groups using full randomization [51, 53, 56, 58], pseudo-randomization [49, 55], or stratified randomization strategies [47, 48].

3.4 AGT Alignment

All included studies had an explicit explanation of AGT alignment. All studies used the TARGET structures (*t*ask, *a*uthority, *r*ecognition, *g*rouping, *e*valuation, and *t*ime) [8]. Eight studies included a description of fidelity or manipulation checks to ensure that the intervention was being implemented according to the TARGET structures [37, 48, 49, 51, 52, 55, 58], three studies did not include a description of fidelity or manipulation checks [47, 53, 56], and one study was unclear if it included fidelity or manipulation checks [50].

3.5 Intervention Implementation

The personnel responsible for intervention implementation varied across studies. Eight studies used individuals who had specific training in motor skills instruction - motor development experts/specialists [48, 49, 58], researchers [37, 51, 52], trained instructors, and/or Ph.D students [37, 51, 53, 56]. In two studies, the intervention was implemented by certified physical education teachers [54, 55]. One used undergraduate students training to become early educators [50] and another was implemented by summer camp instructors [47].

Intervention duration varied with reported interventions lasting from 3-14 weeks. Total intervention dosage (e.g., combined time for warm-up, motor skills practice, and cool-down) in minutes ranged from 540-1680 min, and dosage in minutes for motor skill practice ranged from 432-1260 min. One study did not differentiate between whole-intervention minutes and motor skill practice minutes [47].

3.6 Intervention Efficacy

The Test of Gross Motor Development-2nd Edition (TGMD-2) [59] and the TGMD [60] were the most commonly used measure of motor skills in these studies. The TGMD-2 was used in nine studies [37, 51, 50, 52-56, 58] and the TGMD in two studies [48, 49]. Only one study did not use a version of the TGMD, but rather examined motor performance of a Wushu forward jump kick [47].

Two studies used a within-subject design and both found that children significantly improved their motor skills after the completion of an AGT intervention [37, 50]. In regards to studies with a control condition, children in the AGT interventions improved motor skills across time and were significantly better than their peers in control groups [49, 53, 56, 58]. These results were seen in children with a motor delay, with/without disabilities [48], and in both boys and girls [58]. Three of these studies did not find that children in the control group improved over time [49, 58, 56]. One study reported significant improvements in the control group over time; however, the rate of change was significantly higher in the AGT intervention group compared with the control group [53]. Lastly, one study examined changes in motor skills according to AGT dosage (i.e., 660 vs 720 vs 900 min) and concluded that all three dosages were equally effective at improving motor skills [56].

Studies that included a non-AGT comparison group (i.e., low autonomy or exercise play) reported mixed findings. One study did not include a pre-motor skill assessment which limits the ability to accurately draw conclusions but found that children in the AGT intervention outscored children in the non-AGT comparison group at the post-test [47]. Findings from studies that included pre- and post-intervention motor scores found that some of the non-AGT comparison groups improved [48, 52] whereas others failed to find improvement in the non-AGT comparison groups [54, 55]. One study showed that even though both the AGT and non-AGT comparison groups improved, the AGT group outperformed the non-AGT group in locomotor skills at the post-intervention assessment (Study 1 & 2) as well as object control skills (Study 2) [48]. Conversely, another study that included an AGT, non-AGT comparison, and control group found that the AGT and non-AGT improved over time and were not different from each other at the posttest but were both significantly better than the control group, which did not improve overtime [51].

Three studies included a retention test: one a 6-month retention test [48] and two a 9-week retention test [51, 58]. The study with the 6-month retention test found that children in the AGT group maintained skills across time whereas the non-AGT comparison group significantly decreased from posttest to retention [48]. Robinson and Goodway found the AGT group and non-AGT comparison were not significantly different from each other but were both significantly better than the control group at the retention test [51]. Further, contradictory to Valentini and Rudisill [48], this study reports that both the AGT group and non-AGT comparison group significantly decreased their motor performance from posttest to retention [51]. A second study by Robinson and colleagues found that there are group differences in the rate of change from post to retention motor scores between the AGT and control groups [58]. Authors report that both girls and boys in the AGT group had significantly greater negative rates of change compared with boys and girls in the control group but no difference in rates of change when compared to each other [58].

