

Abstract  
EFFECTS OF PARENTAL OBESITY ON FAT METABOLISM DURING SUBMAXIMAL EXERCISE IN  
CHILDREN

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The aim of the present study was to compare fat metabolism during submaximal exercise in children with a morbidly obese parent – (COP) ( $\text{BMI} \geq 40 \text{ kg/m}^2$ ) to children with relatively lean parents – (CLP) ( $\text{BMI} \leq 28 \text{ kg/m}^2$ ). All participants in the COP and CLP groups ( $n = 10$  per group) completed two, ten minute submaximal exercise sessions at an absolute workload of 15 W and a relative workload of 65%  $\text{VO}_2$  peak as expired gases were measured. Actigraph GT1M accelerometers were also worn by the participants to determine physical activity patterns during periods of normal living. Despite the participants being matched for age, maturity, body composition, cardiovascular fitness, and physical activity levels, the COP group had a significantly higher RER and lower percentage of energy from fat than the CLP group at an absolute workload of 15 W ( $P \leq 0.05$ ). The difference in RER and percentage of energy from fat at the relative workload of 65%  $\text{VO}_2$  peak was not significantly different. From our results there appears to be a decreased reliance on fat for energy at lower intensity exercise in children with at least one morbidly obese parent compared to children with lean parents. This decrease in fat metabolism may be genetically predetermined and increase the risk of being obese.



Effects of Parental Obesity on Fat Metabolism During Submaximal Exercise in Children

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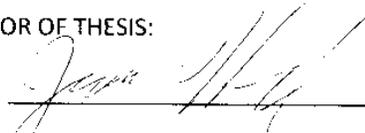
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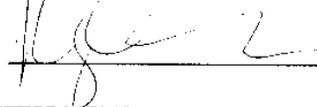
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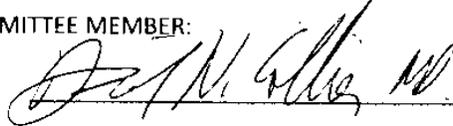
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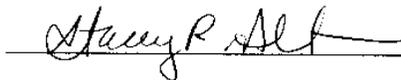
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## DEDICATION

This thesis is dedicated to my family. To my Mama who has taught me by her own example how to be independent, a hard worker, and to not be afraid to voice my opinions. To Wendy for always being proud of even my smallest accomplishments and for always being a protective older sister. To Gina for teaching me to let loose and always make time for fun. And to my Daddy who puts up with us all! I love you all, and I can always count on home as a place of comfort and laughter.

I also dedicate this thesis to Justin. Thank you for your constant support throughout this thesis and always. You continue to put a smile on my face.

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## CHAPTER 1: INTRODUCTION

Obesity has become a widespread epidemic in our nation and in other areas of the world. In the past obesity was a rare occurrence that typically only affected adults. Now obesity affects approximately a third of our population (<http://www.cdc.gov/nccdphp/dnpa/obesity/>). No longer is obesity an adult issue, but children are now living with obesity and the health problems that are associated with it, including type 2 diabetes, hypertension, sleep apnea, and coronary heart disease (<http://www.cdc.gov/nccdphp/dnpa/obesity/>). As reported by Fontaine, Redden, Wang, Westfall, and Allison (2003) obesity causes a decrease in life expectancy ranging from 5 to 20 years, and this is most notable in obese young adults. Not only are obese children physically affected, but there are psychosocial repercussions as well, which can affect their success in the classroom and socially (<http://www.cdc.gov/nccdphp/dnpa/obesity/>). In the state of North Carolina, 2 billion dollars was spent in medical expenditures that were attributed to adult obesity in 2003, and it was estimated that 16 million dollars is spent per year on the direct and indirect costs of childhood obesity with a notable percentage of this being paid through Medicare and Medicaid (<http://www.eatsmartmovemorenc.com>). If the trend of increasing rates of obese and overweight does not slow, these numbers will only escalate. What is the cause for this rise in the prevalence of obesity?

Are Ronald McDonald and the Burger King to blame? Are people overweight and obese only because more calories are taken in than are burned? At rest energy primarily comes from burning fat with a typical respiratory exchange ratio (RER) of 0.75 (McArdle, Katch F., and Katch V., 2007, p. 191). However, a study by Buscemi, Verga, Caimi, and Cerasola (2005) showed that there is a decrease in the ability to utilize fat for energy in obese individuals. Therefore an obese individual may be predisposed to storing fat as it is not used for metabolic needs. In

another study (Guesbeck, Hickey, MacDonald, Pories, Harper, Ravussin, Dohm, and Houmard, 2000) individuals who lost a great deal of weight via gastric bypass still showed a decreased ability to use fat for energy during submaximal exercise. It would seem likely then that the decreased ability to oxidize fat may contribute to the development of obesity. This decrease in the ability to oxidize fat could be attributed to muscle fiber composition or enzyme activity, but it could also be due to heredity and numerous other factors.

A study by Whitaker, Wright, Pepe, Seidel, and Dietz (1997) summarized that “parental obesity more than doubles the risk of adult obesity among both obese and non-obese children less than 10 years of age.” A study by Giacco, Clemente, Busiello, Lasorella, Riviaccio, Rivellese, and Riccardi (2003) found that normal weight children of overweight parents had a decreased ability to oxidize fat. Therefore, family history appears to be a strong predictor of overweight and obesity; however, data indicating that substrate utilization may be involved is sparse.

The purpose of this study was to examine substrate utilization in children with a morbidly obese parent and in children of normal weight parents. We hypothesized a child who has a morbidly obese parent will have a decreased ability to utilize fat for energy in comparison to a child with normal weight parents. In order to test our hypothesis we measured RER in both children with a morbidly obese parent and normal weight parents using a metabolic cart during submaximal and maximal exercise on a cycle ergometer.

### **Delimitations**

- 1) Children between the ages of 8 to 14 years of age were included in this study.

