"A"-KIDS: Activity Kcal Intervention Daily Study. Effects of 100-Kcal Daily Energy Expenditure on Total Moderate-to-Vigorous Physical Activity in 3rd Grade Children

"A"-KIDS: ACTIVITY KCAL INTERVENTION DAILY STUDY EFFECTS OF 100-KCAL DAILY ENERGY EXPENDITURE ON TOTAL MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY IN 3RD GRADE CHILDREN

A Dissertation Presented

by

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DEDICATION

I dedicate this dissertation to a man who has always inspired me with his love for life including all its triumphs and its trials. My father, Brian A. Cook, taught me to always dream big *and* to never give up on those dreams. I will forever cherish his love.

I would also like to dedicate this dissertation to my mother, Dora E. Cook, and my daughter, Amy E. Howe; two people who stood by me throughout this journey as my personal cheerleaders. I thank them both for their many, many words of encouragement.

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ABSTRACT

"A"-KIDS: ACTIVITY KCAL INTERVENTION DAILY STUDY EFFECTS OF 100-KCAL DAILY ENERGY EXPENDITURE ON TOTAL MODERATE-TO-VIGOROUS PHYSICAL ACTIVITY IN 3RD GRADE CHILDREN

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A selection of common children's games were measured in a laboratory-based study to be enjoyable and to elicit sufficient physical activity energy expenditure (PAEE) in 3rd grade children to combat the purported chronic energy surplus of childhood obesity (~100 $kcal \cdot day^{-1}$). PAEE during the games was similar for boys and girls, yet overweight children expended greater PAEE relative to body weight than healthy weight children. During a subsequent simulated recess program, the enjoyment declined over the 10-session program with no significant decline in PAEE. Using the enjoyable games of known energy cost in a structured recess program for 9 weeks successfully increased total daily PA compared to the control school who reported substantially greater amount of free-play time. The greater amount of acquired PA in the intervention school children did not affect the amount of time spent in sedentary pursuits but it did result in a smaller

increase in body weight after 9 weeks. More research is needed to expand on this initial list of games that reduce the excessive weight gain in children when incorporated into a structured recess intervention.

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1. **Body Mass Index (BMI):** body mass (kg) divided by height (m^2).
2. **Physical Activity (PA):** Any bodily movement produced by the contraction of skeletal muscle that increases energy expenditure above resting values (6, 21).
3. **Oxygen Consumption (VO_2):** the difference between the volume of oxygen inspired and expired. This is an indirect measured of metabolism in that increased VO_2 represents an increase in energy metabolism.
4. **Carbon Dioxide Production (VCO_2):** the difference between the volume of carbon dioxide expired and inspired. This is an indirect measured of metabolism in that increased VCO_2 represents increased energy metabolism.
5. **Resting metabolic rate (RMR):** the amount of energy required to sustain vital organs while resting in a supine position in a temperature-controlled, quiet room without digestive activity and in a relaxed, non-stressful state.
6. **Metabolic Equivalents (METs):** the measured VO_2 of a person while at complete rest representing the individual's RMR (1 MET ~3.5 $ml \cdot kg \cdot min^{-1}$). The MET value of an activity is expressed as multiples of RMR to classify the physical activity intensity according to the oxygen requirements.
7. **Physical Activity Energy Expenditure (PAEE):** the amount of energy expended for physical activity above resting metabolism.

8. **Sedentary Behavior (SB):** PA that results in an energy expenditure of ≤1.5 METs. Sedentary behavior is typically associated with time spent sitting, reclining, or lying down during waking hours.
9. **Moderate-to-Vigorous PA (MVPA):** Physical activity of sufficient intensity to elicit a PAEE ≥4 METs.
10. **Light Physical Activity (LPA):** PAEE >1.5 and <4 METs.
11. **Moderate Physical Activity (MPA):** PAEE ≥4 METs and <7 METs.
12. **Vigorous Physical Activity (VPA):** PAEE >7 METs and <10 METs.
13. **Very Vigorous Physical Activity (VVPA):** PAEE >10 METs.
14. **Facial Affective Scale (FAS):** a 9-point Likert scale of facial expressions ranging from crying to happy.(Appendix A)

CHAPTER I

INTRODUCTION

Development of the problem

The prevalence of overweight or obesity (body mass index, BMI ≥85th percentile) in children 6 - 11 year has more than tripled over the past three decades with the average weight for this age group increasing +0.43 kg annually (69, 152). Children classified as either overweight or obese (OW, to be used interchangeably from this point forward) according to the Center for Disease Control (CDC) age- and sex-specific growth charts, have obesity-related risk factors for cardiovascular disease (CVD); 25% have ≥2 risk CVD factors (30, 43). U.S. children born in the year 2000 have a 30 - 40 % risk of being diagnosed with type 2 diabetes mellitus in their lifetime (41). This evidence has pushed the prevention of childhood obesity to the forefront of today's scientific research.

Increased sedentary behavior (SB) and/or the lack of physical activity (PA) are linked to adverse health outcomes. A recent national survey provides the first objective measure of the amount of time children spend in sedentary pursuits with the majority of their waking hours determined to be physically inactive (75, 129). The amount of time children spend in SB (e.g. in the classroom, watching television, or playing video games) is independent of the amount of time spent being physically active and total daily PA energy expenditure (PAEE), and thus, is independently associated with increased risk for obesity and obesity-related health consequences (17, 37, 75, 104, 140). These findings are further highlighted by that fact that obese children have a preference for SB and spend

more time being physically inactive than their non-obese peers (37, 38, 135, 150).

Research studies have shown childhood obesity equates to as little as a +2% imbalance between daily energy intake and EE (47). This small positive imbalance can be abated with approximately 100 – 165 kcal of additional daily EE through increased PA and reduced SB (36, 60, 101, 152). The most recent PA guidelines published by the U.S. Department of Health and Human Services (2008) recommend that children acquire a minimum of 60 min of daily moderate to vigorous PA (MVPA) and limit the amount of time spent in SB to yield beneficial health outcomes (1, 134). These guidelines also recommend this 60 min include vigorous PA for adequate EE to promote healthy changes in BMI (1). Although no large-scale studies have shown that children are meeting these requirements, it has been reported that 1) boys are more active than girls, 2) (HW, BMI <85th percentile) children are more active than their OW counterparts, and 3) children spend the majority of their day in SB (75, 119, 133, 143). However, it is unknown if these group differences are also observed in the energy cost of children's free-play PA. There is a lack of empirical evidence of the energy cost of children's free-play PAEE to support that the dose recommended in the guidelines is sufficient to correct for the energy surplus in all children.

To quantify the energy cost of children's PA, researchers have used measurements of oxygen consumption (VO_2) and carbon dioxide production (VCO_2) to determine PAEE via indirect calorimetry (44, 96, 142, 147). Puyau et

al. used a room indirect calorimeter to measure PAEE during a wide range of activities from video games (0.03 ± 0.01 $kcal \cdot kg^{-1} \cdot min^{-1}$) to treadmill running (0.15 ± 0.03 $kcal \cdot kg^{-1} \cdot min^{-1}$) (96). Although the room calorimeter allows for free-living movements, these movements are restricted to a confined space which could potentially hinder a child's natural movement patterns during free-play. Recently our laboratory measured PAEE in children (n = 18; mean age = 8.6 y) while participating in common children's activities (e.g. jump rope, ball games, and dance-dance revolution) using a portable metabolic analyzer. The portable unit allowed for freedom of movement during play while accurately measuring PAEE via indirect calorimetry. The average PAEE for these activities was 3.46 $kcal \cdot min^{-1}$ (Table 1). At this rate of PAEE, playing these games for 30 $min \cdot day^{-1}$, half of the recommended dose in the PA guidelines for children, may be sufficient to correct for the 100 $kcal \cdot day^{-1}$ energy surplus related to childhood obesity. However, these activities/games were measured in a laboratory setting and may not translate to the same energy cost when played in a free-living environment.

As a means of promoting a healthy age-related increase in BMI, previous school-based PA interventions have been implemented in attempts to increase children's participation in MVPA to correct for this chronic imbalance (54-56). Numerous small- and large-scale interventions have targeted various periods within the school day, such as physical education (PE) class, in the classroom, afterschool and during recess, with mix results. Several intervention studies have successfully increased PA during the school day (29, 32, 42, 72, 92, 101, 108, 117, 122, 151, 153, 157) but few studies have measured and reported a

subsequent increase in total daily PA in response to these interventions (29, 38, 92). However, these PA interventions have failed to accurately measure PA intensity and EE to establish empirical evidence of the PA dose required to curb this excess weight gain in children (27, 72, 92, 94). The lack of success of previous PA interventions has been attributed, in part, to the inaccurate measures of the PA dose of the intervention. Direct observation, accelerometry and heart rate monitors have been used to estimate PAEE during PA in children. Although these methods have been validated for estimating PAEE (79, 136, 141, 144), they are problematic. Heart rate monitors have been shown to be sensitive to factors unrelated to PA as well as to the fitness level of the child (35, 71). Direct observation is limited to group assessments of PA levels (23, 81-84). Activity monitors, such as pedometers and accelerometers, convert a physical measure of steps or counts to a physiological measure of EE using prediction equations that have yet to accurately assess PAEE in children (44, 96, 142, 146). The magnitude of the estimation errors associated with these methods results in errors estimating the PA dose offered by interventions and thereby limits the ability to determine the PA dose required to close the chronic energy gap and impact childhood obesity. Therefore, implementing a PA intervention using enjoyable children's games directly measured to cost ≥100 kcal in 30 min (≥3.3 $kcal \cdot min^{-1}$) in a free-living environment may increase total daily PAEE and thus, slow the age-related increases in BMI of elementary school children by correcting the chronic daily energy imbalance.

Aims of Dissertation Studies

Study 1: Energy Expenditure Measurements for Childhood Activities.

Previous PA intervention research in children have either not measured PA dose (27, 32, 97) or have not accurately assessed PAEE to determine the true relationship between PAEE and BMI (32, 72, 92). Understanding this dose-response relationship between PA and BMI in children will allow for the development of effective school-based PA interventions (34). These interventions should include games chosen on the basis of the energy cost of the game, feasibility of performing the activity in the school environment, and enjoyment of the activity by the children to ensure adequate participation (63, 108). Therefore, the purpose of study one was to accurately measure the PAEE of common children's games in a laboratory setting to determine which games were enjoyable and elicited adequate PAEE (100 $kcal \cdot 30\text{-}min^{-1}$) to be included in a subsequent school-based PA intervention. An initial list of 60 games was established by knowledgeable personnel with extensive experience in teaching PE in 3rd grade children. A focus group of 10 PE teachers assisted in narrowing this list to a selection of 30 games that were measured in this study. PAEE was measured using a portable metabolic unit. The children's perceived enjoyment of the activity was recorded based on a 9-point Likert scale (Facial Affective Scale, FAS; Appendix A). This study determined if the selected and measured games elicited ≥100 $kcal \cdot 30min^{-1}$ PAEE, were enjoyable and were feasible to perform within an elementary school setting.

1. ***Specific Aim:*** Established a menu of enjoyable children's games that elicited ≥100 kcal PAEE above rest (≥3.3 $kcal \cdot min^{-1}$) in 30 min of participation in a laboratory setting.

   a. ***Hypothesis:*** We would be successful in selecting games that were enjoyable and elicited ≥3.3 $kcal \cdot min^{-1}$ regardless of sex or BMI.

   b. ***Hypothesis:*** We hypothesized that boys and HW children would expend more PAEE than girls and OW children during these selected games.

   c. Hypothesis: We further hypothesized that perceived enjoyment of the games would be positively associated with PAEE.

Study 2: Measurement of Free-living Physical Activity Energy Expenditure

Previous PA interventions have been unable to demonstrate a consistent positive effect on childhood obesity. This lack of effectiveness could be due to inadequate measures of PAEE during the interventions (130). Limited research has assessed the energy cost of PA in children and no data is available on the energy cost of common children's games in a free-play environment during interventions over time. Therefore, the purpose of study two was to accurately assess the PAEE and the enjoyment of selected games in a free-living school setting and to determine if PAEE and enjoyment would change over time. Third grade children were asked to participate in a 10-session PA intervention utilizing a subset of six games that were measured to be enjoyable and to elicit ≥100 kcal in 30 min (≥3.3 $kcal \cdot min^{-1}$) in study one. The subset of games represented the range of energy cost and a variety of game mechanics. All the children, selected

from a single 3rd grade classroom, participated in the games as a group in a large gymnasium. One child each session was asked to wear the portable metabolic unit to measure PAEE during the games. All the children wore an activity monitor during each session to assess the PA counts for each game. Following each game all of the children were asked to report their perceived enjoyment of the game using individual FAS score cards.

2. ***Specific Aim:*** To determine if children's games would elicit ≥100 $kcal \cdot 30\text{-}min^{-1}$ PAEE (≥3.3 $kcal \cdot min^{-1}$) in a realistic recess environment and to determine if PAEE would change over time.
    a. ***Hypothesis:*** We hypothesized that the selected games would elicit the same PAEE (≥3.3 $kcal \cdot min^{-1}$) in a free-living environment as in the laboratory-based study.
    b. ***Hypothesis:*** We further hypothesized that OW children and girls would expend less PAEE than HW children and boys.
3. ***Specific Aim:*** To assess the perceived enjoyment of selected games by 3rd grade children when played in a realistic recess environment and to determine if perceived enjoyment would change over time.
    a. ***Hypothesis:*** PAEE would be positively related to perceived enjoyment of the activity in that those games scored highest for enjoyment would elicit the highest PAEE.
    b. ***Hypothesis:*** Enjoyment would decrease during the 10 sessions.
4. ***Specific Aim:*** To develop accelerometer count values for a subset of children's games with corresponding physiological measures of PAEE to

be used for estimating PAEE in the subsequent school-based PA interventions where direct measures of PAEE are not feasible.

a. ***Hypothesis:*** We hypothesized that the activity counts from the accelerometer would be highly correlated with measures of PAEE during the games.

b. ***Hypothesis:*** We hypothesized that the relationship between PAEE and activity counts would be similar for the children wearing the metabolic analyzer and for those not wearing the analyzer.

Study 3: School-based PA intervention.

The school setting, a place where children spend most of their day, has become increasingly sedentary with the reduction or elimination of opportunities for PA, such as PE and recess, in order to spend more time on core academics (2, 5). School-based PA interventions have been shown to successfully increase children's PA during the school day (130). However, children have been reported to compensate for this increase in PA during the school day by reducing their PA level and increase SB outside of school (8, 29, 74). Still other studies have shown that increasing PA during the school day leads to an increase daily PA levels (29, 38, 92). Therefore, the purpose of study three was to compare the effects of a structured 100-kcal·day^{-1} recess intervention to that of a 30-min free-play recess on changes in total daily MVPA and SB in 3rd grade children. The intervention was incorporated into the daily school schedule for a period of 9 weeks during the school year. Physical measures, including height, weight, waist circumference and resting blood pressure and heart rate, were measure before

the program started and during the final week of the study. The children were asked to wear an accelerometer for 7 days prior to the intervention and during the final week of the program to determine the changes in MVPA and SB in both school conditions. The classroom teachers from both schools were asked to complete a PA calendar recording all PA opportunities during one randomly selected week during the study. The children from the intervention and control schools were also asked to wear the accelerometer randomly throughout the program to assess differences in PAEE during recess between school conditions.

5. ***Specific Aim:*** Examined the effects of a structured daily PA intervention on total MVPA in 3rd grade children compared to 30 min of free-play recess in the control school.
    a. ***Hypothesis:*** The 30-min structured recess intervention would increase total daily minutes of MVPA compared to no change in the control school.
    b. ***Hypothesis:*** The increase in total daily minutes of MVPA would be higher for boys and HW children compared to girls and OW children.
6. ***Specific Aim:*** Examined the effects of the structured PA intervention on time spent in SB compared to the 30-min free-play recess control.
    a. ***Hypothesis:*** The 30-min structured recess intervention would decrease total daily minutes of SB compared to the control school.
7. ***Specific Aim:*** Assessed the changes in BMI associated with changes in MVPA in 3rd grade children compared to the control school.

a. ***Hypothesis:*** We hypothesized that a dose-relationship would exist between MVPA and BMI changes. The children with greater increases in MVPA in the intervention school would demonstrate smaller changes in BMI.

Summary of Dissertation Studies

Study 1: Energy Expenditure Measurements for Childhood Activities.

A menu of children's games would be established that resulted in ≥100 kcal of PAEE in 30 min of participation (≥3.3 $kcal \cdot min^{-1}$) and were enjoyable for children across sex and BMI classification in a laboratory setting. It was hypothesized that there would be a positive relationship between PAEE and enjoyment where the games that scored lowest on the FAS would elicit the lowest PAEE. It was further hypothesized that BMI and PAEE would be negatively associated and that boys would elicit greater PAEE than girls.

Study 2: Measurement of Free-living Physical Activity Energy Expenditure

Although the average PAEE would remain ≥3.3 $kcal \cdot min^{-1}$ as measured in the laboratory-based study, it was hypothesized that PAEE and enjoyment would decrease over the 10 sessions when the games were played among a group of peers within a free-living school recess setting. It was hypothesized that PAEE would be positively related to FAS where the games that scored lowest for enjoyment would elicit lower PAEE than those that scored higher for enjoyment. It was further hypothesized that BMI would be negatively associated with PAEE and that boys would expend more energy during the game than girls.

Study 3: School-based PA intervention.

It was hypothesized that 3rd grade children who were exposed to the structured recess intervention would increase the amount of time spent in MVPA resulting in a PAEE ≥100kcal·day^{-1} compared to the children who were provided a free-play recess of the same duration. It was further hypothesized that within the intervention school there would exist a negative relationship between the amount of change in MVPA and change in BMI in that greater changes in daily MVPA would correspond with smaller changes in BMI with a reduction in the incidence of obesity.

Table 1. Activity net Kcaloric expenditure of various activities (unpublished data)

Activity	Net Kcal·min^{-1} Mean (SD)	Range	Net Kcal·15min^{-1} Mean
Brisk Walking (n=6)	2.7 (0.8)	1.9 - 3.8	40.5
Exercise Routine (n=5)	3.8 (1.1)	2.4 - 5.6	57.0
Walking w/ activities (n=8)	2.8 (0.8)	1.9 - 3.7	42.0
Ball Games (n=5)	4.4 (1.4)	2.7 - 7.0	66.0
Dance-Dance Revolution (n=4)	3.1 (0.7)	2.4 - 4.1	46.5

Net Kcal·min^{-1} equals total energy expnediture minus measured resting metabolic rate. Net Kcal·15min^{-1} is the perminute new value multiplied by 15 minutes.

CHAPTER II

LITERATURE REVIEW

Introduction

Because children grow from birth to adulthood and this rate of growth is different between boys and girls, the CDC has developed sex- and age-specific BMI growth charts where BMI ≥85th but <95th percentile is defined as "*OW*" and a BMI ≥95th percentile is defined as "*obese*" (71, 90). Based on these definitions, the prevalence of OW in children 6 – 11 year has more than tripled over the past three decades (152). National survey data of 2003 – 2004 reported that overall 33.6% of youth (2 – 19 y) were classified as OW with a greater incidence in minority children (Mexican-American, 37.0 ± 2.1 and African-American, 35.1 ± 2.1%) compared to white children (33.5 ± 2.3%) (89, 90). Regardless of race and ethnicity, obesity is known to lead to health consequences which until recently were reserved for the adult population. Non-insulin dependent diabetes mellitus (Type 2), once a rare diagnosis in youth, has become increasingly common in children with as many as 45% of the new cases of pediatric diabetes classified as Type 2 (30, 31, 95). Longitudinal studies have revealed that childhood obesity tracks into adulthood, with CVD risk factors presenting earlier in life (28, 53, 120, 128). Data from the Bogalusa Heart Study indicated that OW children have a 60% likelihood of developing CVD risk factors, such as hyperlipidemia, hyperinsulinemia, and hypertension, by age 10 year (18). This evidence was in agreement with other studies delineating the detrimental effects of childhood obesity status on metabolic and CVD risk profiles (10, 127).

Therefore, the prevention of obesity early in life may have a positive impact on the prevalence of health consequences in children and in adults.

Physical Activity Dose and Childhood Obesity

The cause of childhood obesity has been attributed, in part, to a decrease in PA and/or an increase in SB (13, 19, 20, 51, 140). The data from the most recent NHANES survey depicts children from 6 – 11 year as the least sedentary age-group of the US population, although they still spend >40% of their time participating in SB (Figure 1) (75). Today's children spend as much as 10.4 ± 0.8 of their waking hours in sedentary pursuits and more than half of this time (~ 6 hours·weekday^{-1}) within the school setting (100, 114, 139). Gortmaker et al. found that children who engaged in excessive sedentary habits, such as >5 hours·day^{-1} of television viewing, had 4.6 times greater relative risk of obesity compared to those who watched television <2 hours·day^{-1} (51). This trend towards physical inactivity and obesity was observed in a study by Tremblay et al. who compared contemporary children to their more physically active Old Order Mennonite counterparts, children raised in a society that has resisted the technological advances of the new world that promote SB (140). The low incidence of obesity in the Mennonite children may be related to the greater amount of PA and the low level of SB. However, the research has not shown conclusively that increasing children's PA level will reduce the amount of time spent in SB. For example, data from the same NHANES cohort as above revealed that 6 – 11 year old children are also meeting the recommended guidelines of at least 60 min·day^{-1} of MVPA (143). This suggests that the amount

of time children spend being physically inactive is independent of the amount of time they spend being active and further suggests that childhood obesity may be a result of the combination of these two behaviors rather than a reduction of PA or an increase in SB alone (101, 138, 149). Therefore it would be reasonable to suggest that reducing SB by encouraging the substitution of adequate PA to increase daily PAEE may be a rational approach for the prevention of childhood obesity (13, 33, 34, 45, 49, 134). However, to date, no PA intervention study has reported a positive impact on childhood obesity in response to an increase in total daily PA with a concomitant reduction in SB (8, 29, 36, 101, 126).

According to Rowland, when given the opportunity to be physically active, children will naturally choose PA, or active free-play, over more SB due to their innate, biological need to maintain energy homeostasis through physical play (105). Unfortunately, the opportunities for PA have become limited, especially within the school environment (124). The school setting, a place where children spend most of their day during the week, has reduced or eliminated PE and/or recess (2, 5). Currently, only 4% of elementary schools provide daily PE (4, 82, 108). Recently, the National Association for Sport and Physical Education (NASPE) recommended ≥150 $min \cdot week^{-1}$ of PE with a minimum of 50% of this time during PE spent in MVPA (4). However, the Center on Public Education reported that 71% of the districts surveyed across more than 10 states have reduced time allotted for PE to increase time for core academics. Despite the lack of similar regulatory guidelines for recess, NASPE reported that 71.4% of the elementary schools across the United States still offer regularly scheduled

recess (70). Unfortunately, research has shown that when recess is offered in elementary schools, although a large inter-individual variability exists, children do not use this time to be physically active (83, 86, 117, 124).

The large inter-individual variability in PA between children has led to conflicting results in the research with respect to the amount of time children spend in MVPA during the structured environment of PE and the free-play opportunity of recess (86, 109, 117-119). Some research has shown that boys spend more PE time in MVPA compared to girls, whereas other studies have shown no difference between boys and girls (87, 123, 148). It has also been reported that OW children participate less during PE than non-OW children (66). PA participation during recess is less consistent between boys and girls and between HW and OW children compared to PE. During morning and lunch recess Scruggs et al. reported that 5th grade boys were more active than girls (31 – 56% versus 19 – 42% of time spent in MVPA, respectively) (117). In contrast, Mota et al. noted that 8-10 year old girls acquired more MVPA during free-play recess than boys (86). A sex by BMI interaction was reported by Stratton et al. with OW boys participating in less PA compared to HW boys whereas there was no difference between the healthy and OW girls (133). In contrast, most studies report significantly less participation in MVPA during recess for OW children compared to their lean counterparts (83, 133, 145, 158).

The school environment has become increasingly sedentary in nature and yet children are not using their PE and recess periods to be physically active. During PE, the need to spend time on developing the motor skills necessary for

being physically active limits the capacity to substantially increase MVPA. During recess, the evidence indicates OW children may require additional encouragement to increase PA level whereas boys and girls may benefit from a more structured recess environment to encourage increase PA participation. Children spend a large portion of their day in school and recess appears to be a reasonable opportunity for promoting children to be physically active. However, care should be taken to challenge both sexes as well as HW and OW children to increase their activity levels during this otherwise predominantly sedentary time of day.

Energy Balance and Childhood Overweight/Obesity

The obesity epidemic appears to be a result of chronic positive energy imbalance. Based on the 1st law of thermodynamics, the amount of energy stored in the body is equal to energy intake minus EE (33, 59). Any long-term imbalance between energy intake and EE results in changes in body weight and body composition (25). With respect to the growing child, energy balance must account for increases in EE (40% to 57%) due to the expected increases in the body weight of a growing child, as well as energy storage (24% to 36%), conversion of energy within the body (8% to 13%), and diet-induced thermogenesis (10%). Butte et al. used this model to determine the energy requirements for healthy and excessive growth in 488 Hispanic youth (5-19 year) over a 1-year period (25). The study showed that the median energy cost of gaining weight ranged from 93 – 527 $kcal \cdot day^{-1}$ across children of different BMI status and PA levels. These results were greater than those found in Hill et al.

for HW and OW children (75 ± 62 and 144 ± 107 $kcal \cdot day^{-1}$, respectively) (Figure 2) (60). In an earlier study, Wang et al. statistically combined data from several national studies to determine the average weight gain in children over a 10-year period (152). The average weight gain and corresponding energy imbalance was compared to the expected gains, assuming stable distribution over time. The average excess weight increase in 2 – 7 year old children across all races and ethnicities was +0.43 $kg \cdot year^{-1}$ which translated to an average daily energy excess of 110 – 165 $kcal \cdot day^{-1}$ (range = 14 – 270 $kcal \cdot day^{-1}$ over the 10-year period). The difference in energy imbalance between lean and OW children reported in this racially diverse population of children was much lower than the value reported by Butte et al. in her study of Hispanic children (502 $kcal \cdot day^{-1}$) emphasizing the ethnic disparity in childhood obesity (26). However, collectively, this research agrees that if childhood obesity is targeted early in life the energy imbalance is ~100 $kcal \cdot day^{-1}$ (25, 60, 152). This energy surplus is easily abated by adding 30 min of daily MVPA and reducing low-energy-cost SB. These data support the contention that correcting small daily energy imbalances before the onset of obesity in children by increasing PA or reducing SB may be a solution to the childhood obesity epidemic, especially in minority populations.