3.7 Methodological Quality

The methodological quality of included studies is reported in Table 3. None of the included studies reached the threshold to be considered of high methodological quality.

--Insert Table 3--

4 Discussion

Motor skills are an important component of developmental trajectories of health [2], but the literature supports that children do not develop these skills without appropriate instruction and reinforcement [5]. There is a need for interventions to improve motor skills in young children. Some intervention studies has used AGT as a theoretical approach for creating motor skill interventions for children. To our knowledge, there has not been a systematic review to examine the effectiveness of using AGT in motor skill interventions. The purpose of this study was to synthesize the extant literature using AGT in motor skill interventions for young children.

In total, 12 AGT FMS intervention studies were identified. All studies that tested the effects of an AGT intervention on motor skills over time showed that children significantly improved motor skills pre to post AGT intervention. Three studies report that children who completed an AGT intervention demonstrated sustained improvement in motor skills by comparing pre intervention to retained motor skill performance 9-weeks [50, 58] or 6-months [48] after the end of the intervention. However, these studies differ on whether there are declines in performance from post intervention to retention test with one study finding no decline [48] and the other two studies finding significant decline [50, 58]. The discrepancy in findings could be due to differences in the age of children (e.g., kindergarten [48] vs preschool [50, 58]), differences in the retention period (e.g., 6-months [48] vs 9-weeks [50, 58]), or differences in the intervention duration (e.g., 840 min [48] vs 540 min [50, 58]). Kindergarten is a more structured educational environment that includes a formalized physical education curriculum compared to preschools does not provide formalized movement opportunities. Normally, preschool children receive unstructured outdoor free play. As evidenced by no improvements in the control groups, kindergarten physical education curriculum may not be sufficient to teach new skills or foster skill development, but it may allow enough structured time for skill practice, thereby aiding in the retention of skills learned in the intervention. Secondly, the TGMD-2 is sensitive to changes in motor skills that naturally emerge across chronological time with older children scoring higher than younger children. The study that included the 6-month retention period used standard scores which should account for changes with age, but TGMD-2 standard scores are based off 6-month chronological periods. Therefore, depending on children's birthday and testing date they may or may not have moved up age band in standard scores and the 6-month testing may be more reflexive of development and not intervention effects. More work is needed to better understand the long-term motor learning effects of AGT interventions, especially in children of different ages.

There were also discrepancies in the reviewed studies in regards to if AGT interventions are always better than non-AGT interventions (i.e., non-AGT comparison groups). Three studies found that both the AGT and non-AGT comparison groups improved over time [48, 51, 52], whereas two studies reported that non-AGT comparison groups do not improve post-intervention [54, 55]. Further examination reveals that there were several methodological differences between the non-AGT interventions used in comparison conditions. Three studies that found improvements in the non-AGT comparison group used interventions that were similar in time, structure, and focus, (i.e., teaching motor skills) to the AGT intervention but differed methodologically and took a low-autonomy instructional approach. The two studies that failed to find improvements in the non-AGT intervention used a traditional, elementary physical education curriculum [54] and an exercise play intervention [55]. The exercise play intervention was somewhat modeled after the TARGET structures but created an environment focused on movement and exercise, not motor skill instruction. Of the four studies that included a control or no intervention condition (i.e. free-play), only one reported improvements in the control group [53]. This improvement was small, and the rate of change in motor skills was much higher in the AGT group. Collectively, we interpret these data to mean that learning motor skills requires developmentally appropriate, content specific instruction. This finding aligns with the growing body of literature that claims intervention and instruction are necessary for the acquisition and development of fundamental motor skills [5].