- 2) Participating children were prepubescent, not regularly participating in physical activity, and had no medical conditions or were on any type of medication that could affect their exercise performance.
- 3) Experimental group participants had a parent with a current BMI  $\geq 40$  kg/m<sup>2</sup> or a parent who underwent gastric bypass surgery due to possessing a BMI  $\geq 40$  kg/m<sup>2</sup>.
- 4) Control group participants had parents who both had BMI's  $\leq 28.0$  kg/m<sup>2</sup>.
- 5) Control group participants were matched to experimental group participants in terms of gender, age, and race.
- 6) Maximal and submaximal exercise was performed on a Lode Corival cycle ergometer.
- 7) Physical activity habits and perceptions were assessed using a questionnaire.

#### **Limitations**

- 1) Participants were volunteers living in Greenville, North Carolina and surrounding areas.
- 2) Conclusions were limited to the age group tested.

#### **Definitions**

Obese- BMI  $\geq 30$  kg/m<sup>2</sup>.

Morbidly Obese- BMI  $\geq 40$  kg/m<sup>2</sup>.

Respiratory Exchange Ratio (RER) – Ratio of the amount of carbon dioxide produced and the amount of oxygen consumed.

Overweight for children - BMI  $\geq$  the 95<sup>th</sup> percentile on the CDC growth chart.

At risk for overweight for children – BMI between the 85<sup>th</sup> and 94<sup>th</sup> percentile on the CDC growth chart.

## CHAPTER 2: REVIEW OF LITERATURE

### **The Obesity Epidemic**

Today we live in a time of advancement. Social, technological, and medical progresses have left deep impressions in the past few decades. However, as Americans have we had an “advancement” in our size as well? Today being overweight is the norm, and more people than ever are obese. The NHANES surveys show that obesity rates have climbed from 15.0% in the years 1976 to 1980 to 32.9% in the years 2003 and 2004

(<http://www.cdc.gov/nccdphp/dnpa/obesity/>).

Bigger is better, right? No, obesity is a risk factor for many serious health conditions, including hypertension, dyslipidemia, type 2 diabetes, and coronary heart disease (Ludwig, 2007). Being bigger is killing American adults, and this deadly disease is now afflicting children. Childhood overweight has increased dramatically in all age groups from 1976 to 2004

(<http://www.cdc.gov/nccdphp/dnpa/obesity/>). According to the American Heart Association, 16% of all children and adolescents are overweight

(<http://www.americanheart.org/presenter.jhtml?identifier=3000947>).

When discussing overweight and obese in children, the terms are not always clear. The term obese in the past has been avoided with children. At risk for overweight is defined by the CDC as having a BMI between the 85<sup>th</sup> and 94<sup>th</sup> percentile. Overweight in children is defined as having a BMI greater than or equal to the 95<sup>th</sup> percentile on the CDC growth chart

(<http://www.cdc.gov/nccdphp/dnpa/obesity/>). Complications that go along with obesity in adults are now becoming present in children. Overweight children are experiencing high blood pressure, type 2 diabetes, asthma, sleep apnea, and other health problems. If a child has such serious health concerns like cardiovascular disease and type 2 diabetes, what kind of life can

they expect to have in terms of both duration and quality? The increasing prevalence of obesity may cause a drop in the life expectancy of children (Olshansky, Passaro, Hershov, Layden, Carnes, Brody, Hayflick, Butler, Allison, and Ludwig, 2005). Obviously obesity is a huge problem affecting adults and their children, and this problem is not going away. How are we as a country getting so fat?

### **Fat Metabolism in Skeletal Muscle**

A factor that may contribute to the development of obesity are the differences in how the body utilizes energy. The body gets its energy to do work mostly from either carbohydrate or fat. Fats, once ingested, are primarily stored as triglycerides in adipose tissue and skeletal muscle. When needed for energy production in skeletal muscle, these triglycerides are broken down into fatty acids through the process of lipolysis occurring in the cytosol. Once the fatty acids are hydrolyzed from the triglyceride they are free to leave the fat cell and enter the blood stream. If the fatty acid exits the fat cell, it must bind to the protein albumin to travel in the blood stream as a free fatty acid. For the free fatty acid to be used for energy in the muscle it enters the muscle cell via transporters. There are numerous transporters to aid in this process including fatty acid binding protein (FABPpm), fatty acid translocase (FAT), and fatty acid transport protein (FATP). Once in the cell the fatty acid becomes activated by binding with acyl CoA resulting in a fatty acyl CoA (Houston, 2001). Fatty acyl CoA is now transported across the outer mitochondrial membrane by binding with the protein carnitine and a reaction with carnitine acyltransferase I (CPT1). The reaction catalyzes the formation of O-acylcarnitine and is then transported across the inner mitochondrial membrane by a translocase, which passes the acylcarnitine to acyltransferase II in the mitochondrial matrix. Fatty acyl CoA is reformed in the matrix, and carnitine is free to go back across the membranes of the mitochondria. Finally the

fatty acyl CoA is able to begin beta oxidation (Garrett and Grisham, 2007). During beta oxidation, the long fatty acid chains are split into 2-carbon acyl fragments which join with coenzyme A to form acetyl-CoA. Acetyl-CoA is the same end product from glucose in glycolysis. Each acetyl-CoA enters the Krebs cycle. NAD<sup>+</sup> and FAD accept electrons from hydrogen and are effectively reduced into potential energy rich molecules NADH and FADH<sub>2</sub> respectively during the Krebs cycle. NADH and FADH<sub>2</sub> enter the electron transport chain and are then passed down to cytochromes, iron-protein electron carriers on the inner mitochondrial membranes. As these molecules move down the chain they release hydrogen ions and electrons into the intermembrane space of the mitochondria, creating an electrochemical gradient. There is a higher concentration of hydrogen ions in the intermembrane space than in the matrix of the mitochondria. As the hydrogens move back into the matrix via the gradient, ATP is generated. NADH will yield 3 ATPs, and FADH<sub>2</sub> will yield 2 ATPs (McArdle, Katch F., and Katch V., 2007, p. 142). Approximately 460 molecules of ATP are made from 1 triglyceride molecule compared to 36 molecules of ATP from glucose (McArdle, Katch F., V., 2007, p. 159). An important consideration for fat metabolism is that it can only occur in a “carbohydrate flame.” This concept infers that the acetyl-CoA from beta oxidation can only be further metabolized if intermediates from glycolysis, specifically oxaloacetate, are present as well (McArdle, Katch F., V., 2007, p. 162).