Physical Activity Guidelines

In attempts to combat this energy imbalance and prevent childhood obesity, several organizations have published PA guidelines specific for children. These guidelines have increased the recommended dose of PA from the 1998 American College of Sports Medicine recommendation of 20-30 min of daily VPA to the CDC recommendation of 60 min or more of daily MVPA in 2005 (134). To be more in line with the natural activity patterns of children, the Council on Physical Education for Child on behalf of NASPE was first to suggest that the 60 min of MVPA may be accumulated in 10 – 15 min bouts of intermittent PA throughout the day. From the most current NHANES data, Troiano et al. reports that when children's PA was measured in 10-min bouts, compared to min-by-min counts, the amount of total daily MVPA recorded (26 $min \cdot day^{-1}$ & 45 $min \cdot day^{-1}$ for girls and boys, respectively) was below the recommended levels (143). Most recent guidelines of 2008 from the US Department of Health and Human Services removed the stipulation of 10-min bouts of PA indicating that any bout of MVPA, "*regardless of how short*", may count towards this recommendation. This is more in line with the natural patterns of children's free-play PA. In support of this change, analysis of the NHANES data using min-by-min counts Troiano et al. reported that children (6-11 year) acquired 75 $min \cdot day^{-1}$ & 95 $min \cdot day^{-1}$ of MVPA for girls and boys, respectively, with a greater proportion meeting the recommended guidelines (143).

The 2008 guidelines also responded to the increased trend towards physical inactivity and its possible relationship with obesity by recommending that children should avoid SB. Instead suitable, enjoyable, and age-appropriate

aerobic (jumping rope, swimming, or running), muscle-building (playing on playground equipment, climbing trees, or tug-of-war), and bone-strengthening (jumping rope, running, or basketball) activities were recommended to promote a variety of health benefits associated with PA (1).

PA guidelines have evolved over the years in response to continued pediatric PA research. There is evidence that, regardless of the pattern or type of PA, 60 min of accumulated daily MVPA should be adequate to bridge the energy gap associated with childhood obesity. However, inconsistent findings in the research make it difficult to determine whether children are meeting this required amount of MVPA and thereby correcting this imbalance (93). To date there is no large-scale population study that has conclusively determined if children are meeting these recommended PA guidelines and more research is needed to determine if these guidelines are sufficient to resolve the energy gap associated with childhood obesity.

Physical Activity Intervention Studies

Based on the guidelines for children, PA interventions have been developed to add opportunities for PA, especially during the otherwise sedentary school day. The primary focus of the following school-based PA interventions (Appendix B) was to attenuate the excessive increase in BMI in children by increasing MVPA and reducing SB during PE and/or recess (72, 92, 108). In 1991, researchers from 4 states (MN, CA, LA, and TX) implemented the largest school-based, multi-component, randomized control study (N = 5106) of 3rd grade students in 96 schools (72). The Coordinated Approached to Child Health

(CATCH) study was designed to reduce the risk for CVD by promoting proper nutrition and increased PA through a combination of school-based and home-based programs. The goal of the PA component was to promote children's enjoyment and participation of MVPA during PE, recess and outside of the school setting over a 3-year period. There was a small increase in the amount of time spent in MVPA during PE (+4.5 $min \cdot lesson^{-1}$) observed in the intervention schools compared to the control schools. In contrast, the control schools reported more total daily PA (+9 $min \cdot day^{-1}$) compared to the intervention schools. It was further reported that changes in MVPA and dietary intake did not result in significant changes in CVD risk factors, including changes in BMI, in both school conditions. The ineffectual reliability of the Self-administered Physical Activity Checklist (SAPAC) for measuring PA in this population and the group estimates of MVPA using the System for Observing Fitness Instruction Time (SOFIT) did not allow for accurate assessments of individual changes in total daily MVPA or PAEE between groups (46, 155). The lack of accurate or objective measures of PA made it impossible to determine if the PA dose was sufficient to impact energy imbalance and thus, childhood obesity.

The home-based or family-based component was designed to reinforce at home the concepts, activities and skills learned from the CATCH classroom curricula. Those families who completed the homework packets reported improved knowledge and attitudes related to nutrition and PA. The CATCH food service program was designed to reduce the fat and sodium content in the cafeteria meals. This nutritional component did result in lower total fat intake

compared to the control schools. Although the family and nutrition components had a positive effect on nutrition and the home environment, the results did not add sufficiently to the changes in PA to impact BMI or adiposity.

Sallis et al. implemented a 2-year, multi-component, school-based intervention called the Sport, Play and Active Recreation for Kids (SPARK) program for 4th to 5th grade children (72, 108, 131). Seven schools in southern California were randomized into one of three conditions: 1) a PE specialist-led SPARK program, 2) a trained classroom teacher-led SPARK program, or 3) a no-program control. The SPARK schools were observed (SOFIT) to increase the amount of PE time spent in MVPA compared to the control schools (40 & 33 min vs. 18 min, respectively) although, all schools reported similar total daily PA participation over the 2-year period. This similarity in daily PA between groups may explain the similar changes in BMI between groups. Changes in SB in response to the intervention were not measured in this study. Post-intervention accelerometer measures of PA, without baseline data, did not permit the assessment of individual changes in MVPA from pre- to post-intervention. The 1-day PA recall has been reported to be unreliable for the assessment of PA in this age group, which limits the capacity to report accurate group differences in PA (14, 107, 111). Therefore, similar to the CATCH study, the lack of accurate objective measures of PA or SB in SPARK reduces the ability to assess the effectiveness of this intervention to increase daily PA and/or reduce SB and therefore, positively impact BMI.

The SPARK self-management curriculum was implemented to target children's PA behaviors outside of school. The promotion of PA was accomplished through classroom lessons on goal-setting and self-reward techniques and included homework packets to stimulate parent-child interaction. The self-management component did not transfer into increased PA outside of school compared to the control school, primarily due to the quantity rather than quality of program implementation, and therefore, did not significantly contribute to SPARK PA or BMI outcomes.

Ernst and Pangrazi implemented a similar school-based program (Promoting Lifestyle Activity for Youth, PLAY) in 4th to 6th grade Arizona classrooms. PLAY included a health education curriculum delineating the benefits of PA and daily structured PA breaks for the first 4 weeks followed by an 8-week self-monitoring program to encourage 30 – 60 min of daily PA outside of school (39). Self-report measures of PA revealed a significant increase in attraction to and participation in PA in the treatment schools compared to the control schools who received free-play breaks of the same duration (15 min). However, self-report measures of PA in elementary-school children using the Physical Activity Questionnaire for Older Children (PAQ-C) have reported modest validity correlation coefficients ($r = 0.45 – 0.53$) limiting the capacity to assess true changes in PA between groups (67). Post-treatment measures revealed significantly greater pedometer step counts for the intervention schools (12,763 – 12,598 steps) compared to controls (11,180 steps), although there was no positive changes in BMI in the PLAY schools (92). Analysis of the relationship

between PA dose and changes in BMI was not possible due to the post-intervention pedometer measures of PA (155). Interestingly, lower self-reported and measured PA participation in the control schools suggests that simply allowing a 15-min free-play opportunity without a structured program was not effective for increasing PA levels.

Similar school-based intervention studies have manipulated the recess environment to encourage increased PA levels in children. These studies have: a) increased the length of recess time, b) made sport or game equipment available during recess, c) enhanced the aesthetics of the school playgrounds, or d) substituted free-play recess with a structured fitness break (8, 52, 99, 117, 132, 151). Guinhouya et al. found that extending recess time from 30 to 40 $min \cdot day^{-1}$ resulted in an increase in PA of only 6% in 3rd and 4th grade children (52). Accelerometer measures in this study revealed that this increase of approximately 7 min during the longer recess did not translate into a significant increase in total daily PA. In contrast, Alhassan et al. found that recess or total daily PA in preschool-aged children was not affected by an extension in outdoor free-play time (8). The pre-school children were observed to spend this extended recess time in sedentary pursuits such as playing in the sandbox rather than being physically active. Verstraete et al. found that by introducing play equipment, such as hula hoops, balls, jump ropes and badminton racquets, with directions on how to use this equipment, resulted in an increase from 41 to 45% of recess time spent in MPA compared to a decline in the control group who were not given equipment (41 to 34% of recess time) (151). Similarly, Ridgers et al.

found that improving the aesthetics of the school playground by adding colorful markings and physical play structures resulted in modest but significant increases PA levels during recess (+ 2 – 4% of time spent in MVPA) (99). This increase in PA, measured by heart rate and activity monitors, was sustained at 6-month follow-up and was greater for those who were more sedentary at baseline. However, the investigators of this study did not measure how the increase in PA during school affected total daily PA levels. A similar increase in PA during school recess was evident in a study by Scruggs et al. who substituted a free-play recess with a structured fitness break, an obstacle course including sports equipment to complete various activities throughout the course (117). Fifth grade children spent less than half of their free-play morning and lunch recess in MVPA (23 – 47%, respectively) which was significantly increased to 93% during the afternoon structured fitness break. By providing positive cues for PA, children chose to be more active during the structured fitness break. However, it is not known if this also increased their total daily PA levels or whether this increased PA behavior during school resulted in a compensatory increase in SB during the remainder of the day.

Similar interventions used behavioral techniques to encourage children to substitute SB with more physically demanding activities during their free-play time (37, 38, 101, 112, 150). Epstein et al found that children (8 – 12 year) who either received positive reinforcement for being physically active or for not selecting their preferred sedentary activity increased their time spent in more active pursuits compared to the controls (38). Salmon et al. also used behavior

modification techniques and/or sports-related skill development to encourage children to make better choices during their leisure time outside of school (112). Sedentary and PA behavior were measured using accelerometry and self-report questionnaires. The group of 5th grade children who received behavior modification in conjunction with the structured skill-development program substituted more of their leisure time with outdoor PA compared to the group with behavior modification alone. These studies suggested that behavioral approaches, such as positive reinforcement of PA behavior and increasing awareness of health consequences associated with SB, along with functional motor skill development encouraged children to increase PA while reducing inactivity.

In all of the intervention studies, prior to the interventions, in the absence of guidance or prompts, children opted to participate in sedentary activities over more physically demanding ones (8, 37, 38, 150). Several of these interventions have successfully increased PA participation and/or reduced physical inactivity in children through structured programs, improvements in the PE curriculum, or by adding PA prompts or cues to promote PA behavior in an otherwise sedentary school environment. However, these same intervention studies have had little impact on slowing the excessive increases in BMI during childhood or have not measured the impact of the intervention on total daily PA and changes in BMI. There is no empirical evidence that increased PA level during the school day translates to increased total daily PA participation sufficiently to correct for the energy imbalance associated childhood obesity. Although PA interventions have

successfully increased PA behavior, the absence of objective and accurate measures of changes in total daily PAEE associated with the intervention limits the capacity to determine the precise PA dose required for resolving the energy imbalance and thereby impacting childhood obesity.

Measurement of Physical Activity Energy Expenditure

Inadequate, unreliable or lack of objective measures of the volume and intensity of PA in intervention research as well as the lack of continuity in the methodology across intervention studies make it difficult to quantify the PA dose required to correct the ~100 $kcal \cdot day^{-1}$ chronic energy surplus associated with childhood obesity. PA intervention studies have used self-report questionnaires (14, 39), accelerometers (16, 115), heart rate monitors (40, 117) and direct observation systems (80, 81, 84) to assess PA and total daily PA participation in response to intervention-provoked increases in PA during the school day. The validity of these tools to accurately assess PA and PAEE is limited by the quality of the instrument and the criterion measure used to validate the instrument (111).

Several literature reviews have delineated the strengths and weaknesses of the tools used to measure PA behavior in children (111, 125, 130, 155). Many different self-report assessments in the form of questionnaires, interview-based activity recalls, proxy-reports, and self-administered measures have demonstrated low to moderate validity for assessing PA levels in children. This lack of correspondence and the tendency to overestimate PA behavior suggests that self-report tools may require cognitive skills not yet developed in younger children, such as estimating PA duration or intensity, the concept of time, and

memory recall (14). Children are also prone to the influence of social-desirability bias which may result in an exaggeration of their PA participation on self-report questionnaires or recalls. However, validating this instrument with criterion measures that have their own inherent limitations and estimation errors, such as accelerometers or heart rate monitors, may contribute to the problems associated with self-report instruments (125). Therefore, much improvement is needed in the way self-report instruments are validated, administered, scored and interpreted before they should be used to measure PA levels in younger children.

Some tools have been developed to visually assess PA behavior. Direct observation involves time sampling of either an individual or a group of participants at one time to record their PA levels in a free-living setting (23, 81, 84). The trained observer watches the individual or group and periodically records their behavior and the intensity factor associated with the behavior to estimate PAEE. However, the time necessary to record the activities (e.g. 25 sec of every 30 sec) can often lead to missed activities and affect the accuracy of estimating PAEE, especially in children whose short, explosive behaviors last typically 2 – 3 seconds in duration (23). Although direct observation can provide contextual information (location, weather, etc.) about the PA behavior, this can be outweighed by the considerable examiner burden to learn and then implement the observation system to observe and measure children's PA (80, 81, 84). As with self-report instruments, direct observation has been validated against heart rate and activity monitors, two measurement devices that should be used as the

criterion measure with caution due to their own inherent measurement errors (103).

PA has also been assessed using technological devices (e.g. pedometers and accelerometers) rather than through direct observation or self-report tools. Pedometers and accelerometers measure physical movements of the body and can time-stamp the duration of these movements. However, they both require the translation of movement counts or steps (a physical measure) into PAEE (a physiological measure) using statistical models. Pedometers (total steps·day^{-1}) allow only for the interpretation of activity volume or duration rather than measuring the amount of time spent in different PA intensities which limits the ability to accurately measure PAEE and its relationship to changes in BMI (155). Accelerometers have the capacity to sample activity in specified time intervals (1-sec to 1-min intervals) allowing for estimations of activity intensity, volume, amount of time spend in different PA intensities, and PAEE. Depending on the specific device and corresponding equation used, errors in estimating PAEE with accelerometers ranges from 13 to 29% (under- or overestimation) compared to indirect calorimetry as the criterion measure (44, 96, 141, 146). For example, in a study of twelve adolescents (11.4 ± 0.4 y), Eisenmann et al. found the MTI accelerometer (predecessor to the Actigraph) to underestimate four free-living activities by as much as 1 – 3 kcal·min^{-1} (34). These estimation errors associated with activity monitors, both pedometers and accelerometers, limit the ability to accurately measure the PA dose offered by PA interventions and therefore, the dose-response relationship between PA and BMI.

Using physiological measures to estimate children's PA and PAEE can also be problematic. Heart rate, a physiological measure that increases linearly with exercise intensity, has been shown to be sensitive to factors unrelated to PA, such as illness and anxiety. When compared to indirect calorimetry and doubly labeled water, the gold standards for assessing PAEE, estimated errors range from –16.7 to 18.8% (35, 71). The fitness level of a child will also affect the heart rate response to a given workload which may lead to an underestimation of PAEE in a more physically fit child. Recent research has combined the physiology measure of heart rate to the physical measure of the activity monitor in statistical modeling in attempts to improve the accuracy in assessing PA behavior. However, at this time, heart rate monitors remain a less than ideal tool for assessing PA behavior in children.

As previously mentioned, the gold standard for measuring EE during rest or exercise is through either doubly labeled water (DLW) or indirect calorimetry. DLW is limited to measures of total EE over 24 hour periods and is costly to use (96). Indirect calorimetry, the measure of VO_2 and VCO_2 during PA to assess PAEE, is less costly but until recently was limited to either small room calorimeters or large floor-model systems, both of which limit natural movements patterns, especially during children's free-play PA.

Recent technological developments have produced portable indirect calorimeters or metabolic systems that are capable of assessing the quantity and quality of free-play PA and PAEE in children. However, to date researchers have not used these systems to measure the energy cost of children PA during free-

play. Previous studies have measured the PAEE of continuous PA during activities such as treadmill walking or jogging, shooting baskets, and kicking a soccer ball around cones for 3 – 20 min in duration (44, 88, 91, 96, 142, 146, 147). These studies do not allow for the start/stop action of children's games, attempting to attain steady-state VO_2 during each activity. Research has shown that the natural PA patterns of children is characterized as intermittent and highly transitory with short bursts of MVPA and vigorous PA (VPA) lasting an average <5 seconds separated by brief periods of rest and recovery (<4 min) (12, 155). It is this sporadic nature of children's movements that adds to the complexity of measuring PA and associated PAEE in this population (46, 155).

By measuring the actual energy cost of children's free-play PA we enhance our capacity to design effective interventions that will supply adequate PA dose, volume and intensity, to correct the energy imbalance associated with childhood obesity. Using the appropriate tools that accurately assess EE or that are validated against criterion measures that assess the physiological variables associated with EE will allow for the true assessment of children's free-play PAEE.

Summary

It is evident that excess weight gain as a result of a chronic positive energy imbalance is related to health consequences at an early age. By increasing PAEE and balancing the scale of energy intake versus EE, obesity can be prevented or reversed. The precise amount of PA children accomplish as well as the amount of energy they expend on a daily basis has yet to be conclusively determined. PA interventions have attempted to increase PA in children and have had varying degrees of success usually due to non-differential measurement error which weakens the ability to find an association between MVPA, PAEE, and BMI. Questions are raised regarding the most effective interventions for youth to prevent childhood obesity and related health consequences that continue into adulthood.

Research needs to target the chronic positive energy imbalance associated with childhood obesity by acting early in childhood before the onset of obesity and corresponding negative health consequences. PA interventions have not demonstrated that using time within the school setting effectively promotes increases in total daily MVPA due primarily to lack of accurate assessments of the PA dose promoted during the intervention. Although, the structured PA intervention has been more successful than the free-play PA intervention for increasing total daily MVPA in children. Thus, implementing an intervention using enjoyable children's games of known energy cost may be the key to correcting for this chronic energy imbalance and curbing lifelong obesity.

Investigators need to first establish the energy cost of children's free-play PA and then determine the feasibility of children acquiring the necessary amount

of daily PA dose for the prevention of obesity. Once a solid foundation is developed, a PA intervention of known energy cost, then possible confounding variables can be targeted. With a solid foundation, different components can be added, one at a time, to develop a successful, multi-component intervention that will be effective across sex, race and ethnicity, and BMI classifications.

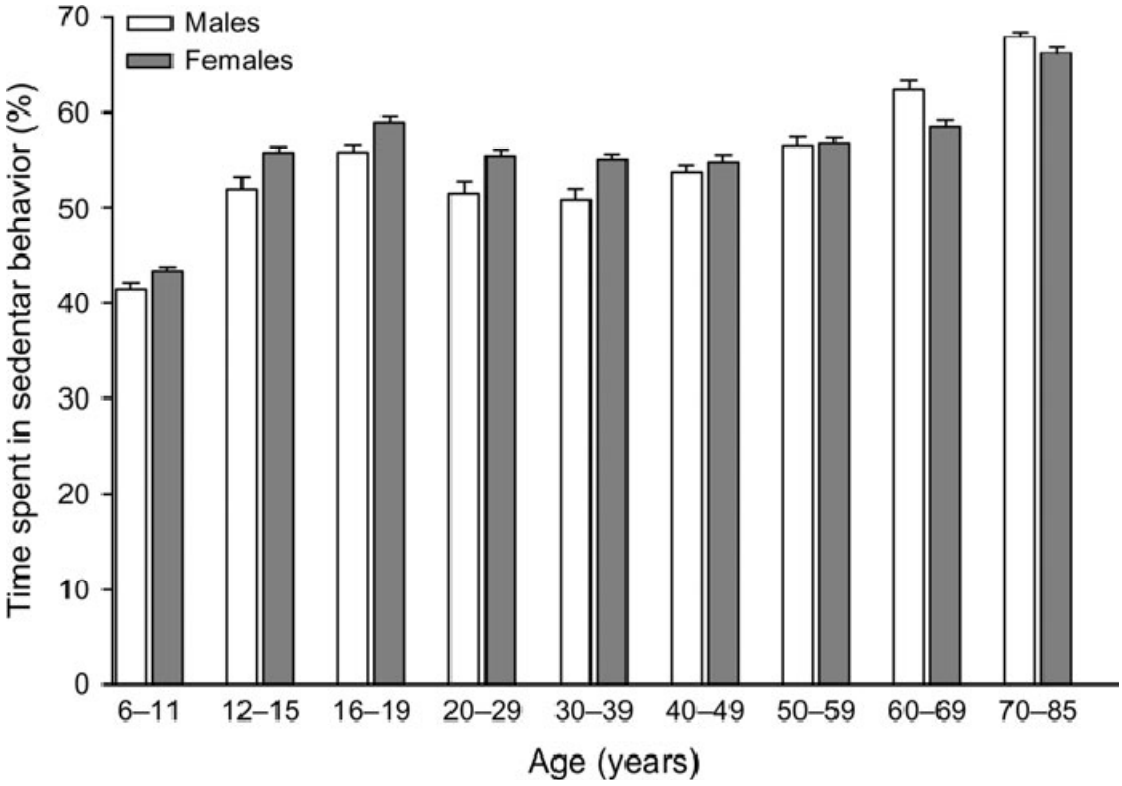


Figure 1. Percentage of time spent in sedentary behaviors, by age and sex, United States, 2003-2004. (Mean ± SEE) (75)

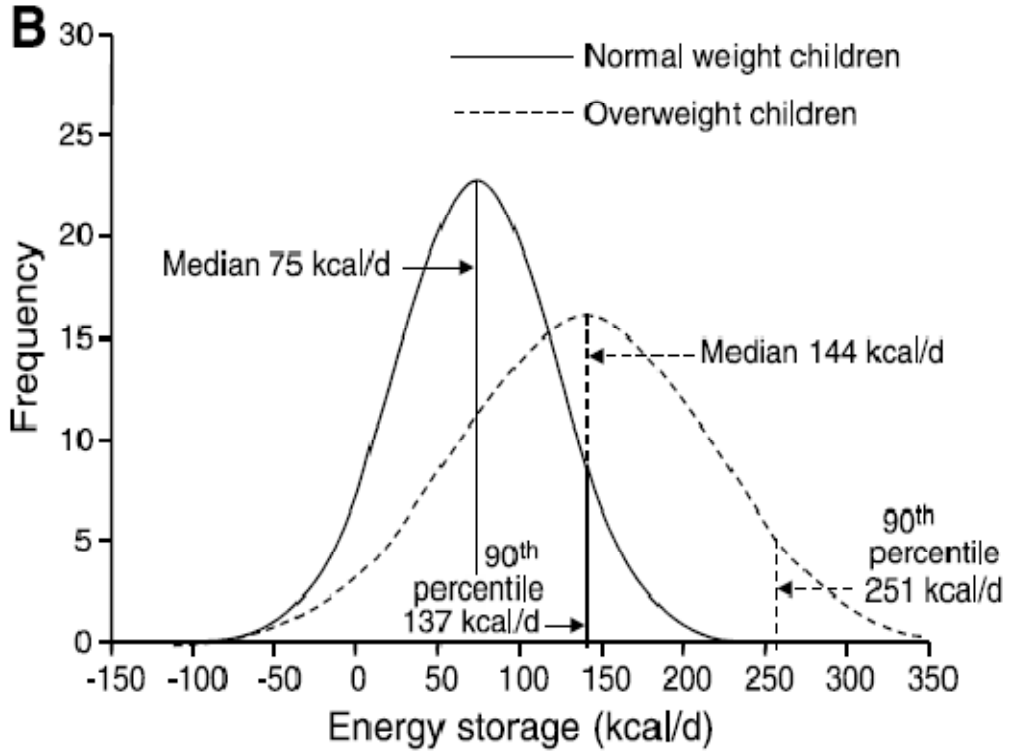


Figure 2. Energy storage in HW and OW children based on the assumptions of Hill et al. (60)

CHAPTER III

METHODS

Study 1: Energy Expenditure of Physical Activity in Children

Focus Group

A panel of 10 experienced elementary school PE teachers from the Springfield Public School system (Springfield, MA) was asked to share their knowledge and expertise in selecting a menu of children's games commonly used during 3rd grade PE classes. An initial list of games adapted from the investigator's previous research (Medical College of Georgia Exercise Project) and the CATCH PE program were presented to the PE teachers on a series of note cards, each depicted a game proposed for the structured recess intervention. Following a brief description of the game and a short group discussion in open forum, the PE teachers were asked to answer a series of standardized questions listed on the back of each game card (Appendix C). The questions were answered anonymously to allow for complete disclosure in responses. Games were eliminated first by a review of comments made by the focus group during the open forum and finally narrowed to a list of 30 games on the basis of:

a. Safety / Low risk of injury (Questions 6 & 10)
b. Adequate movement / Energy cost (Questions 4, 7 & 9)
c. High level of enjoyment (Questions 5 & 9)
d. Ease of implementation (Questions 3 & 8)
e. Age-appropriate skill requirement (Questions 5 & 6)

A score of ≥6 on a 10-point Likert scale was required for all factors for a game to be included in the final list of 30 children's games (Appendix D).

Participant Recruitment

Flyers were sent home through the 3rd grade classrooms of local elementary schools. The flyer contained contact information for parents of interested children to call for additional information about the study. All children were screened for chronic diseases or mental or physical impairments that would limit their ability to participate in regular free-play (Appendix E). Children were excluded if they were taking any medications that would interfere with metabolism. Efforts were made to recruit HW and OW children in each sex group. Children were measured for height and weight to calculate BMI and determine eligibility as part of the screening process. Twenty-eight 3rd grade children (8 – 10 year) were recruited on the basis of sex and BMI status (15 males & 13 females, 16 HW and 12 OW children). Prior to participation both the parent/guardian and child signed the written informed consent/assent documents approved by the University of Massachusetts and Children's Hospital Boston Institutional Review Boards (Appendix F).

To promote a relaxed atmosphere and to simulate a pseudo recess environment the children reported to the laboratory in pairs, usually two friends, for two visits following the informed consent visit – one visit as the measured child and one visit as the playmate. A minimum of 4 people (2 children and 2 adults) were available to play all of the games. The adults were extensively

trained to carefully observe the children during the games and to match their level of play, specifically in level of activity, skill level, and competition.

Upon arrival at the laboratory each child's temperature and blood pressure were measured to ensure they are not ill. Each child's height to the nearest 0.5 cm and weight to the nearest 0.1 kg were measured using a digital scale (Lifesource ProFit precision scale, Milpitas, CA) and stadiometer (Detecto, Webb City, MO), respectively. BMI was calculated as height relative to weight ($kg \cdot m^{-2}$) and classified according to the CDC's age- and sex-specific BMI growth charts (68, 69). Waist circumference was measured at the horizontal plane at the level of the umbilical and recorded to the nearest 0.1 cm. Measurements were repeated twice and the average of the three measurements was recorded.

Resting Metabolic Rate

For the purpose of measuring resting metabolic rate (RMR) the measured child was instructed to fast for 3 hours prior to reporting to the laboratory. During this fasting period they refrained from: 1) eating or drinking anything except for water; 2) any stimulants including caffeinated soft drinks and nutritional supplements, and 3) any intentional PA. Goran et al. has shown that a 2 – 3 hour fast is sufficient to remove the additive energy cost of digestion during the RMR measurement in children (48, 141). The parent confirmed study compliance upon their arrival to the laboratory to ensure the child was properly prepared for RMR measurement.