Careful examination of the included studies reveal similarities and differences in intervention design and implementation. In regard to similarities, all twelve studies created a mastery-oriented climate by adhering to Epstein's TARGET structures [8]. All but one study used the TGMD or TGMD-2 to determine motor skill performance. Studies differed in regard to intervention dosage, participant age, and the personnel responsible for intervention implementation. Interventions ranged from 3- to 14 weeks with total intervention minutes from 540 min (432 motor) – 1680 min (1260 motor). Interestingly, one study found that an AGT intervention was equally as effective across three different dosages (660, 720, 900 min) [56]. This work is consistent with a meta-analysis that did not find intervention dosages in minutes to be significant predictor of intervention efficacy [5]. Most interventions targeted children in preschool or kindergarten and only one study included children in elementary school. Studies included typical developing children, children with motor delays, and children with disabilities. The chronological age of participants is logical based on the developmental timeline for motor skills. These skills should be developed in childhood (i.e. 3-11 years) [1]; therefore, implementing interventions that target motor skills during this time is optimal. The one study that recruited a sample of elementary aged children (Mage 9.7±1.2yrs) examined martial art performance of a Wushu kick [47]. This study was included in the present analysis because it was examining the motor performance (i.e. forward kick) albeit from a sport specific task. The studies were also similar in regard to the personnel responsible for implementing the intervention. Most interventions were implemented by researchers/motor developmentalists, physical educators, early childhood education students, and summer camp instructors. Most of the studies (75%) used a member of the research team to implement the AGT intervention. The remaining 25%, used physical educators [54, 55], early childhood education students [50], or summer camp instructors [47] to implement the intervention. The effectiveness of non-researchers implementing FMS intervention aligns with the recent work by Brian and Goodway [44]. This work demonstrates that early childhood educators can feasibly implement interventions that significantly influences children's motor outcomes [44]. Training educators and practitioners to appropriately implement AGT interventions is an important area for future work.

This systematic review included a number of strengths. We searched through multiple databases and did not restrict sources by date to ensure we were able to find all appropriate studies. Further, all titles were reviewed by a collaborative team so that at least two reviewers examined each title to determine inclusion. We also fully read any sources without an abstract as well as sources with unclear AGT alignment or motor outcomes. This method helped ensure that all relevant studies were identified, and we did not inadvertently exclude an appropriate source. A limitation of the present review was the restriction to only selecting English sources. This systematic review was also limited by the diversity in comparison and control groups. Due to ethical obligations, all children must be afforded an opportunity to move, and therefore even children in control conditions are not a "true control" in the sense they may have the opportunity to engage in skill practice and learn skills across time.

4.1 Methodological Quality

None of the included studies had high methodological quality. As work in this field continues to develop we recommend that researchers refer to the CONSTORT statement to improve the quality of reporting [15]. Simple adjustments to the writing and analysis would ensure the reader has a clear understanding of study methodology and would greatly improve methodological reporting. In particular, though several studies included a statement regarding the randomization process, only one study explicitly stated how this randomization occurred (e.g., using a computer-generated random number sequence [58]). Future work in this area should include an explicit description of how children were randomized. Moreover, many studies were not explicit regarding dropout. Intervention research takes place over an extended period of time (e.g. 3-14 weeks) and it is unlikely that all the original sample was retained throughout this period. Authors should clearly state that all children were retained across the study if this is indeed the case, or if not all children are retained, authors should explicitly report reasons for dropout. Lastly, several studies included between group comparisons at pre assessment but these were part of a post hoc test to another analysis and not as a primary analysis on its own. Reporting group comparisons at pre-test could improve the methodological quality of motor skill intervention studies. Future work in this field should be cognizant of these limitations and work to make quality reporting a priority.

5 Conclusion

This systematic review synthesizes the available literature on using AGT to create motor skill interventions in young children. Using AGT in FMS interventions is an expanding area of research with nine of the twelve studies being published in the past seven years. Across all studies, using AGT to create a mastery-motivational climate is an effective theoretical approach to design interventions for improving motor skills in young children. This work provides evidence that AGT-interventions elicit both immediate (post intervention) and sustained improvements in motor skills. This finding adds to the growing body of work that suggests that motor skills need to be taught using developmentally appropriate pedagogy.