When the body has an excess of acetyl-CoA from either beta oxidation or glycolysis, acetyl-CoA molecules are condensed together making fatty acid chains. Glyceraldehyde phosphate, an intermediate from glycolysis, is converted to glycerol. The glycerol and fatty acid chains combine and are stored as triglycerides. Therefore, fat storage occurs with an excess of either carbohydrate or fat (Marieb, 2004, p. 967). Also an important consideration about fat

metabolism is that the hydrogens from the Krebs cycle are oxidized via respiration. Due to this fact, fatty acid metabolism is directly related to oxygen consumption (McArdle, Katch F., V., 2007, p. 159).

### **Energy Expenditure - RER**

Lipid, carbohydrate, and protein are all energy sources that require oxygen for energy production; however, each of these substrates requires varying amounts of oxygen (McArdle, Katch F., V., 2007, p. 189). Because aerobic metabolism is directly related to oxygen consumption, the amount of oxygen consumed is related to the substrate being used. The respiratory exchange ratio (RER) is the ratio of the amount of carbon dioxide produced and the amount of oxygen consumed and is used to predict the nutrient source of energy. If only carbohydrate is metabolized the respiratory exchange ratio will be equal to 1.00. If lipid is the only energy source, the RER will be 0.696. Generally, a mixture of nutrients is metabolized for energy, but the RER does show what nutrient is primarily being used. A typical value for RER at rest is .75, which means that fat is mostly being used. During moderate intensity exercise, a typical value for RER is .85, indicating increased carbohydrate utilization (McArdle, Katch F., and Katch V., 2007, p. 191).

RER is most often measured using indirect calorimetry. Indirect calorimetry can be used in both adults and children (Aucouturier, Baker, and Duche', 2008). Children typically have lower RER's than adults at similar workloads. Most likely children utilize fat more for energy during exercise because their fat stores are greater or because of lower availability of carbohydrate (Kostyak, Kris-Etherton, Bagshaw, Delany, and Farrell, 2007). An increased availability of lipid promotes lipid oxidation and limits carbohydrate oxidation. Likewise, an

increased availability of carbohydrate promotes carbohydrate oxidation and limits lipid oxidation (Morse, Schlutz, and Cassels, 1949).

A study conducted by Foricher, Ville, Gratas-Delamarche, and Delamarche (2003) compared substrate utilization in prepubertal boys and adults during rest and submaximal exercise using indirect calorimetry. This study found that resting energy expenditure was significantly higher in boys compared to adults, but energy expenditure during exercise was significantly lower in boys than adults. The boys in this study appeared to be more lipid dependent during exercise than the adult males (Foricher et al., 2003). Martinez and Haymes (1992) compared substrate utilization in prepubescent girls and women during 30 minutes of running at the same relative and absolute intensities. In this study, RER was also significantly lower for the girls compared to the adult women during exercise. Also, RER decreased significantly during the exercise for girls but did not in women. These findings suggest a higher reliance on fat for energy in children. Further children's skeletal muscle may have an increased capability for aerobic metabolism and fat oxidation compared with adults (Martinez and Haymes, 1992).

### **RER Changes with Obesity**

Obesity is a multifaceted problem, and not just an issue of excessive overeating and little activity. Obesity may be linked with a decreased ability to oxidize fat in skeletal muscle (Buscemi et al., 2005). This is supported by evidence of decreased mitochondrial size and function in the skeletal muscle of obese subjects (Kelley, He, Menshikova, and Ritov, 2002). In a study conducted by Kim, Hickner, Cortright, Dohm, and Houmard (2000), fat oxidation in the vastus lateralis muscle was compared between obese and lean subjects. The results showed that palmitate oxidation, palmitoyl carnitine oxidation, and octanoate oxidation were all

reduced in the obese muscle compared with the lean. The study also found that this decrease in lipid metabolism accompanied with obesity did not change significantly with different degrees of morbid obesity (Kim et al., 2000). Dagenais, Tancredi, Zierler (1976) reported that 82% of resting oxygen uptake in muscle is used for the oxidation of lipid in the skeletal muscle. Therefore the majority of energy needs of resting skeletal muscle come from fatty acid oxidation (Dagenais et al., 1976). These results imply that obesity may be linked with a reduced ability to metabolize fat.

In a study conducted by Guesbeck et al. (2000), substrate utilization during fasting and submaximal exercise was compared in individuals 24 months post gastric bypass surgery (weight loss group) to controls of the same weight. During resting conditions substrate utilization was not significantly different between groups. However, during submaximal exercise the weight loss group utilized 44% less energy from lipid metabolism compared to the control group. The weight loss group used more carbohydrate and significantly less fat during submaximal exercise at the same absolute and relative workloads as the control group (Guesbeck et al., 2000).

Hulver, Berggren, Cortright, Dudek, Thompson, Pories, MacDonald, Cline, Shulman, Dohm, and Houmard (2002) demonstrated in their study that there is a defect in skeletal muscle fatty acid oxidation with extreme obesity, and that this defect in fat oxidation is still present even with a large amount of weight loss (Hulver et al., 2002). Daily fat oxidation does not relate to daily fat intake (Astrup, Raben, Buemann, and Toubro, 1997). Obesity is almost inevitable in individuals with low fat oxidation, diets high in fat, and limited physical activity (Astrup et al., 1997).

