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FEASIBIITY AND EFFICACY OF A MOVEMENT-TRAINING PROGRAM ON PHYSICAL FITNESS, FUNDAMENTAL MOVEMENT SKILLS, AND PHYSICAL ACTIVITY IN THIRD AND FOURTH GRADE STUDENTS

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FEASIBIITY AND EFFICACY OF A MOVEMENT-TRAINING PROGRAM ON PHYSICAL FITNESS, FUNDAMENTAL MOVEMENT SKILLS, AND PHYSICAL ACTIVITY IN THIRD AND FOURTH GRADE STUDENTS

A Dissertation Presented

by

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ABSTRACT

FEASIBILITY AND EFFICACY OF A MOVEMENT-TRAINING PROGRAM ON PHYSICAL FITNESS, FUNDAMENTAL MOVEMENT SKILLS AND PHYSICAL ACTIVITY IN THIRD AND FOURTH GRADE STUDENTS

SEPTEMBER 2018

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Recent initiatives have focused on exploring the relationship between fitness, fundamental movement skills, psychosocial mediators, and physical activity in children to help design better interventions to improve these behaviors. FUNdamental Integrative Training (FIT) is an approach to physical education that uses age-appropriate exercises to improve physical fitness in youth, with the longer-term goal to physically prepare children for an active lifestyle beyond childhood. We evaluated the feasibility and efficacy of a 12-week, FIT program on physical fitness, fundamental movement skills, psychosocial mediators (self-efficacy, enjoyment and social support), and physical activity, among third and fourth grade students. Seven classrooms in one school were randomly assigned to the intervention (4; INT) or control (3; CON) group. The INT group received a 12-week, teacher-led FIT intervention during the first 15 minutes of their physical education class and an additional session once per week during the before school time period. The CON group continued participating in their regular physical education program.

Process evaluation data were collected throughout the 12 weeks to assess feasibility of delivering the intervention. Preliminary efficacy was measured at three time points to assess changes in fitness, fundamental movement skills, psychosocial mediators, and physical activity. Overall, the intervention was enjoyable for the participants and well-accepted by the teacher. However, there were minimal improvements seen in fitness, fundamental movements skills, and physical activity. The results from this study can be used to improve the feasibility and potential efficacy of future interventions seeking to improve fitness, movement skills, psychosocial variables, and physical activity in third and fourth grade students.

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CHAPTER I

INTRODUCTION

Current health recommendations suggest that children and adolescents accumulate at least 60 minutes of moderate-to-vigorous physical activity daily (1, 2). However, only 42% of children 6-11 years old meet this recommendation (3). This lack of sufficient daily physical activity (PA) is associated with high rates of pediatric obesity and increasing rates of metabolic disease in youth (4). Furthermore, an inactive lifestyle during childhood can lead to similar behavior in adolescence and throughout adulthood, increasing the risk for early onset of obesity-related diseases (5, 6).

Participation in the appropriate amounts of PA during childhood and adolescence is associated with numerous short- and long-term physiological and psychosocial benefits and has the potential to improve the quality of life (7-9). However, the underlying mechanisms for this lack of daily PA are very complex and require further exploration. Recently, it has been shown that many children may lack the fundamental movement skills (FMS) that give them confidence to regularly engage in PA, which could heavily contribute to their interest and/or ability to participate in physical activities (10-12). Fundamental movement skills are basic locomotor, object control, and stability skills (10, 13, 14). Locomotor skills are described as moving the body through space and consist of activities such as running, galloping, leaping, hopping, skipping, and sliding. Object control skills involve manipulating and projecting objects. These skills include catching, throwing, bouncing, striking, kicking and rolling (10, 14). In recent literature, a third subset of skills referred to as stability skills, such as body rolling, bending, and twisting has been included in FMS as another skillset of interest (13).

Cross–sectional data suggest that children who display low levels of aerobic fitness and low FMS are less active (15). In addition, muscle strength, compared with aerobic fitness, has been shown to have stronger associations with FMS in youth (16). Regular participation in fitness programming that includes strength-building exercises is associated with favorable bone-mineral density, body composition, metabolic health, FMS, and muscular strength (16-19). Because of the interconnected associations between muscular strength, FMS, PA and health outcomes, it is important to address poor muscle strength in younger populations, while their neuromuscular system is still developing.

Due to constant growth and maturation processes during childhood, intervention strategies need to be developmentally appropriate. School-based interventions, particularly in physical education (PE), are one strategy for promoting PA in children (20, 21). Elementary PE classrooms provide an ideal setting to introduce and develop important FMS such as locomotion, object control and stability. A new approach to school-based PE interventions known as FUNdamental Integrative Training (FIT) has recently been introduced into elementary PE classrooms (22-24). FIT is a method of conditioning that incorporates age-appropriate strength and conditioning exercises into a structured lesson with the goal of improving health (muscular strength/endurance, flexibility, aerobic fitness) and skill-related (balance, agility, coordination, power) components of physical fitness (22, 25, 26). FIT is designed to improve fitness, but also aims to improve many basic movement patterns that are directly related to the development of FMS. The long-term purpose of FIT is to increase PA in youth by providing them with a necessary skillset to be physically active both now and in the future. This 'skill set' includes proficiency in the areas of physical fitness and FMS.

FIT may impact long-term PA by increasing PA self-efficacy. The FIT intervention could improve self-efficacy through the positive feedback and supportive environment provided during

the intervention implementation (27). Pre-adolescent children should be exposed to numerous opportunities to learn and practice movement activities. The neuromuscular system in a child is still developing which provides an ideal window to build long-lasting movement skills and healthy behaviors (28, 29). Children who participate in a program such as FIT, which includes strength-building exercises and FMS activities, could potentially gain confidence and competence in their physical abilities to engage in games and play outside of the FIT intervention (22, 24, 29).

The intervention tested in this current study, is based on the Social Ecological Model (SEM) and Social Cognitive Theory (SCT). The SEM is a theory-based multi-level framework for understanding personal and environmental factors that influence behavior (30). The five hierarchical levels of the model include individual, interpersonal, community, organizational, and policy. The FIT intervention primarily targeted the first three levels of the SEM. The individual level, which targets characteristics of an individual that influence behavior change, the interpersonal level, which refers to the formal and informal social networks that can influence individual behaviors, and the community level, which targets relationships among institutions.

In addition to the SEM, the SCT framework was also appropriate to incorporate in the theoretical framework. The SCT suggests that behavior is developed through, and reciprocally influenced by, personal, behavioral, and environmental factors (31). By increasing the self-efficacy to perform the activities introduced by the FIT intervention, the intent is to increase self-efficacy to perform other types of PA (personal factors). Participation in FIT gives children the opportunity to learn, practice and perfect the skills that are needed to successfully perform PA in other settings (behavioral factors). By embedding the intervention into their PE class, it provides an environment that allows all students to be exposed to the intervention where they feel safe and comfortable trying new activities (environmental factors).

In the few previous studies, FIT was implemented in second and fourth-grade PE classrooms (22-24). The primary outcome of these studies was physical fitness measured by muscular strength, muscular endurance, flexibility and aerobic fitness. In each study, FIT was implemented for approximately 15 minutes at the beginning of PE. All three studies reported statistically significant improvements in some components of health- and skill-related fitness in the intervention groups when compared with the control groups (22, 24, 32). However, none of these studies included measures of FMS, usual PA or any psychosocial mediators, which are important when assessing long-term impacts of this type of intervention and the mechanisms of behavior change. Additionally, none of these studies included any program feedback from the teacher who led the intervention, or the students who participated in the intervention.

In the most recent study, the FIT intervention was implemented in one of two fourth-grade classrooms (24). The FIT intervention was delivered twice per week for 8 weeks during the first 15 minutes of PE. All participants were assessed for health- and skill-related fitness before and after the intervention. A statistically significant improvement in aerobic capacity, push-ups, sit-and-reach flexibility, and single-leg hop (muscular power) was observed in the intervention group when compared with the control group ($p < 0.05$). Importantly, no injuries were reported in the FIT intervention group, which provides some evidence that this is a safe method for delivering an appropriate dose of activity. This study, similar to previous studies, did not account for PA outside of the intervention sessions, and PA during the intervention sessions was not assessed. Additionally, no mediating psychosocial variables were assessed, such as PA self-efficacy or PA enjoyment.

Children are at an optimal age for FMS learning, which provides an opportunity to develop long-lasting movement skills and desired behaviors (28, 29). The purpose of this study was to use a mixed-methods approach to evaluate the feasibility and efficacy of the FIT

intervention in elementary school students. Feasibility was determined by gathering extensive process evaluation data and qualitative data from the intervention participants and PE teacher to 1) provide information regarding the delivery of the intervention and 2) obtain feedback from the students about their experience being involved in the intervention. The efficacy of the FIT intervention was assessed by identifying changes in physical fitness, FMS and usual PA. To better understand the potential mediating effects of selected psychosocial factors, we measured PA self-efficacy, social support, and enjoyment.

While previous FIT intervention studies have successfully increased several components of health- and skill-related physical fitness, FIT intervention effects on FMS, usual PA, or potential psychosocial variables have not been assessed. This study adds to the current literature by increasing the intervention duration (12 weeks instead of eight weeks), adding measures of FMS, and an objective measure of usual PA using an accelerometer, and assessing potential psychosocial mediators. The long-term purpose of these interventions is to provide the child with the skills and confidence to perform PA outside of the scheduled intervention time. Therefore, the additional measures of usual PA and psychosocial mediators provide an extension to the existing literature.

Research Aims & Hypotheses

Research Aim 1: Test the feasibility and acceptability of a 12-week, PE-based, fitness and FMS intervention in third and fourth grade students.

Hypothesis 1.1: *Feasibility*: We will collect valuable process evaluation measures related to the fidelity of intervention delivery, and that the intervention would be delivered by the PE teacher with high fidelity to the planned intervention.

Hypothesis 1.2: *Acceptability*: The PE teacher and intervention participants will report high acceptability following the 12-week intervention.

Research Aim 2: Evaluate the efficacy of a 12-week, PE-based, fitness and FMS intervention on physical fitness, FMS, and physical activity.

Hypothesis 2.1: Intervention participants will show greater improvements in physical fitness (muscular strength/endurance, flexibility), compared with the control group.

Hypothesis 2.2: Intervention participants will demonstrate a more favorable change in their FMS, compared with the control group.

Hypothesis 2.3: Intervention participants will demonstrate a more favorable change in physical activity, compared with the control group.

CHAPTER II

REVIEW OF LITERATURE

Overview

FMS, PA, and fitness are all key factors when describing the overall health of a child. Cross-sectional studies have demonstrated several positive associations among fitness, FMS, and PA (33). However, the causal pathways that interconnect these variables is still largely under investigation (15, 6, 17-22, 6-8, 13, 23-29, 6, 13, 30-32). In particular, muscle strength is a key factor in the development of FMS. Research findings suggest that it is important to address poor muscle strength during childhood to combat unhealthy lifelong behaviors such as decreased FMS competency and low levels of PA in adolescence and adulthood (34). Despite the reciprocal relationship between fitness and PA, many interventions have focused on the improvement of PA behaviors by increasing time spent performing moderate-to-vigorous PA (36-39). Participation in moderate-to-vigorous PA is associated with numerous physiological and psychosocial benefits and has the potential to improve an individual's quality of life (7, 8). However, current data show that more than 50% of children and adolescents do not participate in the recommended dose of 60 minutes of moderate to vigorous physical activity every day (35). Cross-sectional data show that PA is positively associated with FMS competency and physical fitness, but more longitudinal data is needed to establish the causal pathways between these variables (34, 36).

Children who are not exposed to opportunities to develop and enhance their FMSs tend to be less active, which could lead to sedentary habits later in life (37-39). Recent reports show that children are displaying below-average levels of motor competence, which has important implications for their future behaviors (40). It is suggested that children with lower levels of FMS competence may not be physically prepared for free-play, games, and sports (38, 41). Furthermore, physical fitness is an essential component of FMS performance in youth, making

the importance of promoting activities that enhance muscular fitness crucial (19). In addition to improving muscular fitness and enhancing FMS, regular participation in fitness programs that include strength-building exercises has been found to increase bone-mineral density, improve body composition, enhance metabolic health, and reduce sport-related injuries (16-18). This evidence suggests that PA programs should incorporate components to address poor muscle strength and FMS when targeting PA behaviors.

Many strategies have been explored to increase PA and other healthy behaviors in youth and are typically incorporated using community-based approaches, or into the school day using before or after-school interventions and intervening in physical education (PE) classrooms (42, 43). School-based interventions are a primary strategy for promoting and increasing PA in children because they spend a majority of their time at school, second only to the home (20, 21, 44, 45). In particular, elementary school PE classrooms provide an ideal setting to introduce and develop important fundamental movement skills such as locomotion, object control and stability (10). The immediate goal of these interventions is to increase the amount of time children are performing PA by incorporating physical activities into the intervention. Ultimately, the overarching goal is to create long-lasting behavior change by exposing the children to these opportunities.

Mechanisms of Behavior Change

Different theoretical frameworks have been used in the literature to explore mechanisms of long-term behavior change (31, 46-50). Data suggest interventions that use a theoretical framework are more likely to result in sustainable behavior change, especially when measuring PA in youth (89). Bandura's Social Cognitive Theory (SCT) suggests that behavior is developed

through personal, behavioral, and environmental factors (49). Primary resources of behavior change as described by the SCT include skill and self-efficacy to perform the behaviors. Therefore, early success at performing the behavior enhances self-efficacy to do the behavior again. The SCT is commonly used when designing PA interventions in youth and self-efficacy has been proven to have a direct effect on youth PA (34, 88, 90). The SCT offers a comprehensive framework for understanding and improving health-related behaviors. However, the SCT and many other theories that are used in health behavior change research were developed to explain adult behaviors, and later adapted to children. This can be an issue due to the various developmental, psychological, and behavioral differences that exist between children and adults. Additionally, not all of the models are specific to a particular behavior. For this reason, combining models is often a way to target the behaviors of interest in youth populations.

When targeting health-related behaviors such as PA, new approaches combining physiological and psychological mechanisms in a single model have been proposed. Specifically, the developmental relationship between the risk for obesity and motor competence, perceived motor competence, physical fitness, and physical activity was introduced by Stodden and colleagues (51). In this model, it is suggested that motor competence, perceived motor competence, physical fitness, and physical activity are associated with one another, highlighting the need for research to examine the causal pathways between them.

A recent study used a novel analysis approach to examine the mediation of changes in FMS on the effects of a PA intervention (5). This approach is novel because it combined physiological mechanisms (fitness, FMS) and behavioral outcomes (PA) in one model to better understand how changes in physiological mechanisms influence behavioral outcomes. This was the first study to explore the mediating effects of FMS in a PA intervention in children. The authors found that significant group-by-time interaction effects for PA and cardiorespiratory

fitness were mediated by FMS, suggesting that FMS development should be included as a mechanism of behavior change in interventions targeting child PA and cardiorespiratory fitness.

Interventions to Improve Fitness, FMS, and PA

Interventions designed to improve fitness and PA in children and adolescents have been implemented in a variety approaches, settings, and age groups starting as young as preschool (21, 52-56). Beyond childhood, there is an age-related decline in PA observed when children enter adolescence. For this reason, many studies have targeted the age-related decline between childhood and adolescence by focusing on adolescent girls (57, 58). However, when a child is in preschool, the types of activities that is being performed are very basic (e.g. fundamental). This is an ideal time to focus on and learn FMS (23). Contrary to previous beliefs, it has been established that FMS is not something that is naturally learned (28), but a set of skills that needs to be taught and practiced daily beginning at a very young age. Competently executing FMSs is very crucial to a child's physical development. However, many children are deficient in FMSs when they reach elementary school (28).

In addition to focusing on promoting FMS in younger populations, there is a need to address the deficiencies that occur as children get older before they reach adolescence and adulthood. We know a positive relationship exists between FMS and PA across childhood (28, 34). Many interventions designed to improve FMS have been successful (28, 53, 59, 60). However, it is still important to continue to determine the most effective characteristics of FMS interventions (i.e. minutes of instruction time, instructional approaches) to shape policy and curriculum recommendations of structured movement programs in early childhood settings (61, 62). To date, much of this work has focused on preschool children and there is a lack of research exploring the relationships between FMS and PA in older children and adolescents.

Links between Fitness, Fundamental Movement Skills, and Physical Activity

Several studies have identified positive associations between physical fitness and FMS, FMS and PA, and physical fitness and PA (60, 63, 64). However, the causal pathways among these variables are still largely unknown. To date, many PA intervention programs have focused primarily on increasing the amount of time spent in moderate to vigorous aerobic PA (number of minutes/day or week) during specific times of the day such as before, during, or after-school. The use of more comprehensive curriculums has been suggested as a way to create sustainable behavior change among youth. Researchers have begun to draw the conclusion that simply increasing levels of MVPA may not necessarily lead to meaningful learning experiences for children, particularly during PE. Activities should emphasize the incorporation of meaningful learning experiences and assist them to develop the FMS and attitudes that are necessary for lifetime physical activity (65).

Participation in PA may promote various aspects of fitness. Comprehensive approaches to increasing PA have been introduced to include a focus on physical fitness and skill-related behaviors, in addition to increasing the amount of time spent doing physical activities. One consistent factor associated with PA and fitness is FMS competency. Fundamental movement skills (FMS) are essentially the 'ABC's' of PA and play an important role in the causal pathway between physical activity and obesity (5, 10, 28, 34, 51, 66). To fully understand the relationships among fitness, FMS, and PA, additional studies are needed. To examine the relationships between fitness, FMS, and PA, we can first synthesize the literature focusing on each outcome separately.

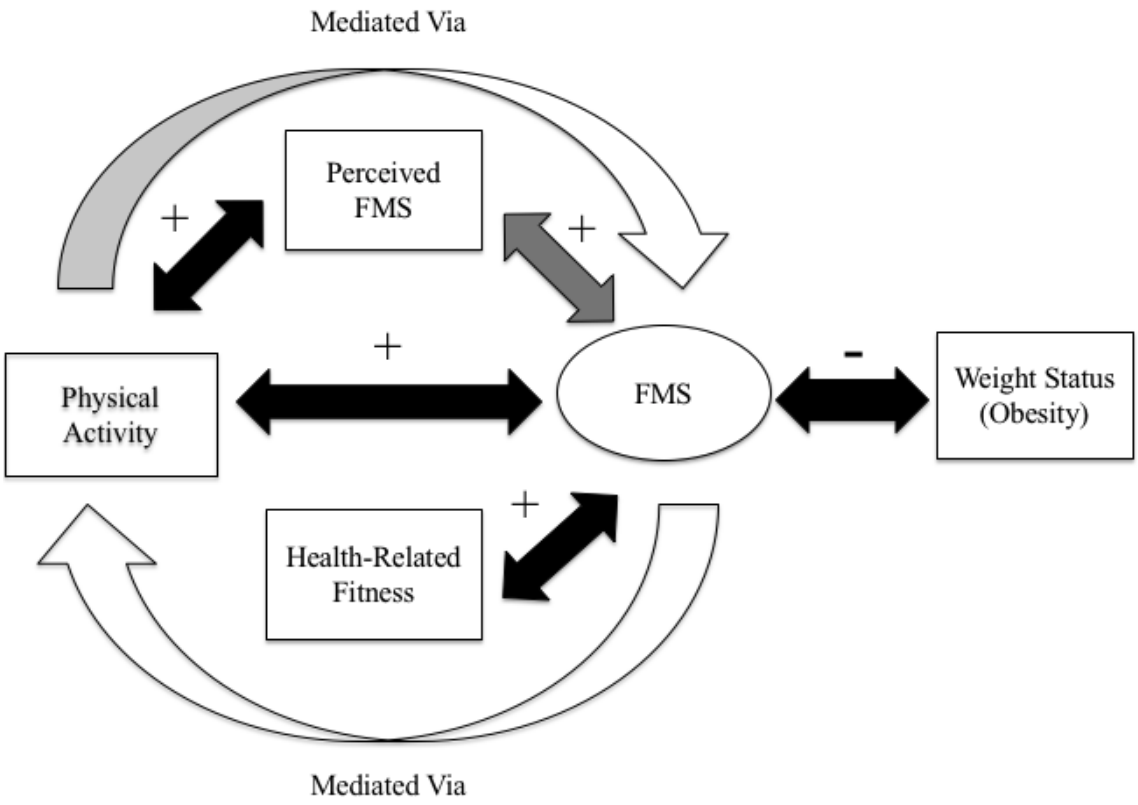


Figure 1: ***Adapted from Robinson et al. 2015*****. (63) Research consensus on FMS and health-related variables. Black arrow indicates extensively tested: consistent relationship; dark grey arrow indicates moderately tested: variable relationship; partial grey arrow indicates partially tested: some evidence; white arrow indicates limited testing. The direction of the relationship is indicated above the arrows.**

School-Based Physical Activity Interventions in Youth

Numerous school-based PA interventions have been evaluated, and evidence suggests that multicomponent interventions are more effective than curriculum-only approaches (67). However, to date, the majority of interventions targeting youth populations have been aimed at increasing minutes of MVPA, not muscular strength or FMS development.

Motor skills (also commonly referred to as FMS) acquisition is considered a key factor in the development of healthy PA behaviors (10). Many PA interventions in children are beginning to recognize the vital role of motor skill development and its effect on obesity and physical

activity (63). Despite numerous studies reporting the positive associations between these variables, limited research is available regarding the causal pathways.

Recent findings even suggest that improvements in FMS competency mediate improvements in PA and cardiorespiratory fitness in children (5). FMSs are considered the "building blocks" for movement in a range of sports and physical activities. FMSs include locomotor (e.g., running and jumping), object-control (e.g., throwing and kicking) and stability (e.g., balancing and twisting) skills (68). In a recent review, FMS competency was found to be significantly associated with PA and cardiorespiratory fitness in youth (53).

Although numerous cross-sectional and longitudinal studies have identified a positive association between FMS competency and physical activity and cardiorespiratory fitness in young people (28), the causal pathways of influence have not been established in experimental studies. For most, FMS competency does not occur naturally and is more likely to be achieved through quality instruction and active play experiences (17). There is strong evidence to suggest a positive association between FMS and PA, and FMS and cardiorespiratory fitness in children, and an inverse association between FMS and weight status in children (28). However, competency among children is considered "poor" (40, 69).