Future work should continue to expand our understanding of using AGT in FMS interventions for children. Particular areas for future research include: (1) examining if there is an optimal age for AGT intervention implementation, (2) training non-researchers to effectively implement AGT interventions, (3) determining the longitudinal effects (> 6 months) of AGT interventions, (4) elucidating the different effects between AGT and high-quality low autonomy interventions, and (5) using new tools and methods to measure children's goal orientation before and after the AGT FMS interventions.

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Table A.1. Methodological Quality Table. Items included in CONSORT Statement Methodological Quality check [15]

Item	Description
A	Groups comparable at baseline on key characteristics (positive if stratified baseline characteristics were presented for age, sex, **intervention with AGT inclusion**, and at least one **motor** outcome; for clustered randomized controlled trials and controlled trials, positive if this was statistically tested; and for all studies only positive when differences observed were controlled for in analyses)
B	Randomization procedure clearly described and adequately carried out
C	Valid measure of Motor Skills used OR validated measures of motor development
D	**Explicit use of Achievement Goal Theory (AGT) and intervention fidelity**
E	Dropout described not more than 20% for studies with follow-up of six months or shorter and 30% for studies with follow-up of more than six months
F	Blinding outcome assessment (positive if those responsible for assessing **motor outcome** at outcome were blinded to group allocation of individual participants)
G	Participants followed up for a minimum of six months
H	Potential confounders accounted for in analyses
I	Summary results, treatment effect and precision estimates presented

Note: Any changes in the original test are denoted in bold.

Table A. 2. Study description and characteristics.

Authors	Purpose	Participants	Group	Research design	Randomization	Motor skill assessment (result type)	TARGET structure alignment (y=yes, n=no, u=unclear)	Intervention fidelity checks (y=yes, n=no, u=unclear)	Dosage	Results
Theeboom, Knop, & Weiss, 1995	To examine the effectiveness of a performance versus mastery oriented teaching program on children's enjoyment, perceived competence, intrinsic motivation, and motor skill development.	119 children	2 Groups: Traditional (n= 38) and Mastery (*n*= 51)	Intervention	Stratified randomization by grade level.	Wushu performance of forward jump kick.	Y	N	40-minute sessions per day over 3-week (TOTAL=600 min)	At the post test, the Mastery groups scored higher than the control group (p<.05). No pre scores recorded.
Valentini & Rudisill, 2004a	To determine if a Mastery Motivational Climate is equally effective for children with and without disabilities	104 children with developmental delay	2 Groups: Intervention (Mastery) and Comparison (no intervention) 2 Subgroups: with and without disability	Pre-post intervention	Randomization but attempts were made to stratify according to age and disability.	TGMD-1; Standard Scores	Y	Y	24, 60 min sessions (45 mins of motor) over 12-weeks (TOTAL=1,440 min, MOTOR=1080).	Children in the Intervention group (with and without disability) improved skills whereas children in the control group did not.
Valentini & Rudisill. 2004b	Use Mastery Motivational Climate to increase motor skill competence in children with developmental delays	S_1: 39 children with motor delay; S_2: 67 children with motor delay	2 Groups: Low autonomy and Mastery (high autonomy)	S_1: Pre and Post Intervention S_2: Pre, Post, Retention (6 months)	Stratified randomization by gender	TGMD-1; Standard Scores	Y	Y	S_1 & S_2: 24, 35-min sessions (30 min of motor) for 12-weeks (TOTAL= 840 min; MOTOR= 720)	S_1: Both groups improved locomotor skills over time, but Mastery was better than LA at posttest. Both groups improved on object control skills and no group differences were observed. S_2: Both groups improved locomotor and object control skills across