If ingested fats are not burned, then they are likely stored. Skeletal muscle has many times been overlooked as a source of metabolic differences between individuals because of its

low energy metabolism during rest, in spite of muscle making up 40% of total body mass in non obese individuals and accounting for 20 to 30% of total resting oxygen uptake (Zurlo, Larson, Bogardus, and Ravussin, 1990). Zurlo et al. (1990) examined the relationship between forearm oxygen uptake and energy expenditure measured by basal metabolic rate and sleeping metabolic rate. They found that oxygen uptake from the forearm positively correlated with the basal metabolic rate ( $r = 0.72$ ,  $P \leq 0.005$ ) and the sleeping metabolic rate ( $r = 0.53$ ,  $P = 0.05$ ). Also variations in resting muscle metabolism are positively associated with differences in resting energy expenditure (Zurlo et al., 1990). Those with lower resting metabolic rates may be at higher risk for weight gain and obesity. One of the factors that may cause obesity is a lower metabolic rate, which puts individuals at a higher risk for positive energy balance and, as a result, weight gain (Zurlo et al., 1990).

What are possible factors causing this decrease in the skeletal muscles' ability to oxidize fat? Skeletal muscle is made up of three different types of fibers: type I (slow twitch oxidative fibers), type IIa (fast oxidative – glycolytic fibers), and type IIb (fast glycolytic fibers) (McArdle, Katch F., V., 2007, p. 383). A low ratio of type I fibers to type II fibers may be a cause of low fat metabolism which could lead to obesity (Astrup et al., 1997). Those who are morbidly obese have been shown to have a higher percentage of type IIb fibers and a lower percentage of type I fibers compared to lean individuals (Hickey, Carey, Azevedo, Houmard, Pories, Israel, and Dohm, 1995). Weight loss does not change fiber type make up of skeletal muscle (Berggren, Hulver, Dohm, and Houmard, 2004).

Another factor could be that enzyme activity in skeletal muscle may be altered in obese individuals. A study done Kim et al (2000) showed a decrease in the activities of enzymes involved in fat oxidation in the vastus lateralis muscle of obese subjects. Zurlo, Nemeth, Choksi,

Sesodia, and Ravussin (1994) compared energy expenditure by measures of basal metabolic rate and sleeping metabolic rate with skeletal muscle fiber composition and enzyme activity. The study found that enzymatic activity was related to fiber type proportions; muscle with more oxidative fibers had more oxidative enzyme activity, and muscle with more glycolytic fibers had more glycolytic enzyme activity (Zurlo et al., 1994). Therefore, obese individuals with decreased oxidative enzyme activity may have fewer oxidative muscle fibers (type I) compared with glycolytic fibers (type IIa and IIb).

### **Obesity and Genetics**

Possibly the most disturbing risk for developing obesity is genetics (Giacco et al., 2003). Buscemi et al. (2005) proposed that some individuals are capable of increasing their energy expenditure with increasing energy intake and that this response is a hereditary trait that may be linked to various mechanisms (Buscemi, 2005). Giacco et al. (2003) found in their study that lean offspring of overweight parents had 56% lower fat oxidation and increased insulin sensitivity to a high fat meal compared to offspring of normal weight parents. Therefore, their results suggest that a family history of overweight and obesity puts an individual at high risk of being overweight or obese (Giacco et al., 2003). The association between weight gain and dietary fat content is weak, but this association is much stronger in individuals who are either overweight, obese, or have a family history of overweight and obesity (Astrup et al., 1997). Whitaker et al. (1997) reported that if a child under the age of 10 years old (obese or nonobese) has one obese parent their risk of being an obese adult is nearly doubled (Whitaker et al., 1997). If obesity is already becoming an epidemic, what can we expect in the future?

### Summary

Although the research done thus far on the etiology of childhood obesity is limited, the outcomes are now being realized. Obese children are having health complications once only seen in adults. Children are suffering from type II diabetes, fatty liver, orthopedic problems, sleep apnea, and other health issues associated with adult obesity (Ludwig, 2007). Obesity does not melt away when these children become adults. Obese children typically become obese adults. Furthermore, obesity as a child is predictive of coronary heart disease, hypertension, and type II diabetes as an adult (Nicklas, Baranowski, Cullen, and Berenson, 2001). A relationship exists between the weight of children and with the weight of their parents (Carrie`re, 2003). Obesity is becoming a vicious family cycle.

From the literature we would assume morbidly obese individuals have a decreased ability to utilize fat for energy in the skeletal muscle. Substrate utilization is reflected by measuring RER using indirect calorimetry. The decreased ability to utilize lipid for energy in skeletal muscle has been postulated to be an inherited trait passing on from one generation to the next. If this is true, there is a high probability that children with an obese parent would also have a decreased capacity to use lipid for energy in the skeletal muscle which could be quantified using RER from indirect calorimetry. Therefore, we hypothesize that children of morbidly obese parents when compared to a control group comprised of children with parents of relatively normal weight will have a decreased ability to utilize fat for energy which will be reflected in their RER gathered from indirect calorimetry. The null hypothesis is that there is no difference in RER between the group of children with a parent who was morbidly obese prior to gastric bypass and the control group.

## CHAPTER 3: METHODS

### **Subject Recruitment**

To begin our research of potential differences in fat oxidation between children with a morbidly obese parent and children with normal weight parents, we aimed our recruitment on two groups. One group consisted of children with at least one morbidly obese parent or a parent who had undergone gastric bypass or lap banding surgery due to morbid obesity. The morbidly obese parent had to have a BMI of at least 40 kg/m<sup>2</sup>, or if post surgery, had a peak BMI greater than or equal to 40 kg/m<sup>2</sup> prior to surgery. In order to recruit participants for this group, we contacted patients who had undergone or were contemplating bariatric surgery, explained the study, and asked if they had any children between the ages of 8 and 12 years who would like to participate. Ten children were recruited for the children of obese parents group (COP).