Table 2.1: School-based Interventions Reporting Increased PA, Fitness, or FMS in Elementary School Children

Author (Year)	Intervention Description	Results
Barbeau, 2007 (70)	Ten-month randomized controlled trial. The treatment consisted of an afterschool program involving 80 min for PA, with focus on skill development, sustained MVPA and toning and stretching.	Girls in the treatment group increased their objectively measured MVPA by about 30 minutes per day.
Cohen 2015 (71)	12-month PA, fitness and FMS intervention for primary schools in low-income communities. Includes teacher professional learning, student leadership workshops, PA policy review, PA equipment packs, parental engagement via newsletters, FMS homework and a parent evening, and community partnerships with local sporting organizations.	Significant group-by-time interaction effects were found for daily MVPA (about 13 MVPA min/day) cardiorespiratory fitness (5.4 laps) and overall FMS competency (4.9 units).

Eather, 2012 (72)	Four primary schools were recruited in and randomized by school into treatment or wait-list control conditions. Treatment group received 8-week Fit-4-Fun intervention program, which included a PE component, at-home component, and daily break-time activity component.	Significant treatment effects were found for CRF (adjusted mean difference, 1.14 levels), body composition (BMI mean, −0.96 kg/m2, and BMI z-score mean − 0.47), flexibility (sit and reach mean, 1.52 cm), muscular fitness (sit-ups) (mean 0.62 stages) and physical activity (mean, 3253 steps).
Kreimler, 2010 (73)	Multi-component PA program. Three structured PE lessons/week + two additional lessons/week, daily activity breaks, and PA homework.	Z-scores for MVPA in school, all day MVPA and total PA in school significantly improved in the INT compared to the CON group.
	Two-year quasi-experimental study in elementary school children. Seven schools were assigned to three conditions:	Students in both treatments got significantly more weekly in-school PA (specialist-led (40 min) and teacher-led (33 min)) PE

Sallis, 1997 (74)	health-related PE taught by PE specialists, trained classroom teachers, or control.	classes than in CON classes (18 min) measured by direct observation.
van Beurden, 2003 (75)	Four-year quasi-experimental study using a whole school approach. Included establishment of school project teams, a teacher "buddy" system, project Web site, teacher-training workshops. Eighteen schools were assigned to the INT and CON groups.	The intervention delivered substantial improvements in every FMS for both genders. The intervention was associated with a non-significant increase in MVPA and a significant increase in VPA.

Evolution of Physical Fitness and Resistance Training in Children and Adolescents

In 1986, results from the National Children's Youth and Fitness Study II described the declining levels of fitness in United States' youth (76-79). The primary finding concluded that the fitness of our youth had declined greatly since the 1960s. The current physical activity guidelines for children recommend 60 minutes of moderate to vigorous physical activity every day, with 2 or more days of muscle and bone-strengthening activities every week (4). The trends of decreased levels of fitness and PA have continued with recent data suggesting that only 42% of children are meeting recommended levels of PA. However, much less is known about the proportion of U.S. children meeting recommended participation in muscle- and bone-strengthening activities (35).

Recently, a position stand was published on youth resistance training (RT) and was endorsed by ten leading international professional organizations including the American Academy of Pediatrics and the North American Society for Pediatric Exercise Medicine (72). In summary, the authors outlined the compelling body of scientific evidence that supports participation in appropriately designed youth RT programs that are supervised and instructed by qualified professionals, and there is a low risk of injury in children and adolescents who follow age-appropriate training guidelines (72). Additionally, it was highlighted that health care providers who continually face the challenge of dealing with overweight and obese youth should not overlook the protective effects of muscular fitness on metabolic health in youth.

The developmental benefits of resistance training in youth have been a topic of interest for researchers, parents, and coaches. The most recent PA guidelines include muscle and bone-strengthening recommendations of 2-3 days per week. However, these guidelines may be too generic to effectively improve muscular strength (4, 73). Resistance training can help youth break through this barrier by increasing muscular strength and improving FMSs. Despite many efforts to promote PA through participation in sports, participation in PA should not begin with

competitive sport but should evolve out of foundational fitness conditioning that is logically progressed over time (17).

FUNdamental Integrative Training

Recently, a new approach to school-based interventions, known as FUNdamental Integrative Training (FIT) (27), has been introduced into elementary PE classrooms (22-24). FIT is a method of conditioning that incorporates age-appropriate strength and conditioning exercises into a curriculum-based lesson to increase health-related (i.e., aerobic fitness, muscular strength, flexibility, and body composition) and skill-related (i.e., agility, balance, coordination, speed, power, and reaction time) components of physical fitness (22, 25, 26).

A program such as FIT may impact spontaneous PA by increasing PA self-efficacy through positive feedback, encouragement, a supportive social environment, promotion of healthy behaviors, and enabling the child to participate in PA (27). Children who participate in a program such as FIT, which includes strength-building exercises and FMS activities, are likely to gain confidence and competence in their physical abilities to engage in games and play outside of the program itself (27). Building a large set of FMS will better prepare children to participate in lifetime activities, which will continue to enhance their overall health and fitness (10).

In previous studies, FIT was implemented for approximately 15 minutes at the beginning of physical education classes. All three FIT studies reported statistically significant improvements in different components of fitness in the intervention groups when compared with the control groups (22, 24, 32). However, no previous FIT studies accounted for free-living PA outside of the intervention sessions and fidelity to the intervention plan was not assessed. Additionally, no mediating psychosocial variables were assessed, such as PA self-efficacy or PA enjoyment, which are key constructs when assessing long-term impacts of this intervention and the

mechanisms of behavior change. No injuries were reported in the previous FIT intervention groups. FIT has been efficiently incorporated into PE curriculums and aims to improve FMS, muscle strength and confidence in performing PA in youth. The long-term purpose of FIT is to increase PA in youth by providing them with a necessary skill-set to be physically active outside the structured program. There are currently no evaluations of FIT that assess changes in free-living PA.

In the most recent study, a FIT intervention was implemented in two, 4th-grade classrooms (24). The classrooms were cluster randomized to the intervention (n=20 students) or control (n=21 students) condition. The intervention classroom received the FIT intervention twice per week for 8 weeks during the first ~15 minutes of PE. All participants were assessed for health- and skill-related fitness before and after the intervention. A statistically significant ($p<0.05$) improvement in aerobic capacity (PACER; laps; FIT: +3.5, CON: -0.6), muscular endurance (push-ups; repetitions; FIT: +4.4, CON: -0.9), sit-and-reach flexibility (cm; FIT: 2.6 CON: -0.2), and muscular power (single-leg hop; cm, FIT: +10.6, CON: -1.4) was observed in the intervention group when compared with the control group with no injuries reported. However, this study, like the others incorporating FIT, did not account for free-living PA outside of the classroom nor did it measure PA during the intervention period. Another overarching limitation to the FIT studies that have been previously implemented is that the same group of researchers in the same geographic location has conducted all previous studies.

Summary

There is an inherent need to explore and better understand the mechanisms that promote positive PA behaviors and prevent adverse health outcomes before children reach adolescence and adulthood. School-based interventions are a key strategy for promoting PA to target inactive

youth who may otherwise not receive opportunities to develop and improve fitness and FMSs due to various other factors. Within the school day, PE classrooms provide an ideal setting to introduce and develop important concepts and skills that contribute to a physically active lifestyle (27).

Past research has highlighted the need for PA interventions that are rooted in theory, use a sustainable approach, and include multiple outcome measures. These PA interventions should include multilevel, multicomponent approaches. The protective effects of fitness are a crucial component to explore when assessing PA in youth and should not be overlooked when creating strategies to improve health. Including FMS and fitness outcomes in addition to minutes of aerobic MVPA can target children in a variety of environments. Ultimately, future PA interventions should incorporate activity programs that enhance physical fitness as a basis for improving FMS and lifelong PA habits.

CHAPTER III

METHODS

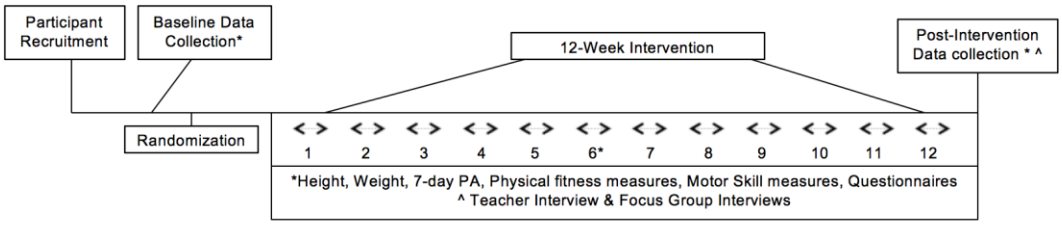
Overview

We designed a randomized controlled trial to assess the feasibility and efficacy of a movement-training program on fitness, fundamental movement skills (FMS), and physical activity (PA) in elementary-aged youth. Participants were recruited from third and fourth grade physical education (PE) classrooms at an elementary school in Western Massachusetts. Participating classrooms (n=7) were randomized (by classroom) into two groups: intervention (n=4; INT) or control (n=3; CON). All students in the INT group classrooms participated in a 12-week movement-training intervention twice per week while the CON group continued participation in regular PE. Process evaluation data were collected throughout the 12-weeks to assess each intervention and control classroom. Efficacy data were collected (from a subset of students who returned signed Parental Informed Consent) at three time points: immediately preceding the intervention, at six weeks, and immediately following the intervention (at 12 weeks; Figure 3.1). Pre-, mid-point, and post-testing measures were used to quantify changes in fitness, FMS, PA, and psychosocial variables between treatment groups.

Study Design

The study design for the 12-week clustered randomized control trial can be seen in Figure 3.1. Participants were recruited using flyers that were distributed to all seven 3rd and 4th grade classrooms from one partnering elementary school (Appendix 1). In addition to the flyer, each child was given an informed consent document to be signed by their parent/guardian if they were interested in participating in the study (Appendix 2). If a child returned a signed informed consent form, they were asked to sign an assent document (Appendix

3) and were enrolled in the study. Baseline data collection occurred during the two weeks immediately preceding the start of the intervention. During this time, data was only collected on the children who returned the proper documentation. Following baseline data collection, the classrooms were stratified by grade and classrooms were randomized to the INT or CON condition, with a *a-priori* decision to have one more INT classroom than CON. All students in the INT classrooms were exposed to the 15-minute intervention at the beginning of their regularly-scheduled PE class (offered once per week) and attended a before-school session once per week. The CON group continued participation in regular PE. All measures were taken again after 6 weeks of the intervention, and again after 12 weeks. Additionally, following the 12-week intervention, two gender-separate focus groups were held with a subsample of intervention participants and an interview was conducted with the PE teacher who led the intervention.



Process evaluation data were collected during weeks 1-12 of the intervention.

Figure 3.1: FIT Study Timeline

Recruitment

Children from the third and fourth grade classrooms (7 total) at one elementary school in Western Massachusetts were recruited to participate in this study. All third and fourth grade students were given the chance to participate in the study by returning a signed informed consent document from their parent/guardian. All students in the INT classrooms were exposed to the

intervention, but data was only collected on students who returned the proper permission from their parents/guardians (written informed consent) and provided their own assent prior to data collection.

Inclusion Criteria

To adhere to the elementary school's policy on inclusiveness, all students in the third and fourth grade were invited to participate in the FIT study. All students in the intervention classrooms were exposed to the intervention and invited to participate to the best of their abilities in assessments if an informed consent was returned.

Randomization

Following baseline data collection, classrooms were stratified by grade and randomly assigned to the INT or CON condition. We made an *a-priori* decision to randomize four classrooms (two 3rd grade, two 4th grade) to the intervention, while the remaining 3 classrooms (one 3rd grade, two 4th grade) were assigned to the CON condition. A random number generator determined which classrooms were assigned to the INT and CON groups.

Due to the nature of this protocol, blinding the researchers or participants to the treatment condition was not feasible after the groups were assigned. Although it was possible for cross-contamination to occur between the groups (classrooms), it is highly unlikely due to the specific equipment needed for this intervention, which was only accessible during the intervention sessions. The study protocol was structured to work within a PE context, making replication outside the PE setting difficult. To monitor delivery of the lessons and help ensure the PE teacher did not provide the intervention to CON classrooms, fidelity data was collected at all PE classes (both INT and CON) to ensure the correct curriculum was being delivered.

Theoretical Framework

The hypothesized mediators in the proposed study are based on Social Cognitive Theory, which suggests that behavior is developed through personal, behavioral, and environmental factors (24, 31). We hypothesized that the FIT intervention would increase PA self-efficacy and enjoyment of PA (personal factors). By participating in the 12-week intervention, the children would have the opportunity to learn, practice and perfect the FIT exercises (behavioral factors). Studies have also shown that social support is a key reinforcing factor in modifying PA behaviors (80). Social support from friends and family were measured at three data collection time points. The FIT intervention introduced a new curriculum using new equipment and incorporated stations and some partner exercises, which was intended to encourage social support from their peers (environmental factors). The theoretical model and hypothesized mediating relationships are presented in Figure 3.2.

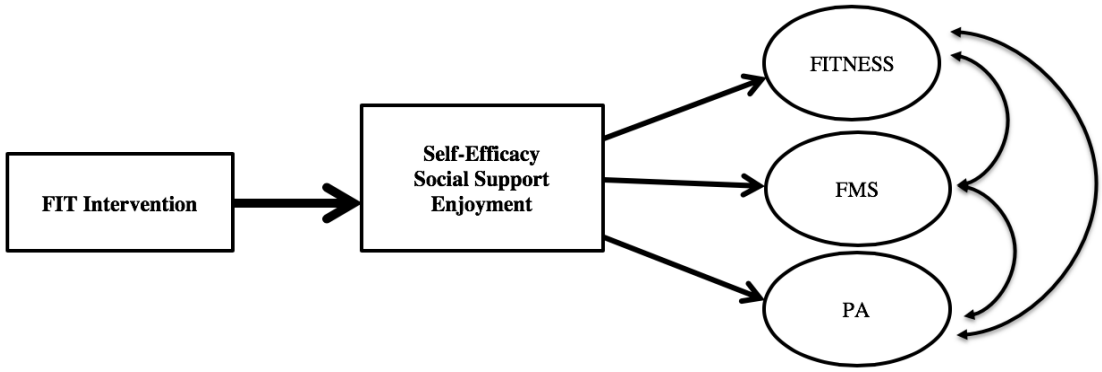


Figure 3.2: Proposed Mechanism of interaction between the FIT Intervention, Psychosocial Mediators, and Outcomes (Fitness, FMS and PA)

Intervention

Classrooms that were randomized to the INT group were scheduled to receive the intervention twice per week, during their weekly regularly-scheduled PE class (offered once per week) and once per week before school, for 12 weeks. Approximately 48 hours were between each PE class and before-school session. The intervention was primarily led by one individual, with 2 individuals assisting. During PE, the teacher was the leader with two trained research staff as assistants. During the before-school sessions, one research staff member took the lead role while two other staff members assisted with the implementation. When the children arrived, they performed a dynamic warm-up to prepare their minds and muscles for the intervention activities. This was standardized among all intervention classrooms. The gymnasium was set up with six stations, each with two exercises per station, as outlined in Table 2. Following the 15-minute intervention session, the students participated in whatever lesson the PE teacher had planned for that day.

Table 3.1. Example FIT Lesson

Station/Exercise	Weeks 1-4 Exercises	Weeks 5-8 Exercises	Weeks 8-12 Exercises
Battle Ropes	ALT FR wave	ALT FR wave	ALT FR wave
	Jumping Jacks	Burpees	Burpees
MB	Lunge	Squat	Squat
	OH Press	Push Up	Push Up
Bosu	Bosu climber	Squat	Squat
	Bosu bridge	Sit Up	Sit Up
SP	Plank	Climber	Climber

	ST surfer	ST surfer	ST Surfer
Slam Ball	Chest Push Squats	OH Slam Wall Sit	OH Slam Wall Sit
Balloons	Knee Tap CrabWalk	Create Your Own	

ALT = Alternating right and left arm; FR = fitness ropes; MB = medicine ball; OH = overhead; SP = Spooner; ST = standing;

At the partnering elementary school, PE is only offered once per week. To stay consistent with the previous research published using this type of intervention (24), a dose of twice per week was needed. Due to constraints set forth by the school, we were unable to offer regular PE more than once per week. Instead, there was a before-school session held for each of the INT classrooms once per week to fulfill the twice-weekly dose. Attendance at the before-school portion of the intervention was treated as mandatory. However, because it was not a part of the curriculum or required activities, it is possible that certain students did not attend the before-school sessions despite being in an intervention classroom. This will be considered in the final analysis and interpretation of study findings. The delivery of the before-school sessions was designed to mimic the PE session, without the additional activities following the FIT intervention circuit. The before-school sessions consisted of a warm-up and the FIT circuit starting at approximately 8:30-8:40AM, still taking ~15 minutes to complete. The start time of the before-school sessions was largely dependent on the arrival of the children via bus or parent drop-off. Following the completion of the circuit, students returned to their classrooms to begin the school day.

During the first 4 weeks of the intervention, each exercise was performed for 30 seconds. For weeks 4-8, each exercise was performed for 35 seconds, and during weeks 8-12 each exercise lasted 40 seconds. There was an approximately 30-second rest/transition period between each station, signaled by the start and stop of kid-friendly music playing over the loudspeakers in the gymnasium.

Classrooms randomized to the CON group participated in regular PE class for the duration of the intervention period including traditional PE lessons and games. These CON classrooms did not participate in any before-school programming. Study participants in the CON classrooms completed the same baseline and follow-up testing as the INT group. Following the 12-week study period, the CON group received an abbreviated form of the intervention due to the timing of the end of the school year.

Table 3.2: Weekly Intervention Schedule

Day of the Week	**Monday**	**Tuesday**	**Wednesday**	**Thursday**	**Friday**
Before-School		Classroom 4	Classroom 7	Classroom 2	Classroom 3
PE	Classroom 1 (CON)	Classroom 2 (INT)	Classroom 3 (INT)	Classroom 5 (CON)	Classroom 7 (INT)
			Classroom 4 (CON)	Classroom 6 (INT)	

Research Assistant Training

Prior to data collection, all data collectors were trained by the principal investigator to collect all outcome measures. Additionally, data collectors were trained to properly fill out the fidelity form and how to lead the intervention in the event the PE teacher was not available or needed assistance.

Teacher Training

There was one PE teacher at the intervention site. The principal investigator began meeting with the PE teacher approximately 15 months prior to the start of the intervention. The purpose of these meetings was initially to gauge whether the teacher would be interested in participating in the intervention, since the success would largely depend on the teacher's ability to lead the 15-minute circuit. It was important to establish this relationship early in the process, so the research team could gather more information about the existing PE curriculum and the teaching style the children were used to receiving. The principal investigator worked with the PE teacher to demonstrate, teach, and explain all of the exercises that would be used in the FIT circuit. This included discussing the proper cues that should be given so that the teacher felt comfortable and confident to deliver the intervention beyond the 12-week study period. Additionally, the PE teacher provided valuable feedback about various aspects of the intervention.

Feasibility and Acceptability

To ensure the intervention was delivered as planned, a trained research staff member was present to observe all intervention sessions for all seven INT and CON classrooms and completed a standardized fidelity form (Appendix 6). The fidelity form was designed to allow for an

assessment of dosage, intervention quality, participant responsiveness, and attendance (Table 3.3). The fidelity measurements included specific details on the exercises performed during each intervention session. A modified version of the FIT fidelity form that did not include the questions related to the implementation of the intervention was used in the CON classrooms (Appendix 7). The primary purpose of this form was to record the PE lesson taught in the CON classrooms, to ensure it did not overlap with the material delivered during the FIT intervention. On both forms, additional notes were collected if necessary (e.g. disruptive behavior).

Fidelity (Quality)

We needed to assess the quality of the intervention that was delivered, compared to the way the intervention was designed for implementation. To measure quality, we included questions on the fidelity form to determine who led the FIT lesson, whether the intervention leader provided encouragement/verbal feedback, and if the lesson was implemented as intended according to the criteria on the fidelity form (within 15 minutes, fun atmosphere, high intensity). These three criteria were all answered at a classroom level as a yes/no response on the fidelity form. The intervention was to be delivered within 15 minutes, in a 'fun' atmosphere, and at a high intensity for the participants. The research assistants and the PE teacher were tasked with keeping a fun atmosphere in the gym by encouraging laughter, smiling, and using positive feedback. The intensity of the intervention session was subjectively measured based on the children breathing hard, sweating, and appeared to be performing the exercises at an appropriate rate given the specified duration of time for each station. The PE teacher was expected to deliver the FIT intervention to allow for sustainability of the program after the data collection was completed. Information on the quality of the intervention delivery was important to better interpret the effect

of the intervention. The teacher and research staff were expected to provide a positive, fun atmosphere for the children and deliver positive feedback as much as possible.

Dose Delivered (Completeness)

We collected information on dosage of the intervention, which was defined as the average duration of each intervention session, the total number of sessions, and the overall dose (total number of sessions*mean duration). On the fidelity form, this was derived from recording the intervention start and stop time. Dose was further characterized for before-school sessions and PE sessions, separately. One goal of the FIT circuit is for it to be incorporated into usual classroom time by keeping it to a 15-minute duration to allow for additional PE instruction afterwards. For this reason, it was crucial to have information on whether the circuit could be completed within that 15-minute window.

Reach

To assess program reach, attendance was collected at every intervention session. Additionally, the number of intervention sessions for each classroom in the INT group was calculated. Using this attendance data, we were also able to calculate the total number of exposures for each participant over the 12-week intervention. Identifying the number of sessions attended allowed us to further explore if the number of exposures to the intervention influenced the efficacy of the intervention.

Satisfaction

To assess the engagement of the children participating in the intervention, the data collectors assessed whether the majority of the children appeared to enjoy participating in the FIT lesson with a “yes/no” response option. Although subjective, it provided a measure of whether the

intervention was eliciting the 'enjoyable' atmosphere that was intended. Additionally, we wanted to collect information on if and how many, at the group level, children were off task during the 15-minute circuit. Data collectors were instructed to record the number of children off-task during the lesson and the approximate average time (minutes) these children were off-task. This off-task behavior was collected because children could be included in attendance, but not actively participating in the intervention.