									intervention. Mastery group maintained skills across the retention. Mastery group outscored LA group at both post intervention and retention test in locomotor skills and at the post intervention in object control skills.
Robinson & Goodway, 2009	To examine the effect of two different instructional climates (Mastery Motivational Climate and Low Autonomy Climate) on motor skills.	117 children	3 Groups: Mastery Motivational Climate (MMC, *n*=39), Low Autonomy (LA, *n*=38) and Control (*n*=40)	Randomized control trial	Random Assignment	TGMD-2: Raw Scores	Y	Y	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	Both the MMC and LA group significantly improved over time. The MMC and LA significantly lowered scores from post to retention but still scored significantly higher than the pretest.
Martin, Rudisill, & Hastie, 2009	To test the effect of Mastery Motivational Climates on motor skills when it is applied in a naturalistic setting.	64 Kindergartners	2 Groups: Mastery Motivational Climate (MMC, *n*=42) and Low Autonomy (LA, *n*=22)	Pre-post intervention. Quasi-experimental	NA	TGMD-2: Raw Scores	Y	Y	30, 30-min sessions (22-25 min of motor) across 6-weeks. (TOTAL=900 min; MOTOR= 660-750 min).	The MMC group significantly improved from pre to post but the LA group did not change.
Robinson, 2011	Follow up from control group from 2009 study	40 Children	1 Group	Pre-post intervention	NA	TGMD-2: Raw Scores	Y	Y	18, 30-min sessions (24 min of motor) across 9-weeks (TOTAL= 540 min; MOTOR= 432 min)	All children significantly improved their object control skills over time

Robinson, Webster, Logan, Lucas, & Barber 2012	To determine if early childhood educators can effectively implement a Mastery Motivational Climate to improve motor skills in young children.	14 Children	1 group. Levels of difficulty for each station (low, moderate, high) chosen by child	Pre-post intervention	NA	TGMD-2: Percentiles	Y	U	22, 30 min sessions (24 min of motor) across 11 weeks. (TOTAL= 660 min; MOTOR= 528)	Significant improvement for total TGMD-2 and locomotor percentiles but not for object control skills.
Logan, Robinson, Webster & Barber, 2013	To describe children's engagement in a high and low autonomy based climate.	25 Children Selected based on Object Control TGMD scores.	2 Groups: High Autonomy and Low Autonomy 2- Subgroups: High skilled and low skilled	Pre-post intervention	NA	TGMD-2: Percentiles	Y	Y	18, 30-min sessions (24 mins of motor) over 9-weeks (TOTAL= 540 min, MOTOR = 432 min).	In both climates, children improved object control skills and children with low skills at the pretest improved more than high-skilled children.
Robinson, Palmer & Bub, 2016	To determine the efficacy of CHAMP on improving motor skills and self-regulation in preschoolers.	113 Children	2 Groups: CHAMP and Control	Pre-post intervention	Randomized control trial- treatment vs. control	TGMD-2: Raw Scores	Y	N	40 min, 15 sessions (20-25 min of motor) across 5-weeks (TOTAL= 600 min; MOTOR = 300-375 min)	The CHAMP group significantly improved motor skills over time and had greater rates of change than the control group. The control group also improved in total score over time, but scored lower than the CHAMP groups at the post test.
Valentini, Pierosan, Rudisill & Hastie, 2016	To determine the effects of a Mastery Climate and Exercise Play intervention on motor skill development and verbal recall in children with and without disabilities.	64 with motor delays, *n*=18 w/ disabilities, *n*= 46 w/o disability	2 Groups: Exercise Play (n=32) and Mastery (n=32)	Pre-post intervention	Children with delays were randomly assigned to a group. Children with disabilities were stratified by disability and then assigned to a group.	TGMD-2 Raw scores	Y	Y	28, 1 hour sessions for 14 weeks (TOTAL= 1680)	Children in the MC improved over time and scored higher than the exercise play group at the post test.