Once a child was recruited to participate in the COP group, we then began recruitment for a match in the children of lean parents group (CLP). We matched the child in the COP group to a child in the CLP group in terms of age, race, and gender. In order for a child to be placed in the CLP group, the child had to have both biological parents with a BMI that placed them in the normal or overweight category (BMI between 18.5 and 28.0 kg/m<sup>2</sup>). Children in CLP group were excluded if a parent had a BMI greater than 28.0 kg/m<sup>2</sup> as this put them closer to the obese category than to a normal weight category. Ten children were also recruited for the CLP group by fliers and by contacting children who had participated in previous studies with the Human Performance Lab.

Subjects were excluded from this study if they regularly participated in an organized sport or other physical activity during the time span of the study. Subjects were also excluded if

they were on any type of medication or had a medical condition that may limit their ability to exercise or pose a risk for exercise.

### **Initial Visit**

Once interest was shown in participating and the child met the screening criteria, the participating child along with a parent came into the FITT lab for an initial visit. First an informed consent was explained to and given to the parent to be read and signed, and an assent was read to and explained to the child. If the child wanted to participate after learning about the study, the child would then sign the assent form. The parent then answered a questionnaire to assess Tanner stage for their child, which has been determined as a valid method to assess sexual development (Davison, Werder, Trost, Baker, and Birch, 2007). The parent was also asked to answer a questionnaire (based on the Behavioral Risk Factor Surveillance Systems survey) to determine physical activity patterns of the child and the parent's own physical activity patterns (Yore, Ham, Ainsworth, Kruger, Reis, Kohl, and Macera, 2007). Parental height and weight was measured in the lab or self reported if one parent was not able to come in to the lab. Anthropometric measures were taken on the child including height, weight, minimum waist circumference, and skinfold measurements at the tricep and medial calf (Lohman and Going, 1998). Seated height was measured as well as standing height to determine peak height velocity, which has been shown to be a valid measure of biological maturity (Mirwald, Baxter-Jones, Bailey, and Beunen, 2002, and Drenowatz, Eisenmann, Pfeiffer, Wickel, Gentile, and Walsh, 2009). A DEXA scan was done as another measure of body composition and determination of lean and fat mass. Also during the initial visit, the child was introduced to the cycle ergometer as well as the head gear, mouth piece, and nose clips they would wear during

their maximal and submaximal exercise tests. Once practice on the cycle ergometer with the VO<sub>2</sub> gear was complete, the child was given the option of wearing an Actigraph GT1M accelerometer for one week. Wearing the accelerometer was optional, but all participants did choose to wear the accelerometer. Accelerometers were used in this study to provide further valid information on the amount of activity each child was participating in each day (Rowlands, 2007). Instructions were given to the child about wearing the accelerometer, as well as a log sheet for the child to record when he or she put on and took off the accelerometer. A second visit was then scheduled for the child's first maximal exercise test.

#### **Maximal Exercise Tests**

The child reported to the lab for a maximal exercise test. The maximal exercise test was done on a Lode Corival cycle ergometer and maximal oxygen consumption assessed using a metabolic cart (ParvoMedics True Max 2400 Metabolic cart). The participant also wore a Polar heart rate monitor during the test. Once positioned on the cycle ergometer with the VO<sub>2</sub> gear, the child was given a 1 to 2 minute warmup at 10 W. The maximal exercise protocol was based on a study by Arngrimsson, Sveinsson, and Johannsson (2008), which included 9 and 15 year old male and female adolescents. The children in our study had an initial and incremental workload of 20 W if their weight was less than or equal to 30 kg or 25 W if their weight was above 30 kg. Workload was increased every third minute until voluntary exhaustion or a pedal rate of 60 rpm could not be maintained. Heart rate, RER, VO<sub>2</sub>, and rating of perceived exertion (RPE) were monitored throughout the test. A true max test was determined by reaching a heart rate greater than or equal to 195 bpm, reaching a RER of at least 1.0, or a plateau of VO<sub>2</sub> despite increasing workload (Arngrimson et al., 2008).

A second maximal exercise test was performed at least 4 days after the initial test. Protocol for the max test was adjusted if necessary for the second maximal exercise test. Two participants were 14 years of age, and after an initial max test time over 20 minutes, were given a different protocol for their second max test. We used the protocol for the 15 year olds in the Arngrimsson et al. study (2008), which used an incremental workload of 50 W for 15 year old boys. Stage time was also adjusted from 3 minutes to 2 minutes with a few children who had difficulty reaching a maximal effort on their first test. If a maximal effort was not reached in either the first or second test, a third maximal exercise test was done.

Instructions were then given for the day of the submaximal exercise session with the importance of coming to the laboratory after an overnight fast stressed to both the child and the parent.

### **Submaximal Exercise Test**

The child reported to the lab in the morning after an overnight fast. The submaximal exercise protocol was based upon a previous study (Guessbeck et al., 2000) examining substrate utilization with obesity. Each child completed 10 minutes of exercise on the cycle ergometer at an absolute workload of 15 W. The child was then given a 10 to 15 minute rest break. After the rest period, the child then completed 10 minutes of submaximal exercise at a relative workload of 65% of VO<sub>2</sub> peak. The order of the tests (15 W and 65% of VO<sub>2</sub> peak) were counterbalanced throughout the study to ensure the order of absolute and relative workload did not influence results. The average of the final three minutes of submaximal exercise was used in data analysis as in the study of Guessbeck et al., 2000. The main variables compared between the COP and CLP groups were VO<sub>2</sub> in L/min, VO<sub>2</sub> in ml·kg·min<sup>-1</sup>, ventilation (VE), heart rate, RER, and substrate utilization (% energy from fat and carbohydrate).