Table 3.3: Process Evaluation Metrics and Outcomes for the FIT Study

Process Evaluation Variable	Measures	Outcome Variable
Fidelity	Who was leading the FIT lesson?	% of sessions led by PE teacher
		% of sessions led by other staff
	Was the intervention implemented within the expected 15-minute duration? (Yes/No)	% of sessions that occurred within the 15-minute duration
	Did the person leading the intervention (PE teacher or research team) provide encouragement during the FIT lesson? (Yes/No)	% of sessions where positive feedback was provided
	Was the lesson implemented as intended? (Mark [X] if this aspect	% of sessions that all 3 boxes were checked (Within 15-minutes, fun atmosphere, high intensity)

	was implemented). Please include any notes about these, if applicable. 15-minutes [ ] Fun atmosphere [ ] High intensity [ ]	
Dose Delivered (Completeness)	Intervention start and stop time	Total exposure time (Total intervention time summed across all sessions)
		Average duration of the FIT circuit
		% of total planned intervention time
Reach (Participation)	How many children were present for the FIT lesson?	Average # of participants across sessions
Satisfaction	Did the majority of the children seem to enjoy the PA lesson?	% of sessions that children seemed to enjoy
	Of the children who were off task, record the average amount of time these children were off task during the 15-minute intervention.	Average time off task across sessions

Focus Groups

The lead researcher conducted focus group interviews with intervention participants following the post-intervention data collection session. Each focus group was recorded with a digital camera (no visual) and transcribed verbatim. Four students (2 boys, 2 girls) from each intervention classroom were recruited (8 boys, 8 girls). The goal of the focus groups was to learn more about the participants' attitudes towards PA and more specifically, the FIT intervention. A list of questions that was used to guide the focus groups is included in Appendix 8. Before the interview and throughout, the students were encouraged to give honest feedback, and reassured that there was not a "right" or "wrong" answer to the questions that were posed.

Teacher Acceptability

Given that this intervention was teacher-led, acceptability of the program was reviewed using information provided from the PE teacher during an interview that was conducted at the conclusion of the study. A trained research staff member conducted an interview with the PE teacher to gather information about which aspects of the study worked well, which aspects did not work, things they would do differently, and general attitudes about leading the intervention. Examples of probing questions from the interview with the PE teacher can be seen in Appendix 9.

Physical Fitness

Physical fitness was assessed with select FITNESSGRAM® assessments: curl ups, push-ups, sit and reach, and horizontal jump (81). The FITNESSGRAM® battery is widely used in PE classes to assess the fitness levels of children ages 6-17. Each fitness test was measured as a

continuous variable. The students were instructed on how to perform each assessment and given demonstrations when necessary. They were allowed to practice a few repetitions to ensure they understood the movement. Following the practice session, each student performed the selected FITNESSGRAM® assessments. If the task was performed incorrectly, the child was given verbal feedback to correct the movement. After one warning, the research assistant discontinued counting repetitions (push-up and curl-up).

The Push-Up test assessed upper body pushing muscular endurance. Participants completed as many consecutive 90° push-ups as possible at a rhythmic pace (using FITNESSGRAM® recording), and total repetitions were recorded. General reliability of FITNESSGRAM® push up assessment administered by 23 teachers on third and fifth grade students, has been reported to be acceptable (74% agreement and .40 modified kappa) (82).

The curl up test assessed abdominal muscular endurance. Participants completed as many curl ups as possible at a rhythmic pace (using FITNESSGRAM® recording), and the total repetitions were recorded. Reliability of FITNESSGRAM® curl up has been reported to be acceptable (78% agreement and 0.56 modified kappa) (82).

Lower back and hamstring flexibility for the left and right legs were evaluated by the sit-and-reach test using a sit-and-reach test box. For this test, participants removed their shoes and bent one leg so that the sole of that foot was flat on the floor with the other knee straight and foot flat against the box. The hands were extended forward on top of the measuring scale with one hand on top of the other and palms down. The student reached forward and held their fingers at the end of the reach. The best score of 3 trials for each leg were recorded to the nearest 0.5 inches, for each leg separately.

The horizontal jump assessed lower body muscular power. Participants began in a two-foot, hip-width stance, performed a partial squat counter-movement, and jumped as far forward as

possible directly besides a measuring tape that was secured to the ground. The distance was recorded based on where the heel(s) of the participant landed. If the feet were staggered upon landing, the foot closest to the starting point was used to record the measurement. Each participant jumped two times, and the furthest distance was recorded to the nearest 0.5cm.

Fundamental Movement Skills

Proficiency in FMS was measured using an abbreviated version of the Test of Gross Motor Development–2 (TGMD-2)(83). The TGMD-2 is a standardized test that measures gross motor abilities in children aged 3 through 10 years. The TGMD-2 looks at 12 gross FMS divided into two subtests: 1) *Locomotor* (run, hop, gallop, leap, horizontal jump, and slide) and 2) *Object Control* (ball skills such as striking a stationary ball, stationary dribble, catch, kick, overhand throw, and underhand roll).

Due to the time constraints imposed by the school schedule, we chose two locomotor tasks (hop, horizontal jump) and two object control tasks (overhand throw, catch) to use for our FMS assessment. The hop, jump, throw, and catch were chosen because they were the most similar to exercises that were performed during the FIT circuit. These four tasks were efficient to demonstrate and score during the limited PE class period. Prior to performing each skill, the students were oriented to the movement, and allowed one to two practices before any scoring was calculated to ensure they understood the movement. Each skill was performed twice and scored both times. The mean of the two scores for each task was calculated and each task was scored separately. The full description of each task and scoring rubric for the FMS measures can be seen in Appendix 12.

Physical Activity

Physical activity was measured using a GT3X+ ActiGraph accelerometer (AG; ActiGraph, LLC, Pensacola, FL). The AG was worn on the participant's right hip using an adjustable elastic belt. Children were instructed to wear the AG during all waking hours for seven full days, except when the device would get completely wet (e.g., showering, bathing, swimming). Participants were given verbal instructions and sent home with a sheet of instructions and a wear log (which was not used for data processing but to remind participants to wear the AG every day). Upon return, the data from the AG was downloaded and processed using R programming software (www.rstudio.com). Non-wear time was defined as at least 30-minutes of consecutive zeros from the AG data (84, 85). Data points for non-wear times were set to missing and not included in any further data processing. Based on the remaining data points, days with less than eight hours of wear time were removed (excessive non-wear time) (85). Data points from days with at least eight hours of data were included for further processing.

After applying the wear time exclusion criteria, we processed the remaining vertical axis AG data using the validated cut points developed by Evenson et al. (86) to identify total time spent in sedentary (SED), light (LPA), and moderate + vigorous PA (MVPA; moderate + vigorous) and total PA (light + moderate + vigorous). Total time spent in SED, LPA, MVPA and total PA were calculated in minutes and used to represent the PA of each participant.

Physical Activity Self-Efficacy

Self-efficacy was assessed with the Child Self-Perception of Adequacy and Predilection for Physical Activity Scale (CSAPPA). The CSAPPA is a widely used 20-item scale that measures children's self-perceptions of their adequacy in performing and their desire to participate in physical activities. The scale was designed for children age 9-16 years old. The

CSAPPA scale has 3 embedded factors: adequacy (confidence in), predilection (preference for), and enjoyment of physical education class. Each of these factors was calculated separately and then combined to produce a total score. The CSAPPA is significantly correlated with aerobic fitness, PA (energy expenditure and self-reported PA), body weight (percentage body fat and BMI), and motor proficiency (87-89). It has demonstrated high test-retest reliability (r=0.84-0.90) and strong predictive and construct validity (87, 90, 91).

Physical Activity Enjoyment

Three items included in the survey asked about enjoyment doing physical activities (92) (93, 94). Participants answered using a 4-point likert-type scale (1 = "Disagree a lot" to 4 = "Agree a lot"). The PA enjoyment questions can be seen below:

When I am physically active…

a. *I feel bored*
b. *I dislike it*
c. *It makes me upset*

Social Support for Physical Activity

To assess social support, we adapted previous surveys used to assess peer and parental social support in regard to PA (80, 95). The social support scale used for the current study included 4 items that each participant answered using a 4-point likert-type scale (1 = "Disagree a lot" to 4 = "Agree a lot"). The social support questions can be seen below:

How much do you agree with these statements?

1. *"My friends are active or play sports a lot."*
2. *"My friends and I like to play sports or do active things together."*

3. *"My parents and I do active things together."*
4. *"My parents sign me up for sports and take me to places where I can be physically active."*

Statistical Analysis

Research Aim 1: Test the feasibility and acceptability of a 12-week, PE-based fitness intervention in third and fourth grade students.

The primary aim of this study was to measure the feasibility and acceptability of delivering the FIT intervention. To assess these outcomes, we conducted descriptive analyses of our process evaluation data to explore the results related to feasibility and acceptability of the 12-week FIT intervention. Additional quantitative analyses were conducted using chi-squares to further describe comparisons between intervention and

control classrooms for selected feasibility outcome measures (off-task time).

As previously described in Table 3.3, variables collected using the FIT study fidelity form included information about fidelity, dose delivered, reach, and satisfaction. To further assess feasibility and acceptability of the intervention, we analyzed the results from focus group interviews with the participants and interview with the PE teacher who was primarily responsible for delivering the intervention. All interviews were transcribed verbatim prior to analysis. Following transcription, the interviews were coded to identify phrases and comments that informed the overall feasibility and acceptability of delivering the FIT intervention.

Research Aim 2: Evaluate the efficacy of a 12-week, PE-based fitness intervention on FMS, fitness, and PA.

Statistical analyses were completed in Stata (Stata 14.0, College Station, TX), with α levels set to $p < 0.05$. Descriptive statistics (mean ± SD or %) were computed for all measured variables. Baseline differences between INT versus CON were assessed with Kruskal Wallis rank-sum tests for continuous variables, and Fisher's exact tests for categorical variables. Mixed-models linear regression is the preferred method of analysis for a cluster RCT. However, due to the small number of clusters (less than 15) in this pilot study, this regression method was not appropriate (96). Due to the non-normally distributed data from the physical fitness, FMS, psychosocial variables, and PA, non-parametric tests (Kruskal Wallis rank-sum tests) were used to compare change scores (post-pre) between groups.

Sample Size and Power Calculations

Sample size and power calculations were performed using G*Power Version 3.1. Although sample size calculations were not necessary to assess feasibility, the power calculation for this proposal was derived from a previous study that used the FIT intervention in similarly-aged children (24). This sample size estimate was derived from previous research reporting a statistically significant improvement in muscular fitness (push-ups) in fourth graders using analysis of variance. Using a calculated effect size of 0.86, a sample of 46 participants yields ~80% power. To account for 20% attrition, we planned to recruit a minimum of 56 participants (28 INT, 28 CON) to account for loss-to-follow-up.

CHAPTER IV

MANUSCRIPTS

FEASIBILITY AND ACCEPTABILITY OF IMPLEMENTING A MOVEMENT-TRAINING PROGRAM IN THIRD AND FOURTH GRADE PHYSICAL EDUCATION CLASSROOMS

Abstract

BACKGROUND: The purpose of this study was to systematically assess the feasibility and acceptability of a teacher-led, PE-based, fitness program in third and fourth grade students using a mixed-methods approach. **METHODS:** Participating classrooms (n=7) were randomized (by classroom) into two groups: intervention (n=4; INT) or control (n=3; CON). All students in the INT group classrooms participated in a 12-week movement-training intervention. Process evaluation data (i.e. fidelity, dose, reach, and satisfaction) were collected throughout the 12-weeks in all INT and CON classrooms. **RESULTS:** Our results indicated that 46 of the 68 sessions (67%) had all three components of the intervention (15 minutes, fun atmosphere, high intensity). During our study, the intervention was delivered within 15-minutes during 59 of the 68 total intervention sessions (87%). Research staff indicated the FIT sessions were conducted in a fun atmosphere 65 out of the 68 total intervention sessions (96%). The intervention classrooms received the FIT intervention an average of 17 times out of a possible 22 planned sessions (78%). The boys and girls who participated in the FIT intervention reported that they enjoyed the 12-week intervention. When asked what was most enjoyable, both groups reported the aspects they found most enjoyable to be the equipment used at the stations (i.e. spooner board) and circuit-like style of the stations

around the gym. The teacher expressed the desire to continue delivering the intervention after the study ended. **CONCLUSIONS:** This study is the first to report on the feasibility and acceptability of delivering a FIT intervention in elementary school-aged children. Overall, the FIT framework was successfully implemented and well-accepted by the students and PE teacher. The feasibility and efficacy of the FIT intervention modality should continue to be tested in larger, more diverse populations over longer durations.

Introduction

Physical inactivity is a health concern that continues to negatively affect children globally (97). Low levels of activity are associated with numerous adverse health outcomes such as obesity and the increased risk of cardiometabolic diseases during childhood and beyond (98). School-based approaches including before- and after-school programs have been identified as an important setting to introduce, promote, and increase physical activity (PA) in children (67).

There is, however, a critical need to better understand the implementation of school-based PA interventions (99, 100). Implementation includes the different processes of program delivery such as fidelity, dose delivered, and satisfaction (101, 102). While many studies have demonstrated improvements in health-related outcomes such as PA (71-74) and fitness (70, 71, 74, 103), fewer have presented details regarding the implementation of the intervention, making replication difficult.

FUNdamental Integrative Training (FIT) (27) is a novel 15-minute circuit style intervention that uses strength-building exercises to increase proficiency in motor skills and improve fitness. One distinctive characteristic of FIT is that it was designed for incorporation into an existing physical education curriculum as a warm-up. Ideally, this would lead to long-term adoption of the program and sustainability after researchers have left the classroom. To date, three studies, all from the same research group, have reported the efficacy of the FIT intervention to improve fitness variables (22), but none have reported the feasibility and acceptability of implementing this type of intervention. Given the anticipated challenge of incorporating a program into an existing curriculum, more information surrounding the implementation of this type of intervention is important.

The purpose of this study was to systematically assess the feasibility and acceptability of a teacher-led, PE-based, fitness program in third and fourth grade students using a mixed-methods approach.

Methods

Study Design

This pilot study was a 12-week, school-based cluster randomized control trial that took place in Western Massachusetts from January to May of 2017. Participating classrooms (n=7) were randomized (by classroom) into two groups: intervention (n=4; INT) or control (n=3; CON). All students in the INT group classrooms participated in a 12-week movement-training intervention twice per week from January to May 2017, while the CON group continued participation in regular PE. Process evaluation data were collected throughout the 12-weeks in all intervention and control classrooms. This study protocol was approved by the Institutional Review Board at the University of Massachusetts, Amherst.

Participant Recruitment

Participants were recruited from third and fourth grade physical education (PE) classrooms (n=7) at one elementary school. Recruitment strategies included in-person recruitment during PE classes, as well as informational handouts that were sent home with all of the students in the participating classrooms. Prior to any data collection, informed consent documents were sent home with all children. This form was signed by the child's parent/guardian and returned to the teacher. Once returned, the child was read an assent document and signed if they wanted to be in the study. Children in INT classrooms who did not return a signed informed consent document were still exposed to the intervention but did not take part in any of the individual data collection.

Intervention Design

Classrooms that were randomized to the INT group were scheduled to receive the intervention twice per week for 12 weeks; once per week during their regularly scheduled PE class and once per week before school. The PE teacher was primarily responsible for delivering all intervention sessions during PE class. Trained research staff assisted with intervention delivery during PE class and led a majority of the before school sessions, due to additional responsibilities of the PE teacher. The maximum amount of intervention sessions possible to attend was 22 sessions (12 classroom, 10 before-school sessions) per classroom. For each FIT lesson, the gymnasium was set up with six stations, each with two exercises per station using equipment such as battle ropes, medicine balls, and slam balls. Each FIT lesson was designed to take approximately 15 minutes to complete. Following the FIT lesson, the students participated in whatever lesson the PE teacher had planned for that day.

At the partnering elementary school, PE is only offered once per week. To stay consistent with the previous research published using the FIT intervention (24), a dose of twice per week was needed. Due to constraints set forth by the school, we were unable to offer regular PE more than once per week. Instead, there was a before-school session held for each of the INT classrooms once per week to fulfill the twice-weekly dose. Attendance at the before-school portion of the intervention was treated as mandatory (Table 4.1).

Table 4.1: Weekly Intervention Schedule

Day of the Week	Monday	Tuesday	Wednesday	Thursday	Friday
Before-School		Classroom 6	Classroom 7	Classroom 2	Classroom 3
PE	Classroom 1 (CON)	Classroom 2 (INT)	Classroom 3 (INT)	Classroom 5 (CON)	Classroom 7 (INT)

			Classroom 4 (CON)	Classroom 6 (INT)	

The delivery of the before-school sessions was designed to mimic the PE session, without the additional PE activities following the FIT intervention circuit. The before-school sessions consisted of a warm-up and the FIT circuit starting at approximately 8:30-8:40AM, still taking about 15 minutes to complete. The start time of the before-school sessions was largely dependent on the arrival of the children via bus or parent drop-off. Following the completion of the circuit, students returned to their classrooms to begin the school day.

During the first 4 weeks of the intervention, each exercise was performed for 30 seconds. For weeks 4-8, each exercise was performed for 35 seconds, and during weeks 8-12 each exercise lasted 40 seconds. There was an approximately 30-second rest/transition period between each station, signaled by the start and stop of kid-friendly music playing over the loudspeakers in the gymnasium.

Classrooms randomized to the CON group participated in regular PE class for the duration of the intervention period including traditional PE lessons and games. These CON classrooms did not participate in any before-school programming. Study participants in the CON classrooms completed the same baseline, mid-point, and follow-up testing as the INT group. Following the 12-week study period, the CON group received an abbreviated form of the intervention due to the timing of the end of the school year.

Research Assistant and Teacher Training

Prior to data collection, all data collectors were trained by the principal investigator to collect all outcome measures. Additionally, data collectors were trained to properly fill out the

fidelity form and how to lead the intervention in the event the PE teacher was not available or needed assistance.

There was one PE teacher at the intervention site. The principal investigator began meeting with the PE teacher approximately 15 months prior to the start of the intervention. The purpose of these meetings was initially to gauge whether the teacher would be interested in participating in the intervention, since the success would largely depend on the teacher's ability to lead the 15-minute circuit. It was important to establish this relationship early in the process, so the research team could gather more information about the existing PE curriculum and the teaching style the children were used to receiving. The principal investigator worked with the PE teacher to demonstrate, teach, and explain all of the exercises that would be used in the FIT circuit. This included discussing the proper cues that should be given so that the teacher felt comfortable and confident to deliver the intervention beyond the 12-week study period. Additionally, the PE teacher provided valuable feedback about various aspects of the intervention.

Process Evaluation Measures

A trained research staff member was present and completed a standardized FIT fidelity form to address fidelity, dose, reach, and satisfaction at all INT and CON sessions for all seven classrooms. Process evaluation from the CON classrooms was collected using a modified version of the FIT fidelity form. To assess these process evaluation components, the FIT fidelity form included specific details on the composition of each intervention session such as start and stop time, a record of the exercises/stations performed that day, and the total time spent participating in the FIT lesson. Satisfaction was qualitatively assessed by research staff as perceived enjoyment during the FIT sessions and included whether the children were participating, smiling or

laughing, and generally seemed happy. The data collectors answered the prompt, "did the majority of the kids seem to enjoy the FIT lesson?" This was a subjective measure of overall enjoyment of the lesson that day. Off-task behavior was measured by counting the number of children who appeared to be off task during the circuit, and for how long. For each intervention session, the data collectors answered the prompt, "of the children who were off task, record the average amount of time these children were off task during the 15-minute intervention below" with the options of 1-2, 3-5, 6-10, or 11-15 (minutes). High amounts of off-task behavior would indicate a lack of engagement in the FIT circuit and, thus, less satisfaction with the program. Additional notes were collected if necessary (e.g. disruptive behavior).

Table 4.2: Process Evaluation Metrics and Outcomes for the FIT Study

Process Evaluation Variable	Measures	Outcome Variable
Fidelity	Who was leading the FIT lesson?	% of sessions led by PE teacher
		% of sessions led by other staff
	Was the intervention implemented within the expected 15-minute duration? (Yes/No)	% of sessions that occurred within the 15-minute duration
	Did the person leading the intervention (PE teacher or research team) provide encouragement during the FIT lesson? (Yes/No)	% of sessions where positive feedback was provided

	Was the lesson implemented as intended? 15-minutes [ ] Fun atmosphere [ ] High intensity [ ]	% of sessions that all 3 boxes were checked (Within 15-minutes, fun atmosphere, high intensity)
Dose Delivered (Completeness)	Intervention start and stop time	Total exposure time (Total intervention time summed across all sessions)
		Average duration of the FIT circuit
		% of total planned intervention time
Reach (Participation)	How many children were present for the FIT lesson?	Average # of participants across sessions
Satisfaction	Did the majority of the children seem to enjoy the PA lesson?	% of sessions that children seemed to enjoy
	Of the children who were off task, record the average amount of time these children were off task during the 15-minute intervention.	Average time off task across sessions

Focus Groups

Gender-separate focus group interviews were conducted with intervention participants following the intervention. For the focus groups, two boys and two girls were randomly selected from each of the four intervention classrooms using a random number generator. These students were asked to provide an additional informed consent and assent form prior to participation in the focus group. These interviews were recorded with a digital recorder and transcribed. The goal of the focus groups was to learn more about the participants' attitudes towards physical activity and more specifically, their experience with the intervention. Before the focus group and throughout, the students were encouraged to give honest feedback, and reassured that there was not a "right" or "wrong" answer to the questions that were posed. These focus groups were conducted by the lead investigator.

Teacher Interview

Teacher acceptability of the program was reviewed using information provided from the PE teacher during an interview that was conducted at the conclusion of the study. Prompts included themes regarding likes/dislikes of delivering the intervention, barriers to delivering the intervention, motivation for delivering the intervention throughout the 12 weeks, and any additional feedback the teacher wanted to provide related to the implementation of the intervention. A trained research staff member (not the PI) conducted the interview.

Statistical Analyses

To assess the feasibility of the intervention, descriptive analyses (means ± SD, percentages) were used to present the process evaluation measures collected throughout the study. Based on the feasibility and qualitative data, chi square analyses were conducted to further

explore differences between before-school and PE sessions for session intensity and off-task behavior. To further assess feasibility and acceptability of the intervention, we analyzed the results from the focus groups with the participants and the interview with PE teacher. All interviews were transcribed in Microsoft Word prior to analysis. The qualitative data were coded to detect trends and common themes in the responses and further inform the process evaluation of the 12-week study.

Results

To present the implementation results of the current FIT intervention, quantitative feasibility results (based on variables identified in Table 2) are presented first, followed by the qualitative acceptability results (focus groups, teacher interview).

Process Evaluation Measures

The intervention was generally delivered as intended. The before-school sessions were slightly less organized because the participants arrived at school at different times depending on what time they arrived at school. Rather than waiting for all the students in that classroom to arrive prior to starting, we often started the intervention session and incorporated the children as they got off the bus and into the gymnasium. During the first few weeks of the intervention, before the research team knew the children, the PE teacher assisted the research team with identifying children who were part of the intervention and reminding them to go to the gym for their before-school session. For the before-school sessions, research staff led 29 out of 31 sessions (97%). There were 2 sessions that the PE teacher was able to lead. The FIT lessons delivered during PE class were primarily led the by PE teacher. For some lessons, a trained member of the research staff led the intervention. This includes instances when the teacher was

absent. During PE, the PE teacher led 35 out of the 37 total sessions (95%), with the research staff leading the other lessons.