Robinson, Palmer & Meehan, in press	To examine the effects of three different CHAMP doses on motor skills in preschoolers.	131 Preschoolers	4 Groups: Control (*n*=56) and 3 CHAMP groups: Treatment 1; 660 min (*n*=27); Treatment 2, 720 min (n=23); Treatment 3, 900 min (n=25)	Pre-post intervention	Randomization	TGMD-2: Raw Scores	Y	N	Dosages varied according to group. All groups completed 40 min sessions either two or three days a week for 12-weeks.	All three groups significantly improved over the intervention but the control group did not change. There were not differences among the three CHAMP groups at the post test.
Robinson, Veldman, Palmer & Okely, in press	To examine effects of CHAMP on boys' and girls' ball skills.	124 preschoolers.	2 Groups: Control (*n*=23), CHAMP (*n*=81) 2 Subgroups: Boys and Girls	Randomized control trial	Randomization	TGMD-2: Raw Scores	Y	Y	18, 30-min sessions (24 mins of motor) over 9-weeks (TOTAL= 540 min, MOTOR = 432 min).	Boys and girls in CHAMP had significantly greater positive rates of change compared to the control group. Both boys and girls in CHAMP had similar rates of change.

Table A.3. Review of methodological quality of included study.

Study	Baseline Characteristics Reported per group	Clear description of randomization process	Valid measure of Motor Skills	Explicit use of AGT and intervention fidelity	Dropout described and not more than 20% for studies with follow-up of six months or shorter and 30% for studies with follow-up of more than six months	Assessor Blinding	Participants followed up for a minimum of six months	Potential confounders accounted for in analysis	Summary results presented +treatment effect+precision estimates	Intention to Treat	Total
Theeboom, Knop, & Weiss, 1995	-	-	-	+	+	+	-	-	-	-	**3**
Valentini & Rudisill, 2004a	-	-	+	+	+	-	-	+	-	-	**4**
Valentini & Rudisill. 2004b (STUDY 1)	-	-	+	+	U	-	-	-	-	-	**2**
Valentini & Rudisill. 2004b (STUDY 2)	-	-	+	+	+	-	-	-	-	-	**3**
Robinson & Goodway, 2009	-	-	+	+	+	-	-	-	-	-	**3**
Martin, Rudisill, & Hastie, 2009	-	-	+	+	U	-	-	-	-	-	**2**
Robinson, 2011	NA	NA	+	+	U	-	-	-	-	-	**2**
Robinson, Webster, Logan, Lucas, & Barber 2012	NA	NA	+		U	-	-	-	-	-	**1**
Logan, Robinson, Webster & Barber, 2013	-	-	+	+	U	-	-	-	-	-	**2**

Robinson, Palmer & Bub, 2016	-	-	+		+	+	-	-	-	-	**3**
Valentini, Pierosan, Rudisill & Hastie, 2016	-	-	+	+	U	-	-	-	-	-	**2**
Robinson, Palmer & Meehan, in press	-	-	+		+	-	-	-	-	-	**2**
Robinson, Veldman, Palmer & Okely, in press	-	+	+		+	+	-		+	-	**5**
Total	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**0**	**0**	