The child rested quietly in a supine position for 10 min after which a nose clip was placed on the child's nose and they were asked to breathe through a

hand-held indirect calorimeter, the MedGem® Analyzer (Microlife, USA, Dunedin, FL). The MedGem was auto-calibrated before each measurement. The first 2 min of data collection was ignored to allow the subject to become accustomed to the device. Steady-state oxygen concentration (VO_2), expressed as $ml \cdot day^{-1}$, was measured from inspired and expired airflow over the next 3 – 8 min by a proprietary fluorescent-quenching sensor. VO_2 was calculated using a standard metabolic formula (77). RMR, expressed as $kcal \cdot day^{-1}$, was calculated from VO_2 and estimated volume of carbon dioxide (VCO_2) using an assumed mixed-diet respiratory quotient of 0.85 and a modified Weir equation (154).

Measurement Protocol

Following the RMR measurement, both subjects were given a small snack of ~150 kcal (e.g. juice and cereal bar). The measured child was asked to walk on a treadmill at 1.12 $m \cdot sec^{-1}$ and 0% grade for 6 min as a controlled exercise condition. Both children (measured child and playmate) were then asked to complete a series of 10 games randomly assigned from the menu of 30 common children's games using a randomized block design. The games were played for 6 min each with a 3 – 4 min rest periods between each game. Before and after each game the children were asked to stand still by playing freeze tag in order to record 15 seconds of non-movement on the measurement instruments. Except for the 15 seconds before and after each game, the children were not required to play continuously for the 6 min of each game. Rather the children were encouraged to play each game as they would normally with their peers at recess,

allowing them to stop and start and vary their movement patterns and intensity according to the demands and within the established rules of the game.

The Facial affective scale (FAS), a series of faces depicting mode (happy to sad) on a 9-point Likert scale, was used to measure the children's perceptions of the games. At the end of each game both children were asked to point to the facial expression that closely resembles their perception of enjoyment on the FAS. Both children were asked independently to rate their perceptions of enjoyment of the game as it was just played and how they would like to play the same game with their friends during recess at school. Care was taken to ensure that the children understand their responses should be an honest reflection of their level of enjoyment of each game for us to develop a future intervention that would be enjoyed by children of similar age.

Physical Activity Energy Expenditure

During the treadmill bout and the games the measured child wore the Oxycon Mobile (OM) portable metabolic analyzer (Cardinal Health, Yorba Linda, CA) to measure EE. The OM is an accurate and reliable system that assesses breath-by-breath metabolic responses to PA when compared to Douglas bag, the gold standard, or other valid metabolic systems. Each breath was analyzed for VO_2 and VCO_2 as a sample of air was collected through the facemask and sent to the analyzer which was secured to the subject's back in a small, light-weight backpack. The data was sent via telemetry to a laptop computer as well as saved to an on-board flash drive, making the device suitable for use in a non-laboratory, free-play environment. Heart rate was also be monitored during the

games using a POLAR heart rate monitor (Polar Electro, Inc., Lake Success, NY) with a strap around the subject's chest and a watch on their wrist. The unrestrictive nature of the OM backpack and the POLAR strap, as well as the light weight (<1.5 kg) metabolic unit, allowed the children to move about freely while accurately measuring the PAEE of free-play PA.

Accelerometers

During the games both children wore an Actigraph GT1M uniaxial accelerometer (Actigraph, LLC., Pensacola, FL). The GT1M was worn on the non-dominant hip over the iliac crest directly in line with the anterior axillary line. The GT1M is a light-weight (27 g) and compact (3.8 x 3.7 x 1.8 cm) activity monitor that accurately and consistently measures and records accelerations ranging in magnitude from 0.05 to 2.0 g. The acceleration signal was sampled at a rate of 30 Hertz and then filtered to detect normal human motion and reject motion from other sources. Each sample was summed over a 1-sec epoch, recorded as a count and then reset to zero.

Statistical Analysis

The mean energy cost and perceived enjoyment was calculated for each game. To qualify for implementation into the structured recess intervention, each game had to meet the following criteria:

1. The lower boundary of the 90% confidence interval for PAEE needed to be ≥3.3 $kcal \cdot min^{-1}$ to increase the likelihood that the children will expend ≥100 kcal in 30 min while playing the game during the subsequent structured recess intervention.

2. The lower boundary of the 90% confidence interval for the FAS needed to be ≥5 (neutral expression) on the 9-point Likert scale to ensure that the children will participate in the game during the subsequent structured recess intervention.

This data was analyzed as a group and with sex and BMI classification as main effects to determine if any game was less likely to qualify according to the above criteria for any subgroup. PROC MIXED ANOVA was used to determine differences in PAEE and FAS with sex and BMI classification as main effects. Mean PA counts ($counts \cdot min^{-1}$) were calculated for each game overall and with the same main effects. The list of qualifying games was used in the structured recess intervention. Based on the limited research evaluating differences in PAEE between groups (boys vs. girls or HW vs. OW children) with a power of 0.80 and a significance level of $p < 0.05$ a sample size of 6 children were necessary to detect a significant difference of 0.45 ± 0.30 $kcal \cdot min^{-1}$. SAS 9.2 software was used for all statistical analyses.

Study 2: Measures of Free-living Physical Activity Energy Expenditure

Participant Recruitment

Similar to study one, flyers were sent home through the 3rd grade classrooms of the local elementary schools in Amherst, MA. The flyer contained contact information for parents of interested children to call for additional information. The children (N = 10) were recruited from a single 3rd grade classroom to promote relaxed play similar to that during their regular school recess. The children were screened in the same manner as study one –

apparently healthy and not taking any medications that would interfere with metabolism. Prior to participation both the parent/guardian and child signed the written informed consent/assent documents approved by the University of Massachusetts and Children Hospital Boston Institutional Review Boards.

During the informed consent visit the each child's height and weight was measured in the same manner as study one. The average of three measurements was recorded. BMI was calculated from height and weight measurements and classified as HW or OW according to the CDC's age- and sex-specific BMI growth charts (68, 69).

Study Protocol

This study served as a pilot intervention to determine if the children's games measured in the laboratory-based study to elicit ≥3.3 $kcal \cdot min^{-1}$ would elicit the same amount of PAEE in a real-life group setting. The children met at a designated UMASS gymnasium for 10 sessions (1 – 2 $sessions \cdot week^{-1}$ for 6 weeks) for 30 min each session, sufficient time to play three games for up to 9 min each. A subset of 6 games were selected from the list of 20 qualified children's games measured in study one in the following manner: 1) the games were ranked according to PAEE; 2) the games were separated into pairs along the intensity range from lowest to highest PAEE; and, 3) one game from each pair was selected while care was taken to choose games with different movement patterns and rules to add variety to the final list of 6 games. The games will be played up to 5 times each in random order throughout the 10 sessions.

All study personnel assisting with pilot intervention underwent training on all selected games, motivation skills, conflict resolution, injury prevention, and adverse event reporting. All personnel were child CPR and first aid certified and completed the human subject certification online course. Because the primary goal of the pilot intervention was to measure the specific energy cost for each game, care was taken to ensure the games were played according to the rules established during study one. During this pilot intervention, if any child deviated from these specific rules, they were corrected by reminding them of the rules. Any child declining to follow the rules was asked to discontinue playing and their data was not used in the analysis for that game.

Physical Activity Energy Expenditure

During each intervention session, one child was randomly chosen to wear the OM portable metabolic analyzer to measure PAEE. Height and weight was also re-measured for accurate assessment of EE with the OM. The same child was also asked to wear a POLAR heart rate monitor with a strap around their chest and a watch on their wrist to measure heart rate.

All children attending the intervention were asked to wear the Actigraph GT1M uniaxial accelerometer on their non-dominant hip over the iliac crest directly in-line with the anterior axillary line. The GT1M's were initialized to sample data at 5-sec epochs and accelerometer counts ($counts \cdot min^{-1}$) were measured for each child for each game. To reduce the inter-instrument variability of measurements, each child wore the same unit for every intervention session (44).

Statistical Analysis

Mean values plus 90% confidence interval were calculated for PAEE, FAS and accelerometer counts for each game. The lower boundary of the 90% confidence interval for PAEE and FAS were compared to the inclusion criteria established in study one: PAEE ≥3.3 $kcal \cdot min^{-1}$ and FAS ≥5. PAEE and To analyze the trend of PAEE, FAS and activity counts over the ten sessions, the MIXED ANOVA was repeated with game and session as main effects. FAS was added to the model as a covariant to evaluate the relationship among PAEE, activity counts and FAS. SAS version 9.2 software (SAS, Cary, NC) was used for all statistical analyses. To compare differences in PAEE between groups with a power of 0.80 and a significance level of $p < 0.05$ a sample of 5 children was necessary to detect significant differences of 0.30 ± 0.10 $kcal \cdot min^{-1}$.

Study 3: Effects of a Structured Recess PA Intervention on MVPA

School Recruitment

Two elementary schools from the Springfield, MA, area were recruited for the intervention study. School eligibility criteria included: 1) not a magnet school; 2) 3rd grade enrollment exceeded 60 students so as to provide sufficient numbers for recruitment; 3) availability of indoor and outdoor facilities to the conduct children's PA intervention; 4) availability of 30 min of recess time; and, 5) willingness to participate in the intervention and measurements during the study period. Permission was obtained from the Springfield School District Superintendent to contact and recruit schools. To encourage participation in the 9-week program each participating school received a monetary incentive of

$1000.00 at the end of the intervention plus the necessary equipment to conduct the structured recess program. The schools self-selected which school would receive the daily 30-min 100-kcal structured recess program (INT) and which school would offer a daily free-play recess (CON) of the same duration. The structured recess intervention was offered to all 3rd grade children regardless if they participated in the measurement portion of the study.

Participant Recruitment

Intervention packets including the study flyer, informed consent and assent documents, and study questionnaires in English and Spanish were sent home through the 3rd grade classrooms at both schools. Interested families completed the documents and returned them to the child's classroom teacher. The parents of each interested child was contacted to make sure the parent understood the study protocol and to screen their child for chronic diseases or mental or physical impairments that may limit their ability to participate in regular free-play as in study one and two. Twenty-seven 3rd grade children (16 CON and 11 INT) were recruited from the two schools.

Study Protocol

Baseline measures were conducted prior to the start of the study on two days per week, one day at the INT school and one day at the CON school, until all 27 children were measured. For baseline measures the children reported to the Nurse's office up to 1 hour before the start of school and rested for 5 min in a seated position with feet and back supported and their arm resting at chest level. Three blood pressure measures were taken at 1-min intervals with a Critikon

Dinamap automated blood pressure monitor (GE Healthcare; Piscataway, NJ). Height, weight and waist circumference were measured using the same protocol and instrumentation as in study one and two. Each child was fitted with an Actigraph GT1M, initialized for 5-sec sampling, and was asked to wear it on their non-dominant hip attached to an elastic strap for next 7 days (if the monitor was placed on the child's hip on Monday at noon they returned the monitor the following Monday morning) during all waking hours except during bathing and swimming. The child, parent and classroom teachers were given instructions on how the child was to wear the activity monitor. The child was asked to record when the monitor was worn during the week on the Accelerometer log (English or Spanish version). Regular contact during this measurement period via e-mail, text or phone calls encouraged compliance with the accelerometer protocol. The accelerometer was returned to the school before classes began exactly one week later. The GT1M was downloaded immediately using the ActiLife Software (version 4.0.4) to ensure a minimum of 1 day complete day of data. The child was asked to re-wear the GT1M if data was not collected properly or if less than 1 day was collected. These same measurements were repeated during the final week of the 9-week intervention study.

Implementation of the Program

Program Staff Training. Training of all personnel assisting with the intervention was essential to the success of the program. The training included instructional sessions covering the goals of the study, the rationale for the activity intervention, the health benefits of PA, safety issues, and appropriate

approaches to engaging students to participate in PA. Since the primary goal of the intervention is to increase MVPA, the training focused on motivation skills and conflict resolution to encourage a positive and enjoyable environment for unfettered, uninterrupted play during the intervention. The training also covered the specific rules of all the selected games to make sure they were played in the same manner in which they were measured. Program staff demonstrated each activity and participated in small groups with role playing sessions designed to teach program staff how to encourage children to participate in PA and deal with problem behavior.

Intervention Protocol. The intervention was conducted on a daily basis, on all regular school days, by trained intervention staff. Program staff was allowed the flexibility to choose activities from the selection of games that were found to be eligible for the intervention in study one. Game selection was influenced by the preference of the children and more than one activity may occur in the group at the same time. If more than one game was played during a single session, care was taken to choose games that required similar equipment to reduce set-up time between games. The program staff to child ratio was at least 2:15 for each session.

The CON school children did not receive the structured recess program, instead they were offered 30 min of free-play daily recess as a comparison condition. At the end of the study, an offer was made to the CON school to training the classroom teacher how to implement the structured recess program as well as to purchase the equipment necessary to conduct the games.

Process Evaluations. The implementation of the program was assessed periodically throughout the study to determine protocol compliance as well as assess competing programs in both schools. The program staff evaluated the extent of delivery of the structured recess intervention. Monthly PA calendars were completed by both schools to document the opportunities for recess, either structured or free-play. The classroom teacher was asked to document the number of minutes of each recess period and the location of the recess (indoors or outdoors). GT1M accelerometers were randomly worn by the INT school children to measure PA levels. The accelerometer counts were compared to the counts achieved during the laboratory-based study to determine if the children were playing at the same intensity.

Process evaluations also assessed the extent of occurrence of other types of PA during the school day including PE classes and special events. The 3rd grade classroom teachers recorded the occurrence and time spent in PE classes during a randomly selected 5-day school week during the intervention.

Statistical Analysis

Differences in physical characteristics and PA measures at baseline between the INT and CON schools were compared using a one-way mixed model ANOVA with school as the main effect. Differences in the changes from baseline to follow-up measures between the INT and CON schools for all variables were compared using a two-way ANOVA with school and measurement time-point (time) as main effects. For the INT school, a regression analysis assessed the relationship among changes in MVPA, SB and BMI. The estimate

of required sample size (N = 30 in each group) was based on conservative estimates of participant attrition from baseline to follow-up (15%) and a final sample size of 25 students per school was needed for adequate power to demonstrate the anticipated intervention effect ($r = 0.80$, $p < 0.05$).

CHAPTER IV

MANUSCRIPTS

Study 1. Energy Expenditure during Simulated Free-Play Physical Activity in Children

Abstract

Purpose: This study directly measured the energy cost and enjoyment of common children's games for developing a school-based intervention to address the energy imbalance associated with childhood obesity; a surplus purported to be ~100 $kcal \cdot day^{-1}$. **Methods:** HW and OW 3rd grade children (15 boys; 13 girls) were recruited for the study. In a large gymnasium, the children performed 10 games randomly chosen from a menu of 30 common games selected from previous interventions. PAEE was measured with a portable metabolic unit and perceived enjoyment was assessed using a 9-point Likert scale of facial expressions. The lower boundary of the 90% confidence interval was use as the minimum criteria for PAEE (≥3.3 $kcal \cdot min^{-1}$) and enjoyment (≥5, neutral). **Results:** The games were classified as moderate intensity (X ± SD = 5.1 ± 1.3 METs). PAEE was higher for HW compared to OW children (0.13 ± 0.04 vs. 0.11 ± 0.03 $kcal \cdot kg^{-1} \cdot min^{-1}$). Twenty of the games were enjoyable and elicited sufficient PAEE. **Conclusion:** It was determined that these children's games could be incorporated into a 30-min intervention to correct for the ~100 $kcal \cdot day^{-1}$ energy surplus associated with childhood obesity.

Introduction

Prescribing a PA intervention specifically for promoting healthy age-related weight gains in children is an arduous task. Research suggests that the

childhood obesity epidemic is a consequence of a chronic energy surplus equal to ~100 – 165 $kcal \cdot day^{-1}$ (25, 152). In order to develop interventions to correct for this energy surplus, it is necessary to first determine the energy cost of the preferred PA behavior for this population. There are relatively few data on the energy cost of children's everyday activities, including free-play, due to the complex nature of this behavior. Children are prone to sporadic changes in activity movement patterns with quick shifts between high and low-intensity activities; 95% of their high intensity activity lasting <15 seconds (12). Although investigators have attempted to quantify PAEE in children, the studies have measured continuous activities, such as throwing a ball or walking on a treadmill for a preset amount of time (3 – 20 min) (96, 146), rather than measuring the preferred free-play behavior to which children are accustomed. Therefore, using these laboratory-based measures of PAEE limits the capacity to develop appropriate interventions for balancing the energy equation and preventing excess weight gain.

Few interventions have had positive effects on obesity (130). The lack of success has been attributed, in part, to the inaccurate measures of the PA dose of these interventions. Direct observation, accelerometry and heart rate monitoring have been validated to estimate PAEE during PA in children (40, 65, 80, 136). However, heart rate monitors are sensitive to factors unrelated to PA (35, 71), direct observation is limited to group assessments of PA level (23, 81), and activity monitors attempt to convert a physical measure of steps or counts to

a physiological measure of PAEE using prediction equations that have yet to accurately assess PAEE in children (44, 96, 142).

Advancements in measurement technology, including portable indirect calorimetry, offer the freedom of movement during measurements thus, improving accuracy of measuring the energy cost of free-play in children. The accurate assessment of a child's preferred PA behavior (free-play) is the first step in developing interventions that will positively impact childhood obesity. Therefore, the purpose of this study was to directly measure the energy cost of common children's games in a simulated free-play environment. It was hypothesized that most games selected would be sufficient energy cost (~100 kcal) to be incorporated into a 30-min structured PA intervention designed for obesity prevention. It was further hypothesized that the energy cost of the games will be positively associated with perceived enjoyment of the games and that PAEE would differ between boys and girls and between HW and OW children.

Methods

Third grade children were recruited from local elementary schools in Amherst, MA. An equal number of boys and girls and HW and OW children were recruited for the study. Each child and parent signed the informed consent/assent documents in accordance with the University of Massachusetts and Children's Hospital Boston Institutional Review Boards. Eligible children were free from cardiorespiratory, metabolic, and neurological disorders, physical

impairments that would prevent them from being physically active, and not taking any medications that would affect metabolism.

Anthropometrics. Upon arrival to the Physical Activity and Health Laboratory the child's stature was measured to the nearest 0.25 cm using a floor stadiometer (Detecto, Webb City, MO) and weight was measured to the nearest 0.1 kg using a digital scale (Lifesource ProFit precision scale, Milpitas, CA). These values were used to determine the child's BMI and BMI percentile using the CDC's age- and sex-specific growth charts (69). Waist circumference was measured to the nearest 0.10 cm at the horizontal line between the superior iliac crests.

Resting Metabolism. Compliance of a 3-hour fast prior to measuring resting metabolic rate (RMR) was confirmed by the parent. The children relaxed in a supine position in a quiet, temperature-controlled room for 10 min. The child was then asked to breathe through a portable metabolic analyzer (MedGem®, MicroLife USA, Dunedin, FL) for a maximum of 10 min. RMR was recorded as EE ($kcal \cdot day^{-1}$).

Activity Protocol. A list of 60 common children's games was developed from previous intervention studies such as CATCH (Coordinated Approach to Child Health) and the Medical College of Georgia Exercise Project (15, 72). A focus group consisting of 10 local elementary school physical education teachers assisted in selecting 30 games that were safe, highly active (moderate intensity level; ≥4 METs) and both appropriate and enjoyable for this age group from the initial list of 60 games (57).

As a control condition, the children completed a 6-min walk on the treadmill at 1.12 $m \cdot sec^{-1}$ and 0% grade. The child was then taken to a large gymnasium to play 10 games randomly selected from the approved list of games. Each game was played for 6 min with a 3 – 4 min rest period between games. Each child was accompanied by a playmate of similar age, usually a good friend, in order to stimulate a more natural free-play during the games. Upon the completion of each game the child was asked to rate their perceived enjoyment by pointing to the appropriate facial expression on the Facial Affective Scale (FAS), a 9-point Likert scale of facial expressions depicting mood (happy to sad).

Instrumentation. The child wore a portable metabolic analyzer (Oxycon Mobile®, Cardinal Health, Dublin, OH) during the games for breath-by-breath gas exchange analysis to determine the energy cost of the activities. The Oxycon Mobile (OM) has been validated against other laboratory methods (e.g. Douglas bag and Sensor Medics and ParvMedics products) for measuring EE and has previously been used as a criterion measure in studies with adults and children (11, 62). The device weighs 950 grams and consists of a facemask connected to a volume sensor, gas analyzer unit (SBx) and a data-storage/telemetry unit (DEx). The SBx and DEx units were secured to the subject in a backpack allowing freedom of movement. Heart rate was monitored using the POLAR S610i with the strap across the child's chest and the watch on their non-dominant wrist. PAEE was calculated as the total EE above RMR. The average PAEE ($kcal \cdot min^{-1}$) was computed for each game, disregarding the first 1 min and last 10 sec of data.

Accelerometry was used to assess PA counts during the games. The Actigraph GT1M (ActiGraph, Pensacola, FL), a piezoelectric uniaxial device, measures acceleration signals in the vertical plane between 0.05 and 2.5 g at a sampling rate of 30 Hz. The GT1M weighs 27 g with the following dimensions: 38 mm wide, 37 mm tall and 18 mm thick. The GT1M has been validated for estimating PAEE in children of all ages (44, 96, 147). The unit was initialized to collect data in 1-sec epochs and average counts per minute were computed for the same time stamp as the metabolic unit.

Statistical Analysis. A two-way ANOVA was used to assess differences in PAEE with sex and BMI class as main effects. Pearson r correlations were calculated to determine the relationship among PAEE, $counts \cdot min^{-1}$ and FAS. The lower boundary of the 90% confidence interval (CI) was calculated to include the majority of subject's responses during the activities. Using the lower CI, a game with ≥3.3 $kcal \cdot min^{-1}$ was considered reasonable for most children to expend ≥100 kcal while playing this game over a 30-min time period. Using the lower CI, a game with ≥5 on the FAS scale (neutral expression) was considered enjoyable to presume sufficient participation by most children. An activity was considered an acceptable game to be incorporated into a future intervention if it met both PAEE and FAS criteria. The same lower CI was used to determine the minimum PA counts from the GT1M for with each game. This $count \cdot min^{-1}$ value for each game could then be used in the field to estimate PAEE when more direct measures are not feasible.

Results

Participant Characteristics. Twenty-eight 3rd grade children (15 boys and 13 girls; 16 HW and 12 OW children) volunteered for the study. The children completed an average of 10.6 games (range = 7 – 11 activities). All of the children completed the treadmill activity while only 23 completed all 11 activities. One child volunteered for only 6 of the games and the protocol was shortened for 4 children due to time constraints or mechanical difficulties.

Participant characteristics are presented in Table 2. Body weight was significantly higher for girls compared to boys and the girls were taller than the boys, although this difference in height was not significant ($p = 0.15$). Body composition measures (BMI and waist circumference) were not significantly different between boys and girls. However, HW children had significantly lower body weight, BMI and waist circumference compared to OW children. RMR values were not significantly different between sex or BMI groups.

Energy Expenditure. The mean (± SD) energy cost of the games was 4.1 ± 1.2 $kcal \cdot min^{-1}$ or 5.1 ± 1.3 METs (Table 3). Group analysis revealed that there was no significant difference in PAEE between boys and girls when expressed as $kcal \cdot min^{-1}$ or METs ($p > 0.05$). However, HW children expended significantly more energy than OW children when expressed relative to body weight ($kcal \cdot kg^{-1} \cdot min^{-1}$).

Using the MET cut-points for children, all of the children's games are considered moderate intensity (≥4 METs) (Table 3). The treadmill bout (TM), designed to be a controlled, light intensity activity, was the only activity found to

be <4 METs (Table 4). Twenty-three of the 30 games elicited sufficient PAEE to meet the criterion for energy cost using the lower boundary of the 90% CI ≥3.3 $kcal \cdot min^{-1}$ (Figure 3).

Enjoyment. All the games combined were considered enjoyable (FAS = 7.1 ± 2.0) by the children and there was no significant difference in perceived enjoyment between sex or BMI groups (Table 3). Four of the 30 children's games did not meet the minimum criterion for perceived enjoyment level with a lower boundary of the 90% CI ≥5 on the FAS (Figure 3). There was no significant relationship between the perceived enjoyment of the games and the corresponding PAEE (R^2 = 0.02). It is interesting to note that three of the least enjoyable games (Pass the Hat, Blob Relay and Race Day) were played at a high enough intensity by most of the children to meet minimum criterion for PAEE regardless of the low level of enjoyment for these specific games. When applying both the PAEE and enjoyment criteria to the data, 20 of the 30 games met both inclusion criteria.

Physical Activity. The mean PA level during the games, as measured by the GT1M, was 2855 ± 1146 $counts \cdot min^{-1}$. There were no significant group differences in $counts \cdot min^{-1}$ between boys and girls and HW and OW children (Table 3). A weak relationship between GT1M $counts \cdot min^{-1}$ and PAEE (R^2 = 0.27). The average $counts \cdot min^{-1}$ was calculated for each game to establish accelerometer data that can be used to determine adequate activity intensity and estimate PAEE when the games are played in future interventions (Table 4).

Discussion

The primary goal of this study was to assess the energy cost and enjoyment of common children's games for developing a PA intervention that would effectively correct for the purported ~100 $kcal \cdot day^{-1}$ energy surplus associated with childhood obesity. A menu of common children's games was chosen from previous interventions that successfully increased PA, specifically CATCH and the MCG Exercise Project. However, in neither study was the intervention's contribution toward total daily EE measured. CATCH used self-report measures for determining the dose of PA at the individual level, a tool which does not provide accurate estimations of EE in this population. The MCG Exercise Project monitored individual PA intensity during each exercise session with heart rate monitors. Investigators have shown that HR monitors are affected by factors that are non-exercise related, such as anxiety and illness (98), and tend to lag behind quick changes in activity intensity. Because children quickly change activity intensity, this lag masks the true energy demands of the activities (71, 76). Although CATCH and the MCG Exercise Project successfully increase PA, these studies provided no evidence as to the individual energy cost of the interventions and how these interventions affected total daily EE.

By accurately measuring individual energy demands of children's free-play PA successful interventions to target childhood obesity can be developed. However, in the few studies that have described the energy demands of children's PA, the methodologies have inherent flaws. The accuracy of the measurement tools used to assess energy cost is questionable. Puyau and

colleagues used a whole room calorimeter to measure energy cost in 6-16 year old children (96). This whole room calorimeter directly and indirectly assesses EE by using a microwave detector to determine heat changes within the room and gas analyzers to detect changes in VO_2 and VCO_2 concentrations. Although this device has been validated for use in children, it may not be sensitive enough to detect the quick changes in activity intensity and the concomitant changes in PAEE to which children are accustomed. A study by Sun et al. (137) described modifications to a similar device that enhanced the capacity to accurately measure EE in 1-min intervals; an epoch still too long to capture the short, explosive nature of children's free play. Also the room, a confined 30-m^3 space, would inhibit the child's natural tendency toward free play. The current study uses a portable metabolic analyzer that allows for freedom of movement within a large gymnasium. The device also analyzes expired air breath-by-breath to capture sudden changes in PAEE.