Another measure of fidelity was the percent of sessions that positive feedback was provided to the participants. According to the fidelity forms, verbal positive feedback was used at 100% of the sessions by the PE teacher and research staff. Some of the most commonly used phrases were “good job”, “keep it up!”, “nice work!” and “keep going!” These were all phrases that were commonly recorded as being said by the PE teacher or another research staff member during the intervention sessions.

The FIT intervention was designed to be delivered within a 15-minute time allotment, in a fun atmosphere, and at a high intensity. Data from the fidelity forms indicated that 46 of the 68 sessions (67%) had all three components (15 minutes, fun atmosphere, high intensity). During our study, the intervention was delivered within 15-minutes during 59 of the 68 total intervention sessions (87%). Research staff indicated the FIT sessions were conducted in a fun atmosphere 65 out of the 68 total intervention sessions (96%). “High intensity” was the component most reported as missing (50/68; 74%). This was a classroom-level observation, so this information was reported on the classroom as a whole (i.e. majority of the kids were not performing at a high intensity). This component was frequently reported missing during the before-school sessions (11/18, 60%), which were commonly led by research staff members. Chi square analyses revealed significant differences in intensity of the FIT lesson between the teacher-led PE sessions and researcher-led before-school sessions. The sessions delivered by the PE teacher were more frequently reported as high intensity (χ^2=3.8, p=0.05, df=3) but also reported as having more off-task time (χ^2=5.1, p=0.02, df=3). Although the observations did not include data on individuals, there were certain classrooms that had consistent issues with classroom behavior. In particular,

notes on the fidelity forms often indicated that Classroom 2 students were “disruptive” or “misbehaving” and thus, often did not participate in the intervention as intended.

The INT classrooms received the FIT intervention an average of 17 times out of a possible 22 planned sessions (78%). The number of before-school and PE sessions varied slightly between classrooms, due to holidays, snow days, and school assemblies. On average, each classroom participated in 8 before-school sessions and 9 PE sessions. The number of times each classroom received the intervention can be seen in Table 3. The average length of the 17 intervention sessions was 14 minutes. Table 4 shows the average session duration (in minutes) for each classroom (total, before-school, and PE). The total intervention delivery time ranged from 193-208 minutes; 58-63% of the planned total intervention time.

Table 4.3: Number of Before School and PE Intervention Sessions by Classroom

Classroom	Total # of INT sessions	Total # of Before School Sessions	Total # of PE Sessions
2	17	8	9
3	19	9	10
6	15	5	10
7	17	9	8
Mean ± SD	17 ± 2	8 ± 2	9 ± 1
Median	17	9	10

Table 4.4: Average Length of the Intervention Sessions by Classroom

Classroom	Average Duration of INT sessions (mins)	Average Duration of Before-School Sessions (mins)	Average Duration of PE Sessions (mins)
2	15	16	14
3	14	16	12
6	13	12	14
7	15	15	14
Mean ± SD	14 ± 3	15 ± 2	14 ± 1
Median	15	16	14

The average attendance for the intervention sessions are presented in Table 5. On average, more participants attended the PE sessions than the before-school sessions (17 students vs. 13 students).

Table 4.5: Average Attendance of the Intervention Sessions by Classroom

Classroom	Average Attendance of INT sessions	Average Attendance of Before-School Sessions	Average Attendance of PE Sessions
2	16	13	18
3	15	12	17
6	14	11	17
7	15	16	14
Mean ± SD	14 ± 3	13 ± 2	17 ± 2

It was reported that for 61 out of 68 sessions (90%), the majority of the children seemed to be enjoying the FIT lesson. An additional measure of satisfaction included the amount of off-task behavior. The results of the off-task behavior are presented in Tables 4.6 and 4.7. Table 4.6 shows a summary of the off-task times for the four intervention classrooms for the INT and PE sessions, respectively. A high amount of off-task time was reported as 1-2 minutes (16 sessions). There were 14 instances during PE was that off-task time as 11-15 minutes. Table 4.7 presents the average number children who were reported as "off-task" in reference to the frequencies presented in Table 4.6. It was typically not the entire class that was off-task, but a few students who were driving these values.

Table 4.6: Frequencies of Off-Task Times for the Before-School and PE FIT Sessions

Amount of time (minutes)	Before-School	PE
1-2	16	11
3-5	13	11
6-10	3	9
11-15	1	14

Table 4.7: Average Number of Children Reported as Off-Task Across all Intervention Sessions

Classroom	Number of Children	Average Amount of time Off-Task (minutes)
2	5	3-5
3	2-3	3-5
6	0-2	1-2
7	2-3	3-5

Control Group Fidelity

We collected fidelity measures for the three CON group classrooms during all of their regularly scheduled PE sessions (33 total). Those classrooms did a structured warm-up that consisted of walking/running/skipping laps around the gymnasium, some stretching, push-ups, and planks. Following the warm-up, the class spent the rest of the 40-minute class period doing a specific sport or game. These were the same lessons that the intervention classrooms received following the FIT circuit. Some of these exercises were similar to those delivered during the FIT sessions. However, there was no evidence of FIT intervention delivery in any of these classroom

sessions due to the specialized equipment that was used for the FIT intervention (battle ropes spooner boards, bosu balls, etc.).

Participant Focus Groups

The boys and girls who participated in the FIT intervention reported that they enjoyed the 12-week intervention. When asked what was most enjoyable, both groups reported the aspects they found most enjoyable to be the equipment used at the stations (i.e. spooner board) and circuit-like style of the stations around the gym. When probed about what aspects of the intervention they did not find enjoyable, or did not like, both groups listed specific exercises they found challenging, rather than broader concepts regarding the actual design of the intervention or the research staff.

One boy specifically mentioned that he enjoyed the FIT intervention because "all of [the stations] were different and very diverse and that it introduced people to new kinds of exercises." Most of the focus group responses are very similar to this one, with the boys discussing that they liked the FIT stations for its variety and novelty. One girl stated, "What I liked most about it was the fun...you and the others tried to make it fun even though it was hard and tiring but—and challenging—but it was also really fun." Most of the responses about enjoyment of the FIT lessons were similar to this example quotation.

Teacher Interview

Generally, the PE teacher reported enjoyment delivering the FIT intervention. The teacher expressed the desire to continue delivering the intervention after the study ended. When asked about the before-school portion of the intervention, the teacher said that it was challenging because the students arrived at different times. Towards the beginning of the study, research staff

did not know and recognize the children, so the teacher was crucial in helping establish the routine of going to the gym before school.

During the interview, we asked the teacher what he liked about delivering the intervention. Generally, he responded that he enjoyed delivering the FIT intervention largely due to the equipment that was used. The equipment included medicine balls, spooner boards, battle ropes, and bosu balls. He said,

> *"A lot of these things are at the high school weight room and so when they get there it's not so much of a thing of just kind of looking at it and initially being intimidated by seeing all of these new things but it's like you've had this early exposure to it and now you can be one of the peers who kind of steps up and can help other people learn how to use it that's within your same age group."*

When asked the prompt, "What didn't you like about delivering the intervention?" he expressed that the things he didn't like were mostly related to classroom management, rather than the intervention itself. At the beginning of the intervention, the kids were not familiar with the equipment, leading to overstimulation. This resulted in the teacher and the research staff taking on more of a supervisory role to manage the classroom rather than motivating and correcting specific exercises the kids were performing. However, this particular teacher had a very good relationship with the students. As the intervention continued, the students displayed less off-task behavior, overall. Other instances that a high amount of off-task behavior was observed included days of school assemblies, field trips, or other atypical scheduled events that caused an alteration in the typical school day.

Discussion

The purpose of this pilot study was to test the feasibility and acceptability of delivering a 12-week FIT intervention in third and fourth grade PE classrooms. Overall, we concluded that this study was feasible to implement over 12-weeks in these third and fourth grade classrooms. Additionally, the FIT curriculum was well accepted by the students who participated, and by the teacher who delivered the intervention. This adds to the current literature surrounding FIT, which currently lacks process evaluation metrics and other qualitative measures regarding this unique type of intervention. Previous FIT studies (22) have not reported process evaluation data, so we do not have other information regarding the implementation of this specific intervention in the PE classroom. This is currently a gap in the FIT literature, particularly because all of the previous FIT interventions were delivered by the same research group.

Previous studies have reported success with teacher-led interventions during PE (71, 73, 104). It is common for PE to be one setting among many that is targeted for a PA intervention. In one multi-component study with 1st and 5th graders in Switzerland, the PE component consisted of 30-minute lessons that were divided into 15-minute sub-components, similar to the FIT framework (104). In contrast with the current study, the Switzerland intervention included daily PE classes (3 led by regular classroom teacher, 2 led by PE research experts). The lessons were designed to improve PA, fundamental movement skills, and to be enjoyable for children. In this study, the authors found that the interventions were most effective when the sessions were led by a "PE specialist" (103). In relation to our study, this would be similar to the PE teacher versus the research staff. However, in the previous study, the PE specialist was a member of the research staff, not the regular teacher, although the PE teachers (15 Swiss elementary schools) were present during the sessions. The Switzerland-based intervention was successful and led to improvements in fitness and physical activity. It is possible that the success of the intervention

was partially due to a combination of researchers and teachers leading the intervention. In the current study, we did have a mix of teachers and researchers, however our research staff were not "experts." Our staff were trained to deliver the FIT intervention specifically, not all physical education curricula.

In another recent study, a 12-month multicomponent physical activity and fundamental movement skill intervention, similar to the FIT study, elicited improvements in moderate to vigorous physical activity (MVPA), FMS, and cardiorespiratory fitness in elementary school students (mean age=8.5 years old) (71). This previous intervention was comprised of multiple phases, with Phase 1 primarily focusing on training the teacher and student leadership development. In the current study, we provided training for the PE teacher delivering the intervention but did not include the students in any of the intervention delivery components. Incorporating the students in the delivery of this previous intervention may have allowed for a more successful intervention delivery because the teachers and students were more invested. Although the previous study did not report extensive process evaluation outcomes, it is possible that engaging the teachers and students early in the intervention led to better classroom behavior (i.e. reduced off-task time) for the students.

In the current study, we had a combination of research staff and the PE teacher leading the intervention sessions. Our results indicate that the sessions led by staff were at a lower intensity than the sessions led by the PE teacher. However, this is confounded by the fact that most of the staff-led sessions occurred first thing in the morning and children may not have been ready for a high intensity exercise session. Off-task behavior was reported more frequently during teacher-led sessions with 14 instances when behavior was characterized as off-task for 11-15 minutes. When interviewing the PE teacher, he did report that certain students/classrooms had poor behavior prior to the intervention, and that instead of disrupting class to correct them, he

often just let them continue misbehaving unless it was affecting other students. There were often certain students who were consistently off-task that may not have attended the before-school sessions. Many times, the majority of the class was participating, but a handful of students were disruptive. Disruptive behaviors included improperly touching equipment, talking to peers, and doing the exercises incorrectly. Since we do not have individual level data on the intensity and off-task behavior, we are only able to report classroom-level summaries.

Qualitative data obtained from the interview and focus groups allowed us to also view the intervention implementation from the teacher and student perspective. The students liked trying new exercises and new equipment, but the teacher found the most difficult aspect of implementing the intervention to be managing the classroom when new exercises and equipment were introduced. The teacher expressed that as the intervention continued, the students got more comfortable and it was easier to implement. Learning and performing the circuits at the beginning of each class took longer than we would have liked due to the limited dose we were able to deliver. In an effort to decrease time to learn new stations, we included pictures of someone correctly performing the exercises at each station so that if the child forgot how to do a certain exercise, they could look at the picture and be reminded of what they were supposed to be doing at that station. Ideally, the FIT intervention would be delivered multiple times a week during PE. The slower adaptation to the circuit is another example of why it would be beneficial to have PE multiple times per week, among many other reasons. It is a challenge to implement PE more regularly in elementary school curricula. To improve the speed of adaptation, modifications to the FIT program could be implemented less frequently, allowing particular station to stay in the circuit for longer. For example, the same exercises could be performed for 6 weeks instead of 4 weeks. However, this could potentially cause the children to become bored with the stations and lead to more off-task behavior.

Study Limitations

There are several limitations to this study. The intervention lasted for 12 weeks; therefore, the overall dose of the intervention was limited. Additionally, the dose was limited by missed sessions due to unavoidable barriers (e.g. snow days and in-school assemblies). However, this is still 4 weeks longer than the previous FIT intervention studies (22, 24). Ideally, our intervention would be implemented at a much higher dose, with multiple days per week during physical education. Since the school that participated in the intervention only offers PE class once per week, we were forced to add a before-school component to attain the 2x/week dose that is consistent with the FIT intervention literature. Another limitation is that both focus groups were moderated by the lead investigator of the study. Ideally, the focus groups would have been led by a trained research staff who was not heavily involved with the intervention. Our plan was to have a trained staff member act as a moderator, but we had to reschedule the focus groups at the last minute due to scheduling conflicts at the school, and the research assistants were not able to accommodate the change. Lastly, the before-school sessions were led mostly by research staff and not the PE teacher, which was not the intended teacher-led method of delivery. Despite the research staff being trained to deliver this intervention, we still believe a PE teacher/specialist with training in classroom management practices is a crucial part of this intervention and should, at the very least, be present when delivering the intervention.

Implementation Recommendations

Future studies that examine the feasibility and efficacy of the FIT intervention should consider a few issues prior to implementation. First, individual-level fidelity data on the intervention participants during the intervention periods would be recommended. Although this

may not necessarily be feasible for every session, a plan could be established to capture individuals a certain number of times during the intervention period (i.e. once every 4 weeks). In the current study, many of our measures are classroom-level estimates, which does not effectively show the variability in many of the fidelity measures, such as satisfaction (i.e. off-task behavior). A more involved level of participant observation would require many more research staff, as well as a strategic plan to ensure each intervention participant is observed throughout the study duration. This plan could be feasible if additional personnel were available to the PE teacher. If possible, the same PE teacher (or another school coach, etc.) would lead the intervention since the children are already familiar with the expectations for those individuals and they will typically be better able to better manage the classroom. For the teacher to lead all the intervention sessions, a plan would need to be established ahead of time with the teacher and the administration to perhaps scale-back outside responsibilities for that teacher during the intervention period. Furthermore, it would be recommended that a more rigorous assessment of the existing PE curriculum be conducted prior to intervention implementation, as it would provide valuable information on whether any components of the intervention are already being delivered by the PE teacher.

Study Strengths

There were several strengths to our study. This study is the first to assess and report the feasibility and acceptability of delivering a FIT intervention. Furthermore, fidelity measures were collected at every intervention session and at every PE lesson for the CON group, providing a robust and complete picture of the implementation of the intervention. We were fortunate that the teacher leading the intervention had an impeccably positive relationship with the students, which was a strength of our study, but may not be the case at other schools. The feasibility results

provide valuable information for future studies regarding implementation strategies for future FIT interventions.

Conclusions

In conclusion, this study is the first to report on the feasibility and acceptability of delivering a FIT intervention in elementary school-aged children. Our results suggest that, overall, the FIT framework was successfully implemented and well-accepted by the students and PE teacher. There are considerations that should be addressed in order to improve the success of this intervention moving forward. More attention should be focused on delivering this intervention in the setting it was designed to be implemented (PE). Lastly, the feasibility and efficacy of the FIT intervention modality should continue to be tested in more diverse populations over longer durations.

EFFECTS OF A TEACHER-LED MOVEMENT-TRAINING PROGRAM ON PHYSICAL FITNESS, MOTOR SKILLS AND PHYSICAL ACTIVITY IN THIRD AND FOURTH GRADE STUDENTS

Abstract

BACKGROUND: FUNdamental Integrative Training (FIT) is a circuit-style strength training approach designed to be implemented in conjunction with a physical education program. The short-term goal of FIT is to improve physical fitness in youth and the longer-term goal of this program is to physically prepare children for an active lifestyle beyond childhood. Currently, no studies have assessed the effects of FIT on fundamental movement skills, psychosocial mediators, or physical activity. The purpose of the current study was to evaluate the effects of a 12-week, FIT program on physical fitness, fundamental movement skills, physical activity, and psychosocial mediators among children in third and fourth grade classrooms. **METHODS:** A total of seven classrooms in one school were randomly assigned to the intervention (INT, n=4) or control (CON, n=3) group. The INT classrooms received a 12-week, teacher-led FIT intervention. The CON group continued participation in regular physical education. At baseline, mid-point, and immediately post intervention, physical fitness (curl-up, push-up, sit & reach), motor skills (hop, jump, throw, catch), objectively measured weekly physical activity and sedentary time, and psychosocial factors (self-efficacy, enjoyment, social support) were measured for all participants. Kruskal-Wallis rank-sum tests were used to compare pre-post changes between the INT and CON groups for all variables. **RESULTS:** Sedentary time decreased for the INT group (-19 minutes) and increased slightly for the CON group (p=0.04). No significant differences were observed between groups for any of the physical fitness, motor skill, or physical activity variables. **CONCLUSIONS:** The current study adds valuable insight into the efficacy of delivering a short,

high intensity FIT intervention dose into an existing PE curriculum. Future studies should continue to explore the relationships between physical activity, fitness, and motor skills in children to identify causal pathways and intervene appropriately. Due to the limited amount of studies using the FIT intervention, more research is needed to determine if the FIT intervention could be a reproducible and efficacious model to improve fitness, FMS, psychosocial variables, and PA.

Introduction

Low levels of physical activity (PA) are a major health concern in the United States with only 42% of children ages 6-11 meeting current recommendations (60 minutes of moderate to vigorous PA, daily). Low PA during childhood has been linked to both short- and long-term health concerns (63). To address this concern, interventions have focused on increasing the amount of time children spend performing moderate to vigorous physical activities.

A number of mechanisms for behavior change have been explored (6), but there is still not a consensus regarding the framework for sustainable behavior change, particularly in youth. Certain psychosocial mediators have been established as key components in the behavior change process, such as self-efficacy, enjoyment, and social support. Recently, an increasing number of studies have identified physiological variables as mediators for behavior change in regard to PA (5-7, 59). Specifically, fundamental movement skills (FMS) have been introduced as a potential mediating variable that should be incorporated into PA intervention frameworks (34, 51, 60, 61, 66). Fundamental movement skills are defined as the building blocks for developmentally advancing movement patterns (68, 105). They are commonly divided into the categories of locomotor skills (e.g. jumping, hopping) and object control skills (e.g. throwing, catching) (68).

Currently, few youth intervention studies have targeted FMS as a primary outcome (5, 28, 53). Several studies have identified positive associations between physical fitness and FMS, FMS and PA, and physical fitness and PA (60, 63, 64). However, the causal pathways among these variables are still largely unknown. Despite the growing body of evidence that PA is associated with physiological variables such as fitness and FMS, many school-based interventions focus on increasing minutes of moderate to vigorous physical activity (MVPA) (20, 106). While some studies have measures other physiological outcomes, only baseline associations of PA with fitness and FMS are typically reported (7, 63, 107). Additionally, many of the previous studies

use various methods measuring these outcomes, specifically fitness, making comparisons between studies difficult.

One intervention that aims to improve physical fitness by inducing changes in psychosocial mediators and FMS is called FUNdamental Integrative Training (FIT). The few studies that have evaluated the effects of the FIT intervention in school-aged children have reported improvements in select components of health- and skill- related physical fitness (22, 23, 27). To date, the FIT intervention studies that have been conducted did not assess any psychosocial factors or FMS as mediators, or free-living PA as a behavioral outcome, despite the intervention framework hypothesizing changes in these variables. Therefore, the purpose of this pilot study was to examine the efficacy of a 12-week movement-training program on physical fitness, FMS, psychosocial variables and PA in third and fourth grade students.

Methods

Study Design

We designed a cluster-randomized controlled trial to assess the impact of a movement-training program on fitness, FMS, psychosocial mediators, and physical activity (PA) in elementary-aged children. Participating classrooms (n=7) were randomized into two groups: intervention (INT, n=4) or control (CON, n=3). The INT group participated in a 12-week movement-training intervention twice per week while the CON group continued participation in regular PE. Data was collected immediately preceding the intervention, and immediately following the intervention. Pre- and post-testing measures were used to quantify changes in fitness, FMS, psychosocial variables, and usual PA, between treatment groups. All data collection

sessions occurred before school or during PE to minimize burden on the participants and their parent/guardian.

Participants

Children from the third and fourth grade classrooms at an elementary school in Amherst, Massachusetts were recruited to participate in this study. All third and fourth grade students were given the chance to participate in the study. Participants were recruited using flyers that were distributed to all seven classrooms. All students in the INT classrooms were exposed to the intervention, but data was only collected on students who returned the proper permission from their parents/guardians (written informed consent) and assent from the child. This study protocol was approved by the Institutional Review Board at the University of Massachusetts, Amherst.

Intervention

Classrooms that were randomized to the INT group were scheduled to receive the intervention twice per week, during their weekly regularly-scheduled PE class (offered once per week) and once per week before school, for 12 weeks. Approximately 48 hours were between each PE class and before-school session. The intervention was primarily led by one individual, with 2 individuals assisting. During PE classes, the PE teacher was the leader with two trained research staff as assistants. During the before-school sessions, one research staff member took the lead role while two others assisted with the implementation. When the children arrived, they performed a dynamic warm-up to prepare their minds and muscles for the intervention activities. This was standardized among all intervention classrooms. The gymnasium was set up with six stations, each with two exercises per station, as outlined in Table 3.1 Following the intervention, the students participated in whatever lesson the PE teacher had planned for that day.

Table 3.1. Example FIT Lesson

Station/Exercise	Weeks 1-4 Exercises	Weeks 5-8 Exercises	Weeks 8-12 Exercises
Battle Ropes	ALT FR wave	ALT FR wave	ALT FR wave
	Jumping Jacks	Burpees	Burpees
MB	Lunge	Squat	Squat
	OH Press	Push Up	Push Up
Bosu	Bosu climber	Squat	Squat
	Bosu bridge	Sit Up	Sit Up
SP	Plank	Climber	Climber
	ST surfer	ST surfer	ST Surfer
Slam Ball	Chest Push	OH Slam	OH Slam
	Squats	Wall Sit	Wall Sit
Balloons	Knee Tap	Create Your Own	
	CrabWalk		

ALT = Alternating right and left arm; FR = fitness ropes; MB = medicine ball; OH = overhead; SP = Spooner; ST = standing;

At the partnering elementary school, PE is only offered once per week. To stay consistent with the previous research published using this type of intervention (24), a dose of twice per week was needed. Due to constraints set forth by the school, we were unable to offer regular PE more than once per week. Instead, there was a before-school session held for each of the INT classrooms once per week to fulfill the twice-weekly dose. Attendance at the before-school portion of the intervention was treated as mandatory. However, because it was not a part of the

curriculum or required activities, it is possible that certain students did not attend the before-school sessions despite being in an intervention classroom. This will be considered in the final analysis and interpretation of study findings. The delivery of the before-school sessions was designed to mimic the PE session, without the additional activities following the FIT intervention circuit. The before-school sessions consisted of a warm-up and the FIT circuit starting at approximately 8:30-8:40AM, still taking ~15 minutes to complete. The start time of the before-school sessions was largely dependent on the arrival of the children via bus or parent drop-off. Following the completion of the circuit, students returned to their classrooms to begin the school day.