### **Statistical Analysis**

Maximal exercise data from test two, submaximal exercise responses at an absolute and relative workload, as well as the accelerometer data from the COP and CLP groups were compared using two way ANOVAs. Significant differences were accepted at  $P < 0.05$ . Values are means  $\pm$  the standard error (SE). Correlations were also run on RER for the absolute and relative workload versus weight measures (including weight, BMI, and percent body fat from DEXA) to ensure differences observed between groups were not attributed to weight.

## CHAPTER 4: RESULTS

### Results

Participants in this study consisted of two groups - Children of Lean Parents (CLP) and Children of Obese Parents (COP). 20 children participated with 10 in each group. Children were matched on age, race, and gender. Each participant was placed in either CLP or COP based only on the Body Mass Index (BMI) of the parents which was calculated from self reported height and weight. At least one parent had to have a BMI  $\geq 40\text{kg/m}^2$  for a child to be placed in the COP group. Recruitment of children with a parent with a BMI  $\geq 40\text{kg/m}^2$  was done by contacting patients who had undergone gastric bypass or lap band surgeries and asking if they had any biological children between the ages of 8 and 12 who may be interested in participating in the study. Eight out of the 10 children in the COP had a parent who had either undergone gastric bypass or lap band surgery. For a child to be placed in the CLP group, both biological parents had to have a BMI  $\leq 28\text{ kg/m}^2$ . Statistical significance was set at a p value  $\leq 0.05$ .

### Parental Characteristics

As presented in Table 1, there was no significant difference between the obese and lean parents, both mothers and fathers, in age or height. As expected, there was a significant difference in terms of the mothers' body mass and BMI between the lean and obese mothers. Mothers of children in the COP group who had gastric bypass or lap band surgery prior to this study, reported their weight before surgery. A significant difference was also observed in body mass of the father between the lean and obese parent groups; however, there was no significant difference between groups in terms of father BMI. In this study, the parent who was morbidly obese was typically the mother.

### Characteristics of Participants

As presented in Table 2, there was little difference between the participants in the CLP group and the COP group. Participants for the CLP group were recruited to be matched in terms of age, race, and gender to the children in the COP group. The participants were comprised of fourteen Caucasian males, two African American males, and four African American females. There was no significant difference in height ( $P = 0.23$ ), weight ( $P = 0.08$ ), BMI ( $P = 0.10$ ), or BMI percentile ( $P = 0.07$ ) between groups. However, there was a significant difference between groups for the BMI Z score ( $P = 0.05$ ). There was no significant difference between groups for percent body fat from DEXA ( $P = 0.15$ ) or calculated from skinfolds ( $P = 0.38$ ). There was also no significant difference between groups in waist circumference ( $P = 0.11$ ). In terms of physical maturity, there was no difference between groups when assessed by either Tanner Staging ( $P = 0.75$ ) or Peak Height Velocity (PHV) ( $P = 0.73$ ). When data from one of the larger individuals in the COP was omitted, values for both body mass ( $40.1 \pm 3.0$  kg vs.  $51.4 \pm 7.4$  kg for CLP and COP groups, respectively,  $P = 0.16$ ) and BMI ( $18.3 \pm 0.7$  kg/m<sup>2</sup> vs.  $21.1 \pm 2.0$  kg/m<sup>2</sup> for CLP and COP group, respectively,  $P = 0.19$ ) became closer. When the subject was excluded, there was also no significant difference for the BMI Z score ( $P = 0.10$ ). Results for the submaximal exercise workloads (see below) remained similar, supporting differences between the groups independent of body mass.

### Maximal Exercise Characteristics

Each participant completed two maximal exercise tests. Performances in both tests were compared for all subjects ( $n = 20$ ). Test 1 had a mean  $\text{VO}_2$  peak of  $36.0 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ , and test 2 had a mean  $\text{VO}_2$  peak of  $38.5 \text{ ml}\cdot\text{kg}\cdot\text{min}^{-1}$ . There was a significance difference between Test 1 and Test 2 ( $p = 0.03$ ) which was also seen when comparing Tests 1 and 2 in  $\text{VO}_2$  peak in

l/min and in maximal workload (watts). The mean VO<sub>2</sub> peak in l/min for tests 1 and 2 were 1.6 l/min and 1.7 l/min respectively ( $p = 0.03$ ). The mean maximal workload for tests 1 and 2 were 114.0 W and 124.5 W respectively ( $p = 0.03$ ). Performance was best in test 2; therefore, further analyses were done using only the results from the second maximal exercise test.

As presented in Table 3, there was no significant difference between the CLP and COP groups in maximal exercise test performance. There was no significant difference between groups for VO<sub>2</sub> in ml·kg·min<sup>-1</sup> ( $P = 0.13$ ). There was also no significant difference for VO<sub>2</sub> in l/min ( $P = 0.50$ ). VO<sub>2</sub> was also compared relative to fat free mass, and again there was no significant difference between groups ( $P = 0.24$ ). Lastly, there was also no significant difference for maximal workload (watts) between groups ( $P = 0.78$ ).

#### **Submaximal Exercise Responses at a Standard Workload of 15 W**

As presented in Table 4, oxygen consumption at an absolute workload of 15 W was not significantly different between groups when measured in ml·kg·min<sup>-1</sup> or l/min. The VO<sub>2</sub> during the absolute workload of 15 W expressed as a percentage of peak VO<sub>2</sub> was also not significantly different between the CLP and COP groups. Both groups were between 35% and 36% of their peak VO<sub>2</sub>'s during the submaximal exercise at the absolute workload. There was also no significant difference in ventilation (VE) or heart rate (HR) between groups.