Other studies have used instruments that allow for freedom of movement and provide frequency, intensity and duration of participation in PA, tools such as accelerometers. These devices have been validated for estimating the energy cost of PA in children and have the sensitivity to detect the explosive nature of children's free play by using short epoch lengths (e.g. 1–sec). However, calibration studies have produced numerous prediction equations to estimate PAEE from the accelerometer counts with a modest degree of accuracy (147). These studies have also limited the measurements to non-characteristic activity patterns for this age group which reduce the accuracy of using these equations

for estimating PAEE during free play (61). The current study established a range of acceptable counts and its corresponding measured PAEE for each game during free-play. Due to the large variability in counts·min^{-1} between games resulting in a weak relationship between accelerometer data and PAEE, more research would be necessary to establish valid accelerometer cut-points for estimating PAEE in the field.

Secondly, the activity modes selected for measurement during previous studies were not representative of children's preferred play behavior. A study by Harrell et al. (57) measured common children's activities, such as walking, homework, jump rope, and household tasks, for a period of 10 min using a portable metabolic unit. Although these activities have been established as common activities for children, they are not typically included in PA interventions for the purpose of obesity prevention. The current study measured games that are typically incorporated into interventions that promote increased PA for the prevention of excessive weight gains. By developing interventions using games that were measured to elicit known PAEE, the capacity to assess the PA dose required to help balance the energy equation is enhanced.

In conclusion, this study demonstrates that in a simulated free-play environment, common children's games will elicit at least 100 kcal/30 min for inclusion in future PA intervention. Although it remains to be seen if these games will elicit a similar PAEE in a field-based intervention, accurate measures of this behavior brings us one step closer to developing effective weight management interventions for children. Future studies should incorporate this

methodology to expand on this initial list of children's games and to determine the energy cost of children's free-play behavior in the field.

Table 2. Study 1 - Participant Characteristics (Mean ± SD)

	Overall	Sex		BMI Classification	
		Boys	Girls	HW	OW
	N = 28	N = 15	N = 13	N = 16	N = 12
Age (y)	8.9 ± 0.4	8.9 ± 0.5	8.8 ± 0.4	8.9 ± 0.4	8.8 ± 0.5
% Minority	17.8%	20.0%	15.4%	25.0%	8.3%
Height (cm)	137.3 ± 6.4	135.8 ± 5.8	138.9 ± 6.9	136.1 ± 6.9	138.8 ± 5.7
Weight (kg)	35.7 ± 8.3	35.0 ± 8.1*	36.5 ± 8.7*	30.5 ± 4.4*	42.7 ± 7.0*
BMI (kg/m^2)	18.8 ± 3.7	18.9 ± 3.8	18.8 ± 3.8	16.4 ± 1.3*	22.1 ± 3.4*
BMI (%ile)	65.8 ± 28.9	66.1 ± 32.8	65.5 ± 24.9	45.8 ± 22.1*	92.5 ± 4.7*
Waist circ. (cm)	67.1 ± 11.2	67.0 ± 10.9	67.4 ± 10.8	59.4 ± 5.0*	77.5 ± 8.2*
RMR ($kcal \cdot day^{-1}$)	1366.0 ± 217.6	1329.3 ± 232.0	1408.2 ± 200.3	1365.4 ± 233.0	1366.7 ± 205.4

BMI = Body mass index; Waist circ. = waist circumference; RMR = resting metabolic rate; HW = Healthy weight (BMI < 85th percentile); OW = Overweight/Obese (BMI ≥ 85th percentile).

* Values are significantly different between groups. ($p < 0.05$)

Table 3. Study 1 - Energy cost and enjoyment of the 30 games. Mean ± SEE

		Physical Activity Energy Expenditure			Physical Activity		Facial Affective Scale
	N	$Kcal \cdot min^{-1}$	$Kcal \cdot kg^{-1} \cdot min^{-1}$	METs	$Counts \cdot min^{-1}$	N	
Total	298	4.1 ± 0.1	0.118 ± 0.002	5.1 ± 0.1	2855 ± 66.4	278	7.1 ± 0.1
Female	138	4.0 ± 0.1	0.113 ± 0.003	4.8 ± 0.1	3008 ± 112.2	128	6.9 ± 0.2
Male	160	4.1 ± 0.1	0.122 ± 0.003	5.2 ± 0.1	2724 ± 75.8	150	7.3 ± 0.2
HW	173	3.9 ± 0.1	0.127 ± 0.003*	4.8 ± 0.1	2963 ± 94.4	161	7.3 ± 0.2
OW	125	4.4 ± 0.1	0.105 ± 0.003*	5.4 ± 0.1	2706 ± 88.2	117	6.9 ± 0.2
Female HW	96	3.8 ± 0.1	0.120 ± 0.004	4.6 ± 0.1	3058 ± 139.3	89	7.0 ± 0.3
Female OW	42	4.5 ± 0.2	0.097 ± 0.004	5.5 ± 0.2	2893 ± 187.3	39	6.8 ± 0.3
Male HW	77	3.9 ± 0.2	0.136 ± 0.005	5.1 ± 0.2	2845 ± 121.4	72	7.7 ± 0.3
Male OW	83	4.4 ± 0.1	0.109 ± 0.003	5.4 ± 0.1	2612 ± 92.3	78	7.0 ± 0.2

SEE = standard estimation error; HW = healthy weight (BMI <85th percentile); OW = overweight/obese (BMI ≥85th percentile); N = all possible comparisons (child x the number of activities completed by each child)

* Significant difference between groups. ($p < 0.05$)

Table 4. Study 1 - Physical activity energy cost and counts by game. Mean ± SD

Activity	N	Physical Activity Energy Expenditure			Physical Activity
		Kcal·min^{-1}	Kcal·kg^{-1}·min^{-1}	METs	Counts·min^{-1}
Barker's Hoopla	9	4.1 ± 1.2	0.13 ± 0.04	5.2 ± 1.56	2913.5 ± 741.9
Blob Relay	9	4.3 ± 0.9	0.13 ± 0.02	5.4 ± 1.13	2489.4 ± 600.6
Builders & Dozers	9	5.2 ± 0.6	0.16 ± 0.02	6.0 ± 0.79	4912.0 ± 1520.5
Can't Touch This	10	4.2 ± 1.0	0.12 ± 0.03	5.4 ± 1.21	2495.3 ± 692.1
Capture the Flag	9	4.2 ± 0.9	0.12 ± 0.03	4.9 ± 0.96	2274.0 ± 375.4
Cardio Course	8	4.0 ± 1.1	0.11 ± 0.03	4.7 ± 0.97	4496.5 ± 1755.2
Castles	9	3.7 ± 1.1	0.11 ± 0.02	4.9 ± 1.27	3173.5 ± 871.0
Clean your Room	9	5.0 ± 0.6	0.13 ± 0.03	5.9 ± 0.56	3812.8 ± 1142.8
Computer Virus	9	5.8 ± 1.1	0.17 ± 0.04	6.7 ± 1.44	4681.6 ± 1121.2
Couple Tag	8	4.6 ± 0.9	0.14 ± 0.03	5.5 ± 0.81	2577.0 ± 499.4
Crazy Soccer	9	4.0 ± 0.9	0.11 ± 0.04	4.9 ± 0.42	2186.6 ± 607.2
Crows & Cranes	9	3.6 ± 0.7	0.10 ± 0.02	4.4 ± 0.71	1991.0 ± 526.1
Domino Relay	7	3.2 ± 1.0	0.10 ± 0.03	4.3 ± 1.29	2379.5 ± 581.4
Dragon's Tail	10	4.6 ± 1.1	0.13 ± 0.04	5.3 ± 0.87	2903.6 ± 657.3
Dribblers & Shooters	10	4.5 ± 1.2	0.13 ± 0.03	5.7 ± 1.26	3273.0 ± 937.0
Eagles & Sparrows	8	3.6 ± 0.8	0.10 ± 0.03	4.6 ± 0.51	2066.1 ± 492.2
Fitness Tag	10	4.1 ± 1.2	0.11 ± 0.04	4.8 ± 1.20	2715.8 ± 616.0
Fox & Hound	8	4.2 ± 0.9	0.13 ± 0.03	5.3 ± 1.29	1973.5 ± 355.8
Great Escape	9	3.7 ± 0.8	0.11 ± 0.02	4.8 ± 0.95	3767.9 ± 534.2
Hibernation	9	3.5 ± 0.9	0.10 ± 0.03	4.3 ± 0.76	2530.9 ± 735.4
Hot Spot	10	4.4 ± 1.1	0.13 ± 0.02	5.7 ± 1.10	3728.1 ± 939.6
I'm a New Skunk	9	4.7 ± 1.2	0.14 ± 0.03	5.8 ± 1.14	2314.9 ± 517.1
Mini Kickball	8	4.7 ± 0.7	0.13 ± 0.03	5.6 ± 0.45	2546.6 ± 664.6
Monkey in the Middle	9	3.7 ± 1.3	0.09 ± 0.03	4.6 ± 1.04	1935.3 ± 910.8
Pass the Hat	9	4.2 ± 1.0	0.12 ± 0.02	5.1 ± 1.18	3696.6 ± 978.8
Pirate's Treasure	10	4.5 ± 1.4	0.13 ± 0.04	5.3 ± 1.53	3042.5 ± 695.9
Race Day	9	5.2 ± 1.6	0.15 ± 0.04	6.1 ± 1.73	4068.3 ± 1119.6
Shark's & Minnows	9	3.8 ± 1.2	0.11 ± 0.03	5.2 ± 1.36	1845.8 ± 655.6
Steal the Bacon	10	4.7 ± 1.1	0.13 ± 0.04	5.4 ± 1.39	2775.6 ± 749.3
Stop & Go	10	4.0 ± 0.9	0.11 ± 0.04	4.7 ± 0.65	2811.1 ± 1022.3
TM (1.12 m·sec^{-1})	28	2.3 ± 0.6	0.06 ± 0.01	3.4 ± 0.66	1857.5 ± 421.1

N = all possible comparisons (child x # of activities completed by each child).

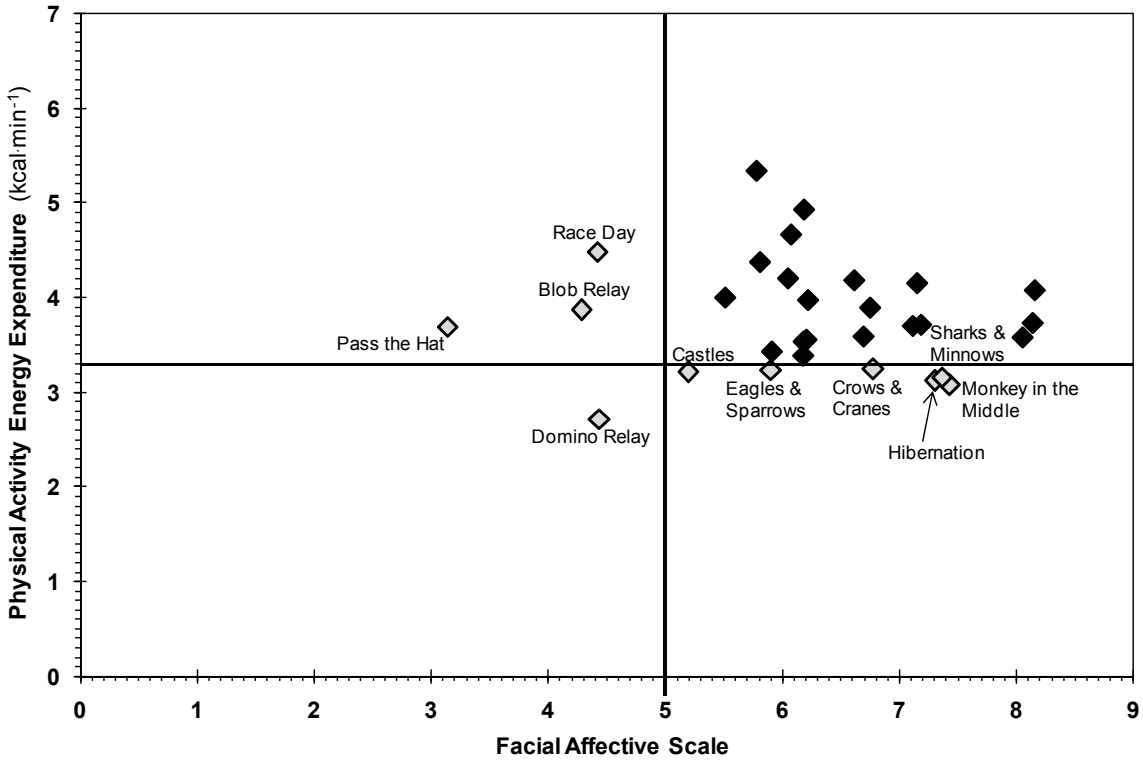


Figure 3. Study 1 - The Relationship between the energy cost and enjoyment of each activity using the lower boundary of the 90% confidence intervals. The lines represent the minimum criterion for energy cost and enjoyment. (R^2 = 0.002).

Study 2. Children's simulated recess program: measures of energy cost and enjoyment

Abstract

Purpose: The purpose of this study was to evaluate the changes in energy cost and enjoyment of children's games over a 10-session simulated free-play recess program. **Methods:** Ten 3rd grade children (8 boys and 2 girls) were recruited from a single classroom to participate in ten 30-min sessions within a 6 week period. During each session the children played a random selection of 3 games from a list of 6 games measured previously to be enjoyable and elicit ≥100kcal·30 min^{-1}. All of the children wore an activity monitor to measure PA levels during each session and rated their perceived enjoyment using the 9-point Likert scale of facial expressions. Each session one child was randomly chosen to wear the portable metabolic unit to measure PAEE. **Results:** The children perceived the games as enjoyable, although enjoyment significantly declined over the 10 sessions. Mean (± SEE) PAEE of the games was 5.0 (± 0.32) kcal·min^{-1}, with great variability observed during the program. The games were classified as MVPA according to the average counts·min^{-1} and this also declined during the program. The children who wore the metabolic unit acquired significantly less counts·min^{-1} during the games compared to the non-measured children, although this did not affect the intensity classification of the games. **Conclusions:** Children's games were measured to be enjoyable and MVPA yet this declined over time. More research is necessary to determine if this decline would reduce the effectiveness of longer interventions.

Introduction

The prevalence of overweight or obesity in 6 – 11 year old children has increased dramatically (from 4.0% to 17.0%) in the past three decades in the United States (69, 152). The underlying cause of obesity has been equated to a small positive imbalance (~2%) between daily energy intake and EE (50). This energy surplus may be abated through the addition of PA equaling ~100 – 165 $kcal \cdot day^{-1}$ (60, 152).

The most recent guidelines published by the U.S Department of Health and Human Services (2008) recommend children acquire a minimum of 60 min of daily MVPA for weight management and health (1, 134). PA intervention studies have successfully increased children's level of MVPA (54, 72), although the effect of this increased activity on adiposity levels has been weak and inconsistent (130). However, most intervention studies fail to accurately measure the energy cost of the activities prescribed during the intervention, making it difficult to establish sufficient empirical evidence of the PA dose required to curb excess weight gain in children (15, 72). Some data suggest that the intensity of the games and activities promoted during previous PA interventions, such as tag or capture the flag, are at least MVPA. Pediatric PA research studies have attempted to quantify PAEE in children using indirect calorimetry, the gold standard for measuring energy metabolism. However, these studies have elected to measure continuous activities, such as throwing a ball or walking on a treadmill for a preset amount of time (3 – 20 min) (57, 96, 146), rather than measuring the intermittent and sporadic free-play behavior to which children are

accustomed. Therefore, these laboratory-based measures of PAEE do not provide adequate empirical data to inform the development of enjoyable PA interventions for the prevention of excess weight gain among children.

Research has also shown that enjoyment is a potential mediator for encouraging PA participation in children (64, 110, 113). If enjoyment is in fact an important factor for predicting PA participation, then an intervention including games that have been empirically shown to be enjoyable would encourage greater participation. However, no studies have measured children's perception of enjoyment for specific games or activities, including those that have been incorporated into previous intervention studies.

In summary, an intervention for the prevention of excess weight gain in children should incorporate enjoyable games or activities that are sufficient energy cost to correct for the purported energy surplus associated with childhood obesity. The purpose of this study was to directly measure the energy cost and enjoyment of common children's games during a 10-session simulated free-play recess program and to determine if these values change over time. Success of these future interventions is dependent on adequate participation while playing the games in the field. Therefore, a secondary purpose of the study was to identify accelerometer cut-points for these games to be used as point estimates of EE field where more direct measures of EE are not feasible.

Methods

Recruitment. Third grade children from a single classroom of an elementary school in Amherst, MA, were recruited to participate in the study.

Each child and parent signed the approved informed consent/assent documents in accordance with the University of Massachusetts Institutional Review Board regulations. Eligible children were free from cardiorespiratory, metabolic, and neurological disorders, physical impairments and were not taking any medications that would prevent them from being physically active or would affect metabolism.

Physical Measures. During the informed consent visit the child's stature was measured to the nearest 0.25 cm using a floor stadiometer (Detecto, Webb City, MO) and weight was measured to the nearest 0.1 kg using a digital scale (Lifesource ProFit precision scale, Milpitas, CA). BMI percentile was calculated using the CDC's age- and sex-specific growth charts (69). Children with a BMI <85th percentile were classified as HW while those with a BMI ≥85th percentile were classified OW (69).

Resting Metabolism. It was not feasible to measure resting metabolic rate (RMR) for this study. Therefore, a prediction equation was used to estimate RMR for each child. In a previous study in our laboratory, measured RMR from third grade boys and girls (N = 28) using a portable metabolic analyzer (MedGem®, MicroLife USA, Dunedin, FL) was compared to the estimated RMR (RMRest) values from various age-appropriate prediction equations (Table 5) (7, 9, 73, 85, 116) A paired t-test was used to assess the differences between measured and estimated RMR for the group and within sex and BMI classification subgroups. Four of the five prediction equations significantly overestimated RMRest compared to the measured RMR (136.1 – 220.8 kcal·day^{-}

^{1}; $p<0.05$). RMRest using the WHO equation was not significantly different from measured RMR (61.4 $kcal \cdot day^{-1}$; $p = 0.17$) and was therefore used in the current study to estimate resting metabolism for each child.

Recess Program Protocol. Twenty common children's games were determined previously in study one to be enjoyable and elicit an EE of at least 100 kcal above resting metabolism in 30 min (≥ 3.3 $kcal \cdot min^{-1}$) by third grade girls and boys. A subset of 6 games were selected from this list of 20 games to be used in the current study on the basis of differences in typical movement patterns (chasing, dribbling, throwing, calisthenics, etc.), games objectives (individual or team games, skill-based, fitness-based, relay-type games, etc.) and energy costs (range = 3.5 ± 0.3 to 4.7 ± 0.2 $kcal \cdot min^{-1}$). A brief description of the games is presented in Table 6.

The 10 sessions of this simulated recess program were schedule 1 – 2 times per week over a 6 week period with 3 – 7 days between sessions. During each of the 10 sessions the children participated in 3 games randomly chosen from this subset of 6 games for up to 9 min each. During a brief period between games (~ 1 min), the children were asked to rate their perceived enjoyment of each game by circling the appropriate facial expression on their individual Facial Affective Scale (FAS) posted on the wall. An effort was made to keep this break to less than 1 minute in order to maximize the use of the entire 30-min recess session.

Instrumentation. During each session a different child was chosen at random and asked to wear a portable metabolic analyzer, the Oxycon Mobile®

(OM; Cardinal Health, Dublin, OH), for breath-by-breath gas exchange analysis to measure the energy cost of the games. The OM has been validated against other laboratory methods (e.g. Douglas bag and Sensor Medics and ParvMedics products) for measuring total EE (TEE) and has previously been used as a criterion measure in studies with adults and children (11, 62). The device weighs 950 grams and consists of a facemask connected to a volume sensor, a gas analyzer unit (SBx) and a data-storage/telemetry transmission unit (DEx). The SBx and DEx units were secured to the subject in a backpack designed to allow freedom of movement. Heart rate was monitored using the POLAR S610i with the strap across their chest and the watch on their non-dominant wrist. PAEE was calculated as TEE minus RMRest. The average PAEE ($kcal \cdot min^{-1}$) from the OM was computed for each activity using approximately 7 min and 50 sec of breath-by-breath data, disregarding the first min and last 10 sec of data.

During all recess sessions, every child was fitted with an activity monitor on the non-dominant hip with an elastic belt to assess PA levels during the games. The Actigraph GT1M (ActiGraph®, Pensacola, FL), a piezoelectric uniaxial device, measures acceleration signals in the vertical plane between 0.05 and 2.5 g at a sampling rate of 30 Hz. The GT1M weighs 27 g with the following dimensions: 38 mm wide, 37 mm tall and 18 mm thick. The GT1M has been validated for estimating PAEE in children of all ages (44, 96, 147). The unit was initialized for collecting data in 5-sec epochs and average $counts \cdot min^{-1}$ was computed for the same time interval as the metabolic measurement system.

Statistics. A repeated measures ANOVA (RMANOVA) was used to determine significant differences in PAEE, FAS and counts·min^{-1} with BMI, game and session as main affects. FAS was introduced into the model as a covariate to assess the relationship among enjoyment and counts·min^{-1} and PAEE during the games. Each game was then analyzed individually and compared against two criteria for inclusion in future PA interventions: lower 90% confidence boundary on mean PAEE was at least 3.3 kcal·min^{-1} (≥ 100 kcal·30 min^{-1}), and lower 90% confidence boundary on mean FAS was at least 5 on the 9-point FAS scale. Mean counts·min^{-1} were computed for each game and compared to published cut-points defining MVPA for this age group (44).

Results

Characteristics of Participants. Ten children (8 boys and 2 girls) from a single 3rd grade classroom volunteered to participate in the 10-session recess program. The general characteristics of the group are presented in Table 7. The mean BMI was 18.5 ± 2.9 kg·m^{-2}. There was a significant difference between HW (n = 6) and OW (n = 4) children for weight, BMI and BMI percentile ($p < 0.05$). RMRest was 18.1% higher in OW compared to HW children ($p = 0.02$).

Energy Expenditure. The mean ± SEE PAEE of the 6 games was 5.0 ± 0.32 kcal·min^{-1} (6.6 ± 0.28 METs) (Table 8) and this value did not change over the length of the program ($p = 0.22$) (Figure 4). When comparing the games individually, all 6 of the games were considered MVPA (≥4 METs) although the values were highly variable between games and between sessions. All of the children's games, except for Fitness Tag, met the PAEE criterion of ≥3.3

$kcal \cdot min^{-1}$ (Figure 5). The energy cost of the games was not affected by BMI classification; OW children expended only slightly more energy during the games compared to HW children (5.7 ± 0.6 vs. 4.4 ± 0.3 $kcal \cdot min^{-1}$, respectively) ($p = 0.15$).

Enjoyment. All of the games combined were perceived enjoyable by the children (FAS = 6.7 ± 0.16; Table 9). All 6 games met the criterion for enjoyment with the lower boundary of the 90% confidence interval ≥5 on the 9-point Likert scale. Enjoyment of the recess session was not affected by BMI classification (6.6 ± 0.2; $p = 0.93$) or by wearing the metabolic unit (6.6 ± 0.16 to 6.8 ± 0.37; $p = 0.95$). The average FAS score for the recess sessions declined over the length of the program ($p = 0.017$), although this decline in enjoyment had no significant affect on the energy cost of the games ($R^2 = 0.0005$). When combining the PAEE and FAS results, 5 of the 6 games met both criteria for inclusion in future PA interventions (Figure 5).

Accelerometer Counts. The mean $counts \cdot min^{-1}$ for all 6 games was 3508.7 ± 72.0 counts/min. Although all of the games exceeded the 804 – 1017 $counts \cdot min^{-1}$ cut-point value for MVPA for this age range (Table 10), there was significant variability in $counts \cdot min^{-1}$ between games ($p < 0.0001$) with Clean Your Room as the most intense (4712 ± 215.4 $counts \cdot min^{-1}$) and Fitness Tag as the least intense (2860 ± 121.2 $counts \cdot min^{-1}$) activity. BMI classification had no affect on activity counts for the games ($p = 0.90$). PA levels were significantly lower for the children who were wearing the metabolic unit ($p = 0.001$), although this did not affect the intensity classifications of the games. Over the 10 sessions, PA

levels significantly declined an average of 47.7 ± 16.3 counts·min^{-1} per session ($p = 0.004$). When co-varied for enjoyment, activity counts decreased an average of 57.2 ± 20.2 counts·min^{-1} for every decrease of 1 unit of enjoyment ($p = 0.005$).

Discussion

The energy cost and enjoyment of the children's games were directly measured in a free-living environment among a group of peers over repeated sessions to determine the feasibility of incorporating them into a future PA intervention. This methodology informs the development of PA interventions that are sufficient EE to correct the energy imbalance associated with childhood obesity. Further, directly measuring the perceived enjoyment of specific games increases the likelihood of developing an enjoyable intervention and thus, enticing greater participation and EE by the children. Five out of 6 of the games were measured to be enjoyable and elicit sufficient EE to be incorporated into future PA interventions for the prevention of excess weight gain in children.

This study is one of the first to directly measure the energy cost and perceived enjoyment of children's games that are commonly used in PA interventions while simultaneously promoting natural free-play behavior. Previous researchers have successfully measured the energy demands of various activities in this population. However, these studies have either 1) measured continuous or constrained activities that children do not frequently participate in during free play, 2) used methods of measurement tools that are not sensitive to the quick changes in activity intensity common in children's play behavior, or 3) have not accounted for the influence of perceived enjoyment on

measurement outcomes. Harrell et al. measured steady state oxygen consumption during activities such as bench and leg press, jump rope, and running continuously for 10 min in 8 – 18 year old children (57). Children are not prone to reach and maintain steady state oxygen consumption during free-play, but instead they make quick and repeated changes between high and low intensity PA (12). The activities measured in Harrell's and other measurement studies are not commonly included in PA interventions designed for children. Although these studies accurately assess PAEE, they do not provide any empirical data on the energy demands of children's free-play PA. The current study measured the energy cost of common children's games from previous PA intervention studies while allowing the freedom for natural free-play behavior.

Many studies have used questionnaires to assess a child's attraction or enjoyment of PA and have found that enjoyment is positively related to PA participation (24, 109). However, other studies have shown that enjoyment accounts for less than 20% of the variability in PA participation in children. The lack of consistent findings can be related to the error associated with using questionnaires in this population (63, 109). Jago et al. recently published the results of a focus group of 10 -11 year old children revealing that enjoyment was the most important factor in maintaining PA participation and that peer support influenced this level of enjoyment during PA (64). This may support the need for better tools for assessing enjoyment and its relationship with PA participation. Although the Facial Affective Scale (FAS) was originally developed for assessing perception of pain in children (78), this tool was easily understood and scored by

the children in the current study for identifying perceptions of enjoyment. Interestingly, no relationship was found between enjoyment and energy cost in this study, although PA level (counts·min^{-1}) was positively related with enjoyment. It was also important to note that the level of enjoyment declined over the length of the program independent of energy cost.