During the first 4 weeks of the intervention, each exercise was performed for 30 seconds. For weeks 4-8, each exercise was performed for 35 seconds, and during weeks 8-12 each exercise lasted 40 seconds. There was an approximately 30-second rest/transition period between each station, signaled by the start and stop of kid-friendly music playing over the loudspeakers in the gymnasium.

Classrooms randomized to the CON group participated in regular PE class for the duration of the intervention period including traditional PE lessons and games. These CON classrooms did not participate in any before-school programming. Study participants in the CON classrooms completed the same baseline and follow-up testing as the INT group. Following the 12-week study period, the CON group received an abbreviated form of the intervention due to the timing of the end of the school year.

Measures

All measures were collected during the school day by trained data collectors. All outcomes were collected before the start of the 12-week intervention, and during the 2 weeks immediately following the intervention.

Physical Fitness

Physical fitness was assessed with select FITNESSGRAM® assessments: curl ups, push-ups, sit and reach, and horizontal jump (82). The FITNESSGRAM® battery is widely used in PE classes to assess the fitness levels of children ages 6-17. Each fitness test was measured as a continuous variable. The students were instructed on how to perform each assessment and given demonstrations. They were allowed to practice a few repetitions to ensure they understood the movement. Following the practice session, each student performed the selected FITNESSGRAM® assessment. If the task was performed incorrectly, the child was given verbal feedback to correct the movement. After one warning, the research assistant discontinued counting repetitions (push-up and curl-up) if the student's form was not corrected.

The Push-Up test assessed upper body pushing muscular endurance. Participants completed as many consecutive 90° push-ups as possible at a rhythmic pace (using FITNESSGRAM® recording), and total repetitions were recorded. General inter-rater reliability of FITNESSGRAM® push up assessment administered by 23 teachers on third and fifth grade students, was reported to be acceptable when compared to an expert tester (74% agreement and 0.48 modified kappa) (82).

The curl up test assessed abdominal muscular endurance. Participants completed as many curl ups as possible at a rhythmic pace (using FITNESSGRAM® recording), and the total

repetitions were recorded. Reliability of the FITNESSGRAM® curl up test has been reported to be acceptable (78% agreement and 0.56 modified kappa) (82).

Lower back and hamstring flexibility for the left and right legs were evaluated by the sit-and-reach test using a sit-and-reach test box. For this test, participants removed their shoes and bent one leg so that the sole of that foot was flat on the floor with the other knee straight and foot flat against the box. The hands were extended forward on top of the measuring scale with one hand on top of the other and palms down. The student reached forward and held their fingers at the end of the reach. The best score of 3 trials for each leg were recorded to the nearest 0.5 inches and averaged, for each leg.

Motor Skills

To measure FMS, four motor skill tasks from the Test of Gross Motor Development – 2 (83). Due to the limited amount of time for data collection during the school day, we chose two locomotor tasks (hop, horizontal jump) and two object control tasks (overhand throw, catch) to use for our motor skill variable. For this efficacy study, the hop, jump, throw, and catch were chosen because they were the most similar to exercises that were performed during the FIT circuit. These four tasks were efficient to demonstrate and score during the limited PE class period. Prior to performing each skill, the students were oriented to the movement, and allowed one to two practices before any scoring was calculated to ensure they understood the movement. Each task was tabulated separately as well as summed together to create a composite score (possible range 0-32) for each participant.

Psychosocial Variables

Studies have identified psychosocial variables that are potential mediators for behavior change. The psychosocial mediators, self-efficacy(108, 109), enjoyment (94), and social support (110) were selected based on their use in previous behavior change studies in children.

Self-efficacy was assessed with the Child Self-Perception of Adequacy and Predilection for Physical Activity Scale (CSAPPA). The CSAPPA is a widely used 20-item scale that measures children's self-perceptions of their adequacy in performing and their desire to participate in physical activities. The scale was designed for children age 9-16 years old. The CSAPPA scale has 3 embedded factors: adequacy (confidence in), predilection (preference for), and enjoyment of physical education class. Each of these factors was calculated separately and then combined to produce a total score. The CSAPPA is significantly correlated with aerobic fitness, PA (energy expenditure and self-reported PA), body weight (percentage body fat and BMI), and motor proficiency (87-89). It has demonstrated high test-retest reliability (r=0.84-0.90) and strong predictive and construct validity (87, 90, 91).

Three items included in the survey asked about enjoyment doing physical activities (92) (93, 94). Participants answered using a 4-point likert-type scale (1 = "Disagree a lot" to 4 = "Agree a lot"; range=3-12). The PA enjoyment questions can be seen below:
When I am physically active…

a) *I feel bored*
b) *I dislike it*
c) *It makes me upset*

To assess social support, we adapted previous surveys used to assess peer and parental social support in regard to PA (80, 95). The social support scale used for the current study

included 4 items that each participant answered using a 4-point likert-type scale (1 = "Disagree a lot" to 4 = "Agree a lot"; range=4-16). The social support questions can be seen below:
How much do you agree with these statements?

a) *"My friends are active or play sports a lot."*
b) *"My friends and I like to play sports or do active things together."*
c) *"My parents and I do active things together."*
d) *"My parents sign me up for sports and take me to places where I can be physically active."*

Physical Activity

Usual weekly PA was measured using the GT3X+ ActiGraph accelerometer (AG; ActiGraph, LLC, Pensacola, FL). The AG was worn on the participant's right hip. Children were instructed to wear the AG during all waking hours for seven full days, except when the device would get completely wet (e.g., showering, bathing, swimming). Participants were given verbal instructions and sent home with a sheet of instructions with a wear log. After the 7 days of wear, children returned the AG. Upon return, the data from the AG was downloaded using ActiLife software (Version 6) and processed using R programming software. Non-wear time was defined as at least 30-minutes of consecutive zeros from the AG data using a modified algorithm (85). Data points for non-wear times were set to missing and not included in any further data processing. Based on the remaining data points, days with less than eight hours of wear time were removed (excessive non-wear time) (85) Data points from days with at least eight hours of data were included for further processing. After applying these exclusion criteria, we processed the remaining vertical axis AG data using the validated cut points developed by Evenson et al.

(86) to identify total time spent in sedentary, light, moderate, vigorous, moderate + vigorous PA (MVPA). Total time spent in MVPA was calculated in minutes (mean minutes/day) and used to represent the PA of each participant.

Statistical Analysis

Statistical analyses were completed in Stata (Stata 14.0, College Station, TX), with α levels set to $p \leq 0.05$. Descriptive statistics (mean ± SD or %) were computed for all measured variables. Baseline differences between intervention versus control were assessed using a two-sample Kruskal-Wallis rank-sum test for continuous variables, and Fisher's exact tests for categorical variables. Mixed-models linear regression is the preferred method of analysis for a cluster RCT. However, due to the small number of clusters (less than 15) in this pilot study, this regression method was not appropriate (96). To measure changes in physical fitness, FMS, psychosocial variables, and PA between groups, change scores (post-pre) were calculated. Due to the non-normal distribution of the data, change scores were analyzed using Kruskal-Wallis rank-sum tests to compare groups.

Results

Baseline characteristics for each group are presented in Table 4.9. Demographic characteristics of the groups did not differ significantly at baseline. The student population at this elementary school is 51.6% male, and 55.6% white. There was high variability among the outcome measures, which is common when collecting these measures in younger populations. Due to the relatively small sample size, we did not remove any outliers. Among outcome variables, the only significant difference at baseline between groups was observed in the hop test, with the intervention group demonstrating a higher mean score ($p=0.04$).

The summary of outcome measures can be seen in Table 4.10. No significant changes were observed in fitness variables (curl up, push up, sit and reach; p=0.39-0.92). No significant differences were observed in the change scores between groups for the four motor skill variables (hop, jump, throw, catch; p=0.06-0.77). A significant decrease in sedentary time was observed when comparing the pre-post changes between the INT and CON groups, with the INT group demonstrating a greater decrease (p=0.04). No significant differences were observed between INT and CON groups for MVPA or the other accelerometer-derived PA variables (p=0.45-0.98). Physical activity self-efficacy was not different between groups at post intervention (p=0.77). Physical activity enjoyment did not improve for either group following the intervention (p=0.06).

Discussion

The purpose of this study was to evaluate the efficacy of a 12-week, FIT intervention program on physical fitness, FMS, psychosocial mediators, and usual PA among children in third and fourth grade classrooms. Overall, INT and CON groups were not statistically significantly different in change from baseline to post-intervention.

Previous FIT studies have reported improvements in fitness (22, 23). In one FIT study, an 8-week program that was incorporated into a second grade PE curriculum elicited a significant improvement in push-up and curl-up performance (23). The intervention group participated in this program for the first 15 minutes of PE class, twice a week. In an 8-week study conducted in fourth graders using a similar FIT program, significant increases in push-up and sit and reach flexibility scores, but not curl up scores, were observed in the intervention group compared with the control group (22).

Faigenbaum et al. also reported improvements in long jump and single leg hop performance in their 8-week training program study in second graders (24). However, in a fourth-

grade FIT intervention, completed by the same research group (24), no improvements in curl up were observed, similar to the findings of the current study. These differences in curl up scores could be attributed to the differences in age between the two samples (2^{nd} vs. 4^{th} graders). In our sample, the horizontal jump was used as a motor skill task, so it was scored differently. However, the participants in our study were third and fourth graders, which would suggest our finding of no significant improvement between treatment groups is similar to the one previous FIT intervention study in that age group.

In the most recent FIT study, a significant improvement was observed in the INT group compared to the CON for aerobic fitness, push-up, single-leg hop, and sit and reach (24). No differences were observed for the curl up or long jump. The population for this previous study was fourth grade students with an average age of nine years old, similar to the current study. However, the sample for the previous study was much smaller than ours (two classrooms, n=41). The authors chose to analyze the data using a repeated measures ANOVA to assess the interactions and main effects for time and group on the dependent fitness variables, as well as present the individual group changes in each variable. In this study, the researchers used long jump and single-leg hop as a fitness measure, rather than a motor skill variable therefore our results for those tests are not comparable. However, for curl-ups, push-ups, and sit and reach, the baseline values for the study sample are similar to the current study. Much like the other FIT studies, the research group who created the FIT protocol implemented these studies (27).

The pre-post change was significantly different between the INT and CON groups for sedentary time, suggesting that one potential outcome of the intervention could be a decreased amount of time spent sedentary, outside of the time spent in the intervention. No previous FIT studies have measured sedentary time, or any other physical activity metrics. However, the FIT intervention may have displaced some sedentary time during warm up activities for CON PE

classes. School-based interventions targeting sedentary behavior have produced comparable decreases in this population (111, 112).

Although the participants in this study did not meet PA recommendations at the beginning or end of the intervention, the average daily minutes of MVPA for both groups was similar compared to their age-matched peers (35). This is approximately 11 minutes/day away from meeting the current guidelines of 60 minutes per day.

To effectively implement a behavioral intervention, multiple trials to assess the feasibility of delivering the intervention and identifying the proper outcomes should be tested. The null findings from the current study might suggest that additional and/or different outcome measures should be explored to assess the effectiveness of the FIT intervention in this population. Perhaps using outcomes that are more directly comparable to exercises performed during the intervention circuits would be another option (i.e. planks and other stability skills, bodyweight squat tests).

Limitations

There are several limitations to the current study. Due to the clustering of students within classrooms, the current study was not powered to detect changes in many of the outcome variables. Also, data collection occurred during PE and the before-school time period. This was not ideal because the students who were not enrolled in the study were still participating in regular PE during data collection weeks, which caused some disruptions during assessments. However, the data collection sessions were physically separated from the rest of the class by using the moveable divider in the gymnasium. In addition, data collections during the school day allowed for higher retention of our participants. Lastly, the dose of the intervention was limited by the school's policy of only having PE once per week. We were able to expose our participants to a higher dose of the FIT intervention by adding the before-school component, but it would

have been more consistent with the previous literature if both weekly doses were delivered during PE twice (or more) per week. A ceiling effect was observed for some variables, suggesting there was not much room for improvement for many of the participants in the study for those outcomes. One example is the self-efficacy survey with the average score for the INT and CON group being 59.2 ± 14.7 and 59.9 ± 9.9 respectively with a maximum possible score of 60. Future research could target larger samples to include students who have lower levels of fitness, FMS, and PA. Our study did not assess intensity of intervention time periods, so we relied heavily on subjective measures of intensity as collected by our research staff. Future PE interventions should consider the use of an objective measure of intensity, such as a heart rate monitor. For the current study, we did not use an accelerometer to measure intensity because we did not feel it was appropriate given the types of exercises that were being performed during the intervention (i.e. strength exercises that would not be detectable on a hip-worn accelerometer). Lastly, measures that are currently validated to assess motor skills (i.e. TGMD-2) are not ideal when doing data collection in a school-based setting because they are lengthy and require a fairly controlled setting. In the future, researchers should consider creating a shorter, but valid and reliable field-based test battery to assess motor skills, using the TGMD-2 as the criterion measure.

Strengths

There are many strengths to our study. The FIT intervention was 12 weeks; 4 weeks longer than any other FIT intervention study (22-24). However, despite being longer than previous FIT studies, the duration may not have been enough time to observe changes in the outcomes of interest, especially usual PA and psychosocial mediators. Previous FIT studies did

not report fidelity outcomes of dose, so it is unclear if those interventions faced similar barriers to the current study. Often, changes in behavioral outcomes such as PA are observed in studies that last 6-months or a full school year (53). Future research efforts should consider implementing FIT interventions for a longer duration (i.e. the full school year) to better assess behavior-related changes. The current study is the first to assess the effects of FIT on FMS, psychosocial measures, and usual PA. Lastly, no adverse outcomes or injuries were reported during this study adding more evidence to the literature about safety of the FIT resistance training modality in children.

Conclusion

In conclusion, future studies should continue to explore the relationships between fitness, FMS, psychosocial variables, and PA in children. The current study adds valuable insight into the efficacy of a short, high intensity circuit-based intervention into an existing PE curriculum, potentially as part of a larger multi-level intervention. Future FIT studies should focus on finding the proper dose that consistently produces meaningful and significant improvements in fitness and FMS. It is hypothesized that fitness and FMS improvements will co-evolve with constant feedback loops between the two. Future studies may want to focus on frequency, intensity and duration of the FIT intervention model to first demonstrate improvements in these physiological measures. Once the child's body is strong and confident in the ability to move (improved fitness and FMS), then studies should focus on how those physiological improvements affect changes in behavior (PA and sedentary time) and psychosocial mediators. Additionally, future studies could include larger and more diverse samples.

Table 4.8: Exercises performed during the 12-week FIT Intervention

Station/Exercise	Weeks 1-4 Exercises	Weeks 5-8 Exercises	Weeks 8-12 Exercises
Battle Ropes	Battle Rope wave	ALT FR wave	ALT FR wave
	Jumping Jacks	Burpees	Burpees
MB	Lunge	Squat	Squat
	OH Press	Push Up	Push Up
Bosu	Bosu climber	Squat	Squat
	Bosu bridge	Sit Up	Sit Up
SP	Plank	Climber	Climber
	ST surfer	ST surfer	ST Surfer
Slam Ball	Chest Push	OH Slam	OH Slam
	Squats	Wall Sit	Wall Sit
Balloons	Knee Tap	Create Your Own	
	CrabWalk		

BR = battle ropes; MB = medicine ball; OH = overhead; SP = Spooner; ST = standing; ALT = Alternating right and left arm

Table 4.9: Baseline characteristics of study participants.

Variable	Intervention (n=33)	Control (n=44)	p-value[a]
Age (years)	9.4 ± 0.5	8.5 ± 0.5	0.39
Sex (% male)	45.7	40.0	0.80
Curl-Ups (repetitions)	25.1 ± 25.8	24.4 ± 20.9	0.71
Push-Ups (repetitions)	7.1 ± 6.8	7.8 ± 7.9	0.39
Sit & Reach – Left (cm)	28.2 ± 10.2	28.9 ± 7.8	0.93
Sit & Reach – Right (cm)	28.7 ± 10.0	28.3 ± 8.3	0.58
Jump	7.3 ± 1.0	7.3 ± 1.1	0.70
Hop	7.3 ± 1.5	8.0 ± 1.5	**0.04**
Catch	5.6 ± 0.6	5.7 ± 0.6	0.82
Throw	4.5 ± 2.0	5.1 ± 2.0	0.20
Sedentary (avg. min/day)	480.9 ± 106.7	448.0 ± 75.6	0.15
Light PA (avg. min/day)	225.5 ± 48.3	237.8 ± 223.9	0.27
Moderate PA (avg. min/day)	30.6 ± 12.9	28.5 ± 11.1	0.49
Vigorous PA (avg. min/day)	14.9 ± 8.1	11.7 ± 7.1	0.10
MVPA (avg. min/day)	45.3 ± 19.2	42.4 ± 18.3	0.27
Self-Efficacy (Maximum possible score: 60)	59.2 ± 14.7	59.9 ± 9.9	0.61
Enjoyment (Possible range: 3 to 12)	10.3 ± 2.0	11.0 ± 1.6	0.18
Social Support (Parents) (Possible range: 2 to 8)	5.7 ± 1.7	6.4 ± 1.5	0.06
Social Support (Friends) Possible range: 2 to 8)	6.7 ± 1.5	6.9 ± 1.3	0.81

[a]P-values were calculated using 2-sample t-tests for continuous variables and Fisher's exact test for categorical variables.

Table 4.10: Summary of Outcome Variables for Intervention and Control Groups

Variable	Time	Intervention (n=33)	Control (n=44)	p-value
Curl-Ups (repetitions)	Pre	25.1 ± 25.8	24.4 ± 20.9	
	Post	34.1 ± 29.0	33.9 ± 30.6	0.39
Push-Ups (repetitions)	Pre	7.1 ± 6.8	7.8 ± 7.9	
	Post	3.7 ± 5.1	6.9 ± 7.8	0.70
Sit & Reach – Left (cm)	Pre	28.2 ± 10.2	28.9 ± 7.8	
	Post	28.9 ± 6.3	28.9 ± 6.3	0.92
Sit & Reach – Right (cm)	Pre	28.7 ± 10.0	28.3 ± 8.3	
	Post	27.4 ± 8.6	28.1 ± 7.6	0.58
Jump	Pre	7.3 ± 1.0	7.3 ± 1.1	
	Post	7.2 ± 1.1	7.4 ± 0.9	0.68
Hop	Pre	7.3 ± 1.5	8.0 ± 1.5	
	Post	7.7 ± 1.7	7.9 ± 1.5	0.06
Catch	Pre	5.6 ± 0.6	5.7 ± 0.6	
	Post	5.8 ± 0.4	5.6 ± 0.5	0.77
Throw	Pre	4.5 ± 2.0	5.1 ± 2.0	
	Post	4.7 ± 2.0	5.5 ± 2.1	0.61
Sedentary (avg. min/day)	Pre	448.0 ± 75.6	480.9 ± 106.7	
	Post	431.2 ± 83.2	489.7 ± 27.3	0.04
Light PA (avg. min/day)	Pre	225.5 ± 48.3	237.8 ± 223.9	

	Post	249.8 ± 41.3	240.4 ± 41.6	0.45
Moderate PA (avg. min/day)	Pre	30.6 ± 12.9	28.5 ± 11.1	
	Post	34.0 ± 15.9	31.3 ± 10.8	0.48
Vigorous PA (avg. min/day)	Pre	14.9 ± 8.1	11.7 ± 7.1	
	Post	14.8 ± 11.1	17.6 ± 14.0	0.76
MVPA (avg. min/day)	Pre	45.3 ± 19.2	40.2 ± 2.9	
	Post	48.8 ± 25.6	48.9 ± 22.3	0.98
Self-Efficacy (Maximum possible score: 60)	Pre	59.2 ± 14.7	59.9 ± 9.9	
	Post	57.2 ± 20.6	57.6 ± 18.4	0.77
Enjoyment (Possible range: 3 to 12)	Pre	10.3 ± 2.0	11.0 ± 1.6	
	Post	11.1 ±1.0	11.4 ± 0.9	0.06
Social Support (Parents) (Possible range: 2 to 8)	Pre	6.4 ± 1.5	5.7 ± 1.7	
	Post	6.5 ± 1.5	6.4 ± 1.4	0.80
Social Support (Friends) (Possible range: 2 to 8)	Pre	6.9 ± 1.3	6.7 ± 1.5	
	Post	6.4 ± 1.5	7.1 ± 1.2	0.18

[a]P-values were calculated by Wilcoxon Rank-sum tests using change scores from Time 1 to Time 3 for all variables.

CHAPTER V

CONCLUSIONS

Summary of Study Results

The intervention was mostly delivered as intended. The before-school sessions were slightly less organized because the participants arrived at school at different times depending on the mode of transportation to school. For the before-school sessions, research staff led 29 out of 31 sessions (97%). The FIT lessons delivered during PE class were primarily led the by PE teacher. For some lessons, a trained member of the research staff led the intervention. This includes instances when the teacher was absent. During PE, the PE teacher led 35 out of the 37 total sessions (95%). Verbal positive feedback was used at 100% of the sessions by the PE teacher and research staff.

The FIT intervention was designed to be delivered within a 15-minute time allotment, in a fun atmosphere, and at a high intensity. Data from the fidelity forms indicated that 46 of the 68 sessions (67%) had all three components (15 minutes, fun atmosphere, high intensity). During our study, the intervention was delivered within 15-minutes during 87% of the sessions. Research staff indicated the FIT sessions were conducted in a fun atmosphere during 96% of the intervention sessions. "High intensity" was often reported as missing (74%). PE sessions were more frequently reported as high intensity (χ^2=3.8, p=0.05, df=3), but also reported as having more off-task time (χ^2=5.1, p=0.02, df=3).

The intervention classrooms received the FIT intervention 78% of the original intended dose. The number of before-school and PE sessions varied slightly between classrooms, due to holidays, snow days, and school assemblies. The average length of the 17 intervention sessions was 14 minutes. The total intervention delivery time was 58-63% of the original planned total

intervention time. On average, more participants attended the PE sessions than the before-school sessions (17 students vs. 13 students).