Note: NA, not applicable; U, unclear; +, positive; -, negative

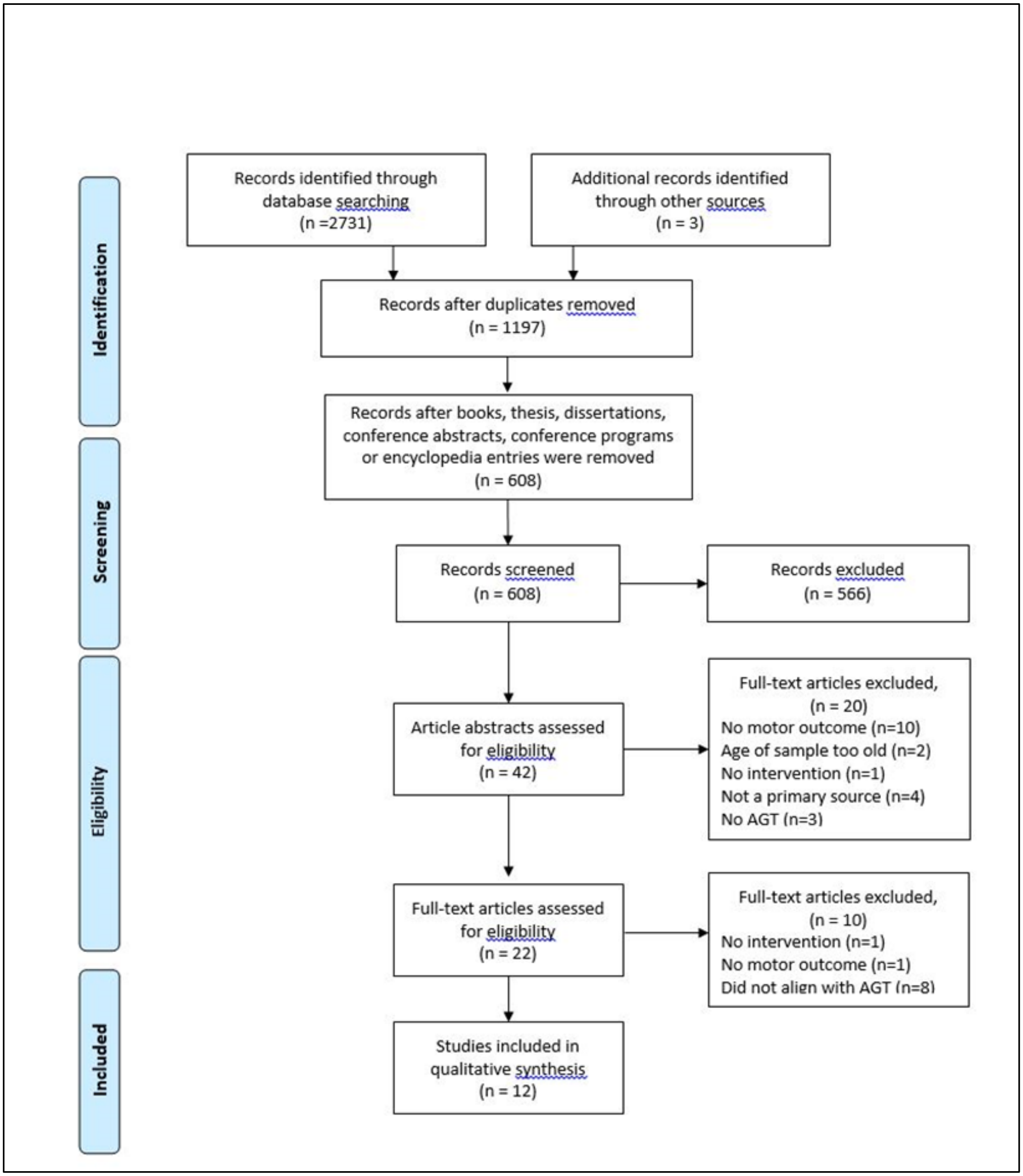

Figure A. 1. PRISMA flow diagram of study selection process.

APPENDIX B

Data Collection Forms

CHAMP Fidelity Checklist

CHAMP and TARGET Structures Fidelity Check

Session Date ________________________ **Recorder** __________________________________

Instructor __________________________ **Skills** ____________________________________

____

Place an "X" if the criteria was meet during the intervention. Make any additional notes and comments on the back.