A major strength of the current study included the repeated measures of enjoyment, energy cost and PA level with the games repeated 3 – 6 times within the 10-session program. Measuring the energy cost of an activity during a single visit does not provide information about changes in these variables and their interactions over the length of a PA intervention. In the current study, as perceived enjoyment and PA levels declined, energy cost did not change. This discrepancy in the relationships might be due to the difference in the number of measures for each variable as well as the great variability in PAEE between games and sessions. Having only one portable metabolic unit limited the measures of energy cost to a single child per session while accelerometry data was collected on every child each session. Using accelerometry data (counts·min^{-1}) as an estimated of energy cost during each session, rather than the indirect calorimetry data, would support the possibility that energy demands of the recess program decreased over time relative to enjoyment. More time series measures of indirect calorimetry would be needed to determine if this is correct.

Although, the portable metabolic unit allows for freedom of moving during free-play, it is suggested that the added burden may impact the child's PA level

as well as the enjoyment of the games. However, by accounting for this factor in the model, wearing the portable metabolic unit had no affect on the enjoyment but, it did have a negative effect on PA level. The children who were not wearing the portable metabolic unit had significantly greater counts·min^{-1} than the children who was wearing the portable metabolic unit. Thus, by evaluating counts·min^{-1} alone, this would suggest that when playing the games in the field without the portable metabolic unit, children may move more freely and expend even greater energy compared to the PAEE directly measured using the portable metabolic unit in this study.

In conclusion, common children's games played in a free-living environment elicit an EE response (~150 kcal in 30min) sufficient to be included in future PA interventions for the prevention of excess weight gain in children. The enjoyment and PA counts during the sessions declined over the short duration of this program. Methods of encouragement, including a larger menu of children's games for variety, may be necessary to maintain sufficient participation levels during more prolonged PA interventions. More research is necessary to determine if PAEE would also follow a similar trend as enjoyment and PA counts·min^{-1} and decline over time.

Table 5. Comparison of measured and predicted RMR in 3rd grade boys and girls. Mean ± SEE

		Prediction Equation	Mean	Bias	95% CI	
RMR	**N = 28**	**Criterion**	**1366.0 ± 39.7**	**- -**	**1284.7**	**1447.2**
Altman *	N >200 – 300	♀ = (0.778*Wt + 24.11) * 24	1222.1 ± 31.2	-143.9	1158.1	1286
		♂ = (0.815*Wt + 21.09) * 24				
Maffeis *	N = 130	♀ = 1552 + 35.8*Wt + 15.6*Ht - 36.3*Age	1145.2 ± 17.7	-220.8	1109	1181.4
		♂ = 1287 + 28.6*Wt + 23.6*Ht - 69.1*Age				
Molnar *	N = 371	♀/♂ = 50.2*Wt + 29.6*Ht - 144.5*Age - 550*Sex + 594.3	1166.6 ± 28.7	-199.4	1107.8	1225.4
Schofield-HW *	N > 7500	♀ = 16.97*Wt + 1.618*Ht + 371.2	1229.9 ± 28.5	-136.1	1171.5	1288.2
		♂ = 19.6*Wt + 1033*Ht + 414.9				
WHO	N > 7500	♀ = 22.5*Wt + 499	1304.5 ± 34.1	-61.4	1234.7	1374.3
		♂ = 22.7*Wt + 495				

CI = confidence interval; SEE = standard error of estimation; RMR = resting metabolic rate; ♀ = female; ♂ = male; Wt = weight in kg; Ht = height in cm; Age in years; Sex = 0 for males, 1 for females.

* Significant difference between predicted and measured RMR. ($p < 0.05$)

Table 6. Description of games for simulated recess program.

Game	Description
Barkers Hoopla	**Organization:** hoops with 8 - 10 items; teams of 2 - 3 players per hoop
	Objective: collect similar items from the other hoops; different modes of locomotion; first team with all items wins
	Movement Patterns: running, bending, hopping, crawling, skipping, throwing
Clean Your Room	**Organization:** Two play areas (two rooms) and bean bags, etc. thrown around the area; 2 teams
	Objective: toss items into other team's room; if a tossed item is caught by the other team, the thrower performs task before continuing the game (e.g. 5 jumping jacks)
	Movement Patterns: bending, tossing, crawling, kneeling, catching, walking, jumping, running
Dragon's Tail	**Organization:** scarves tucked into waistband or back pocket (tail)
	Objective: Collect scarves while protecting your own; if your scarf is nabbed a task is completed before returning to the game
	Movement Patterns: twisting, running, walking, turning, reaching, spinning, pulling; standing
Fitnes Tag	**Organization:** different colored bean bags or balls and matching cones; different activity at each cone
	Objective: if tagged you earn the colored bean bag, move to matching cone, perform activity and return to game
	Movement Patterns: funky jumping jacks, seal walk, crab kicks, reverse crunches, crab-ups, running, standing, sitting, chasing, jutting, cutting, etc.
Hot Spot	**Organization:** Poly spots scattered around a basketball goal; Teams of 2-3 in hoops placed at center court
	Objective: Take turns dribbling to a spot for 1 shot on the goal, spot is earned for the team if successful
	Movement Pattern: dribbling, running, shooting baskets, bending, jutting, chasing, etc.
Stop 'n Go	**Organization: Each** of two teams has their own designated end zone at opposite ends of the play area
	Objective: Played similar to ultimate frisbee, players pass the ball (basketball or football) to reach the end zone; players are not allowed to move while they are in possession of the ball
	Movement Pattern: passing, catching, running, jumping, turning, chasing, cutting, etc.

The games were modified from two previous physical activity intervetnions: CATCH (69) and the MCG Exercise Project (14)

Table 7. Study 2 - Simulated Recess Participant Characteristics (Mean ± SD)			
	All Children	**HW Children**	**OW Children**
	(N = 10)	(n = 6)	(n = 4)
Age (y)	8.4 ± 0.5	8.3 ± 0.5	8.5 ± 0.6
% Minority	60.0%	71.4%	33.3%
Weight (kg)	33.1 ± 6.7	29.4 ± 4.4*	38.7 ± 5.6*
Height (cm)	133.4 ± 5.8	132.6 ± 4.6	134.6 ± 7.8
BMI ($kg \cdot m^{-2}$)	18.5 ± 2.9	16.6 ± 1.4*	21.3 ± 2.3*
BMI (%ile)	69.5 ± 27.2	54.4 ± 25.1*	92.0 ± 6.1*
RMRest ($kcal \cdot day^{-1}$)	1246.6 ± 151.2	1162.4 ± 99.7*	1373.0 ± 128.7*

SD = standard deviation; BMI = body mass index; RMRest = resting metabolic rate derviced from the WHO prediction equation; HW = healthy weight (BMI <85th percentile); OW = overweight/obese (BMI ≥85th percentile)

* Significant difference between HW and OW children. ($p<0.05$)

Table 8. Study 2 - Energy cost of the games (Mean ± SEE)				
		Physical Activity Energy Expenditure		**METs**
	N	($kcal \cdot min^{-1}$)	($kcal \cdot kg^{-1} \cdot min^{-1}$)	
All Games	27	5.0 ± 0.32	0.146 ± 0.007	6.6 ± 0.28
Barkers Hoopla	4	5.9 ± 0.89	0.157 ± 0.015	7.3 ± 0.73
Clean Your Room	3	4.4 ± 0.54	0.160 ± 0.007	6.5 ± 0.27
Dragon's Tail	5	5.2 ± 0.66	0.161 ± 0.013	7.1 ± 0.59
Fitness Tag	5	4.0 ± 0.74	0.121 ± 0.021	5.8 ± 0.78
Hot Spot	4	5.4 ± 0.95	0.157 ± 0.012	7.0 ± 0.77
Stop & Go	6	4.9 ± 0.80	0.133 ± 0.017	6.4 ± 0.73

SEE = standard estimation error.

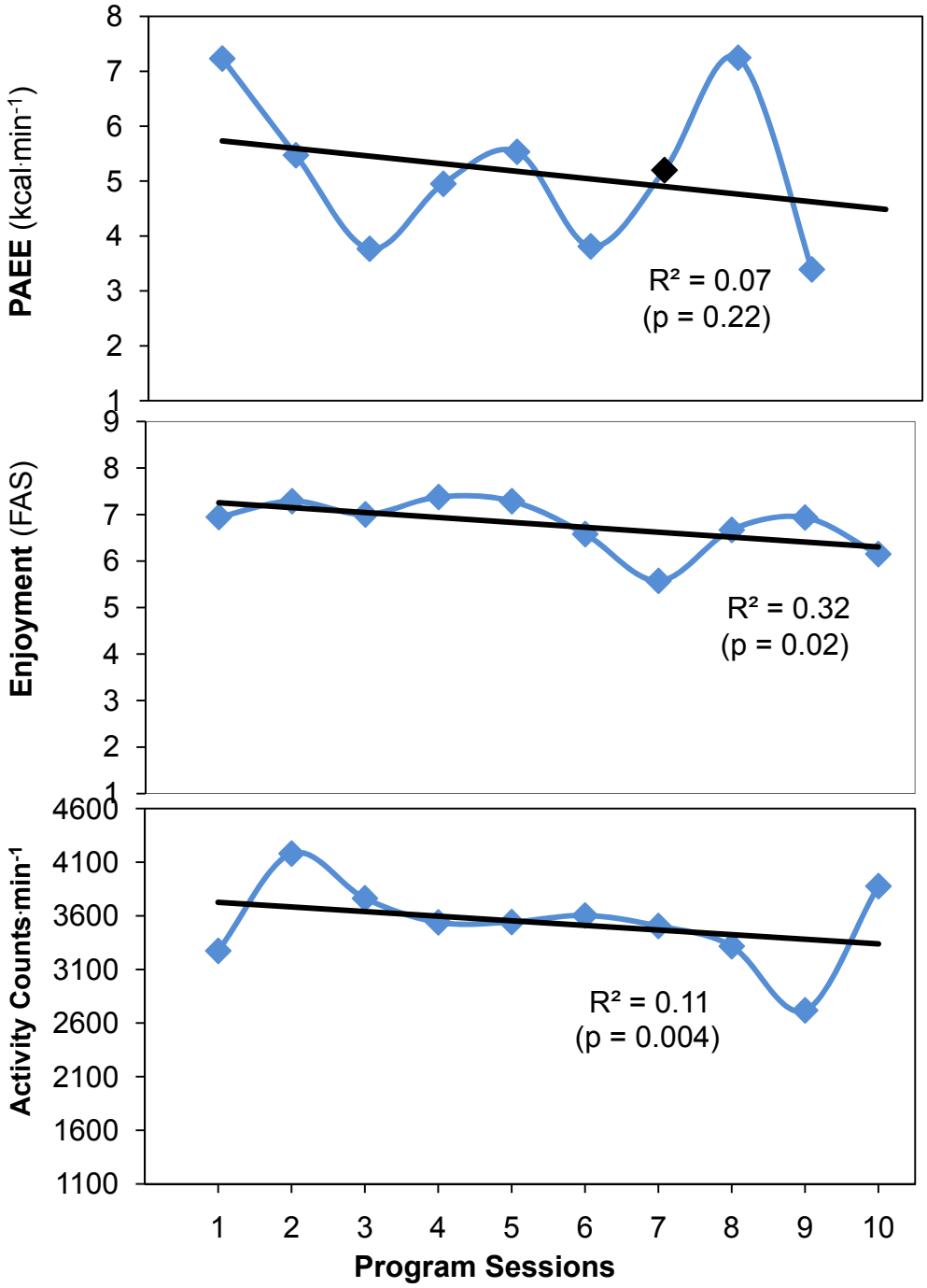


Figure 4. Average PAEE, FAS, and Counts·min^{-1} over the 10-session recess program. Lines represent the line of best fit. PAEE was the mean for one child per session with no data for sessions 7 & 10 and session 9 represents the average of two individually measured children. Missing data point for session 7 (black symbol) was entered as the group average for the variable.

Table 9. Study 2 - Enjoyment levels of the games (Mean ± SEE)

	N	All Children	N	Non-Measured	N	Measured
All Games	240	6.7 ± 0.16	210	6.8 ± 0.37	30	6.8 ± 0.37
Barkers Hoopla	40	7.0 ± 0.31	35	7.4 ± 0.7	5	7.4 ± 0.7
Clean Your Room	42	6.2 ± 0.43	38	6.8 ± 0.8	4	6.8 ± 0.8
Dragon's Tail	41	6.0 ± 0.44	36	6.8 ± 0.8	5	6.8 ± 0.8
Fitness Tag	42	7.3 ± 0.32	37	6.6 ± 1.1	5	6.6 ± 1.1
Hot Spot	37	6.9 ± 0.42	32	6.2 ± 1.4	5	6.2 ± 1.4
Stop & Go	40	7.0 ± 0.39	32	7.0 ± 0.9	6	7.0 ± 0.9

All Children = all children who attended each session; Measured children = those who wore the oxycon mobile during the recess sessions; N = child x # of games play by each child.

Table 10. Study 2 - Physical activity counts·min^{-1} for the games (Mean ± SEE)

	N	All Children	N	Non-Measured	N	Measured
All Games	237	3508.7 ± 72.0	207	3601.3 ± 76.0*	30	2870.2 ± 183.2*
Barkers Hoopla	40	3717.1 ± 152.4	35	3839.9 ± 157.3	5	2857.2 ± 356.7
Clean Your Room	41	4712.1 ± 215.4	37	4801.5 ± 223.0	4	3885.9 ± 750.7
Dragon's Tail	41	3238.6 ± 114.0	36	3300.9 ± 124.5	5	2790.3 ± 178.9
Fitness Tag	42	2860.1 ± 121.2	37	2950.5 ± 120.7	5	2190.9 ± 408.5
Hot Spot	36	3229.8 ± 88.4	31	3252.1 ± 98.8	5	3091.6 ± 181.3
Stop & Go	37	3257.0 ± 159.7	31	3374 ± 157.5	6	2652.0 ± 524.8

All Children = all children who attended each recess session; Measured children = the chld who wore the portable metabolic unit; N = all possible comparisons (child x # of games played by each child).

* Significantly different between measured and non-measured child

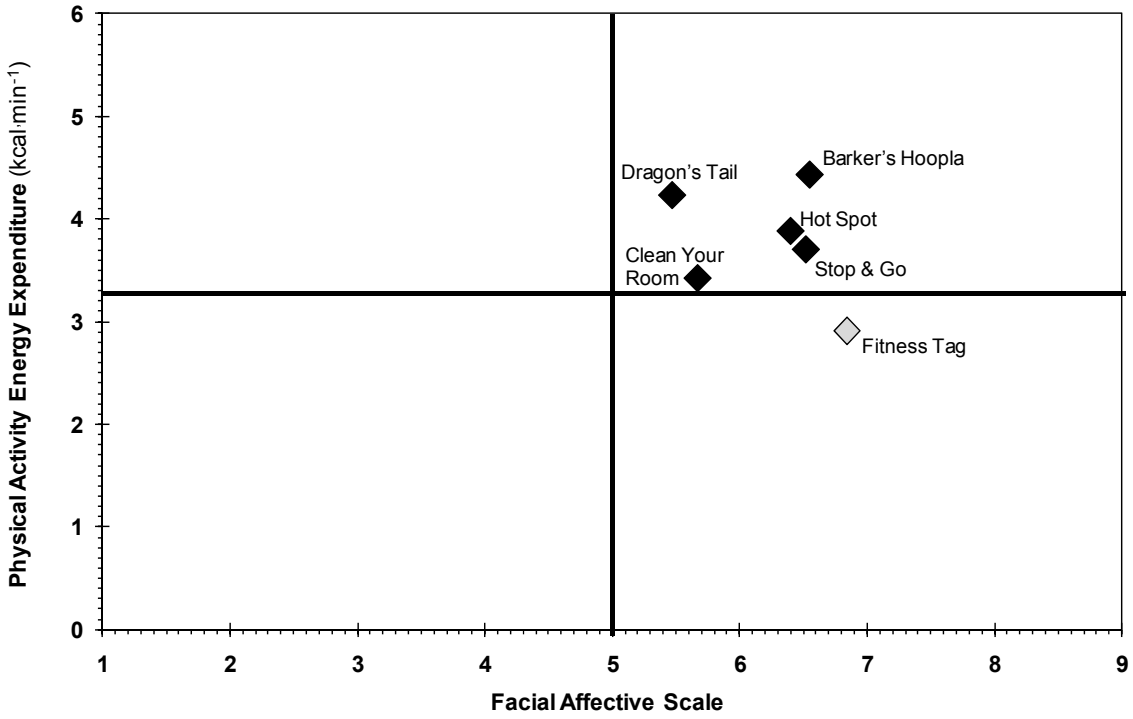


Figure 5. The relationship between the energy cost and enjoyment of each activity. Symbols depicts the lower 90% confidence boundary for mean energy cost and enjoyment of the 6 games. The red lines represent the two criteria: PAEE ≥ 3.3 kcal·min^{-1} and FAS ≥ 5. All games met both the energy cost and enjoyment criteria. Correlation analysis shows no association between energy cost and enjoyment (R^2 = 0.018).

Study 3. The Effects of a Daily 100-Kcal Structured Recess Program on Total Daily Moderate-to-Vigorous Physical Activity.

Abstract

Purpose: This study examined the effects of a 30-min structured recess program of known energy cost on total daily MVPA and SB compared to a free-play recess of the same duration in 3rd grade children. **Methods**: Twenty-seven 3rd grade children (14 boys and 13 girls) were recruited from two elementary schools designated as either the intervention (INT) or control (CON) school. The structured recess program was conducted five days·week^{-1} for 9 weeks for all 3rd grade children at the INT school. The games incorporated into the structured recess were directly measured to be enjoyable and to elicit an EE of ~150 kcal in 30 min (unpublished data). Changes in MVPA and SB from baseline to follow-up were compared between schools using a mixed model ANOVA. **Results**. The INT school children significantly increased MVPA during the school day (X ± SD: 11.0 ± 4.8 min) and for the total day (29.6 ± 9.7 min) compared to CON school (-1.2 ± 3.4 and 3.9 ± 7.0 min). There was no significant effect of the intervention on SB. The INT school gained 1.0 ± 0.5 kg (LSMean ± SEE) less body weight than the CON school over the 9-week program. **Conclusion**. A structured recess program where children participated in games that were measured to elicit an EE of ~150 kcal in 30 min is an effective means to increase PA and prevent excess weight gain in children.

Introduction

The unique patterns of children's free-play activity are reflected in the most recent PA guidelines published by the U.S. Department of Health and

Human Services (USDHHS) (1). These guidelines suggest age-appropriate and enjoyable activities, such as tag, hopscotch, and climbing, that may count towards the recommended 60 min of MVPA for health promotion and weight management. In addition, based on evidence that SB has been linked to increased risk for obesity and obesity-related diseases independent of PA (17, 51, 101), the USDHHS guidelines encourage children to reduce the amount of time spent in SB.

A factor contributing to children's SB is the school environment, which has become increasingly sedentary with the reduction of PA opportunities in physical education (PE) and recess (2, 5, 52). While 71% of the schools across the United States still offer regularly scheduled recess (70), research has shown that children spend the majority of this time being sedentary (74, 83). Research studies using a structured recess as opposed to a free-play recess have demonstrated increases in MVPA during the school day (92, 117). However, implementing school-based interventions designed to increase MVPA do not always lead to increases in total daily MVPA. Children sometimes compensate for the additional PA accrued while participating in a PA intervention with a reduction in PA or an increase in SB outside of school, which results in no net change in total daily MVPA (29, 39, 74, 92). Furthermore, the energy cost of children's free-play PA is unknown, which may also contribute to the lack of consistent success among previous PA intervention studies in reducing excessive weight gain in children (22, 58, 121, 156). Although studies have measured children's PAEE, either the activities that were measured were those

not typically included in PA interventions or the activities were not measured in a free-play environment (57, 96).

Currently, the impact of a structured PA program with a known energy cost during recess on total daily MVPA and SB is unclear. In addition, both initiation and maintenance of PA in children is promoted through enjoyment of the activities (64); however most intervention studies have not empirically assessed the enjoyment of the games that were implemented in these interventions. Previous studies in our laboratory have directly measured the energy cost and enjoyment of a selection of common children's games (unpublished data) that included several of the "*age-appropriate and enjoyable*" activities suggested in the USDHHS guidelines. The mean energy cost of the different games was ~150 kcal in 30 min of structured PA; this energy cost closely approximates the purported daily energy imbalance associated with childhood obesity (100 – 165 kcal/day) (50, 60, 152). Interventions designed to encourage children to be sufficiently active for the prevention of excess weight gain need to include games that are enjoyable and lead to a PAEE sufficient to match the energy surplus. Therefore, the purpose of this study was to determine if an enjoyable 30-min structured recess program of known energy cost increases total daily MVPA, while reducing SB, as compared to a free-play recess of the same duration in 3rd grade children.

Methods

Recruitment of Schools. This study was approved by the University of Massachusetts (UMASS) and Children's Hospital Boston Institutional Review

Boards. Access to the elementary schools and permission to implement a 30-min daily recess program was obtained from the Superintendent of Schools for Springfield, MA. Flyers containing the details of the study were sent via e-mail to all Principals and Vice Principals of the school district requesting those schools interested in participating in the study to contact the UMASS Physical Activity and Health Laboratory. A meeting among the two interested schools, a school board research liaison, and the project staff was arranged to discuss the proposed program, the recruitment of subjects, and the planned baseline and follow-up measurements. A signed agreement between the selected elementary schools and UMASS stated that the structured program would be conducted during a daily 30-min recess at one school (INT) while the same amount of time for free-play would be offered at the second school (CON) for 9 weeks.

Recruitment of Participants. Recruitment packets were sent home with the children in the 3rd grade classrooms and included the approved informed consent and assent documents, health screening form and parent questionnaires (e.g. socioeconomic status and contact information questionnaires). The packets included an English and Spanish version to accommodate the large Spanish speaking population in the school district. The parents were encouraged to contact the research staff by phone or e-mail or attend one of three face-to-face socials if they had any questions or concerns about the study prior to or after parental consent and child assent was given. Eligible children were free from cardiorespiratory, metabolic, and neurological disorders and physical

impairments that would prevent them from being physically active, and were not taking any medications that would affect metabolism.

Physical Measures. For baseline physical measures, the children were asked to report to the school Nurse's office at least 30 min prior to the beginning of the school day. The child was asked to sit quietly in a comfortable chair for a minimum of 5 min before measuring resting blood pressure (BP) and heart rate (HR) using an automated blood pressure system (GE Dinamap ProCare 100, Piscataway, NJ). Height was measured without shoes using a portable stadiometer (Seca Road Rod 214, Snoqualmie, WA) to the nearest 0.1 cm and weight was measured in light clothing using a portable digital scale (Lifesource ProFit, Milpitas, CA) to the nearest 0.1 lb then converted to kilograms. Children were classified according to the CDC's age- and sex-specific growth charts as HW or OW (69). Waist circumference was measured to the nearest 0.1 cm using a Gulick tape measure in a horizontal line between the suprailiac crests. The average of three repeated measures was calculated and recorded for all physical measures. All of these measures were repeated at the follow-up visit during the final week of the program.

Physical Activity Measures. Children's PA was measured with the Actigraph GT1M (ActiGraph, Pensacola, FL) activity monitor. The children were asked to wear the activity monitor for seven days (except while sleeping or bathing) prior to the start of the study (baseline) and during the final week of the program (follow-up). The GT1M was initialized to sample data in 5-sec epochs and the monitor was attached to an elastic belt and placed on the participant's

non-dominant hip at the suprailiac crest in line with the anterior axillary line. The child was asked to place their hands on their hips to provide a reference point that would help them secure the monitor in the correct position on the hip. In addition, the classroom teachers and parents were instructed how the activity monitor was to be worn by the children. Participants were given an activity monitor log to record when the monitor was removed and for what reason and when it was put back on.

At the end of each seven 7-day measurement period the GT1M was collected from the participants and the data was downloaded onto a laptop computer using the ActiLife Software, version 4.0.4 (Actigraph, Pensacola, FL). The accelerometer data were analyzed following the same guidelines as the NHANES data (143). Any period of at least 30 min of zeros was considered non-wear time and was omitted from the analyses. A day was defined as the time between when the child put the monitor on and took the monitor off according to their activity monitor logs. Average counts·day^{-1} were calculated for each day and for each school day (8:30 a.m. – 3:30 p.m.). Using the age-specific accelerometer cut-points established by Freedson et al. (44), the amount of time spent in SB and the amount of time spent in all of the activity intensity (light (LPA), moderate (MPA), vigorous (VPA), very vigorous (VVPA) and MVPA) during each day and during the school day were calculated.

Recess Program. The children at both schools were allotted 30 min of daily recess time for a period of 9 weeks. At the CON school, the children were free to participate in any type of activity during a free-play recess period. The

children in the INT school were offered the structured recess program conducted by intervention-trained research staff. The program was offered to the entire class of 3rd grade children irrespective of their participation in the measurement portion of the study.

To measure the exposure to PA opportunities during the school day (including recess, PE and special events), the classroom teachers were asked to complete a PA record calendar for one randomly selected week during the intervention period. To measure the activity intensity of the games as they were implemented in the structured recess program, GT1M's were worn by the INT school children during randomly selected program sessions. A similar assessment of activity intensity during recess was not permitted in the CON school.

The games used in the structured recess program were previously measured to be enjoyable and to elicit a PAEE of at least 100 $kcal \cdot 30min^{-1}$ in a laboratory-based study (Mean ± SD = 123.0 ± 36.0 $kcal \cdot 30min^{-1}$) and in a simulated recess study (149.3 ± 9.5 $kcal \cdot 30min^{-1}$). Sufficient PA participation in the 19 different games during the intervention was determined by comparing accelerometer $counts \cdot min^{-1}$ to the values obtained for each game as they were measured during the previous studies (range = 1846 ± 656 to 4912 ± 1521 $counts \cdot min^{-1}$).

As per our agreement with the schools and the Springfield School Board, the classroom teachers at the INT school were taught the structured recess program and encouraged to participate in the daily sessions. This was to

encourage the continuation of the program after the intervention study was completed. Equipment for the program was purchased for the INT school prior to the start of the program and it remained property of the school upon completion of the study. The same equipment and training opportunity was offered to the CON school at the end of the study.

Statistical Analysis. A mixed model ANOVA was used to assess differences in physical measures and in PA and SB levels between schools at baseline. Change scores in physical and PA measures were assessed using a mixed model ANOVA for PA counts·min^{-1} and min spent in each PA intensity, LPA, MPA, VPA, VVPA, and MVPA, with school condition and measurement time-point (visit) as main effects. Each day of accelerometer data for each subject and visit was treated as a single unit of analysis with subject-to-subject and day-to-day (residual) variations as random effects. This analysis accounted for the differences in the number of days of accelerometer data between children. This analysis was repeated for the total day and for the school day. Pearson correlation coefficients were calculated to determine the relationship between in-school and total daily PA and between changes in MVPA and changes in BMI. Statistical analyses were performed using SAS version 9.2 (SAS Institutes, Inc., Cary, NC).