The intervention was well-received by the boys and girls who participated. When asked what was most enjoyable, boys and girls reported the aspects they found most enjoyable to be the equipment used at the stations (i.e. spooner board) and circuit-like style of the stations around the gym. We observed that children appeared to be enjoying the intervention the majority (90%) of the FIT sessions.

Generally, the PE teacher reported enjoyment delivering the FIT intervention. The teacher expressed the desire to continue delivering the intervention after the study ended. When asked about the before-school portion of the intervention, the teacher said that it was challenging because the students arrived at different times. Towards the beginning of the study, research staff did not know and recognize the children, so the teacher was crucial in helping establish the routine of going to the gym before school.

The PE teacher enjoyed delivering the FIT intervention largely due to the equipment that was used. The equipment included medicine balls, spooner boards, battle ropes, and bosu balls. He said,

At the beginning of the intervention, the kids were not familiar with the equipment, leading to overstimulation. This resulted in the teacher and the research staff taking on more of a supervisory role to manage the classroom rather than motivating and correcting specific exercises the kids were performing. As the intervention continued, the students displayed less off-task behavior, overall.

We successfully collected fidelity measures for the three CON group classrooms during all of their regularly scheduled PE sessions (33 total). There was no evidence of FIT intervention delivery in any of these classroom sessions.

For most outcome measures, no differences in changes scores were detected between groups. No significant changes were observed in fitness variables (curl up, push up, sit and reach; p=0.15-0.87). No significant differences were observed in the change scores between groups for the four motor skill variables (hop, jump, throw, catch; p=0.15-0.84). A significant difference was observed in sedentary time between INT and CON groups following the intervention (p=0.04). but no differences were observed for MVPA or the other accelerometer-derived PA variables (p=0.45-0.98). Physical activity self-efficacy was not different between groups at time 3 (p=0.65). Physical activity enjoyment did not improve for either group following the intervention (p=0.27). Parental social support for physical activity was slightly lower in the CON group at baseline, compared to the INT group. No significant differences were observed when comparing changes in parental social support (p=0.80) or friend social support (p=0.18) following the intervention.

Limitations and Future Directions

There are several limitations to the current study. The study was not powered to detect changes in many of the outcome variables, which may have led to some of the null results. The majority of data collection occurred during PE, and the rest during the before-school time. This was not ideal because the students who were not enrolled in the study were still participating in regular PE during data collection weeks, which caused it to be slightly disordered. However, data collections during the school day allowed for higher retention of our participants. Lastly, the dose of the intervention was limited by the school's policy of only having PE once per week.

We were able to expose our participants to a higher dose of the FIT intervention by adding the before-school component, but it would have been more consistent with the previous literature if both weekly doses were delivered during PE twice (or more) per week. The intervention lasted for 12 weeks; therefore, the overall dose of the intervention was limited.

Additionally, the dose was limited by missed sessions due to unavoidable barriers (e.g. snow days and in-school assemblies). Ideally, our intervention would be implemented at a much higher dose, with multiple days per week during physical education. Since the school that participated in the intervention only offers PE class once per week, we were forced to add a before-school component to attain the 2x/week dose that is consistent with the FIT intervention literature. Another limitation is that both focus groups were moderated by the lead investigator of the study. Ideally, the focus groups would have been led by a trained research staff that was not heavily involved with the intervention. Our plan was to have a trained staff member act as a moderator, but we had to reschedule the focus groups at the last-minute due scheduling conflicts at the school, and the research assistants were not able to accommodate the change.

Lastly, the before-school sessions were led mostly by research staff and not the PE teacher, which was not the intended teacher-led method of delivery. Despite the research staff being trained to deliver this intervention, we still believe the PE teacher is a crucial part of this intervention and should, at the very least, be present when delivering the intervention.

Lessons Learned

There were many valuable lessons that I learned from implementing this randomized trial as my dissertation project. Above all, the effort and time that was put in to create the partnership between UMass Amherst and Wildwood Elementary was necessary for the success of my intervention and opened my eyes to how involved it is to do community-based research. As scientists, our long-term goal is to use our research to inform others. Community-based research is challenging but also very rewarding. Moving forward, I intend to put an equal (if not greater) effort into establishing these relationships with communities I work with in the future. This proved to be a crucial component of the teacher's comfortability with delivering the intervention.

In regard to the FIT study, there were many things that worked well and other things that did not work as well. Collecting measurements during the school day proved to be challenging. This particular school, like many other elementary schools, has a very busy daily schedule. The limited amount of time we had to collect outcome measures from the participants was a significant barrier. After learning this, I would be mindful of how many measures I intend to collect. While it would be best to have as much data as possible, it may not be feasible with limited space and time during the school day. Although challenging, I do believe the study benefitted from using school time to collect data on the participants because it did not require additional commitment from parents, who are already very busy. Additionally, many of the outcome measures we used to test fitness and fundamental movement skills are difficult to collect in a non-research setting. In the future, developing methods of measuring fitness and fundamental movement skills in a field-based setting is important to gather high quality data.

The delivery of the FIT intervention was mostly successful. If other researchers would like to use this curriculum, it is suggested that the PE teacher has some type of assistance. For example, a school-university partnership would be valuable, so college students could help the PE teacher deliver the FIT sessions on a day-to-day basis. I do think that a PE teacher would have difficulties delivering the intervention as it was designed without assistance.

Conclusions

In conclusion, this study is the first to report on the feasibility and acceptability of delivering a FIT intervention in elementary-aged children. Our results suggest that, overall, the FIT framework was successfully implemented and well-accepted by the students and PE teacher. There are considerations that should be addressed in order to improve the success of this intervention moving forward. More attention should be focused on delivering this intervention in

the setting it was designed to be implemented (PE classes). Lastly, the feasibility and efficacy of the FIT intervention modality should continue to be tested in more diverse populations over longer durations.

Future studies should continue to explore the relationships between physical activity, fitness, and motor skills in children. The current state of the literature is limited by lack of follow-up studies examining the causal pathways between the aforementioned variables. Additionally, more studies with a longer duration (>12 weeks) are needed in larger, more diverse students who are not already meeting PA recommendations. The current study adds valuable insight into the feasibility and efficacy of delivering a short, high intensity dose into an existing PE curriculum, potentially as part of a larger multi-level intervention. The FIT intervention was enjoyable for the teacher who implemented it, and the students who participated. Future FIT studies should focus on finding the proper dose to produce an effect on fitness, FMS, psychosocial mediators, and PA in schools where access to PE classroom instruction may be limited.

APPENDIX A

FLYER

Summary Page

FUNdamental Integrative Training in Elementary School Students: The F.I.T. Study
University of Massachusetts Amherst and Wildwood Elementary School

Who is invited to participate?
All 3rd and 4th Graders at Wildwood Elementary are invited to participate. We will randomly select 2 classrooms from each grade to receive the F.I.T. Program first.

What if my child is in one of the control-group classrooms?
After the first group (Group A) has received the F.I.T. Program, the other classrooms (Group B) will receive it.

What is the study about?
We hope to improve **fitness** and **physical activity** using an intervention called "FUNdamental Integrative Training"! It is a circuit-style training program that replaces about 15 minutes of your child's P.E. class.

When does the study start and end?
The study will start in **January** and last **12 weeks**, finishing in **May**. The study will take place **during your child's regular P.E. weekly class period**, with an optional before-school component (8:30AM once per week).

What is involved?

1. All children will be exposed to the F.I.T. Program but **we need your permission to collect data from your child.**
2. If you would like your child to participate, please sign and return the attached forms in the sealed envelope provided. Your child's teacher will ensure they get to Mr. Barnes.
3. Children in Group A will have an **optional** before-school activity session once per week. This will occur in the gym and replace the morning walk (~8:30AM).
4. Assist your child with putting on/removing the activity monitor during the weeks they will be wearing it.

Will my child be compensated?
Your child can earn up to **$10** per data collection (up to **$30.00** total) The compensation amount is the same for Groups A and B.

CONTACT INFORMATION:

Brittany Masteller, M.S.
Email: bmasteller@kin.umass.edu
Phone: 413-545-1583

John R. Sirard, Ph.D.
Email: jsirard@kin.umass.edu
Phone: 413-545-7898

We hope you and your child will be a part of this study! ☺

APPENDIX B

RECRUITMENT SCRIPT

Hello everyone! We are researchers from UMass Amherst. We would like to find out if a physical activity program called F.I.T. will change your activity and fitness (make you stronger). FIT training uses fun equipment <<show pictures of some of the equipment>> that helps you have fun while getting stronger. We are asking all 3rd and 4th grade students here at Wildwood Elementary to join this study.

This study will take place during your physical education class with Mr. Barnes and also one day before school each week (instead of the morning walk). If you agree to join this study, you will be asked to do a few things.

1. Everyone will do a first visit to measure your fitness (like the Curl-Up and PACER tests). After the first visit, you will be asked to wear a small watch-sized activity monitor on a belt around your waist wrist for seven days. <<display for students to see>>

2. Once everyone does his or her first visit, we will flip a coin to see which group your classroom will be in.
    a. FIT Program Group –During the 15 minutes of PE, the classrooms in this group will do the FIT intervention.
    b. Control Group – This group does not do the FIT – just their normal physical education classes. After the FIT Program Group does the intervention, this group will get to participate in the intervention.

3. Everyone does a second visit to measure your physical activity and fitness again.

4. Everyone does a third visit to measure your physical activity and fitness for the final time.

5. After the first group does the intervention, Mr. Barnes will teach the FIT program during the other 3rd and 4th grade PE classes. Just like with your regular physical education classes and sports practices, there is risk of injury with participation in this study.

APPENDIX C

PARENTAL INFORMED CONSENT

University of Massachusetts, Amherst

PARENT PERMISSION FOR MINOR TO PARTICIPATE IN RESEARCH

Feasibility and Efficacy of a Movement Training Program on Fitness and Activity Profile in Elementary School Students

Researcher(s): John R. Sirard, PhD, *Faculty Sponsor*

Brittany Masteller, MS, *Student Researcher*

Department of Kinesiology

Study Title: Feasibility and Efficacy of a Movement Training Program on Fitness and Activity Profile in Elementary School Students

What is this form?

This Informed Consent form will give you the information you will need to understand why this study is being done and why your child is being invited to participate. It will also describe what your child will need to do to participate and any known risks, inconveniences or discomforts that your child may have while participating. We encourage you to take some time to think this over and ask questions now and at any other time. If you decide to have your child participate, you will be asked to sign this form and you will be given a copy for your records.

WHO IS ELIGIBLE TO PARTICIPATE?

Children in all 3rd and 4th grade classrooms at Wildwood Elementary School are eligible to participate.

Why is this study being done?

This study is to assess the effectiveness of a movement-training program on physical activity, fitness, and attitudes/beliefs towards physical activity in 3rd and 4th graders. We hope to measure the effects of a movement-training program (FUNdamental Integrative Training or "FIT") on improving fitness and physical activity in 3rd and 4th graders.

WHERE WILL THE STUDY TAKE PLACE?

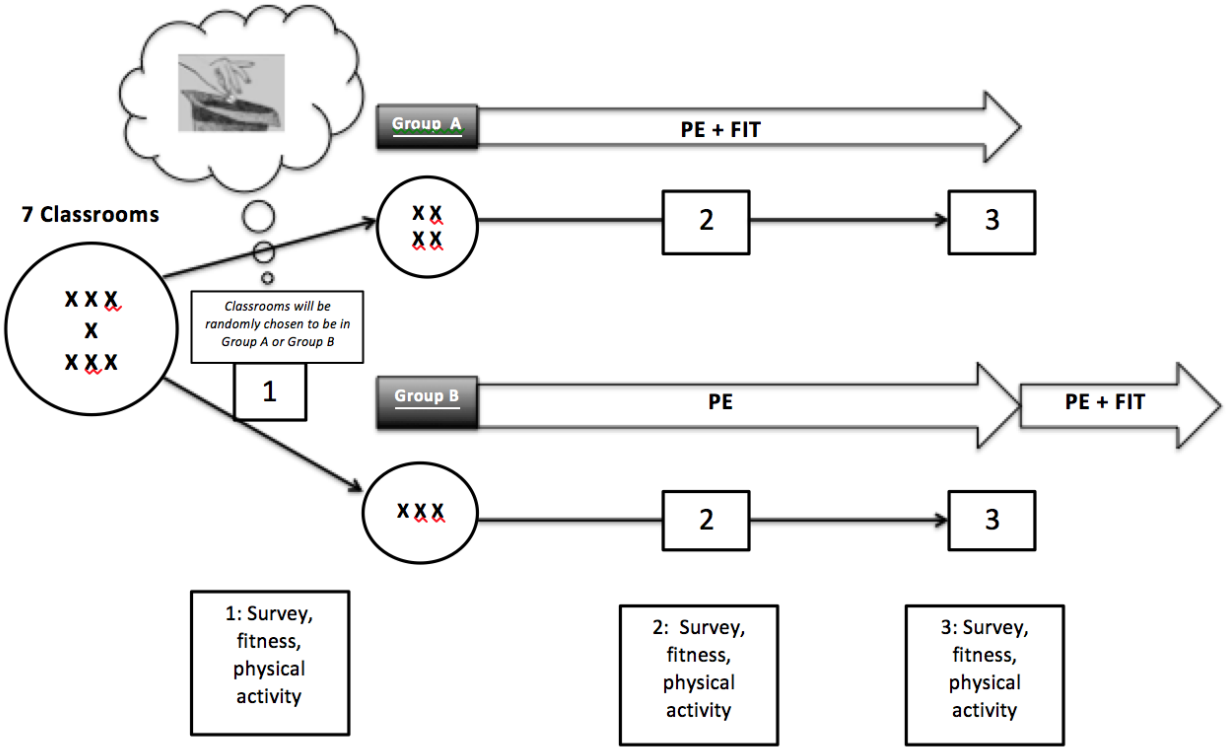
This study will take place at Wildwood Elementary School in Amherst, MA.

What other choices do I/my child have if my child does not participate?

If you and your child decide they will not participate, they will still receive the FIT program during PE class. No measurements will be collected from our research staff. They will still participate in all activities during PE class.

What will happen if my child takes part in this research study?

All participants will be asked to participate in the three measurement visits during their regularly scheduled physical education class. These measurement visits will include; physical activity (using an activity monitor), survey questions, resting physical measures, and fitness/performance measures. For this project, two 4th grade classrooms and two 3rd grade classrooms will be randomly chosen to receive the program first (Group A). The students in Group A will be asked to participate in the FIT program during their physical education class once per week and one before-school session per week for 12 weeks. Students in the other classrooms (Group B) will get the program after our last measurement visits are done. Children with physical disabilities are welcome to participate in the FIT program to the best of their abilities.



The figure above outlines the randomization process that will take place. Seven total classrooms will be randomly selected to Group A or Group B. Both groups will participate in all of the data collection sessions (3; survey, fitness, activity). Group A will do the FIT program first. After the final round of assessments, Group B will do the FIT program. No further testing will take place.

Baseline, Mid-Point and Follow-Up Assessment Visits

Physical Activity – Your child will be asked to wear one activity monitor (on hip) for 7 days to assess daily physical activity levels.

Psychological Surveys – Your child will be asked 27 questions relating to their confidence, enjoyment and support of physical activity. Your child is allowed to skip any questions they do not feel comfortable answering.

Resting Physical Measures – We will measure your child's height and weight.

Fitness Measures (Pictures attached to the end of this document in Appendix A) – We will assess your child's fitness using the following tests. Most of these are common to many physical education classes:

FITNESSGRAM® Curl Up Test: The cadence of the curl-up (sit ups) will be set with a metronome (1 curl-up per 3 seconds). The maximum repetitions performed with proper technique after 1 test will be recorded.

FITNESSGRAM® 90° Push-Up Test: Participants will complete as many 90° push-ups as possible at a rhythmic pace to assess upper body pushing muscular endurance.

FITNESSGRAM® Sit and Reach: Participants will sit on the floor with their legs stretched, knees straight and feet flat against the front end of the test box. In a slow, steady movement, lean forward at the hips. Where the hands land will be recorded. The best score of 3 trials will be recorded.

Isometric Prone Plank (Picture below): Participants will hold an isometric prone plank (image below) position as long as possible to assess core muscular endurance. Time will be recorded to the nearest 0.1 seconds.

Functional Movement Screen: Participants will complete and be scored on a series of seven movements to assess their mobility. The seven movements include squatting, stepping, lunging, reaching, leg-raising, push-up, and shoulder flexibility.

Motor Skill Measures

We will assess your child's motor skill competence using the following 6 tasks.

Standing Long Jump: Participants will start in a two-foot, hip-width stance and jump as far forward as possible to assess muscular power. Distance will be recorded to the nearest 0.1 cm.

Hop: Participants will hop three times on preferred foot and three times on the other foot. Two trials will be measured on each foot and the average will be taken to create the score.

Catch: Two lines will be marked 15 feet about. Someone will toss a 4-inch plastic ball underhand directly to the child with a slight arc aiming for his or her chest. The child will be instructed to catch the ball with both hands. Two trials will be performed.

Overhand Throw: Participants will stand 20 feet away from a wall and instructed to throw the ball at the wall hard. Two trials will be performed.

Log Roll: Participants will lay face up on a mat with arms extended above their head. They will then attempt to roll in a straight line across the mat to their stomach. Four rolls will be considered one trial. Two trials will be performed.

Back Support: Participants will be positioned on a foam mat. They will sit on the mat with legs straight and together, with arms extended and placed at a comfortable position behind the body. When the test is about to begin, the participants will raise their hips up off the ground, forming a wedge shape with the body. Participants will hold this as long as possible. Two trials will be performed.

DESCRIPTION OF FIT PROGRAM

Participants assigned to Group A group will be asked to participate in two FIT sessions per week for 12 weeks. One session will take place during regularly scheduled physical education. The other session will take place before school (7:45am) one day per week and each classroom will have one before-school session per week. If your child cannot attend the before-school portion of the study, they are still eligible to participate in the FIT program (we will keep track of attendance at all sessions). All sessions will take place at Wildwood Elementary School and will be led by the PE teacher, Mr. Barnes, or a member of our trained research staff. FIT sessions will include a warm-up, a 15-minute circuit-style training program, and a cool-down. Images of example equipment and exercises can be found in Appendix B. Students will perform the exercises in stations with rest periods in between. During one of the FIT sessions, your child will be asked to wear an activity monitor on a belt around his/her waist and a watch around his/her wrist to measure physical activity. This is to measure how much physical activity your child is engaging in during the FIT sessions.

How long will my child be in the research study?

There will be three measurement visits. The first measurement visit will be scheduled before the start of the program. The programs will he held for 12 weeks. After the program is halfway over, a mid-point measurement will take place. A follow-up measurement visit will be scheduled within two weeks after the end of the program. The study will begin in January 2017 and end in May 2017.

What are the benefits of being in this study?

Potential benefits of participating in this study include the possibility of improved physical activity and fitness levels. Program participants may increase their physical activity confidence, enjoyment of physical activity, and perceived social support for physical activity. All participants will gain knowledge on proper exercise training techniques. It is possible that your child may not directly benefit from participation in this study.

WILL MY CHILD RECEIVE COMPENSATION FOR PARTICIPATING?

Yes, your child can earn up to $30.00 for participating in the study. Payments are broken down as follows: $1.00 for completing the survey + $2.00 for completing the fitness measures + $1.00/day they wear the accelerometer (7 possible days; must wear at least 10 hours) = $10.00 per data collection session. There are three data collection sessions ($10.00 x 3 = $30.00). Compensation will be provided in the form of gift cards to a local establishment.

Are there any potential risks or discomforts that my child might experience from participating in this study?

Your child may have an increased risk of injury related to physical activity during the measurement visits and program sessions in this study. The intensity of these sessions will be no greater than his/her regular school physical education classes or athletic sports practices. Your child may experience some slight discomfort from wearing the ActiGraph on their waist.

How will information about my child's participation be kept confidential?

The information obtained from this study will be treated as privileged and confidential. Participants will be assigned a numerical ID number at the beginning of the study and only ID numbers will identify all data. The link between the participant name and study ID number will be kept as a hard copy in a locked file cabinet in the secure Physical Activity and Health Laboratory at UMass Amherst. Study surveys and data collection forms will only have study ID - no names will be on these documents. Electronic data information will be saved on password-protected documents with limited accessibility. Written participant information and completed forms will be placed in a file cabinet that will be locked. Only research staff for this study will have access to participant data. At the conclusion of this study, the researchers may publish their findings. Information will be presented in summary format and you will not be identified in any publications or presentations.

CAN MY CHILD STOP BEING IN THE STUDY?

Your child does not have to be in this study if he/she does not want to. If he/she agrees to be in the study, but later changes his/her mind, he/she may drop out at any time. There are no penalties or consequences of any kind if he/she decides that he/she do not want to participate.

WHAT IF MY CHILD IS INJURED?

The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subject's research, but the study personnel will assist you in getting treatment. Research staff members are certified in basic first aid and CPR/AED. Basic first aid can be administered at the study location. In the event of an emergency, our staff will immediately notify the teacher and school nurse and contact local emergency medical personnel. Participants that experience injuries or require medical assistance will be referred to their health care provider and medical clearance may be required before returning to study participation.

What are my and my child's rights if he or she takes place in this study?

You can choose whether or not you want your child to be in this study, and you may withdraw your permission and discontinue your child's participation at any time. Whatever decision you

make, there will be no penalty to you or your child, and no loss of benefits to which you or your child were otherwise entitled. Your child may refuse to answer any questions that he/she does not want to answer and still remain in the study.

WHO CAN I CONTACT IF I HAVE QUESTIONS?

Take as long as you like before you make a decision. We will be happy to answer any questions you have about this study. If you have further questions about this project or if you have a research related problem, you may contact the graduate student researcher, (Brittany Masteller) at 413-545-1583 or bmasteller@kin.umass.edu or Dr. John Sirard (Faculty Advisor; jsirard@kin.umass.edu; 413-545-7898). If you have any questions concerning your child's rights as a research subject, you may contact the University of Massachusetts Amherst Human Research Protection Office (HRPO) at (413) 545-3428 or humansubjects@ora.umass.edu.

SUBJECT STATEMENT OF VOLUNTARY CONSENT

When signing this form I am agreeing for my child to voluntarily enter this study. I have had a chance to read this consent form, and it was explained to me in a language that I use and understand. I have had the opportunity to ask questions and have received satisfactory answers. I understand that I can withdraw my child at any time. A copy of this signed Informed Consent Form has been given to me.

UMASS AMHERST HUMAN RESEARCH PROTECTION OFFICE (HRPO):

If you have questions about your child's rights while taking part in this study, or you have concerns or suggestions and you want to talk to someone other than the researchers about the study, please call the HRPO at (413) 545-3428 or email humansubjects@ora.umass.edu.