However, as reported in Table 4, there was a significant difference between the CLP and COP groups in the respiratory exchange ratio (RER) during the absolute workload. The COP group had significantly higher RER's than the CLP group, meaning that more energy was coming from carbohydrate substrate. The COP group used significantly more carbohydrate when expressed as percent energy from carbohydrate than the CLP group (Table 4). There was also a significant difference between groups in percent of energy coming from fat. The COP group

used a significantly lower percentage of fat for energy (Table 4 and Figure 2). These differences remained when data from a subject with a large BMI and body mass was deleted from the COP group, as mentioned in the characteristics of participants section. When data from this subjects was omitted RER ( $0.813 \pm 0.02$  vs.  $0.857 \pm 0.01$  for CLP and COP, respectively,  $P=0.04$ ) and percent energy from fat ( $63.4 \pm 5.4$  vs.  $46.8 \pm 3.4\%$  for CLP and COP, respectively,  $P=0.02$ ) still differed in a manner indicating that the COP group utilized less fat during exercise. A regression analysis was performed in regards to RER for weight, BMI, and percent body fat from DEXA to ensure that the significant difference in RER was not due to the weight or fat percent of the child (See figures 3, 4, and 5). There were no significant correlations between or within groups.

#### **Submaximal Exercise Responses at a Relative Workload of 65% VO<sub>2</sub> Peak**

As presented in Table 5, there were no significant differences between groups for any of the variables measured at the workload approximating 65% of VO<sub>2</sub>peak. While the COP group did have a very slightly increased RER at the relative workload when compared with the CLP group, the difference was not statistically significant.

#### **Activity Measures**

Accelerometers were worn voluntarily by participants for one week. All participants elected to wear the accelerometer. However, not all participants wore the accelerometer every day of the week. Accelerometer data was not included if less than 3 days of data were gathered. Sample size for the CLP group was 8, and the sample size for the COP group was 6. Minutes per day of sedentary ( $P = 0.98$ ), light ( $P= 0.89$ ), moderate ( $P= 0.90$ ), vigorous ( $P= 0.15$ ), total active time ( $P= 0.84$ ), as well as counts per minute ( $P= 0.42$ ) were measured and reported in Table 6. There were no significant differences between groups.

| Table 1: Parental Characteristics |                        |              |                 |
|-----------------------------------|------------------------|--------------|-----------------|
| Mother                            | Variable               | Lean Parents | Obese Parent(s) |
|                                   | Age, yr                | 38.0 ± 1.6   | 36.3 ± 1.4      |
|                                   | Mass, kg               | 67.8 ± 3.3   | 123.1 ± 5.3 *   |
|                                   | Height, cm             | 165.6 ± 1.8  | 168.4 ± 2.6     |
|                                   | BMI, kg/m <sup>2</sup> | 24.6 ± 1.0   | 44.8 ± 1.3 *    |
| Father                            |                        |              |                 |
|                                   | Age, yr                | 38.3 ± 1.8   | 39.8 ± 2.1      |
|                                   | Mass, kg               | 86.8 ± 4.1   | 102.5 ± 6.3 *   |
|                                   | Height, cm             | 180.7 ± 2.5  | 182.6 ± 2.8     |
|                                   | BMI, kg/m <sup>2</sup> | 26.5 ± 1.1   | 30.7 ± 1.9      |

Values are means ± SE.

\* Significant difference between groups ( $P \leq 0.05$ ).

| Table 2: Descriptive Characteristics of Participants |               |                 |
|------------------------------------------------------|---------------|-----------------|
| Variable                                             | CLP           | COP             |
| Age, yr                                              | 10.9 ± 0.6    | 10.4 ± 0.5      |
| Mass, kg                                             | 40.1 ± 3.0    | 56.0 ± 8.1      |
| Height, cm                                           | 146.8 ± 3.3   | 154.8 ± 5.6     |
| BMI, kg/m <sup>2</sup>                               | 18.3 ± 0.7    | 22.4 ± 2.2      |
| BMI Z score                                          | 0.108 ± 0.220 | 0.942 ± 0.330 * |
| BMI percentile                                       | 53.0 ± 7.6    | 74.1 ± 7.7      |
| % BF Skinfolts                                       | 23.2 ± 1.6    | 26.3 ± 3.0      |
| % BF DEXA                                            | 20.4 ± 2.7    | 27.7 ± 4.1      |
| Minimum Waist, cm                                    | 62.4 ± 1.9    | 71.9 ± 5.4      |
| Tanner Stage                                         | 1.4 ± 0.2     | 1.5 ± 0.2       |
| PHV, yr                                              | 3.2 ± 0.4     | 3.4 ± 0.4       |

Values are means ± SE. Subjects were initially matched on age, race, and gender; n = 10 subjects/ group.

\* Significant difference between groups ( $P \leq 0.05$ ).

**Table 3: Maximal Exercise Characteristics of Participants - Children of Lean Parents or Obese Parent(s)**

| Variable                              | CLP           | COP           |
|---------------------------------------|---------------|---------------|
| Peak VO <sub>2</sub> , ml/kg/min      | 42.1 ± 3.1    | 34.9 ± 3.4    |
| Peak VO <sub>2</sub> , l/min          | 1.6 ± 0.1     | 1.9 ± 0.3     |
| Peak Watts                            | 121.0 ± 11.9  | 128.0 ± 21.2  |
| Peak VO <sub>2</sub> /kg of lean mass | 0.053 ± 0.003 | 0.047 ± 0.003 |

Values are means ± SE.  
There were no statistically significant ( $P \leq 0.05$ ) differences between groups.