Results

Participant Characteristics (Baseline). Twenty-seven children volunteered for the study (INT = 11, CON = 16). There were no significant differences in the physical characteristics between the participants at the two

schools at baseline (Table 11). Resting BP and heart rate were within the normal ranges for this population with no significant differences between schools at baseline resting heart rate and systolic BP. However, diastolic BP was slightly lower in the INT school compared to the CON school (57 ± 1.5 vs. 60 ± 1.0 mm Hg) ($p < 0.05$).

Participant Characteristics (Change scores). There were no significant changes in the physical measures between the INT and CON schools from baseline to follow-up. Although not statistically significant, the INT group gained on average 1.0 ± 0.5 kg (LSMean ± SEE) less body weight over the 9-week program compared to the CON school ($p = 0.057$). However, a modest effect size of 0.64 existed for changes in body weight between school conditions. Resting BP did not change between baseline and follow-up for both schools, although resting heart rate was significantly lower for the INT school children at follow-up ($p < 0.05$).

PA measures (Baseline). Total daily PA counts (Figure 6) and the amount of time spent in all activity intensities (Figures 7 – 9), including the amount of time spent in SB (Figure 10), are presented by school condition as total day and in-school means ± SEE. The children wore the accelerometers for an average of 6.2 ± 1.9 days (236.6 ± 8.8 $min \cdot day^{-1}$) during the baseline measurement period. There were no significant differences in all PA measures between the INT and CON schools at baseline. Although not significantly different, the INT school acquired 11.7 ± 7.8 min (LSMean ± SEE) more MVPA than the CON school during the school day at baseline ($p = 0.15$). Using the

age-specific prediction equation to estimate EE, there was no significant difference between the INT and CON school children at baseline for in-school EE (353.8 ± 26.8 and 318.0 ± 22.7 kcal) and total daily EE (669.6 ± 49.9 and 678.8 ± 44.8 kcal).

PA measures (Change Scores). During the follow-up measurement period the children wore the accelerometer an average of 6.7 ± 1.8 days (253.7 ± 10.7 $min \cdot day^{-1}$). When analyzing the differences in PA between schools during the school day, the two-way ANOVA (school by time) revealed several significant interactions between INT and CON schools from baseline to follow-up measures. Although great variability exists, Figure 6 depicts an increase in PA counts from baseline to follow-up for the INT school compared to the decrease in the CON school (+32413 ± 14485 vs. -2393 ± 10429 counts; $p = 0.05$); the INT school children acquired significantly greater counts during the school day at follow-up compared to the CON school children ($p < 0.05$). Similarly, the amount of time spent in MVPA increased 11.0 ± 4.8 min for the INT school children compared to a decline of 1.2 ± 3.4 min for the CON school (Figure 7). The difference was influenced by a significant increase in time spent in MPA by the INT school with a concomitant decrease in the CON school (Figure 8). Changes during the school day in all other activity intensities from baseline to follow-up did not differ between school conditions ($p > 0.05$). From baseline to follow-up the INT school children increased their in-school EE compared to a decrease in CON school children (+86.2 and -24.1 kcal).

However, when analyzing the PA data over the entire day, few significant school-by-time interactions were revealed for changes in activity levels. Total daily counts remained unchanged from baseline to follow-up in response to either the structured or the free-play recess. There was no change in SB across either school condition. However, the INT school children added 29.6 ± 9.7 min of MVPA to their entire day as compared to only a slight increase in the CON school children (3.9 ± 7.0 min). This increase in MVPA at the INT school was a result of a greater increase in both MPA and VPA. From baseline to follow-up a greater increase in total daily EE was observed in the INT compared to the CON school children (173.2 and 14.1 kcal).

Process Variables. The amount of PA opportunities during recess available to the children was significantly greater for the CON school compared to the INT school (150.0 ± 0.0 vs. 128.0 ± 11.3 $min \cdot week^{-1}$). The CON school also reported daily PE classes of 40 $min \cdot day^{-1}$ compared to 1-2 PE $classes \cdot week^{-1}$ at the INT school. Therefore, the CON school was offered 167 ± 20.1 $min \cdot week^{-1}$ (91.2%) more PA opportunities compared to the INT school. During the structured recess sessions at the INT school the accelerometer counts averaged 1991.2 ± 455.6 $counts \cdot min^{-1}$. This was within the range of mean $counts \cdot min^{-1}$for the different games as measured previously in our laboratory (>1846 $counts \cdot min^{-1}$) with the corresponding PAEE of ≥100 $kcal \cdot 30min^{-1}$.

Discussion

Implementing a PA intervention for the prevention of excess weight gain in children has been unsuccessful in previous research (22, 58). It is purported that

this lack of success is due to implementing interventions that include activities that are not enjoyable or expend insufficient energy and thus, do not effectively increase PAEE enough to prevent excess weight gain. The current study was a physiologically-based intervention using common children's games that have been shown to be both enjoyable and elicit sufficient EE (125 – 150 kcal in 30 min; unpublished data) to correct for the energy imbalance associated with childhood obesity. The results of our study indicate that the 30-min structured recess program successfully increased in-school and total daily MVPA and produce healthier age-related weight gains in 3rd grade children compared to a free-play recess. However, this increase in PA did not successfully reduce the amount of time the children spent in SB.

Previous school-based interventions attempting to increase the amount of time children spend in MVPA at school have shown mixed results (5, 100, 134). Alhassan et al. (8) showed that a substantial increase in the amount of time offered for free-play during preschool recess resulted in an increase in the amount of time spent playing sedentary-type activities (e.g. playing in the sandbox) rather than increasing MVPA. In contrast, Guinhauya et al. (52) found that extending recess from 30 to 40 min·day^{-1} significantly increased MVPA during the school day in 8 – 10 year old children. In the present investigation, although the CON school reported substantially more time available for free-play PA, yet they decreased the amount of time spent in MVPA during school hours by 1.2 min·day^{-1} compared to an increase of 11.2 min·day^{-1} in the INT school. This reinforces the idea that increasing free-play PA opportunities during school

hours does not consistently increase in-school min of MVPA (22, 58) and that a structured recess program is required, rather than free-play, to effectively increase MVPA. These findings concur with research by Scruggs et al. (106, 117) who found that 5th grade children spent more time in MVPA during a structured fitness break recess compared to free-play recess periods. Ernst and Pangrazi (39) also implemented a 15-min structured break and found that 4th – 6th grade children reported more MVPA compared to controls. It is clear that a more structured recess is necessary to effectively increase children's MVPA during the school day.

However, it is not clear whether increasing MVPA during school recess leads to an increase in total daily MVPA (29, 52, 74). Mallam et al. found that total daily MVPA is independent of MVPA during the school day; i.e., elementary school children who accumulated more in-school MVPA reduced MVPA outside of school and vice versa (74). In contrast, Guinhouya et al. found that increasing recess time by 10 min significantly increased total daily MVPA ($p < 0.05$). In the present investigation, the significant increase in total daily MVPA in addition to the increased in-school MVPA is in support of the findings by Guinhouya et al. However, the increases we observed were much larger than previously reported (99, 108, 132, 151). The difference between previous studies and the current findings may be attributable to the beneficial effects of the structured recess program compared to free-play.

The United Stated Department of Health and Human Services guidelines not only recommend that children increase their amount of PA but also reduce

their sedentary time. While SB has been shown to be independently related to obesity and obesity-related health problems, few studies have assessed changes in SB in response to PA interventions. Many studies have successfully used various strategies for reducing sedentary time through positive reinforcement and health education (36, 37, 101) but no studies have reported changes in SB in response to the implementation of a PA intervention. The current study found that the increases in MPVA did not result in concomitant reductions in SB. This suggests that the children did not substitute in increased time in MVPA for their SB and that other strategies may be necessary to achieve both an increase in MVPA and a reduction in SB.

Although the intervention did not impact the amount of SB, the change in overall daily MVPA was enough to correct for the chronic energy imbalance associated with childhood obesity. The average daily EE increased by 25.9% from baseline to follow-up in the INT school compared to a 2.1% increase in the CON school. This equated to less weight gain (1.0 ± 0.5 kg) over the 9-week program in the INT school children. However, this change in body weight was not reflected in BMI changes between schools due to the fact that the children in the CON school grew 0.5 cm taller than the INT school children in this same time period. A longer intervention would be necessary to determine if this relationship would continue or if the attenuation in weight gain would eventually result in healthy age-related changes in BMI.

As with all studies, our findings do not come without limitations. Due to discipline issues and the daily school schedules, the structured recess program

was not implemented to its fullest on a daily basis. Rarely was the recess program conducted for the full 30 $min \cdot day^{-1}$ and the playing areas were less than ideal (auditorium or indoor concrete area rather an outdoor field). In contrast, the CON school reported that the recess period was held relatively constant throughout the intervention with two 15 min periods (morning and afternoon). In addition, the choice of games used in the structured program were limited to games with little or no competition or physical contact within the first 4 – 6 weeks of the program to minimize discipline problems. Also, in the first few weeks of the intervention it was noticeable that the INT school children lacked the social interaction skills necessary for productive free-play among a group of their peers. Although enjoyment was not measured during this study, it was apparent through overall participation levels and a reduction in discipline issues as the program progressed that the children began to learn to play together and enjoy the intervention games. Although these facts are listed as limitations of the study, they can also be seen as strengths of the program. The results clearly show that, although the INT school did not always receive the full 30-min intervention, the structured recess was sufficient to significantly increase MVPA compared to a free-play recess.

In conclusion, this study demonstrates that a structured recess program that uses games measured to be enjoyable and sufficient energy cost to balance the energy surplus associated with childhood obesity can lead to an increase in MVPA for 3rd grade children. However, this increase in MVPA was not at the expense of the amount of time spent in sedentary pursuits. Future studies are

necessary to determine if this increased MVPA in an intervention of longer duration will have a positive impact on weight management.

Table 11. Study 3 - Participant Characteristics. (Mean ± SEE)

	Baseline		Follow-up	
	INT	**CON**	**INT**	**CON**
	(N = 11)	(N = 16)	(N = 10)†	(N = 16)
Age (years)	9.4 ± 0.3	9.6 ± 0.2	9.6 ± 0.3	9.8 ± 0.2
Heart Rate (beats/min)	88.8 ± 2.7	94.3 ± 2.8	83.2 ± 4.6*	94.1 ± 2.7*
Systolic BP (mmHg)	107.7 ± 3.6	105.2 ± 2.1	104.9 ± 3.2	101.7 ± 2.5
Diastolic BP (mmHg)	57.1 ± 1.5*	60.3 ± 1.0 *	55.6 ± 1.2	55.3 ± 0.6
Height (cm)	133.3 ± 1.1	135.0 ± 2.0	134.7 ± 1.2	136.7 ± 2.1
Weight (kg)	36.9 ± 3.1	39.4 ± 3.7	38.3 ± 3.1	40.7 ± 3.8
Waist Circ. (cm)	70.1 ± 4.5	70.5 ± 4.3	70.9 ± 4.2	69.9 ± 4.1
BMI (kg/m^2)	20.6 ± 1.6	21.1 ± 1.6	21.0 ± 1.6	21.3 ± 1.5
BMI (%ile)	72.0 ± 9.1	72.2 ± 7.2	77.7 ± 7.7	71.9 ± 7.1

SEE = standard error of estimation; INT = intervention school; CON = control school; BP = blood pressure; Waist circ. = waist circumference; BMI = body mass index. † One child from the INT school was unavailable for follow-up measures.

* Significant difference between schools at the same measurement time point. ($p < 0.05$)

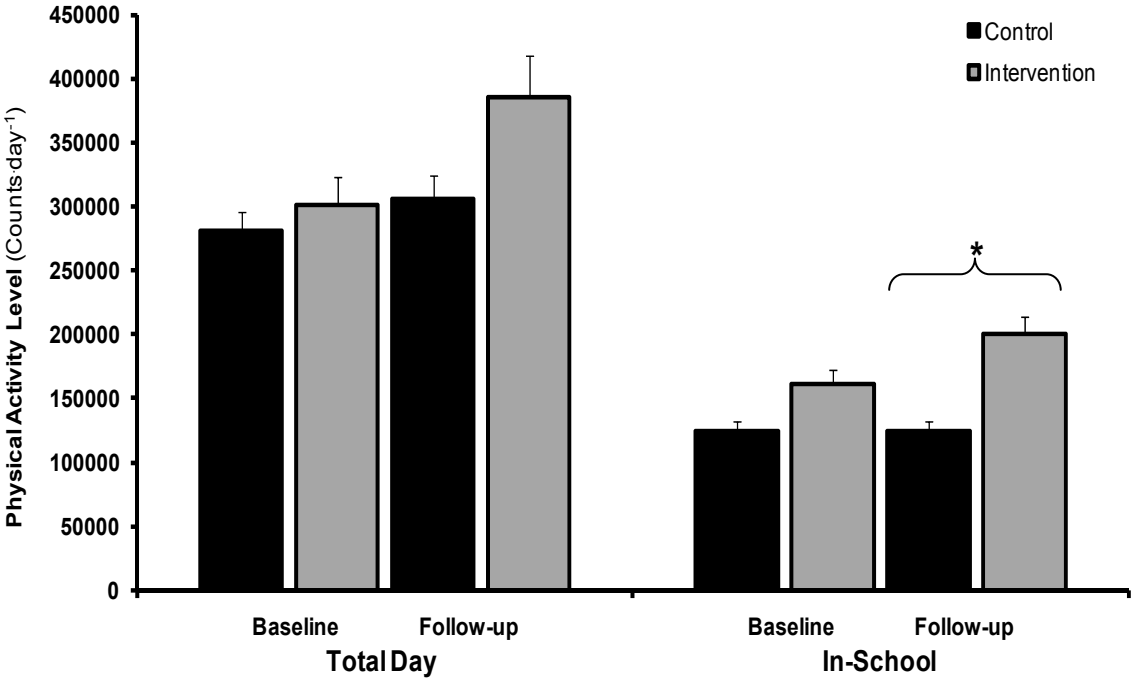


Figure 6. Study 3 – Accelerometer counts·day^{-1} between the INT and CON schools. (Mean SEE)
* Significant difference between values at the same measurement time point.

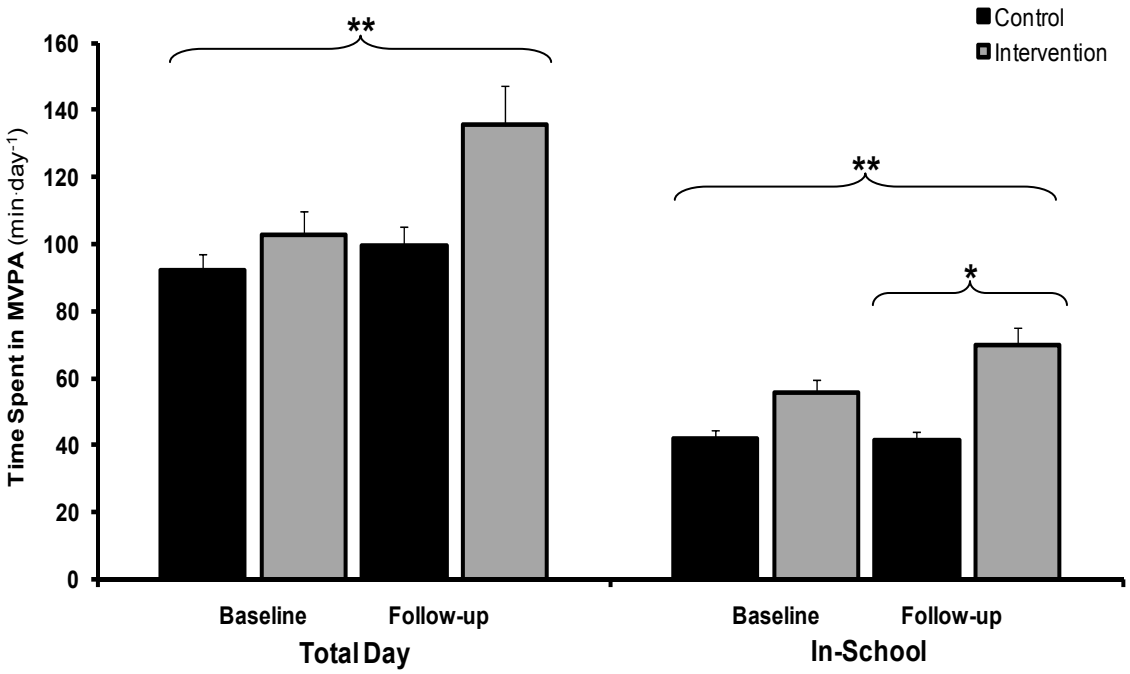


Figure 7. Study 3 – Total day and in-school MPVA between INT and CON schools. (Mean SEE)
* Significant difference between values at the same measurement time point.
** Significant time by school interaction.

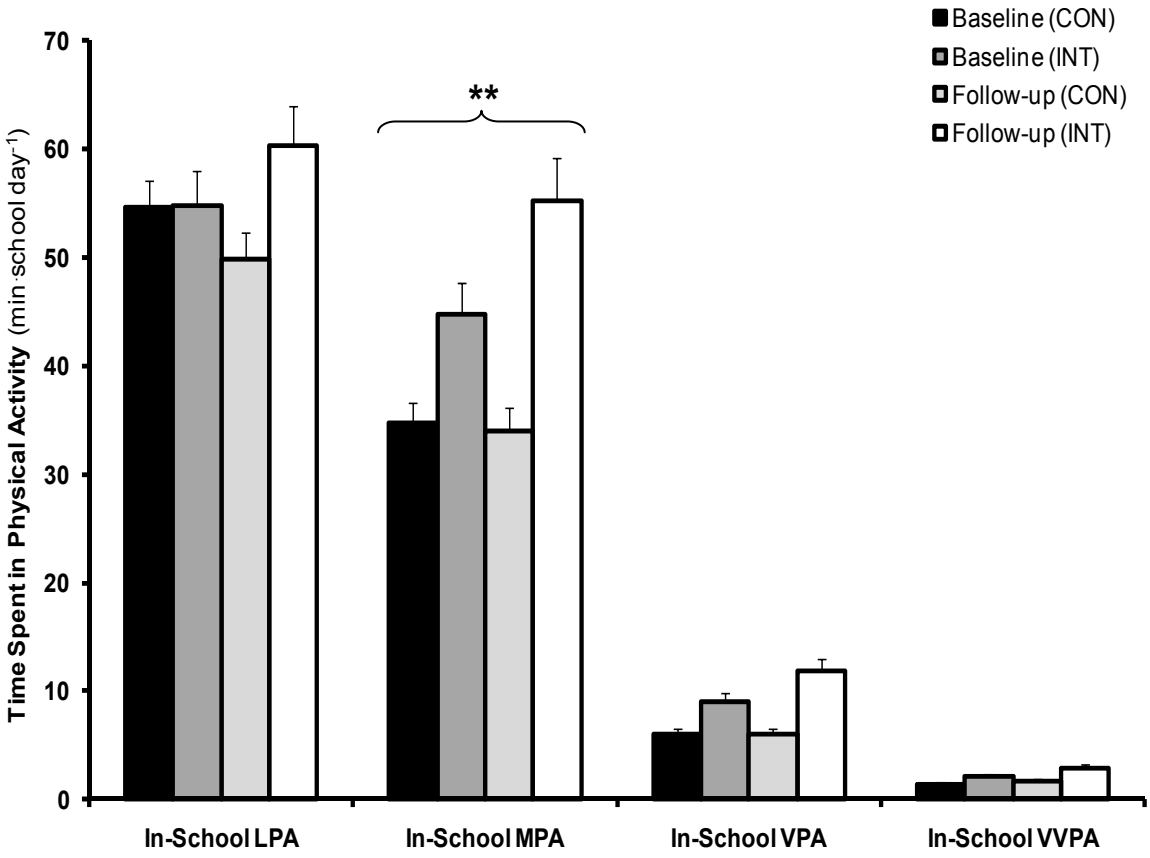


Figure 8. Study 3 - In-school PA between INT and CON schools across activity intensity. (Mean SEE)
** Significant time by school interaction.

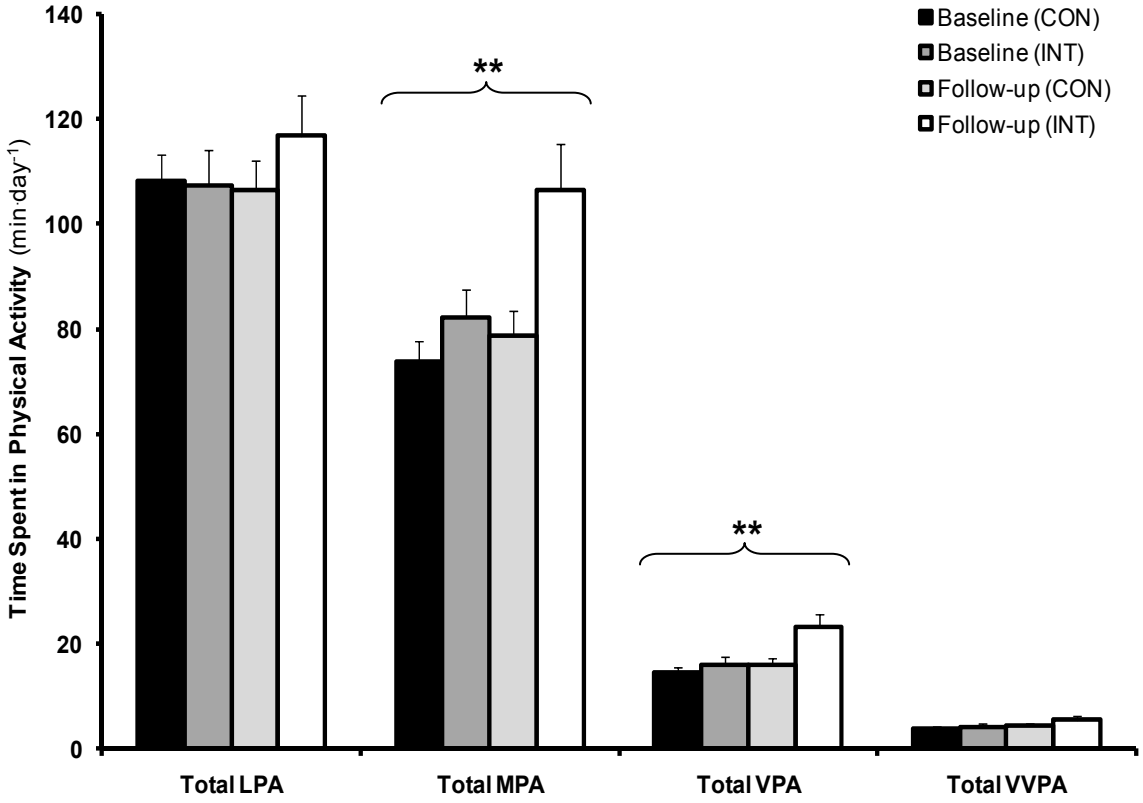


Figure 9. Study 3 - Total daily PA between INT and CON schools across activity intensity. (Mean SEE)
** Significant time by school interaction.

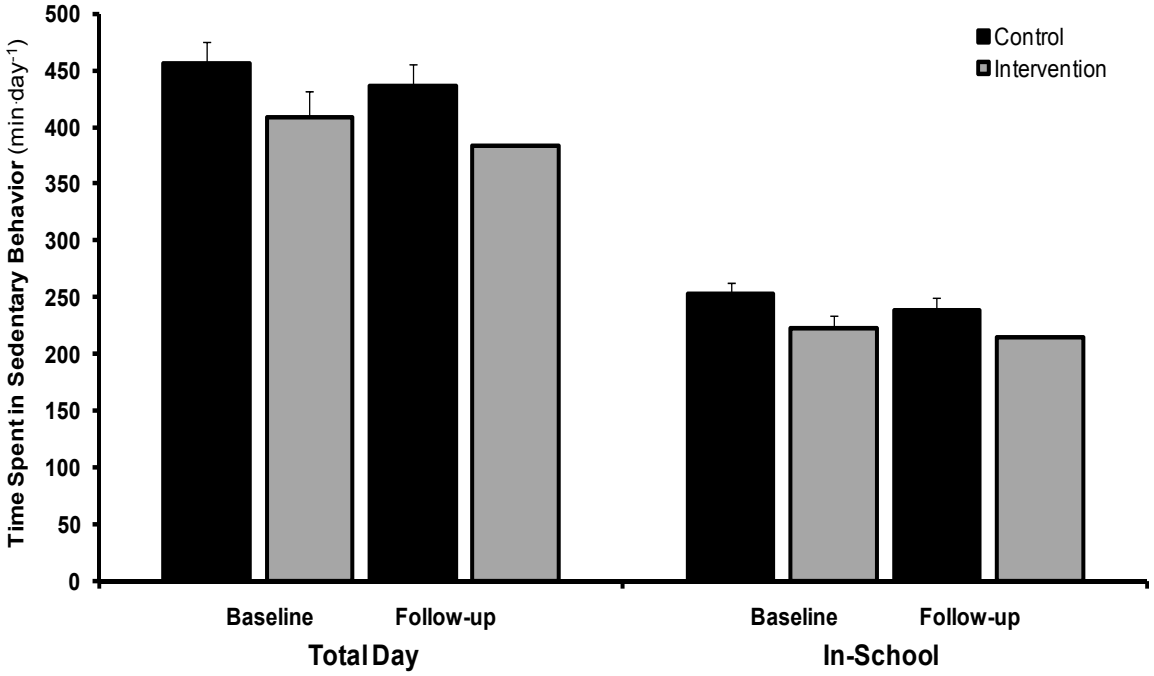


Figure 10. Study 3 – Time spent in sedentary behavior between the INT and CON schools. (Mean SEE)

CHAPTER V

CONCLUSION

Summary of Study Results

The overall goal of this dissertation was to develop an enjoyable, physiologically-based structured recess program of known energy cost that would increase total daily MVPA, while reducing SB, sufficiently to correct for the purported energy surplus (100 – 165 $kcal \cdot day^{-1}$) associated with childhood obesity. In order to accomplish this task a selection of 30 common children's games were directly measured for enjoyment using the Facial Affective Scale (criterion: ≥5 on 9-point scale) and to determine PAEE using a portable metabolic unit (criterion: ≥100 $kcal \cdot 30min^{-1}$). As a result of the laboratory-based study, 20 of the selected 30 games met the criteria for both PAEE (123 ± 3.0 $kcal \cdot 30\ min^{-1}$) and enjoyment (FAS = 7.1 ± 0.1). Although the children were encouraged to move about freely within the large gymnasium to meet the objectives of each game, the games were only played once by each child and with limited peer influence. It was unclear if the data obtained in this laboratory-based study would elicit the same PAEE and enjoyment response in a more realistic recess environment among a group of peers throughout the structured intervention period (9 weeks).