You will be given a copy of this information to keep for your records.

SIGNATURE OF PARENT OR LEGAL GUARDIAN

_____

Name of Child

Name of Parent or Legal Guardian

Signature of Parent or Legal Guardian | Date

SIGNATURE OF PERSON OBTAINING CONSENT *[include only if consenting in person]*

Name of Person Obtaining Consent | Contact Number

Signature of Person Obtaining Consent | Date

APPENDIX D

ASSENT SCRIPT

Feasibility and Efficacy of a Movement Training Program on Fitness and Activity Profile in Elementary School Students

University of Massachusetts, Amherst

<<Read Assent Form to students>>

We would like to find out if a physical activity program called F.I.T. will change your activity and fitness (make you stronger). FIT training uses fun equipment **<<show pictures of some of the equipment>>** that helps you have fun while getting stronger. We are asking 3rd and 4th grade students at Wildwood Elementary to join this study. This study will take place during your physical education class at Wildwood and one day before school each week (instead of the morning walk).

If you agree to join this study, you will be asked to do a few things.

1. Everyone will do a first visit to measure your fitness (like the Curl-Up test). Then, you will be asked to wear a small watch-sized activity monitor on a belt around your waist for seven days. **<<display for students to see>>**
2. Once everyone does the first visit, we will flip a coin to see which classrooms will get the FIT program first **<<Show study diagram>>**.
    a. FIT Program Group –During the first 15 minutes of PE, the classrooms in this group will do the FIT intervention.
    b. Control Group –After the FIT Program Group does the intervention, this group will get to participate in the intervention.
3. Everyone does a second visit to measure your physical activity and fitness again.
4. Everyone does a third visit to measure your physical activity and fitness for the final time.
5. After the first group does the intervention, Mr. Barnes will teach the FIT program to the other 3rd and 4th grade classrooms.

Just like with your regular physical education classes and sports practices, there is risk of injury with participation in this study. You can tell the researchers or Mr. Barnes if anything is uncomfortable and we will teach you how to perform all movements safely.

We do not know if being in this study will help you. We expect that the FIT sessions will be fun, may improve your activity and fitness, and may make you feel better about physical activity.

Your parent or guardian knows about this study and we are asking if you would like to be part of it. You do not have to join this study. It is up to you. You can say okay now and change your mind later. All you have to do is tell us you want to stop. No one will be mad at you if you don't want to be in the study or if you join the study and change your mind later and ask to stop.

Before you say **yes or no** to being in this study, we will answer any questions you have. If you join the study, you can ask questions at any time. Just tell your parent or the researcher that you have a question.

If you want to be in this study, please write your name below.

Participant Name_____
Date_____
↑ Write your name here ↑

Name of Person Obtaining Assent _____
Date_____

APPENDIX E

ASSENT FORM

University of Massachusetts Amherst

Feasibility and Efficacy of a Movement Training Program on Fitness and Activity Profile in Elementary School Students

Assent Form

We would like to find out if a physical activity program called FIT will change your activity and fitness (make you stronger). FIT training uses fun equipment that helps you have fun while getting stronger. We are asking 3rd and 4th grade students at Wildwood Elementary to join this study. This study will take place during your physical education class at Wildwood and one day before school each week (instead of the morning walk).

Everyone does the FIT program as part of PE class, but we need your permission to collect your information.

If you agree to join this study, you will be asked to do a few things.

1. Everyone will do a first visit to measure your fitness (like the Curl-Up test). Then, you will be asked to wear a small watch-sized activity monitor on a belt around your waist for seven days. You will be asked 27 questions about your feelings about being active and how much time you spend looking at screens. You can always skip any questions that you don't want to answer.
2. Once everyone does the first visit, we will flip a coin to see which classrooms will get the FIT program first
    a. Group A –During the first 15 minutes of PE, the classrooms in this group will do the FIT program.
    b. Group B –After Group A does the FIT program, Group B will get to participate in the FIT program as part of PE class.
3. Everyone does a second visit to ask you questions and measure your physical activity and fitness again.
4. Everyone does a third visit to ask you questions and measure your physical activity and fitness for the final time.
5. After the first group finishes, Mr. Barnes will teach the FIT program to the other 3rd and 4th grade classrooms.

Just like with your regular physical education classes and sports practices, there is risk of injury with participation in this study. You can tell the researchers or Mr. Barnes if anything is uncomfortable and we will teach you how to perform all movements safely.

We do not know if being in this study will help you. We expect that the FIT sessions will be fun and healthy.

If you agree to be in this study, you will get 1 dollar each time you answer the questions. You will get 2 dollars each time you do the fitness test. You will also get 1 dollar for each day you wear the monitor on your waist. This equals a total of 30 dollars if you answer all of the questions and do all of the tests.

Your parent or guardian knows about this study and we are asking if you would like to be part of it. You do not have to join this study. It is up to you. You can say okay now and change your mind later. All you have to do is tell us you want to stop. No one will be mad at you if you don't want to be in the study or if you join the study and change your mind later and ask to stop.

Before you say **yes or no** to being in this study, we will answer any questions you have. If you join the study, you can ask questions at any time. Just tell your parent or the researcher that you have a question.

If you want to be in this study, please write your name below.

Participant Name_____

↑ Write your name here ↑

Date_____

Name of Person Obtaining Assent _____

Date_____

APPENDIX F

INTERVENTION FIDELITY FORM

FIT Study Fidelity Form

Classroom (Code #): _____
Date: _____
Researcher: _____
Class Start Time: _____
Intervention Start Time: _____
Intervention Stop Time: _____
Class Stop Time: _____

1. How many children were present for the FIT lesson? _____

2. Who was leading the FIT lesson? _____

3. YES NO Was the PI present at the FIT lesson? If yes, where? _____

4. YES NO Was the intervention implemented in the expected 15-minute duration? If no, how long did it take? _____

5. YES NO Did the majority of the children seem to enjoy the FIT lesson?

6. YES NO Did the person leading the intervention provide encouragement during the FIT lesson? If yes, what phrases were used? (Keep tally beside in ( ) for # of times phrase was used)

7. YES NO Was the lesson implemented as intended? (Mark [X] if this aspect was implemented). Please include any notes about these, if applicable.
15-minutes [ ] Fun atmosphere [ ] High intensity [ ]

_____

8. YES NO Did the students follow the instructions that were given throughout the lesson? If no, was there a particular station where the students had more questions?

_____

_____

BEFORE-SCHOOL / PE (Circle One)

9. Of the children who were off task, record the average amount of time these children were off task during the 15-minute intervention below:

0 minutes _____
1-2 minutes_____
3-5 minutes_____
6-10 minutes_____
11-15 minutes_____

10. List the name/duration of Exercises Performed:

Station	Duration

Other Notes:

_____
_____
_____
_____
_____
_____
_____
_____
_____

CLASSROOM CODES
1 = Monday 10:40
2 = Tuesday 11:30
3 = Wednesday 11:30
4 = Wednesday 10:40
5 = Thursday 10:40
6 = Thursday 11:30
7= Friday 11:30

APPENDIX G

CONTROL GROUP FIDELITY FORM

FIT Study Fidelity Form - CONTROL

Classroom (Code #): _____
Date: _____
Researcher: _____
Class Start Time: _____

Please describe the activities that were done during PE class today.

_____
_____
_____
_____
_____
_____
_____
_____

APPENDIX H

FOCUS GROUP PROMPTS

Discussion Prompts for Focus Groups

We are going to ask you some questions about the FIT study you have been participating in over the last several weeks. When we say "FIT study" we mean the circuit that you did before school once a week, and at the beginning of PE. There are no right or wrong answers; we just want to know your thoughts. If you do not feel comfortable talking about any of the questions, you don't have to answer.

When you think about answering these questions, think about physical activity as any movement you do with your body that requires energy.

- Would you say you enjoy doing physical activity?
    a. Probe: Why? Why not? Some activities you enjoy and others you don't?

Now let's talk about the FIT Study.

- What were the parts you liked the most about the FIT study stations?
- What were the parts you didn't like about the FIT study stations?
- Was there a FIT study station that you liked most? Which one?
- How did you feel after completing all of the stations?
- If you could change something about the how the stations were set up, what would it be?
- Did you show your parents any of the exercises you did at the FIT Study Stations?
- Did you do any of the exercises we did during the FIT study at home?
- Do you think doing a burpee challenge with your parents be fun?

APPENDIX I

TEACHER INTERVIEW PROMPTS

Discussion Prompts for PE Teacher

- What did you like about implementing the FIT intervention?
- What didn't you like about implementing the FIT intervention?
- Did you come across any barriers to delivering the intervention?
- Is the FIT study circuit something you would implement into your regular PE classes? Would you change anything?
- Do you feel like you delivered the intervention as intended?
- Can you describe if there were any changes in your motivation to deliver the intervention in the beginning of the intervention vs. the end?
- How was delivering the before-school portion of the intervention?
- Are there any things you would change about the intervention if you were to use it in your classes?

APPENDIX J

PARTICIPANT DEMOGRAPHICS

1. How old are you? _____

2. Are you a boy or a girl?

   a. boy
   b. girl

3. What language do you use with your parents most of the time?

   a. English
   b. Spanish
   c. Other_____ (write in language)
   d. About the same in English and Spanish
   e. About the same in English and _____(write language)

4. How do you describe yourself?

   a. Black or African American
   b. Mexican American, Latino or Hispanic
   c. White, Caucasian or Anglo
   d. Vietnamese
   e. Chinese
   f. Indian or Pakistani
   g. Other Asian
   h. American Indian or Alaska Native
   i. Other (write in other)_____

5. Do you play any sports? Yes No

If yes, what sports?

_____
_____

APPENDIX K

PHYSICAL ACTIVITY ENJOYMENT

When I am physically active…

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
a. I feel bored	☐	☐	☐	☐
b. I dislike it	☐	☐	☐	☐
c. It makes me upset	☐	☐	☐	☐

APPENDIX L

SOCIAL SUPPORT QUESTIONS

How much do you agree with these statements?

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
a) My friends are active or play sports a lot				
b) My friends and I like to play sports or do active things together				

For these next questions, think about your parents. How much do you agree with these statements?

	Disagree a lot	Disagree a little	Agree a little	Agree a lot
a) My parents and I do active things together				
b) My parents sign me up for sports and take me to places where I can be physically active				

APPENDIX M

CSAPPA

Child Self-Perception of Adequacy and Predilection for PA Scale (CSAPPA)

WHAT'S MOST LIKE ME!!

INSTRUCTIONS:
In this survey you have to read a pair of sentences and then circle (○) the sentence you think is ***MORE LIKE YOU***.

Try the following example.

SAMPLE QUESTION

Some kids have one nose on their face!	**BUT**	**Other kids have three noses on their face!**

That shouldn't be too hard for you to decide! Once you have circled the sentence that is more like you, then you have to decide if it is ***REALLY TRUE*** for you or ***SORT OF TRUE*** for you.

Here is another sample question for you to try. Remember; first circle the sentence that is more like you and then put a check (✓) in the correct box if it is really true or only sort of true for you. THERE ARE NO RIGHT OR WRONG ANSWERS, JUST WHAT IS ***MOST LIKE YOU***.

SAMPLE QUESTION

REALLY TRUE for me	**SORT OF TRUE for me**			**SORT OF TRUE for me**	**REALLY TRUE for me**
❑	❑	Some kids like to play with computers .	**BUT**	other kids don't like playing with computers. ❑	❑

Now you are ready to start filling in this form. Take your time and do the whole form carefully. If you have any questions just ask! If you think you are ready you can start now. BE SURE TO FILL IN BOTH SIDES OF EACH PAGE!

REALLY TRUE for me	SORT OF TRUE for me				SORT OF TRUE for me	REALLY TRUE for me
❑	❑	Some kids can't wait to play active games after school.	**BUT**	Other kids would rather do something else.	❑	❑
❑	❑	Some kids really enjoy physical education class.	**BUT**	Other kids don't like physical education class.	❑	❑
❑	❑	Some kids don't like playing active games.	**BUT**	Other kids really like playing active games.	❑	❑
❑	❑	Some kids don't have much fun playing sports.	**BUT**	Other kids have a good time playing sports.	❑	❑
❑	❑	Some kids think physical education is the best class.	**BUT**	Other kids think physical education isn't much fun.	❑	❑
❑	❑	Some kids are good at active games.	**BUT**	Other kids find active games hard to play.	❑	❑
❑	❑	Some kids don't like playing sports.	**BUT**	Other kids really enjoy playing sports.	❑	❑
❑	❑	Some kids always hurt themselves when they play sports.	**BUT**	Other kids never hurt themselves playing sports.	❑	❑
❑	❑	Some kids like to play active games outside.	**BUT**	Other kids would rather read or play video games.	❑	❑
❑	❑	Some kids do well in most sports.	**BUT**	Other kids feel they aren't good at sports.	❑	❑
❑	❑	Some kids learn to play active games easily.	**BUT**	Other kids find it hard learning to play active Games.	❑	❑

REALLY TRUE for me	SORT OF TRUE for me				SORT OF TRUE for me	REALLY TRUE for me
❑	❑	Some kids think they are the best at sports.	**BUT**	Other kids think they aren't good at sports.	❑	❑
❑	❑	Some kids find games in physical education hard to play.	**BUT**	Other kids are good at games in physical education.	❑	❑
❑	❑	Some kids like to watch games being played outside.	**BUT**	Other kids would rather play active games outside.	❑	❑
❑	❑	Some kids are among the last to be chosen for active games.	**BUT**	Other kids are usually picked to play first.	❑	❑
❑	❑	Some kids like to take it easy during recess.	**BUT**	Other kids would rather play active games.	❑	❑
❑	❑	Some kids have fun in physical education class.	**BUT**	Other kids would rather miss physical education class.	❑	❑
❑	❑	Some kids aren't good enough for sports teams.	**BUT**	Other kids do well on sports teams.	❑	❑
❑	❑	Some kids like to read or play quiet games.	**BUT**	Other kids like to play active games.	❑	❑
❑	❑	Some kids like to play active games outside on weekends.	**BUT**	Other kids like to relax and watch TV on weekends.	❑	❑

THANK YOU VERY MUCH FOR COMPLETING THE CSAPPA SCALE! ☺

APPENDIX N

MOTOR SKILL TESTS

Horizontal Jump:

Skill	Directions	Performance Criteria
Horizontal Jump (Maximum Possible Score = 8)	1. Mark off a startling line on the floor. 2. Have the child start behind the line. 3. Tell the child to jump as far as he or she can. 4. Repeat steps 2 and 3.	✓ Preparatory movement includes flexion of both knees with arms extended behind body. ✓ Arms extend forcefully forward and upward reaching full extension above the head. ✓ Take off and land on both feet simultaneously. ✓ Arms are thrust downward during landing.

Hop:

Skill	Directions	Performance Criteria
Hop (Maximum Possible Score=10)	1. Tell the child to hope three times on his/her preferred foot (established before testing). 2. Then three times on the other foot. 3. Repeat a second trial.	✓ Nonsupport leg swings forward in pendular fashion to produce force. ✓ Foot of nonsupport's leg reminds behind body. ✓ Arms flex and swing forward to produce force. ✓ Takes off and lands three consecutive times on preferred foot. ✓ Take off and lands three consecutive times on nonpreferred foot.

Catch:

Skill	Directions	Performance Criteria
Catch (Maximum Possible Score=6)	1. Mark off two lines 15 feet apart. The child stands on one line and the tosser on the other. 2. Toss the ball underhand directly to the child with a slight arc aiming for his or her chest. 3. Tell the child to catch the ball with both hands. 4. Only count those tosses that are between the child's shoulders and belt. 5. Repeat a second trial.	✓ Preparation phase where hands are in front of the body and elbows are flexed. ✓ Arms extend while reaching for the ball as it arrives. ✓ Ball is caught by hands only.

Overhand Throw:

Skill	Directions	Performance Criteria
Overhand Throw (Maximum Possible Score=8)	1. Attach a piece of tape on the floor 20 feet from a wall. 2. Have the child stand behind the 20-foot line facing the wall. 3. Tell the child to throw the ball hard at the wall. 4. Repeat a second trial.	✓ Windup is initiated with downward movement of hand/arm. ✓ Rotates hip and shoulders to a point where the non-throwing side faces the wall. ✓ Weight is transferred by stepping with the foot opposite the throwing hand. ✓ Follow-through beyond ball release diagonally across the body toward the non-preferred side.

REFERENCES

1. Organization WH. Global Recommendations on Physical Activity for Health. Switzerland: WHO Press; 2010.

2. U.S. Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans Washington, D.C.2008 [cited 2008 March 6, 2009]. Available from: http://www.health.gov/paguidelines/pdf/paguide.pdf.

3. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc. 2008;40(1):181-8. doi: 10.1249/mss.0b013e31815a51b3. PubMed PMID: 18091006.

4. McMurray RG, Butte NF, Crouter SE, Trost SG, Pfeiffer KA, Bassett DR, et al. Exploring Metrics to Express Energy Expenditure of Physical Activity in Youth. Plos One. 2015;10(6):e0130869. doi: 10.1371/journal.pone.0130869. PubMed PMID: 26102204; PubMed Central PMCID: PMCPMC4477976.

5. Cohen KE, Morgan PJ, Plotnikoff RC, Barnett LM, Lubans DR. Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. J Sports Sci. 2015;33(18):1908-18. doi: 10.1080/02640414.2015.1017734. PubMed PMID: 25716899.

6. Ortega FB, Ruiz JR, Castillo MJ, Sjostrom M. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes (Lond). 2008;32(1):1-11. doi: 10.1038/sj.ijo.0803774. PubMed PMID: 18043605.

7. Ortega FB, Ruiz JR, Hurtig-Wennlof A, Vicente-Rodriguez G, Rizzo NS, Castillo MJ, et al. Cardiovascular fitness modifies the associations between physical activity and abdominal

adiposity in children and adolescents: the European Youth Heart Study. Br J Sports Med. 2010;44(4):256-62. doi: 10.1136/bjsm.2008.046391. PubMed PMID: 18463298.

8. U. S. Department of Health and Human Services. Healthy People 2000: National Health and Disease Prevention Objectives. Washington,DC1991. 91-125 p.

9. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. The International Journal of Behavioral Nutrition and Physical Activity. 2010;7:40. doi: 10.1186/1479-5868-7-40. PubMed PMID: 20459784; PubMed Central PMCID: PMCPMC2885312.

10. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. Quest. 2008;60(2):290-306. PubMed PMID: ISI:000255882500007.

11. Babic MJ, Morgan PJ, Plotnikoff RC, Lonsdale C, White RL, Lubans DR. Physical activity and physical self-concept in youth: systematic review and meta-analysis. Sports medicine (Auckland, NZ. 2014;44(11):1589-601. doi: 10.1007/s40279-014-0229-z. PubMed PMID: 25053012.

12. Raudsepp L, Liblik R. Relationship of perceived and actual motor competence in children. Percept Mot Skills. 2002;94(3 Pt 2):1059-70. doi: 10.2466/pms.2002.94.3c.1059. PubMed PMID: 12186225.

13. Rudd JR, Barnett LM, Butson ML, Farrow D, Berry J, Polman RC. Fundamental Movement Skills Are More than Run, Throw and Catch: The Role of Stability Skills. Plos One. 2015;10(10):e0140224. doi: 10.1371/journal.pone.0140224. PubMed PMID: 26468644; PubMed Central PMCID: PMCPMC4607429.

14. Haywood KM, Getchell LH. Lifespan motor development. 4th ed. ed. Champaign, IL: Human Kinetics; 2005.

15. Haga M. The relationship between physical fitness and motor competence in children. Child Care Health Dev. 2008;34(3):329-34. Epub 2008/04/16. doi: 10.1111/j.1365-2214.2008.00814.x. PubMed PMID: 18410639.

16. Behringer M, Vom Heede A, Matthews M, Mester J. Effects of strength training on motor performance skills in children and adolescents: a meta-analysis. Pediatr Exerc Sci. 2011;23(2):186-206. Epub 2011/06/03. PubMed PMID: 21633132.

17. Faigenbaum AD, Myer GD. Pediatric resistance training: benefits, concerns, and program design considerations. Curr Sports Med Rep. 2010;9(3):161-8. doi: 10.1249/JSR.0b013e3181de1214. PubMed PMID: 20463500.

18. Myer GD, Faigenbaum AD, Stracciolini A, Hewett TE, Micheli LJ, Best TM. Exercise deficit disorder in youth: a paradigm shift toward disease prevention and comprehensive care. Curr Sports Med Rep. 2013;12(4):248-55. doi: 10.1249/JSR.0b013e31829a74cd. PubMed PMID: 23851413; PubMed Central PMCID: PMCPMC4137789.

19. Malina R, Bouchard, C., Bar-Or, O. . Growth, maturation, and physical activity. 2nd ed.s ed. Champaign, IL: Human Kinetics; 2004.

20. Dobbins M, Husson H, DeCorby K, LaRocca RL. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. Cochrane database of systematic reviews (Online). 2013;2:CD007651. doi: 10.1002/14651858.CD007651.pub2. PubMed PMID: 23450577.

21. Kriemler S, Meyer U, Martin E, van Sluijs EM, Andersen LB, Martin BW. Effect of school-based interventions on physical activity and fitness in children and adolescents: a review of

reviews and systematic update. Br J Sports Med. 2011;45(11):923-30. doi: 10.1136/bjsports-2011-090186. PubMed PMID: 21836176; PubMed Central PMCID: PMCPMC3841814.

22. Faigenbaum AD, Farrell A, Fabiano M, Radler T, Naclerio F, Ratamess NA, et al. Effects of integrative neuromuscular training on fitness performance in children. Pediatr Exerc Sci. 2011;23(4):573-84. PubMed PMID: 22109781.

23. Faigenbaum AD, Myer GD, Farrell A, Radler T, Fabiano M, Kang J, et al. Integrative neuromuscular training and sex-specific fitness performance in 7-year-old children: an exploratory investigation. J Athl Train. 2014;49(2):145-53. doi: 10.4085/1062-6050-49.1.08. PubMed PMID: 24490841; PubMed Central PMCID: PMCPMC3975769.

24. Faigenbaum AD, Bush JA, McLoone RP, Kreckel MC, Farrell A, Ratamess NA, et al. Benefits of Strength and Skill-based Training During Primary School Physical Education. J Strength Cond Res. 2015;29(5):1255-62. doi: 10.1519/JSC.0000000000000812. PubMed PMID: 25536540.

25. Chiodera P, Volta E, Gobbi G, Milioli MA, Mirandola P, Bonetti A, et al. Specifically designed physical exercise programs improve children's motor abilities. Scand J Med Sci Sports. 2008;18(2):179-87. doi: 10.1111/j.1600-0838.2007.00682.x. PubMed PMID: 17490452.