TIMING	(min)	**INSTRUCTION**		**TARGET Structures**	
START TIME:		Provided clear instruction at each station.		**Task:** 3 motor skills activities with 3 – 4 levels of task difficulty for each motor skill activity is present, enabling students to move up and/or down task continuum/ progressions to meet their interests and developmental needs. If a learner chooses to independently modify or extend a task to meet their needs, it is appropriate.	
Introductory Activity (General Intro & Warm-up Activity; 1 – 2 mins) ***Min: 1-2***		Introduction used critical cue words.			
Skill/Activity Introduction (Introduces the skills to the children) ***Min: 3 - 8***		Instructor provided a demonstration that incorporated either themselves and/or students.		**Authority:** Participants independently choose activities and actively participate in the process of establishing rules and decision-making. Children chose where and when they engage, how long they engage, and with whom they engage.	
Motor Practice (Active motor engagement; 20 mins) ***Min: 9 - 28***		Checked for student understanding		**Recognition:** Feedback focus on progress, effort, and improvement. Feedback is based on learner progress and not in comparison to others. Intrinsic visual feedback can occur independently at each station (e.g., when throwing at a target a successful throw will result in intrinsic motivation from hitting the target).	
		Stations was completed as noted in the lesson plan. If modified, how was if modified?			
Closing Activity (Reinforces the activity; 3 – 7 mins) ***Min: 29 – 35***				**Grouping:** children have the option and freedom to work in heterogeneous small groups, with peers, or individually. Children can change their grouping structure as often as they like.	
FINISH TIME:		Provided specific, corrective and/or evaluative feedback on motor performance. (ex. You threw with your sticker foot – specific; next time step and throw with your sticker foot – corrective)		**Evaluation:** teacher provides feedback on participant's accomplishments, efforts, and performance. (i.e., similar to Recognition)	
		Used manual manipulation to aid in skill learning when needed. (ex. Physically move the sticker foot when throwing)		**Time:** active motor engagement session (i.e., 35-38 min) is self-paced. Children have the autonomy to decide how much time they spend at each station. The amount of time spent on each skill varies for each child. *Teacher can take control and bring children together for safety concerns and issues.	
		Provided a closing review that reinforced the critical elements of the skills.			

MAP Fidelity Checklist

MAP Fidelity Checklist

DATE: ____

Item	Y	N	Notes
Were all stations implemented according to the lesson plan?			
Did the skill demonstration include all critical skill elements?			
Did the children receive any skill instruction from an adult?			
Did the children engage in play with any adults?			
Did the children use the skills stations for skill practice?			
Did the children use the other items for skill practice?			
Did the children use the equipment for items other than skill practice?			
Did the children being observed notice you were observing them? Did this change their behavior?			
Were there any changes to the daily schedule?			

Engagement Record Form (min 1-5)

Engagement Recording Form

Date		School		CHAMP Card #s	
Time Start		Observer		No. Girls	
Time End		Location	Outdoor or Indoor	No. Boys	

MINUTES 1-5

Sub	Int	Task		Sed	Tran	Play	Skill	S1:			S2:			S3:			S4:			Notes
		ON	OFF					L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	L_1	L_2	L_3	
1 M/F	1	Y	M N P/O	Y		Y	Y													
	2	Y	M N P/O	Y		Y	Y													
	3	Y	M N P/O	Y		Y	Y													
	4	Y	M N P/O	Y		Y	Y													
2 M/F	1	Y	M N P/O	Y		Y	Y													
	2	Y	M N P/O	Y		Y	Y													
	3	Y	M N P/O	Y		Y	Y													
	4	Y	M N P/O	Y		Y	Y													
3 M/F	1	Y	M N P/O	Y		Y	Y													
	2	Y	M N P/O	Y		Y	Y													
	3	Y	M N P/O	Y		Y	Y													
	4	Y	M N P/O	Y		Y	Y													
4 M/F	1	Y	M N P/O	Y		Y	Y													
	2	Y	M N P/O	Y		Y	Y													
	3	Y	M N P/O	Y		Y	Y													
	4	Y	M N P/O	Y		Y	Y													
5 M/F	1	Y	M N P/O	Y		Y	Y													
	2	Y	M N P/O	Y		Y	Y													
	3	Y	M N P/O	Y		Y	Y													
	4	Y	M N P/O	Y		Y	Y													

M=motor (ex twirling)
N=noise (ex crying)
P/O=passive (spacing out)

R=run **W**=walk
S=stand **O**=other

Sed= sitting or lying down
Play= active, non skill activities
Skill= active, skill activities (include @ stations or elsewhere)

Tally of practice attempts

"X" in L_1= at station but did not complete a skill practice attempt

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