To assess the PAEE and enjoyment of children's games over time in a realistic environment, a subset of 6 qualified games from the laboratory-based study was further investigated during a 10-session simulated recess program among a group of peers. It was found that 5 of the 6 games continued to meet

the established criteria for enjoyment (FAS = 6.7 ± 0.2) and PAEE (150 ± 9.6 kcal·30 min^{-1}). All of the games were classified as MVPA using the age-specific accelerometer cut-points (3508 ± 72 counts·min^{-1}), although over the course of the 10-session recess program enjoyment and accelerometer counts·min^{-1} significantly declined. There was no trend for a decline in PAEE due to the high variability in PAEE between sessions and between games. Combining the results of the two preliminary studies, 19 of the 30 games (63.3%) were suitable for inclusion in the enjoyable, 100-kcal structured recess program.

The final study examined the effects of the enjoyable 30-min structured recess program of known energy cost on total daily MVPA and SB in 3rd grade children. In response to the structured recess program, the INT school children significantly increased in-school MVPA by 11 min·day^{-1} and total daily MVPA by 29 min·day^{-1} with no change in SB. The children in the CON school, although they were offered 91% (33 min·day^{-1}) more free-play time during school hours compared to the INT school children, in-school MVPA decreased by 1 min·day^{-1} and total daily MVPA increased by only 4 min·day^{-1}. The greater increase in the amount of MVPA observed in the INT school children resulted in an attenuation in weight gain compared to the CON school children. However, the smaller increase body weight was overshadowed by the larger height increase in the CON school children over the same period resulting in a failure to observe any significant differences in BMI changes between school conditions.

Significance

The most recent PA guidelines suggest various games and activities that can count towards the recommended PA dose of at least 60 min of daily MVPA for children for health promotion and weight management. However, research studies have used such games and activities in previous PA interventions with minimal effect on the prevention of excess weight gain in children. These disappointing results are due, in part, to a lack of accurate measures of the energy cost of free-play PA and thus, the lack of empirical evidence as to whether these games are correctly classified as MVPA and could correct the energy imbalance associated with childhood obesity (109). The first step in developing a successful intervention to combat this epidemic is to accurately measure the energy cost of common children's games in a free-play environment to determine if they are sufficient to balance the energy equation.

This study not only provides some of the first empirical data of the energy cost, but also the perceived enjoyment, of common children's games. Enjoyment is a key element for enticing children to be physically active (109). By incorporating games into an intervention that have been directly measured to be enjoyable increases the likelihood of adequate PA participation during the intervention to promote a healthy energy balance.

Of the 30 games tested in this study, only 63% met the enjoyment and energy cost criteria to counterbalance the daily energy surplus of obesity (~100 kcal) in 30 min. This implies that previous school-based interventions have been implementing games that are likely ineffective for promoting healthy age-related changes in BMI. Although the addition of a small amount of time for PA (e.g. 30-

min recess period) has been shown to improve rather than hinder academic performance, schools are still reluctant to take time away from core academics for PA, especially for daily recess. Therefore, it is essential that future interventions maximize this time when available. By implementing enjoyable games of known energy cost in a structured format during recess provides an appropriate stimulus to encourage increased PA participation and PAEE to make the most of this valuable time during the school day.

To encourage an increase in-school and total daily MVPA and PAEE, this initial list of qualified children's games should be expanded and then made available to PA interventionists, Physical Educators and Recess Monitors. This list includes the measured energy cost of the games with corresponding PA levels (counts·min^{-1}) that can be used to measure PA level and estimate PAEE in the field when direct measures PAEE is not feasible. Although there was great variability in the accelerometer data for mean values of PAEE for the different games, more research will help define the association between counts·min^{-1} and the energy cost of children's games. However, at the present time this information provides an initial set of tools to develop and monitor a successful PA intervention for weight management in children.

The final study of this dissertation provides evidence that an enjoyable structured recess program of known energy cost increases total daily min of MVPA compared to a free-play recess period. Although research suggests that when given the opportunity to for free-play children will naturally chose to be physically active (105), recent data have indicate that children spend very little of

their recess time in MVPA (3, 52, 86). Providing the structure of organized games offers today's children, who are more prone to chose SB during this time, the means to increase their MVPA during an otherwise sedentary time.

Unfortunately, there was no effect of the structured intervention on the amount of time the children spent in SB. This supports the idea that the amount of time spent in SB is independent of the amount of time spent in MVPA and that other strategies might be necessary to reduce SB in children. Multi-component or comprehensive studies have implemented combinations of behavior management techniques and dietary interventions along with strategies for increasing PA to promote healthy age-related increases in BMI (36, 72, 97, 102, 108). These studies have used the "kitchen sink" approach without the knowledge regarding the specific behaviors or PA dose required to positively impact BMI. The scope of this dissertation was to establish the PA dose required to prevent accelerated weight gain through direct measures of EE. The singular focus of this study permitted the development of a sound, physiologically-based intervention that can be used as the foundation for future comprehensive studies.

Limitations and Future Direction

There were limitations associated with each of the three studies in this dissertation. The small sample size and the narrow age range of the children (3rd grade children) reduce the general application of these findings to children of different age, gender, minority status and BMI classification. Differences in PAEE and enjoyment of the games were observed between sex and BMI groups during the laboratory-based study. However, similar group analyses were not

possible during the simulated recess program or during the structured recess intervention due to the limited sample sizes. The laboratory-based study and simulated recess program were both conducted on a different sample of the population compared to the intervention study with respect to the minority status and age range of the children. To add to the sample bias issue, the children who volunteered for the laboratory-based and simulated recess program are those who have a greater propensity to choose to be physically active. This is in contrast to the intervention study children who were only volunteering for the measurement portion of the study and may not have this same propensity. Future studies targeting larger schools would increase the size of the recruitment population and may allow for adequate sample size for age, sex, minority and BMI group comparisons.

Children also have a greater tendency to change their behaviors to accommodate the researcher (i.e. social desirability bias) which may have artificially inflated, or even reduced, the measured PAEE or perceived enjoyment of the selected games. However, efforts were made to create a comfortable, free-play setting to encourage the children to play naturally. During the laboratory-based study the children were recruited and tested in pairs to offer peer support for the child who wore the metabolic unit. Also, in the preliminary measurement studies, the laboratory-based and simulated recess program, the children were allowed to move freely about the large gymnasium, to stop and start as they wished and to use any movement patterns they desired to accomplish the objectives of each game. This is unique to previous

measurement studies that either asked the children to perform activities continuously to reach steady state or they used whole room calorimeter as the criterion. Both of these methods would hamper the natural tendencies of children's play behavior. To fully delineate the energy cost of children's play behavior and to expand on this initial list of effective games these studies should be replicated in a larger sample of children of varying age, gender, minority status, and BMI status using a larger selection of children's games across a wider range of PA intensities.

Although the laboratory-based study was valuable for developing the methods for accurately measuring children's PA, it was unknown if these values would persist during an actual recess program over time among a group of peers. To answer this question, the simulated recess program was designed to measure changes in PAEE and enjoyment over time in a more realistic recess setting. A comfortable social environment similar to that observed in the school playground was created by recruiting children from a single 3rd grade classroom – children who normally play together at recess. However, the length of this study was much shorter than most PA interventions. It remains to be seen if enjoyment and PA levels would continue to decline during a longer intervention to a level that would reduce the effectiveness of the intervention. Repeated measures of PAEE, PA levels, and enjoyment during a longer intervention study are recommended to determine how these values would change over an extended period of time in the field.

Quality and quantity of an intervention program are both measured to determine the impact of the PA dose on outcome measures. Although the quality of the program was verified through preliminary PAEE and enjoyment measures, the intervention study was not implemented as fully as it was intended (30 $min \cdot day^{-1}$) for several reasons: 1) serious discipline issues shortened or canceled individual recess periods; 2) the limited availability of suitable play areas (concrete surface or confined space) limited the game selection to reduce the risk of injury; 3) the low levels of social interaction skills of the INT school children restricted the type of games that could be implemented (limited physical-contact or competitive-type games); and 4) the lack of consistent scheduling during the school day often resulted in shortened recess periods. These factors resulted in less exposure to the structured recess program than proposed, yet the level of exposure was sufficient to increase total daily MVPA. Anecdotally, the children learned that it was more fun to share the equipment in order to accomplish a common objective then to possess the item individually and play alone. This was evidenced by a reduction in disciplinary issues and greater participation during the recess sessions as the program progressed. To determine the full impact of this structured recess program on MVPA and SB, it would be necessary to replicate this study in schools with suitable play areas and a distinct recess schedule to accommodate the daily 30-min program.

The impact of the structured recess program on the prevention of excess weight gain in children could not be truly assessed in this study due to the brevity

of the intervention. A longer structured recess program (>4 months) may reveal an attenuation in weight gain over time that would positively impact BMI.

The amount of time the INT children spent in SB was not different between school conditions indicating no positive impact of the structured recess program on this behavior. The method used to analyze the accelerometer data for measuring SB may have resulted in significant estimation errors. The data files were "cleaned" prior to analysis, meaning that the zeros during non-wear time were removed. However, this method was used across all data files for baseline and follow-up measures which would have resulted in similar estimation errors for both the INT and the CON group. To use accelerometry to detect changes in SB, better methods for analyzing the data for this behavior are necessary to reduce the possible estimation errors.

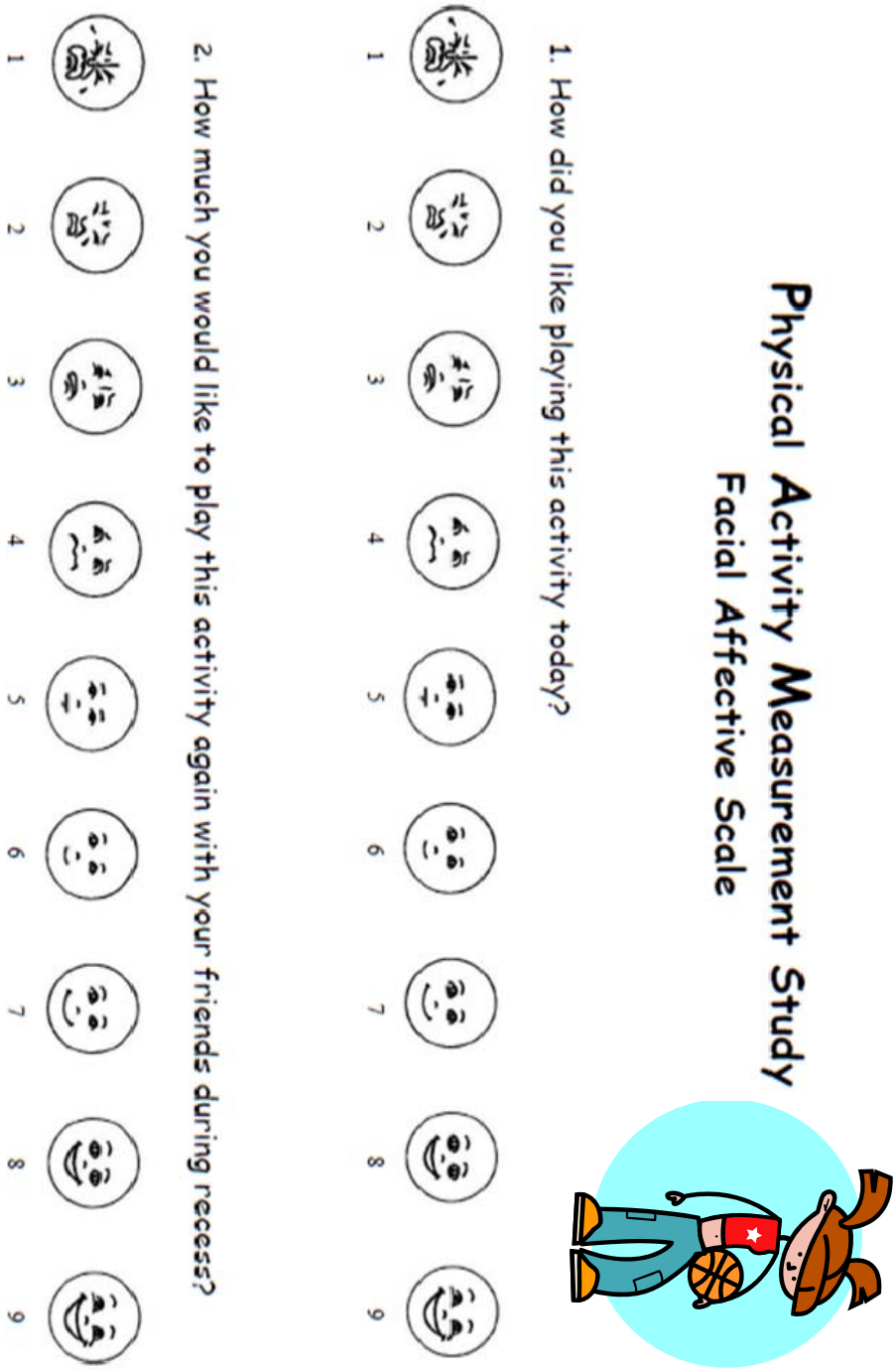
Conclusion

The obesity epidemic persists and today's children continue to grow more obese and more vulnerable to obesity-related disease. Developing successful interventions to combat this obesity problem requires knowledge of the energy cost and perceived enjoyment of children's free-play PA, factors that until now have been difficult to measure due, in part, to the complexity of this particular behavior. These studies have shown that children can expend more than 100 kcal in 30 min by playing enjoyable and age-appropriate children's games, although the PAEE and enjoyment of the games may decline over time. This research found that using these games in a 30-min structured recess intervention increased total daily MVPA and attenuated the excess weight gain in 3rd grade

children compared to free-play recess of the same duration. This evidence furthers the empirical knowledge of children's free-play PA to inform the development of successful PA interventions. Further research is necessary to expand this initial list of suitable children's games and to determine if a structured recess program of known energy cost would eventually slow the obesity epidemic over time.

APPENDIX A

FACIAL AFFECTIVE SCALE



APPENDIX B

SUMMARY TABLE OF SCHOOL-BASED AND RECESS PHYSICAL ACTIVITY INTERVENTIONS

Study	Year	Location	Design & Framework	Sample	Group Randomization
School-based Physical Activity Interventions					
CATCH (Coordinated Approach to Child Health) [Luepker, Perry, McKinlay, Nader, Parcel, Webber, Stone]	1991 - 1994	CA, LA, MN, TX	Multi-site RCT; Organizational Change & SCT	5106 3rd - 5th grade girls and boys; 96 schools	Randomized by school within each site; 14 Tx & 10 Con
SPARK (Sports, Play and Active Recreation for Kids!) [Sallis, McKenzie]	1990 - 1993	San Diego, CA	Quazi-experimental Design; Behavior Change model	955 4th grade girls and boys; 7 schools	Randomized by school; 3 Tx & 4 Con by minority status; 7 smallest schools
PLAY (Promoting Lifetime Activity for Youth) [Pangrazi & Ernst]	1996	Arizona	RCT; Pre-post and Post-measure Design	606 4th grade girls and boys; 35 schools	Randomized by school; 1) PLAY + PE; 2) PE only; 3) PLAY only; 4) no PLAY or PE control
Planet Health [Gortmaker]	1995 - 1997	Boston, MA	RCT; SCT	1295 6th - 7th grade girls and boys; 10 schools	5 Tx & 5 Con; matched by school size and minority status

RCT = Randomized Controlled Study; SCT = Social Cognitive Theory; Tx = Treatment group; Con = Control group; PE = Physical Eduction.

Study	Components	Quantity	Outcome measures	Results
School-based Physical Activity Interventions				
CATCH (Coordinated Approach to Child Health) [Luepker, Perry, McKinlay, Nader, Parcel, Webber, Stone]	The Adventures of Hearty Heart and Friends; Go For Health; FACTS for 5; The Home Team; Family Fun Nights; Eat Smart School Nutritional Program; CATCH PE; Smart Choices	2 years; 3 sessions/week	**Individual:** self-report diet/PA, risk factors, questionnaires; **School-level:** MVPA during PE, school lunch content	**Individual:** ↑PA levels; ↓fat intake; ↔BMI, BP or serum cholesterol; ↑knowledge, self-efficacy & social support; **School-level:** ↑MVPA in PE; Impoved school lunches
SPARK (Sports, Play and Active Recreation for Kids!) [Sallis, McKenzie]	PE teacher/teacher workshops; PE curriculum; Self-management program	3 years; 3 PE sessions/week; weekly 30-min classroom sessions	Self-report & measured PA; Muscle strength & CV endurance; BMI and skinfold thickness	↑MVPA and PE class time; ↑CV and muscle fitness; ↔ body compostion
PLAY (Promoting Lifetime Activity for Youth) [Pangrazi & Ernst]	PLAY: 15-min Physical Activity breaks; enhanced PE curriculum; Self-management program	4 weeks Tx + 8 weeks self-management (12 weeks)	BMI; PA levels (pedometers); Self-report PA levels	Steps/min: PLAY>PE alone or Con; Self-report: girls ↑PA, boys ↔PA; ↔ BMI changes
Planet Health [Gortmaker]	TV viewing; nutritional habits; physical activity	2 years; 32 lessons in health and PE classes	BMI + Tricep skinfold; self-reported TV watching, dietary intake & PA levels	↓TV viewing Tx> Con; ↓ BMI & skinfolds Tx>Con in girls only

Tx = Treatment group; Con = Control group; PE = Physical Eduction; PA = Physical Activity; MVPA = Moderate-to-Vigorous Physical Activity; MVHR = Moderate-to-Vigorous Heart Rate; VHR = Vigorous Heart Rate; ↑= increase; ↓= decrease; ↔= no change.

Study	Year	Location	Design	Sample	Randomization
School Recess Physical Activity Interventions					
Alhasson et al. 2007	2006	Redwood City, CA	RCT	32 Latino preschool girls and boys	Individual was the unit of randomization; 17 Tx & 15 Con
Ridgers et al. 2007	2003 - 2005	England	RCT	238 elementary girls and boys; 26 schools	Randomized by school; 15 TX & 11 Con; matched on socioeconomic status
Scruggs et al. 2003	Prior to 2003	Utah	RCT	27 5th grade girls and boys	No randomization; Group baseline measured used as Control group
Verstraete et al. 2006	Prior to 2006	Belgium	RCT	235 5th & 6th grade girls and boys; 7 schools	Classroom was the unit of randomization; 7 Tx & 6 Con

RCT, Randomized Controlled Study; Tx, Treatment group; Con, Control group.

Study	Components	Quantity	Outcome measures	Results
School Recess Physical Activity Interventions				
Alhasson et al. 2007	2 additional 30-min outdoor free-play recess periods	2 days	Recess PA and total daily PA measured with accelerometry	↑Recess PA Tx>Con; ↔total daily PA
Ridgers et al. 2007	playground redesigned for sports, multi-activity and quiet play areas	6 week & 6 month follow-up	MVPA & VP measured with HR telemetry and accelerometry	Tx ↑MVPA & VP (4 - 2.4%); Con ↔
Scruggs et al. 2003	Morning and lunch free-play recess; afternoon Fitness break with obstacle course and sport-related equipment	3 days; 30-min/session	Pedometers: Steps/min; HR telemetry: % of time in MVHR & VHR zones; Liking score	↑% time in MVHR and VHR zones during Fitness break; ↑ step/min during Fitness break; Girls liked free-play > Fitness break; Boys like Fitness break > free-play
Verstraete et al. 2006	Game and sport-related equipment and "activity cards"	3 month follow-up	PA levels measured with accelerometry	Tx: ↑% MPA & MVPA; ↓% LPA in girls only; ↔ %VPA; Con: ↔ in all variables

Tx = Treatment group; Con = Control group; PA = Physical Activity; LPA = Low-intensity Physical Activity; MVPA = Moderate-to-Vigorous Physical Activity; MVHR = Moderate-to-Vigorous Heart Rate; VHR = Vigorous Heart Rate; ↑= increase or improvement; ↓= decrease; ↔= no change.

APPENDIX C

FOCUS GROUP QUESTIONS

1.	Degree of knowledge of this game/activity:	Never played before		Have played something similar			Have played before			Play this game often	
2.	How often have you played this game with 3rd grade this year?			0-5		5-10		10-20		>20	
3.	Amount of time required to set up for this game? (1 = > 10 min, 5 = 5 min, 10 = < 1 min)	1	2	3	4	5	6	7	8	9	10
4.	Typical activity level during this game/activity? (1 = none, 3 = light, 6 = moderate, 9 = vigorous, 10 = very vigorous)	1	2	3	4	5	6	7	8	9	10
5.	Ease of 3rd grade children learning the game? (1 = difficult, 10 = easy to learn)	1	2	3	4	5	6	7	8	9	10
6.	Skill level required for this game? (1 = great skill, 10 = no skill required)	1	2	3	4	5	6	7	8	9	10
7.	Ease of overweight children to participate? (1 = difficult, 10 = easy and fun for all children)	1	2	3	4	5	6	7	8	9	10
8.	Ease of completing in 30 minute period? (1 = difficult, 10 = easy to implement)	1	2	3	4	5	6	7	8	9	10
9.	Likelihood of keeping children engaged? (1 = difficult, 10 = easy to keep engaged in Mod-Vig PA)	1	2	3	4	5	6	7	8	9	10
10.	Safety level of 3rd graders playing this game? (1 = great risk, 10 = no risk of injury)	1	2	3	4	5	6	7	8	9	10
11.	Ethnic or gender issues with implementing this activity?										
12.	Modifications: (e.g. name of activity, changes in how it is played)										
13.	Concerns/Suggestions/Alternatives:										

APPENDIX D

DESCRIPTION OF CHILDREN'S GAMES

Game		Description
1	**Barkers Hoopla**	**Organization:** hoops w/ 8 - 10 items; teams of 2 - 3 players/hoop
		Objective: collect all similar items for your hoop; vary modes of locomotion
		Movement Patterns: running, bending, hopping, crawling, skipping, throwing
2	**Bears in the Cave (Hibernation)**	**Organization:** 3-4 bears (the "its") begin in center; other students are scattered around the area
		Objective: tag another child before they run out of the area; tagged child becomes the bear
		Movement Patterns: can use different animal movements for transport
3	**Blob tag**	**Organization:** 2 - 4 teams; long rope tied into a circle; children run together with 1 child inside
		Objective: run the course with each child having their turn inside the blob; first team done wins
		Movement Patterns: running, turning
4	**Builders & Bulldozers**	**Organization:** Multiple cones (4 - 6 dozen) – optional alphabet letters on the cones
		Objective: to get all the cones either up or down; or to spell a name/word with the cones
		Movement Patterns: walking, running, bending, reaching
5	**Can't Touch This**	**Organization:** 1 soccer or playground ball per player; remove balls throughout the game
		Objective: maintain control of your ball while kicking other's balls out of play area
		Movement Patterns: dribbling, kicking, turning, running, etc.
6	**Capture the Flag**	**Organization:** 1 flag per team; flag belts for each child
		Objective: to capture another teams flag
		Movement Patterns: darting, chasing, tagging, bending, turning, cutting, etc.
7	**Cardio Course**	**Organization:** circular course with cones indicating different movements
		Objective: to move about the course completing the movements designated between cones
		Movement Patterns: hopping, skipping, jumping, running, different animal walks, etc.
8	**Castles**	**Organization:** 2 Teams on either side of center; line of cones at center court; 1 softy ball/player
		Objective: knock down all the cones; can keep count per team or time the entire class
		Movement Patterns: throwing, running, catching, bending, etc.
9	**Clean Your Room**	**Organization:** 2 play areas w/ scattered bean bags, etc.; 2 teams
		Objective: toss items into other team's room; if item is caught by the other team, the thrower performs a task before returning to the game (e.g. 5 jumping jacks)
		Movement Patterns: bending, tossing, crawling, kneeling, catching, walking, jumping, running

Game		Description
10	**Computer Virus**	**Organization:** buckets w/ poly spots scarttered around; hula hoop for each team w/ 10 - 15 beanbags across play area; each child takes a turn to run to a spot at a bucket; throws beanbag into the bucket
		Objective: to get the most beanbags into the buckets; or be first team to sink all beanbags
		Movement Patterns: running, throwing, bending, etc.
11	**Couple Tag**	**Organization:** 2 children joined by a scarf; child from the "it" pair swtiches places with the tagged child
		Objective: to avoid getting caught
		Movement Patterns: chassing, holding the scarf, moving together, tagging, darting, cutting, etc.
12	**Crazy Soccer**	**Organization:** 2 - 4 teams with a small cone as the goal for each team; 1 large cage ball
		Objective: to score by knocking down the other team's cone
		Movement Patterns: kicking, running, turning, passing, etc.
13	**Domino Relay**	**Organization:** 2 - 4 teams; member of each team at a station (a different action at each station - dribbling, jump rope, hula hoop, etc.); first team to finish relay; actions continues at each station
		Objective: child completes action while moving to next station; line move to the end and back
		Movement Patterns: various movements depending on equipment available
14	**Dragon's Tail**	**Organization:** scarves in waistband/back pocket (tail)
		Objective: Steal scarves & protect your own; if scarf is nabbed complete a task before returning
		Movement Patterns: twisting, running, walking, turning, reaching, spinning, pulling; standing
15	**Dribblers & Shooters**	**Organization:** Teams of 2; 1 basketball/player; 1 spot per pair; line of cones per pair or large circle for all pairs
		Objective: teammate scores as baskets from their spot while other dribbles course and switch
		Movement Patterns: throwing, catching, running, dribbling
16	**Eagles and Sparrows**	**Organization:** 2 people (Eagles) crouch at center; others circle nest; Eagles pounce when music stops (like musical chairs)
		Objective: to capture all the sparrows until there are only 2 sparrows left - they become the new Eagles
		Movement Patterns: chasing, tagging, running, darting, bending, ducking, crouching, etc.
17	**Fitness Tag**	**Organization:** Colored bean bags or balls and matching cones; different activity at each cone
		Objective: if tagged with bean bag, move to matching cone, perform activity and return to game
		Movement Patterns: calisthenics at cones, running, standing, sitting, chasing, jutting, cutting, etc.

Game		Description
18	**Fox & th Hound**	**Organization:** 1 - 2 hounds the rest are foxes; one less cone (den) as foxes used as safe zones
		Objective: avoid getting tagged by the hound; only one fox can occupy a den at one time
		Movement Patterns: tag, chassing, darting, running, reaching, etc.
19	**Great Escape**	**Organization:** 2 - 4 teams; alternate between tunnels and bridges
		Objective: create an obstacle course of bridges (over) and tunnels (under) to reach other side
		Movement Patterns: squatting, core exercises, jumping, crawling
20	**Hot Spot**	**Organization:** Poly spots scattered around a basketball goal; Teams of 2-3 in hoops placed at center court
		Objective: earn spots by dribbling to a spot for 1 shot on the goal, spot is earned if successful
		Movement Patterns: dribbling, running, shooting baskets, bending, jutting, chasing, etc.
21	**I'm a New Skunk**	**Organization:** Hula hoop in the center; soft ball used for tagging
		Objective: to avoid getting tagged; tagged person returns to hoop to announce a new skunk
		Movement Patterns: tag, chassing, darting, running, reaching, etc.
22	**Mini Kickball**	**Organization:** teams of 2 - 4 with 2 - 4 markers for bases in a line, triangle or diamond configuration
		Objective: kicker runs between the markers as many times as possible before pitcher tags a marker
		Movement Patterns: rolling, kicking, catching, running, cutting, etc.
23	**Monkey in the Middle**	**Organization:** a beachball for each team of 5; 1 of 5 students is in the middle
		Objective: to prevent the Monkey from intercepting a pass; Monkey switches places with the thrower
		Movement Patterns: throwing, catching, jumping, bending, reaching, running, darting, etc.
24	**Odds & Evens**	**Organization:** Cones to designate activity area, dice, flag belts
		Objective: to capture all the players from the other team before they reach their safe zone
		Movement Patterns: chasing tagging running, turning, darting ,etc.
25	**Pass the Hat**	**Organization:** line of students follow the leader around a track; item is passed down the line; last child races to front with the item is passed; it is thrown in bucket; a new item is passed down the line
		Objective: run the track until all the items are in the bucket; two teams can race on separate tracks
		Movement Patterns: children are encouraged to be creative
26	**Pirate's Treasure**	**Organization:** hula hoops with 10 - 15 items (beanbags, etc.)
		Objective: steal the treasure from other team without getting tagged
		Movement Patterns: chasing, tagging, running, darting, ducking, etc.