26. Jones RA, Riethmuller A, Hesketh K, Trezise J, Batterham M, Okely AD. Promoting fundamental movement skill development and physical activity in early childhood settings: a cluster randomized controlled trial. Pediatr Exerc Sci. 2011;23(4):600-15. PubMed PMID: 22109783.

27. Bukowsky M, Faigenbaum AD, Myer GD. FUNdamental Integrative Training (FIT) for Physical Education. Journal of Physical Education, Recreation and Dance. 2014;85(6):23-30.

28. Lubans DR, Morgan PJ, Cliff DP, Barnett LM, Okely AD. Fundamental movement skills in children and adolescents: review of associated health benefits. Sports medicine (Auckland, NZ. 2010;40(12):1019-35. doi: 10.2165/11536850-000000000-00000. PubMed PMID: 21058749.

29. Myer GD, Faigenbaum AD, Chu DA, Falkel J, Ford KR, Best TM, et al. Integrative training for children and adolescents: techniques and practices for reducing sports-related injuries and enhancing athletic performance. Phys Sportsmed. 2011;39(1):74-84. doi: 10.3810/psm.2011.02.1864. PubMed PMID: 21378489.

30. Kumar S, Quinn SC, Kim KH, Musa D, Hilyard KM, Freimuth VS. The social ecological model as a framework for determinants of 2009 H1N1 influenza vaccine uptake in the United States. Health Educ Behav. 2012;39(2):229-43. Epub 2011/10/11. doi: 10.1177/1090198111415105. PubMed PMID: 21984692; PubMed Central PMCID: PMCPMC3916095.

31. Bandura A. Social Foundations of Thought and Action: A Social Cognitive Theory. Englewood Cliffs: Prentice Hall; 1986.

32. Faigenbaum AD, Farrell A, Fabiano M, Radler T, Naclerio F, Ratamess NA, et al. Effects of intergrative neuromuscular training on fitness performance in children. Pediatric Exercise Science. 2011;23(4):573-84.

33. Barnett LM, Lai SK, Veldman SLC, Hardy LL, Cliff DP, Morgan PJ, et al. Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis. Sports Med. 2016;46(11):1663-88. Epub 2016/02/20. doi: 10.1007/s40279-016-0495-z.

34. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Health. 2009;44(3):252-9. doi: 10.1016/j.jadohealth.2008.07.004. PubMed PMID: 19237111.

35. Troiano RP, Berrigan D, Dodd KW, Masse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medicine and Science in Sports and Exercise. 2008;40(1):181-8. doi: 10.1249/mss.0b013e31815a51b3. PubMed Central PMCID: PMC18091006.

36. Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. Pediatrics. 2006;118(6):e1758-65. doi: 10.1542/peds.2006-0742. PubMed PMID: 17142498.

37. Barnett TA, O'Loughlin JL, Gauvin L, Paradis G, Hanley J, McGrath JJ, et al. School opportunities and physical activity frequency in nine year old children. Int J Public Health. 2009;54(3):150-7. doi: 10.1007/s00038-009-7110-0. PubMed PMID: 19305948.

38. Hardy LL, Reinten-Reynolds T, Espinel P, Zask A, Okely AD. Prevalence and correlates of low fundamental movement skill competency in children. Pediatrics. 2012;130(2):e390-8. Epub 2012/07/25. doi: 10.1542/peds.2012-0345. PubMed PMID: 22826575.

39. Lopes VP, Rodrigues LP, Maia JA, Malina RM. Motor coordination as predictor of physical activity in childhood. Scand J Med Sci Sports. 2011;21(5):663-9. doi: 10.1111/j.1600-0838.2009.01027.x. PubMed PMID: 21917017.

40. Hardy LL, Barnett L, Espinel P, Okely AD. Thirteen-year trends in child and adolescent fundamental movement skills: 1997-2010. Med Sci Sports Exerc. 2013;45(10):1965-70. Epub 2013/09/21. doi: 10.1249/MSS.0b013e318295a9fc. PubMed PMID: 24048319.

41. Woodward-Lopez G, Kao J, Ritchie L. To what extent have sweetened beverages contributed to the obesity epidemic? Public health nutrition. 2011;14(3):499-509. doi: Doi 10.1017/S1368980010002375. PubMed PMID: ISI:000288050600015.

42. Webber LS, Catellier DJ, Lytle LA, Murray DM, Pratt CA, Young DR, et al. Promoting physical activity in middle school girls: Trial of activity for adolescent girls. American Journal of Preventive Medicine. 2008;34(3):173-84. doi: 10.1016/j.amepre.2007.11.018.

43. Ward DS, Saunders R, Felton GM, Williams E, Epping JN, Pate RR. Implementation of a school environment intervention to increase physical activity in high school girls. Health Education Research. 2006;21(6):896-910. doi: 10.1093/her/cyl134. PubMed PMID: 1710.

44. Sleap M, Warburton P. Physical activity levels of 5-11 year-old children in England: Cumulative evidence from three direct observation studies. International Journal of Sports Medicine. 1996;17(4):248-53. PubMed PMID: 1692.

45. Webber LS, Catellier DJ, Lytle LA, Murray DM, Pratt CA, Young DR, et al. Promoting physical activity in middle school girls: Trial of Activity for Adolescent Girls. Am J Prev Med. 2008;34(3):173-84. doi: 10.1016/j.amepre.2007.11.018. PubMed PMID: 18312804; PubMed Central PMCID: PMCPMC2275165.

46. Kerr J, Norman GJ, Sallis JF, Patrick K. Exercise aids, neighborhood safety, and physical activity in adolescents and parents. Medicine and Science in Sports and Exercise. 2008;40(7):1244-8. PubMed PMID: 18580403.

47. Heitzler CD, Levin Martin S, Duke J, Huhman M. Correlates of physical activity in a national sample of children aged 9-13 years. Preventive Medicine. 2006;42(4):254-60.

48. Becker MH. The Health belief model and personal health behavior. San Francisco: Society for Public Health Education; 1974. p. 324-511 p.

49. Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Psychol. 2001;52:1-26. PubMed PMID: 11148297.

50. Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. Am J Health Promot. 1997;12(1):38-48. PubMed PMID: 10170434.

51. Stodden D, Langendorfer S, Roberton MA. The association between motor skill competence and physical fitness in young adults. Res Q Exerc Sport. 2009;80(2):223-9. doi: 10.1080/02701367.2009.10599556. PubMed PMID: 19650387.

52. Pate RR, Trost SG, Mullis R, Sallis JF, Weschler H, Brown DR. Community interventions to promote proper nutrition and physical activity in youth. Preventive Medicine. 2000;in press. PubMed PMID: 550.

53. Morgan PJ, Barnett LM, Cliff DP, Okely AD, Scott HA, Cohen KE, et al. Fundamental movement skill interventions in youth: a systematic review and meta-analysis. Pediatrics. 2013;132(5):e1361-83. doi: 10.1542/peds.2013-1167. PubMed PMID: 24167179.

54. Fitzgibbon ML, Stolley MR, Dyer AR, VanHorn L, KauferChristoffel K. A community-based obesity prevention program for minority children: Rationale and study design for Hip-

Hop to Health Jr. Preventive Medicine. 2002;34(2):289-97. doi: DOI 10.1006/pmed.2001.0977. PubMed PMID: ISI:000173788200023.

55. Robinson TN, Matheson DM, Kraemer HC, Wilson DM, Obarzanek E, Thompson NS, et al. A randomized controlled trial of culturally tailored dance and reducing screen time to prevent weight gain in low-income african american girls: Stanford GEMS. Arch Pediat Adol Med. 2010;164(11):995-1004. doi: 10.1001/archpediatrics.2010.197.

56. Alhassan S, Sirard JR, Robinson TN. The effects of increasing outdoor play time on physical activity in Latino preschool children. Int J Pediatr Obes. 2007;2(3):153-8. doi: Doi 10.1080/17477160701520108. PubMed PMID: ISI:000249501100004.

57. Pate RR, Ward DS, Saunders RP, Felton G, Dishman RK, Dowda M. Promotion of physical activity among high-school girls: A randomized controlled trial. American Journal of Public Health. 2005;95(9):1582-7. PubMed PMID: 1404.

58. Stevens J, Murray DM, Catellier DJ, Hannan PJ, Lytle LA, Elder JP, et al. Design of the Trial of Activity in Adolescent Girls (TAAG). Contemporary Clinical Trials. 2005;26(2):223-33. PubMed PMID: 1667.

59. Wright MD, Portas MD, Evans VJ, Weston M. The effectiveness of 4 weeks of fundamental movement training on functional movement screen and physiological performance in physically active children. J Strength Cond Res. 2015;29(1):254-61. doi: 10.1519/JSC.0000000000000602. PubMed PMID: 25072666.

60. Lai SK, Costigan SA, Morgan PJ, Lubans DR, Stodden DF, Salmon J, et al. Do School-Based Interventions Focusing on Physical Activity, Fitness, or Fundamental Movement Skill Comptency Produce a Sustained Impact in These Outcomes in Children and Adolescents? A Systematic Review of Follow-Up Studies. Sports medicine (Auckland, NZ. 2014;44:67-79. doi: 10.1007/s40279-013-0099-9.

61. Logan SW, Robinson LE, Wilson AE, Lucas WA. Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. Child Care Health Dev. 2012;38(3):305-15. doi: 10.1111/j.1365-2214.2011.01307.x. PubMed PMID: 21880055.

62. Riethmuller AM, Jones R, Okely AD. Efficacy of interventions to improve motor development in young children: a systematic review. Pediatrics. 2009;124(4):e782-92. doi: 10.1542/peds.2009-0333. PubMed PMID: 19736263.

63. Robinson LE, Stodden DF, Barnett LM, Lopes VP, Logan SW, Rodrigues LP, et al. Motor Competence and its Effect on Positive Developmental Trajectories of Health. Sports medicine (Auckland, NZ. 2015;45(9):1273-84. doi: 10.1007/s40279-015-0351-6. PubMed PMID: 26201678.

64. Hardy LL, O'Hara BJ, Rogers K, St George A, Bauman A. Contribution of organized and nonorganized activity to children's motor skills and fitness. J Sch Health. 2014;84(11):690-6. Epub 2014/10/03. doi: 10.1111/josh.12202. PubMed PMID: 25274168.

65. Lonsdale C, Rosenkranz RR, Sanders T, Peralta LR, Bennie A, Jackson B, et al. A cluster randomized controlled trial of strategies to increase adolescents' physical activity and motivation in physical education: results of the Motivating Active Learning in Physical Education (MALP) trial. Prev Med. 2013;57(5):696-702. Epub 2013/09/17. doi: 10.1016/j.ypmed.2013.09.003. PubMed PMID: 24035889.

66. Barnett TA, Gauvin L, Craig C, Katzmarzyk PT. Distinct trajectories of leisure time physical activity and predictors of trajectory class membership: A 22 year cohort study. International Journal of Behavioral Nutrition and Physical Activity. 2008;5(57):doi:10.1186/479-5868-5-57.

67. Dobbins M, De Corby K, Robeson P, Husson H, Tirilis D. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6-18. Cochrane Database Syst Rev. 2009;(1):CD007651. Epub 2009/01/23. doi: 10.1002/14651858.CD007651. PubMed PMID: 19160341.

68. Gallahue DL, Ozmun JC, Goodway J. Understanding Motor Development: Infants, Children, Adolescents, Adults2006.

69. Erwin HE. Test-Retest Reliability of a Preadolescent Environmental Access to Physical Activity Questionnaire. Journal of physical activity & health. 2008;5:S62-S72.

70. Barbeau P, Johnson MH, Howe CA, Allison J, Davis CL, Gutin B, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. Obesity (Silver Spring). 2007;15(8):2077-85. Epub 2007/08/23. doi: 10.1038/oby.2007.247. PubMed PMID: 17712126.

71. Cohen KE, Morgan PJ, Plotnikoff RC, Callister R, Lubans DR. Physical activity and skills intervention: SCORES cluster randomized controlled trial. Med Sci Sports Exerc. 2015;47(4):765-74. Epub 2014/07/23. doi: 10.1249/MSS.0000000000000452. PubMed PMID: 25051389.

72. Eather N, Morgan PJ, Lubans DR. Improving the fitness and physical activity levels of primary school children: results of the Fit-4-Fun group randomized controlled trial. Prev Med. 2013;56(1):12-9. Epub 2012/10/31. doi: 10.1016/j.ypmed.2012.10.019. PubMed PMID: 23107669.

73. Kriemler S, Zahner L, Schindler C, Meyer U, Hartmann T, Hebestreit H, et al. Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial. BMJ. 2010;340:c785. Epub 2010/02/25. doi: 10.1136/bmj.c785. PubMed PMID: 20179126; PubMed Central PMCID: PMCPMC2827713.

74. Sallis JF, McKenzie TL, Alcaraz JE, Kolody B, Faucette N, Hovell MF. The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. American Journal of Public Health. 1997;87(8):1328-34. PubMed PMID: 242.

75. van Beurden E, Barnett LM, Zask A, Dietrich UC, Brooks LO, Beard J. Can we skill and activate children through primary school physical education lessons? "Move it Groove it"--a collaborative health promotion intervention. Prev Med. 2003;36(4):493-501. Epub 2003/03/22. PubMed PMID: 12649058.

76. Pate RR, Ross JG. National Children and Youth Fitness Study II: Factors associated with health-related fitness. Journal of Physical Education, Recreation and Dance. 1987;Nov/Dec. PubMed PMID: 577.

77. Pate RR, Ross JG, Baumgartner TA, Sparks RE. National Children and Youth Fitness Study II: The modified pull-up test. Journal of Physical Education, Recreation and Dance. 1987;Nov/Dec. PubMed PMID: 576.

78. Ross JG, Pate RR, Capersen CJ, et al. The National Children and Youth Fitness Study II: Home and community in children's exercise habits. Journal of Physical Education, Recreation and Dance. 1987;58:85-92. PubMed PMID: 879.

79. Ross JG, Pate RR. National Children and Youth Study II: Summary of findings. Journal of Physical Education, Recreation and Dance. 1987;Nov/Dec. PubMed PMID: 575.

80. Silva P, Lott R, Mota J, Welk G. Direct and indirect effects of social support on youth physical activity behavior. Pediatr Exerc Sci. 2014;26(1):86-94. doi: 10.1123/pes.2012-0207. PubMed PMID: 24018255.

81. Welk GJ, Going SB, Morrow JR, Jr., Meredith MD. Development of new criterion-referenced fitness standards in the FITNESSGRAM(R) program: rationale and conceptual overview. Am J Prev Med. 2011;41(4 Suppl 2):S63-7. Epub 2011/10/14. doi: 10.1016/j.amepre.2011.07.012. PubMed PMID: 21961614.

82. Morrow JR, Jr., Martin SB, Jackson AW. Reliability and validity of the FITNESSGRAM: quality of teacher-collected health-related fitness surveillance data. Res Q Exerc Sport. 2010;81(3 Suppl):S24-30. Epub 2010/11/06. doi: 10.1080/02701367.2010.10599691. PubMed PMID: 21049835.

83. Ulrich DA. Test of gross motor development-2. Austin: Prod-Ed. 2000.

84. Evenson KR, Terry JW, Jr. Assessment of differing definitions of accelerometer nonwear time. Res Q Exerc Sport. 2009;80(2):355-62. doi: 10.1080/02701367.2009.10599570. PubMed PMID: 19650401; PubMed Central PMCID: PMCPMC3321743.

85. Choi L, Liu Z, Matthews CE, Buchowski MS. Validation of accelerometer wear and nonwear time classification algorithm. Med Sci Sports Exerc. 2011;43(2):357-64. doi:

10.1249/MSS.0b013e3181ed61a3. PubMed PMID: 20581716; PubMed Central PMCID: PMCPMC3184184.

86. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. J Sports Sci. 2008;26(14):1557-65. doi: 10.1080/02640410802334196. PubMed PMID: 18949660.

87. Hay J. Adequacy in and predilection for physical activity in children. Clinical Journal of Sports Medicine. 1992;2:192-201.

88. Faught BE, Hay JA, Cairney J, Flouris A. Increased risk for coronary vascular disease in children with developmental coordination disorder. J Adolesc Health. 2005;37(5):376-80. doi: 10.1016/j.jadohealth.2004.09.021. PubMed PMID: 16227122.

89. Klentrou P, Hay J, Plyley M. Habitual physical activity levels and health outcomes of Ontario youth. Eur J Appl Physiol. 2003;89(5):460-5. doi: 10.1007/s00421-003-0814-6. PubMed PMID: 12684807.

90. Visser J. Developmental coordination disorder: A review of research on subtypes and co-morbidities. Human Movement Science. 2003;22:479-93.

91. Hay J. Benefits to physical activity of integrating learning disabled children into the classroom. Pediatr Exerc Sci. 1999;11:273.

92. Motl RW, Dishman RK, Saunders R, Dowda M, Felton G, Pate RR. Measuring enjoyment of physical activity in adolescent girls. American Journal of Preventive Medicine.1-31.

93. Motl RW, Dishman RK, Saunders R, Dowda M, Felton G, Pate RR. Measuring enjoyment of physical activity in adolescent girls. American Journal of Preventive Medicine. 2001;21(2):110-7.

94. Dishman RK, Motl RW, Saunders R, Felton G, Ward DS, Dowda M, et al. Enjoyment mediates effects of a school-based physical-activity intervention. Med Sci Sports Exerc. 2005;37(3):478-87. PubMed PMID: 15741848.

95. Sallis JF, Prochaska JJ, Taylor WC. A review of correlates of physical activity of children and adolescents. Medicine and Science in Sports and Exercise. 2000;32(5):963-75. PubMed PMID: 567.

96. Hayes RJ, Moulton LH. Cluster Randomised Trials, Second Edition. New York: Chapman and Hall/CRC; 2017. 424 p.

97. Hallal PC, Bertoldi AD, Goncalves H, Victora CG. [Prevalence of sedentary lifestyle and associated factors in adolescents 10 to 12 years of age]. CadSaude Publica. 2006;22(6):1277-87. PubMed PMID: 1627.

98. Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A, et al. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. JAMA. 2012;307(7):704-12. Epub 2012/02/18. doi: 10.1001/jama.2012.156. PubMed PMID: 22337681; PubMed Central PMCID: PMCPMC3793121.

99. Naylor PJ, Nettlefold L, Race D, Hoy C, Ashe MC, Wharf Higgins J, et al. Implementation of school based physical activity interventions: a systematic review. Prev Med. 2015;72:95-115. Epub 2015/01/13. doi: 10.1016/j.ypmed.2014.12.034. PubMed PMID: 25575800.

100. Newland B, Dixon MA, Green BC. Engaging children through sport: examining the disconnect between program vision and implementation. J Phys Act Health. 2013;10(6):805-12. Epub 2012/10/18. PubMed PMID: 23074153.

101. Durlak JA, DuPre EP. Implementation matters: a review of research on the influence of implementation on program outcomes and the factors affecting implementation. Am J

Community Psychol. 2008;41(3-4):327-50. Epub 2008/03/07. doi: 10.1007/s10464-008-9165-0. PubMed PMID: 18322790.

102. Saunders RP, Evans MH, Joshi P. Developing a process-evaluation plan for assessing health promotion program implementation: a how-to guide. Health Promot Pract. 2005;6(2):134-47. Epub 2005/04/28. doi: 10.1177/1524839904273387. PubMed PMID: 15855283.

103. Cooper AR, Goodman A, Page AS, Sherar LB, Esliger DW, van Sluijs EM, et al. Objectively measured physical activity and sedentary time in youth: the International children's accelerometry database (ICAD). Int J Behav Nutr Phys Act. 2015;12:113. Epub 2015/09/18. doi: 10.1186/s12966-015-0274-5. PubMed PMID: 26377803; PubMed Central PMCID: PMCPMC4574095.

104. Zahner L, Puder JJ, Roth R, Schmid M, Guldimann R, Puhse U, et al. A school-based physical activity program to improve health and fitness in children aged 6-13 years ("Kinder-Sportstudie KISS"): study design of a randomized controlled trial [ISRCTN15360785]. BMC Public Health. 2006;6:147. Epub 2006/06/08. doi: 10.1186/1471-2458-6-147. PubMed PMID: 16756652; PubMed Central PMCID: PMCPMC1513202.

105. Hulteen RM, Morgan PJ, Barnett LM, Stodden DF, Lubans DR. Development of Foundational Movement Skills: A Conceptual Model for Physical Activity Across the Lifespan. Sports Med. 2018;48(7):1533-40. Epub 2018/03/11. doi: 10.1007/s40279-018-0892-6. PubMed PMID: 29524160.

106. Lonsdale C, Rosenkranz RR, Peralta LR, Bennie A, Fahey P, Lubans DR. A systematic review and meta-analysis of interventions designed to increase moderate-to-vigorous physical activity in school physical education lessons. Prev Med. 2013;56(2):152-61. Epub 2012/12/19. doi: 10.1016/j.ypmed.2012.12.004. PubMed PMID: 23246641.

107. Okely AD, Booth ML, Patterson JW. Relationship of physical activity to fundamental movement skills among adolescents. Med Sci Sports Exerc. 2001;33(11):1899-904. PubMed PMID: 11689741.

108. McAuley E, Blissmer B. Self-efficacy determinants and consequences of physical activity. Exerc Sport Sci Rev. 2000;28(2):85-8. Epub 2000/07/21. PubMed PMID: 10902091.

109. Calfas KJ, Sallis JF, Oldenburg B, Ffrench M. Mediators of change in physical activity following an intervention in primary care: PACE. Prev Med. 1997;26(3):297-304. Epub 1997/05/01. doi: 10.1006/pmed.1997.0141. PubMed PMID: 9144753.

110. Lewis BA, Marcus BH, Pate RR, Dunn AL. Psychosocial mediators of physical activity behavior among adults and children. Am J Prev Med. 2002;23(2 Suppl):26-35. Epub 2002/07/23. PubMed PMID: 12133735.

111. DeMattia L, Lemont L, Meurer L. Do interventions to limit sedentary behaviours change behaviour and reduce childhood obesity? A critical review of the literature. Obes Rev. 2007;8(1):69-81. Epub 2007/01/11. doi: 10.1111/j.1467-789X.2006.00259.x. PubMed PMID: 17212797.

112. Wagner A, Dallongeville J, Haas B, Ruidavets JB, Amouyel P, Ferrieres J, et al. Sedentary behaviour, physical activity and dietary patterns are independently associated with the metabolic syndrome. Diabetes Metab. 2012;38(5):428-35. Epub 2012/06/23. doi: 10.1016/j.diabet.2012.04.005. PubMed PMID: 22721723.