Game		Description
27	**Race Day**	**Organization:** Teams of 2 - 4; raceway w/ cones; pit-stop for each team
		Objective: complete a list of activities at the pit-stop by all team members while each takes a turn running the track
		Movement Patterns: jumping jacks, hopping, skipping, running, etc.
28	**Sharks & Minnows**	**Organization:** 1 - 2 sharks; remaining minnows w/ flagbelt
		Objective: sharks tags minnows as they attempt to cross the ocean; last minnow becomes next shark
		Movement Patterns: running, darting, chasing, tagging
29	**Steal the Bacon**	**Organization:** various items (beanbags, small cones, balls) scattered in area divided for each team
		Objective: steal the other team's bacon without getting tagged
		Movement Patterns: chasing, tagging, running, darting, ducking, etc.
30	**Stop 'n Go**	**Organization:** Two teams have their own designated end zone at opposite ends of the play area
		Objective: Played similar to ultimate Frisbee, players pass the ball (basketball or football) to reach the end zone; players are not allowed to move while they are in possession of the ball
		Movement Patterns: passing, catching, running, jumping, turning, chasing, cutting, etc.

APPENDIX E

RECRUITMENT FORMS

Study Screening Form

Parents' Name: _____ Child's Name: _____

School: _____ Grade: _____ Teacher: _____

Address: _____ City: _____ Zip: _____

Home Phone: _____ Work Phone: _____

Cell Phone: _____ Best Time to Call: _____

Inclusion/Exclusion Criteria:

Gender: female male **Age:** _____ **DOB:** _____

Race: _____ **Hispanic/Latino:** YES NO **Treadmill:** YES NO

Would your child be able to walk on a treadmill without holding on? Y N

Approximate Height: _____ **Approximate Weight:** _____

Has your doctor ever diagnosed your child with any of the following medical problems?

Heart Disease/Problems/Abnormalities	YES	NO
High Blood Pressure	YES	NO
Asthma / Breathing disorders	YES	NO
Epilepsy / Neurological disorders	YES	NO
Diabetes / Metabolic diseases	YES	NO
Joint pain / Physical impairment	YES	NO

Does your child take any medication on a regular basis? YES NO

Does your child participate in recreation/competitive sports? YES NO

Does your child have any medical problems which would prevent him/her from participating in a vigorous exercise program? YES NO

Has your child participated in any other research study? YES NO

"YES" to any of the above, explain: _____

Preliminary eligibility: YES NO *if NO, why* _____

If subject DECLINES, reason given: _____

Parent Baseline Questionnaire – AKIDS Study

Dear Parent,

Thank you for agreeing to participate in the "AKIDS" study being conducted at your school by researchers from the University of Massachusetts, Amherst, MA and Children's Hospital, Boston. As part of the evaluation of the program, we would like you to answer some questions that ask about your child and your family and the neighborhood where you live. These questions should be answered only about the child in your family who is participating in the AKIDS Study at his or her school.

This questionnaire should only be completed by child's parent or legal guardian. There are no right or wrong answers to these questions. Completing this survey is completely voluntary and you may refuse to answer any specific question at any time. Your responses to these questions are completely confidential and will only be seen by research staff. Your name and your child's name will not be linked to these individual responses and the results from this questionnaire will only be presented in research publications in a summary form without names.

Upon completing the questionnaire, please mail it back to researchers in the enclosed, self -addressed, stamped envelope within the next week.

Thank you for your time.

QUESTIONS

1. What is **your Child's** date of birth? ___ ___ / ___ ___ / ___ ___ ___ ___
   M M D D Y Y Y Y

2. What is **your Child's** gender? (Circle one)
   - Male 1
   - Female 2

3. What is **your Child's** race? (Circle all that apply)
   - Caucasian 1
   - Black / African American 2
   - Asian 3
   - American Indian /Alaskan native 4
   - Native Hawaiian/Other Pacific Islander 5
   - Other, specify 6
   - I do not know ..... -8

4. What is **your Child's** ethnicity (Circle one):
   - Hispanic 1
   - Non Hispanic 2
   - I do not know ..... -8

5. What is the highest level of education that **your child's** mother or female legal guardian(s) has completed?

Less than High School 1
Some High School 2
High School graduate or GED 3
Trade School 4
Some college 5
College graduate 6
Post graduate degree 7
I DO NOT KNOW ..... -8
NOT APPLICABLE ..... -1

6. What is the highest level of education that **your child's** father or male legal guardian(s) has completed?

Less than High School 1
Some High School 2
High School graduate or GED 3
Trade School 4
Some college 5
College graduate 6
Post graduate degree 7
I DO NOT KNOW ..... -8
NOT APPLICABLE ..... -1

7. What is your **total household income** for one year and from all sources? (Please circle one)

Below $20,000 1
$20,000 –$29,999 2
$30,000 –$39,999 3
$40,000 –$49,999 4
$50,000 –$59,999 5
$60,000 –$69,999 6
$70,000 –$79,999 7
$80,000 –$89,999 8
$90,000 –$99,999 9
Above $100,000 10
I DO NOT KNOW 11

8. Does **your child** participate in the free or reduced lunch program? (Circle one)

NO 1
YES 2

9. What is your relationship to this child?

Mother 1
Father 2
Legal Guardian-related 3
Legal Guardian-unrelated 4
Other, specify 5

THANK YOU

APPENDIX F

INFORMED CONSENT / ASSENT DOCUMENTS

INFORMED CONSENT DOCUMENT

Title of Study: Energy Cost of Physical Activity in Children

Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

Introduction

You have indicated your child, _____, has an interest in participating in a research study to measure the energy cost of physical activity in children. Participation in this research involves your child wearing an indirect calorimetry monitor including a face mask attached to a lightweight back pack, several motion sensors and a heart rate monitor while at rest and while being physically active. Before deciding to give consent for your child to participate you are being given written information and a chance to ask any questions you or your child may have about the study. The essence of this study is as follows:

Purpose of this Research

The purpose of this study is to measure the actual energy cost of activities anticipated to burn 50 kcal per 15-minute session in a small representative sample of 3rd and 4th grade children. Motion sensors will assess how much movement is associated with each activity. Your child will be given the opportunity to rate the activities to determine the level of enjoyment for each activity.

Eligibility

Your child is one of 30 children selected to participate in this study because he/she is a 3rd and 4th grade child (8 - 10 y), is in good health (no diagnosis with cardiovascular, pulmonary, or metabolic disease), and is willing to comply with the project protocol.

Procedures

There will be one testing session when your child, accompanied by a parent or guardian, will report to the Exercise Physiology Lab following a 4 hour fast. An investigator will measure and record your child's height and weight and date of birth. Then your child will lie down on a single bed and rest quietly for a period of 15 minutes. Resting metabolic rate will be measure following this rest period for 10-15 minutes using the MedGem analyzer. During this resting measurement period your child will be ask to lie quietly and only speak in a normal tone when necessary.

Following the resting measurement, your child will be asked to place a transmitter belt around his/her chest next to the skin for the measurement of heart rate. The monitor (watch) will be placed on his/her non-dominant wrist. The accelerometers (motion sensors) will be placed on his/her hip using a belt.

Your child will then be fitted with a face mask and backpack to measure the energy cost of the activities. These measurements will be assessed during 7 - 10 different activities such as playing soccer, jump rope, stepping, etc. Each activity will be completed for 6 minutes with 3 minutes rest in between. Following each activity your child will indicate on a Likert scale how much he/she enjoyed and would like to continue playing the activity.

Possible Risks and Discomforts
Since the testing protocol is requiring your child to be physically active, there are health risks associated with your child's participation in this study. The facemask may be uncomfortable, although no injury to the skin should result from wearing the device and the discomfort should be minimal. The probability and magnitude of harm or discomfort anticipated for participation in the proposed research are no greater than those ordinarily encountered in daily life, such as during play, physical education or recess at school. The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subject research but the study personnel will assist you in getting treatment for your child in the unlikely event it is necessary.

Benefits
Your child may not derive any benefit from participation in this study. Participation in this study will simply allow your child to contribute to our ability to accurately assess energy cost of physical activity in children.

Confidentiality
In this study, confidentiality is assured for all participants with regard to any information you provide for yourself and for your child. The information obtained from this study will be treated as privileged and confidential. Your child will not be personally identified if the results are published. All data collected will be numerically coded for data analysis, thereby assuring anonymity for all individuals. No individual data will be identifiable in any publication resulting from this research.

Voluntary Participation
Participation in this study is voluntary and you or your child may choose to discontinue participation in this study at any time without prejudice.

Compensation
Your child may be compensated for his/her time and effort in the amount of up to $30.00 for their participation in this research study.

Request for Additional Information
You and your child are encouraged to ask questions about the study. The investigators will attempt to answer all your questions to the best of their knowledge. The investigators fully intend to conduct the study with your child's best interest, safety, and comfort in mind. They have read and understand the

Assurance of Compliance with OHRP Regulations for Protection of Human Research Subjects. Should you have any questions about your child's treatment or any other matter relative to your child's participation in this project, or if you experience a research related injury at any time during this study, you may call Dr. Freedson at 413-545-2620 or Cheryl Howe at 413-545-1583. If you would like to speak with someone not directly involved in the research study, you may contact the Office of Research Affairs at the University of Massachusetts via
e-mail: humansubjects@ora.umass.edu
Telephone: (413-545-3428)
Mailing address: Office of Research Affairs
Research Administration Building
University of Massachusetts Amherst,
70 Butterfield Terrace, Amherst, MA 01003

Participation Statement of Voluntary Consent
When signing this form I am agreeing to allow my child to voluntarily enter this study. I understand that, by signing this document, I do not waive any of my legal rights. I have had a chance to read this consent form, and it was explained to me in a language that I use and understand. My child and I have had the opportunity to ask questions and have received satisfactory answers. A copy of this signed Informed Consent Form has been given to me on behalf of my child.

_____ _____ _____
Parent/Guardian (print) Signature Date

Address: _____

_____

Phone: Home: _____ Work/Cell: _____

Email: _____

Child's Information

Name: _____ Date of Birth: _____

Age: _____ Gender: Male Female Grade: _____

Study Representative Statement
I have explained the purpose of the research, the study procedures, the possible risks and discomforts, the possible benefits, and have answered any questions to the best of my ability.

_____
Study Representative Name (print or type)

_____ _____
Signature Date

INFORMED ASSENT DOCUMENT
Title of Study: Energy Cost of Physical Activity in Children
Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

We are doing a research study about how much energy children use during different children's games and activities. A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked to wear a facemask and a small backpack, some small monitors on your hip and a heart rate monitor around your chest while you are playing games. This will take about 3 to 4 hours to play about 10 different games.

There are some things about this study you should know. Before you come to our lab you will not eat or drink anything for 4 hours. You may have as much water as you want during that time. When you come to the lab we will measure how tall you are and how much you weigh. Then you will lie down on a bed and rest for 15 minutes. After this rest we will hand you a small tube and some nose plugs and you will breathe through the tube for about 10 minutes. After your rest, we will place a heart rate monitor band around your chest and a watch on your wrist. A small monitor will be placed on your hip using a belt. We will fit a facemask over your nose and mouth. You will be able to breathe easily because the facemask has a big whole in the front. A backpack will sit on your back. Then you will be asked to play different games and activities, such as playing soccer, jump rope, and tag, for 6 minutes. You will have a short break between each game. During this break you will circle a picture of the face that shows us how you felt about playing the game. There is a slight chance that you might get hurt while playing the games, like twist an ankle. The facemask may be a little uncomfortable, but that will go away when you take the facemask off.

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We feel there are no benefits for you in this study. When we finish this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too. For being in the study you will be paid up to $30.00.

If you decide you want to be in the study, please print and sign your name.

I, _____, want to be in this research study.
(Print your name here)

_____ _____
(Sign your name here) (Date)

PARENTAL CONSENT DOCUMENT
Title of Study: AKIDS Pilot Intervention
Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

Introduction
Your child, _____, is invited to participate in a research study to measure the energy cost of common children's games during a 5-week structured physical activity program. Participation in this study involves your child being measured for height, weight, waist circumference, and blood pressure at the beginning of the study. Physical activity measurements will involve your child wearing an activity monitor while playing the selected games. The activity monitor is a motion sensor that is approximately the size of a small pager and is worn on the hip attached to a belt. Your child will also be randomly asked 1 – 2 times during the program to wear an indirect calorimetry monitor including a face mask attached to a lightweight back pack (weighs approximately 2 lbs.) while playing the children's games. Before deciding to give consent for your child to participate you are being given written information and a chance to ask any questions you or your child may have about the research study.

Purpose of this Research
The purpose of this study is to examine how much energy 3rd grade children burn while playing common children's games during a structured physical activity program.

Eligibility
Your child is one of 10 - 15 children selected to participate in this study because he/she is a 3rd grade student (8 - 9 years of age), is in good health (no diagnosis of cardiovascular, pulmonary, or metabolic disease), and is willing to participate in the children's games.

Procedures
During the first visit to the laboratory your child will be asked to complete some physical measurements and some questionnaires about themselves, their environment and about physical activity. You will also be asked to fill out a questionnaire about your child's health history for screening purposes. An investigator will measure your child's height, weight, waist circumference and blood pressure before they begin the activity program. Once all children have been measured, your child will be asked to participate in a 30-min structured physical activity program two days per week for 5 weeks. The first visit will take approximately 1 hour. Every remaining session should typically take 45 minutes. The program will be run on Wednesday afternoons and Saturday mornings in a UMASS gymnasium. Activities will be fun and safe and designed to keep them moving for a total of 30 minutes per session. These activities will include tag-like games such as capture the flag and "fishy, fishy cross my ocean" and other similar children's games. Each session your child will be asked to play two different games at their own desired intensity for 15 minutes each. Verbal

encouragement will be given to help motivate your child to continue actively playing each game.

Possible Risks and Discomforts
Your child will be asked to be physically active during this structured program. There are health risks associated with your child's participation in this physical activity program. The probability and magnitude of harm or discomfort likely to occur with participation in this program are no greater than those ordinarily experienced in daily life, such as during outdoor play, physical education class or regular recess at school. The program staff will be trained to run the games in a safe manner. The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subject research but the study personnel will assist you in getting treatment for your child in the unlikely event it is necessary.

Benefits
There are no direct benefits associated with participating in the study. Your child may benefit from possible increases in physical activity and improvements in their personal health status.

Confidentiality
In this study, confidentiality is assured for all participants with regard to any information you provide for yourself and for your child. The information obtained from this study will be treated as privileged and confidential. All data collected will be numerically coded for data analysis, thereby assuring anonymity for all individuals. All data and personal information will be stored on a password protected computer and in a locked cabinet for 7 years. No individual data will be identifiable in any publication resulting from this research.

Voluntary Participation
Participation in this study is voluntary and you or your child may choose to discontinue participation in this study at any time without prejudice.

Compensation
For completing the study program, your child will receive an award for his/her time and effort at the end of the study.

Request for Additional Information
You and your child are encouraged to ask questions about the study. The investigators will attempt to answer all your questions to the best of their knowledge. The investigators fully intend to conduct the study with your child's best interest, safety, and comfort in mind. They have read and understand the *Assurance of Compliance with OHRP Regulations for Protection of Human Research Subjects.* Should you have any questions about your child's treatment or any other matter relative to your child's participation in this project, or if you experience a research related injury at any time during this study, you may call Dr. Freedson at 413-545-2620 or Cheryl Howe at 413-545-1583. If you would like to speak with someone not directly involved in the research study, you may

contact the Office of Research Affairs at the University of Massachusetts via e-mail, telephone or mail.

E-mail: humansubjects@ora.umass.edu
Telephone: (413-545-3428)
Mailing address: Office of Research Affairs
Research Administration Building
University of Massachusetts Amherst,
70 Butterfield Terrace, Amherst, MA 01003

Participation Statement of Voluntary Consent

When signing this form I am agreeing to allow my child to voluntarily enter this study. I understand that, by signing this document, I do not waive any of my legal rights. I have had a chance to read this consent form, and it was explained to me in a language that I use and understand. My child and I have had the opportunity to ask questions and have received satisfactory answers. A copy of this signed Informed Consent Form has been given to me on behalf of my child.

_____
Parent(s)/Guardian(s) (print clearly)

_____ _____
Signature Date

Address: _____

Phone #'s: Home: _____ Work: _____

Cell: _____ Other: _____

Email: _____

Child's Information

Name: _____ Date of Birth: _____

Age: _____ Gender: Male Female School: _____

Study Representative Statement

I have explained the purpose of the research, the study procedures, the possible risks and discomforts, the possible benefits, and have answered any questions to the best of my ability.

_____
Study Representative Name (print clearly)

_____ _____
Signature Date

INFORMED ASSENT DOCUMENT
Title of Study: Pilot Intervention
Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

We are doing a research study about how much energy children use during different children's games and activities during. A research study is a way to learn more about people. If you decide that you want to be part of this study, you will be asked to play different games and activities with a group of children your own age on Wednesday and Saturday's for a total of 5 weeks. The first visit to the laboratory will take about 1 hour. Every other visit will typically take about 45 minutes.

There are some things about this study you should know. When you come to the lab we will measure your height, weight, waist circumference, and blood pressure. You will be asked to fill out some questionnaires about yourself, the environment and about physical activity. We will place a heart rate monitor band around your chest and a watch on your wrist. A small monitor will be placed on your hip using a belt. Each visit you will play 2 different games such as soccer, jump rope and tag for 15 minutes each. You will have a short break between each game. During this break you will circle a picture of the face that shows us how you felt about playing the game. For 2-3 of the visits you will be asked to wear a facemask over your nose and mouth. You will be able to breathe easily because the facemask has a big hole in the front. The facemask will connect to a backpack which will sit on your back. There is a slight chance that you might get hurt while playing the games, like twist an ankle. The facemask may be a little uncomfortable, but that will go away when you take the facemask off.

Not everyone who takes part in this study will benefit. A benefit means that something good happens to you. We feel there are no benefits for you in this study. When we finish this study we will write a report about what was learned. This report will not include your name or that you were in the study.

You do not have to be in this study if you do not want to be. If you decide to stop after we begin, that's okay too.

If you decide you want to be in the study, please print and sign your name.

I, _____, want to be in this research study.
(Print your name here)

_____ _____
(Sign your name here) **(Date)**

PARENTAL CONSENT DOCUMENT
Title of Study: "A"KIDS – Activity Kcal Intervention Daily Study
Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

Introduction
Your child, _____, is invited to participate in a research study looking at the effects of a structured physical activity program during school recess on children's activity level and health status. Participation in this research involves your child being measured for height, weight, waist circumference, blood pressure and physical activity three times throughout the school year (fall, winter and spring). Physical activity measurements will involve your child wearing an activity monitor for 7 days. The activity monitor is a motion sensor that is approximately the size of a small pager and is worn on the hip attached to a belt around the waist. You and your child will also be asked to complete some questionnaires about you and your child's physical activity habits and beliefs about your environment. Before deciding to give consent for your child to participate you are being given written information and a chance to ask any questions you or your child may have about the study.

Purpose of this Research
The purpose of this study is to examine how a structured physical activity program during school recess affects the physical activity level, the health status, and the beliefs toward physical activity in 3rd grade children.

Eligibility
Your child is one of 60 children selected to participate in this study because he/she is a 3rd grade student (8 - 9 years of age) at one of the participating schools, is in good health (no diagnosis of cardiovascular, pulmonary, or metabolic disease), and is willing to participate in the study.

Procedures
There will be three testing sessions when your child, accompanied by a parent or guardian, will report to the nurse's office, or other designated room in their school, before morning classes or at lunch to complete some questionnaires and measurements. An investigator will measure your child's height, weight, waist circumference, and blood pressure. Then a monitor will be placed on your child's right hip with a belt to measure their movement similar to a pedometer. This monitor is to be worn for the next 7 days, except when they bathe or go swimming to prevent the monitor from getting wet. The monitor will be removed at bedtime and put back on in the morning after your child gets out of bed. You and your child will be shown how to take the monitor off and put it back on properly. You will be given clear instructions to take home with you. You will also assist your child in keeping a monitor log of when the monitor was taken off and put back on for bathing, sleeping, etc. You will receive periodic reminder phone calls, text messages or e-mails to help you and your child complete this

process. You will also be reminded at the end of this 7 day period that your child will be greeted at their school by an investigator to collect the monitor and the monitor log either before school or at lunch. These measurement procedures will be repeated during the winter and at the end of the school year.
Once all children have been measured in the fall, the two schools will be randomized into either the program or the control school. In the program school, all the 3rd grade students will participate in a daily structured physical activity program during recess. Activities will be fun and safe and designed to keep them moving for a total of 30 minutes. These activities will include jump rope, soccer, basketball, tag, and other active children's games. The control school will not be offered the program but will continue to have a regular, daily recess for free play.

Possible Risks and Discomforts
Your child, if they attend the program school, will be asked to be physically active during the program. There are health risks associated with your child's participation in this physical activity program. The probability and magnitude of harm or discomfort likely to occur with participation in the program are no greater than those ordinarily experienced in daily life, such as during play, physical education or regular recess at school. The program staff will be trained to run the program activities safely. The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subject research but the study personnel will assist you in getting treatment for your child in the unlikely event it is necessary.

Benefits
Your child, if they attend the program school, may benefit from possible increases in physical activity and improvements in their personal health status. Those children who attend the control school do not benefit directly from the research study but will contribute to an important research project to gain information about how schools may help prevent childhood obesity.

Confidentiality
In this study, confidentiality is assured for all participants with regard to any information you provide for yourself and for your child. The information obtained from this study will be treated as privileged and confidential. You or your child will not be personally identified if the results are published. All data collected will be numerically coded for data analysis, thereby assuring anonymity for all individuals. No individual data will be identifiable in any publication resulting from this research.

Voluntary Participation
Participation in this study is voluntary and you or your child may choose to discontinue participation in this study at any time without prejudice.

Compensation
At the end of the study each child in your child's classroom may receive a prize for his/her time and effort. This value of this prize may range from $6.00 to $30.00 and will reflect the amount of participation in the study (depending on the number of days your child wears the monitor during each of three measurement session – Fall, Winter and Spring).

Request for Additional Information
You and your child are encouraged to ask questions about the study. The investigators will attempt to answer all your questions to the best of their knowledge. The investigators fully intend to conduct the study with your child's best interest, safety, and comfort in mind. They have read and understand the *Assurance of Compliance with OHRP Regulations for Protection of Human Research Subjects.* Should you have any questions about your child's treatment or any other matter relative to your child's participation in this project, or if you experience a research related injury at any time during this study, you may call Dr. Freedson at 413-545-2620 or Cheryl Howe at 413-545-1583. If you would like to speak with someone not directly involved in the research study, you may contact the Office of Research Affairs at the University of Massachusetts via e-mail, telephone or mail.
E-mail: humansubjects@ora.umass.edu
Telephone: (413-545-3428)
Mailing address: Office of Research Affairs
Research Administration Building
University of Massachusetts Amherst,
70 Butterfield Terrace, Amherst, MA 01003

Participation Statement of Voluntary Consent
When signing this form I am agreeing to allow my child to voluntarily enter this study. I understand that, by signing this document, I do not waive any of my legal rights. I have had a chance to read this consent form, and it was explained to me in a language that I use and understand. My child and I have had the opportunity to ask questions and have received satisfactory answers. A copy of this signed Informed Consent Form has been given to me on behalf of my child.

_____
Parent(s)/Guardian(s) (print clearly)

_____ _____
Signature Date

Address: _____

Phone #'s: Home: _____ Work: _____

Cell: _____ Text messaging: YES NO

Email: _____

Child's Information

Name: _____ Date of Birth: _____

Age: _____ Gender: Male Female School: _____

Study Representative Statement

I have explained the purpose of the research, the study procedures, the possible risks and discomforts, the possible benefits, and have answered any questions to the best of my ability.

_____

Study Representative Name (print clearly)

_____ _____

Signature Date

CHILD ASSENT DOCUMENT
Title of Study: "A"KIDS – Activity KCAL Intervention Daily Study
Co-Investigators: Patty S. Freedson, Ph.D., Stavroula Osganian, MD, Sc.D., Cheryl A. Howe, M.S.

We are doing a project about doing a physical activity program during school recess. This project is a way to learn more about people. If you decide that you want to be part of this project, you will be asked to wear a small box on your hip for 7 days, except when you sleep, take a bath or go swimming. We will also measure your height, weight, around your belly, and your blood pressure. You will also be asked to answer some questions about how you feel about physical activity and about your life. All of these measurements will be done during the fall as school begins, before winter break and then again before the end of school in the spring.

There are some things about this project you should know. The measurements of your body will be done in the nurse's office or in another private room at your school either before schools starts in the morning or during your lunch period. Your parent may be there with you during these measurements. The blood pressure measurement might be a little uncomfortable just like when you have it taken at your doctor's office. The small box that you will wear on your hip for 7 days should not bother you or get in your way of playing or participating in sports.

Your school may be selected to have the physical activity program during your regular recess time. If it is, all the 3rd grade students will take part in the program every day and play such games as tag, jump rope, soccer, and other children's games. If your school is not selected for the program you will still have your regular recess time when you can play. There is a very small chance that you might get hurt while playing games during the program, like twist an ankle.
Not everyone who takes part in the project will benefit. A benefit means that something good happens to you. The children who get to be in the physical activity program at their school may see changes in how much physical activity they do every day and they may see changes in their health. The children who are not offered the program may not benefit from this project. When we finish this study we will write a report about what was learned. This report will not include your name or that you were in the project.

You do not have to be a part of this project if you do not want to be. If you decide to stop after we begin, that's okay too. For being a part of the project each child in your class may receive a prize at the end of the school year that will be worth up to $30.00. How much your prize is worth will depend on how much you wear the small box: the prize will be worth the full amount ($30.00) if you wear the small box for all 7 days and less if you do not wear the small box every day we ask you to wear it.

If you decide you want to be in the project, please print and sign your name.

I, _____, want to be a part of this project.
(Print your name here)

_____ _____
(Sign your name here) **(Date)**

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