**Table 4: Responses at a Standard Submaximal Workload - 15 W**

| Variable                           | Children of Lean Parents (CLP) | Children of Obese Parent(s) (COP) |
|------------------------------------|--------------------------------|-----------------------------------|
| VO <sub>2</sub> (ml/kg/min)        | 14.4 ± 0.9                     | 12.2 ± 1.3                        |
| VO <sub>2</sub> (l/min)            | 0.56 ± 0.02                    | 0.63 ± 0.07                       |
| % Peak VO <sub>2</sub> (ml/kg/min) | 35.4 ± 2.5                     | 36.4 ± 3.1                        |
| % Peak VO <sub>2</sub> (l/min)     | 35.6 ± 2.4                     | 36.4 ± 3.2                        |
| VE                                 | 11.7 ± 0.5                     | 13.2 ± 1.1                        |
| HR                                 | 109.4 ± 4.3                    | 106.5 ± 4.1                       |
| RER                                | 0.81 ± 0.02                    | 0.85 ± 0.01 *                     |
| % CHO                              | 37.5 ± 5.3                     | 51.6 ± 3.3 *                      |
| % Fat                              | 63.4 ± 5.4                     | 47.9 ± 3.3 *                      |

Values are means ± SE.  
\* Significant difference between groups ( $P \leq 0.05$ ).

| Table 5: Responses at a Relative Submaximal Workload - 65% VO <sub>2</sub> Peak |                                |                                   |
|---------------------------------------------------------------------------------|--------------------------------|-----------------------------------|
| Variable                                                                        | Children of Lean Parents (CLP) | Children of Obese Parent(s) (COP) |
| Watts                                                                           | 59.5 ± 6.3                     | 57.5 ± 10.3                       |
| VO <sub>2</sub> (ml/kg/min)                                                     | 26.7 ± 2.1                     | 21.4 ± 2.2                        |
| VO <sub>2</sub> (l/min)                                                         | 1.05 ± 0.10                    | 1.14 ± 0.17                       |
| % Peak VO <sub>2</sub> (ml/kg/min)                                              | 62.0 ± 2.1                     | 59.9 ± 2.6                        |
| % Peak VO <sub>2</sub> (l/min)                                                  | 62.2 ± 2.1                     | 60.8 ± 2.4                        |
| VE                                                                              | 22.7 ± 1.9                     | 24.2 ± 3.0                        |
| HR                                                                              | 151.1 ± 4.1                    | 144.0 ± 4.6                       |
| RER                                                                             | 0.90 ± 0.01                    | 0.91 ± 0.01                       |
| % CHO                                                                           | 66.9 ± 2.9                     | 69.2 ± 3.0                        |
| % Fat                                                                           | 33.3 ± 3.1                     | 30.5 ± 3.0                        |

Values are means ± SE.

There were no statistically significant ( $P \leq 0.05$ ) differences between groups.

| Table 6: Minutes of Activity per Day |                |               |
|--------------------------------------|----------------|---------------|
| Mins./Day                            | CLP            | COP           |
| Sedentary                            | 1023 ± 29.30   | 1022 ± 45.11  |
| Light                                | 325.3 ± 18.79  | 331.1 ± 39.23 |
| Moderate                             | 39.59 ± 8.156  | 41.02 ± 7.683 |
| Vigorous                             | 2.304 ± 0.7779 | 4.725 ± 1.513 |
| Total Active                         | 367.2 ± 24.06  | 376.9 ± 44.69 |
| Counts Per Minute (cpm)              | 794.6 ± 35.44  | 852.5 ± 65.25 |

N = 8 for the CLP group. N = 6 for the COP group.

Values are means ± SE.

There were no statistically significant ( $P \leq 0.05$ ) differences between groups.

### Respiratory Exchange Ratio at 15 W and 65% VO<sub>2</sub> Peak

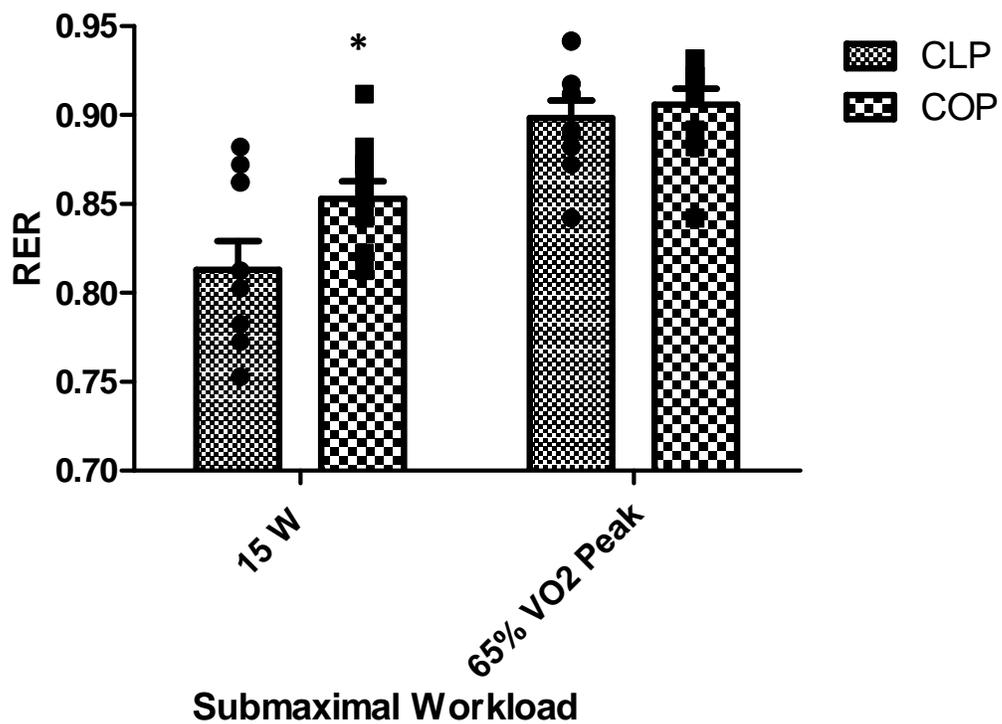


Figure 1: Respiratory Exchange Ratio (RER) for CLP and COP at an absolute workload of 15 W and a relative workload of 65% VO<sub>2</sub> peak. COP had a significantly higher RER at 15 W than the CLP group. There was no significant difference between groups in RER at 65% VO<sub>2</sub> peak.

## Energy from Fat at 15 W and 65% VO<sub>2</sub> Peak

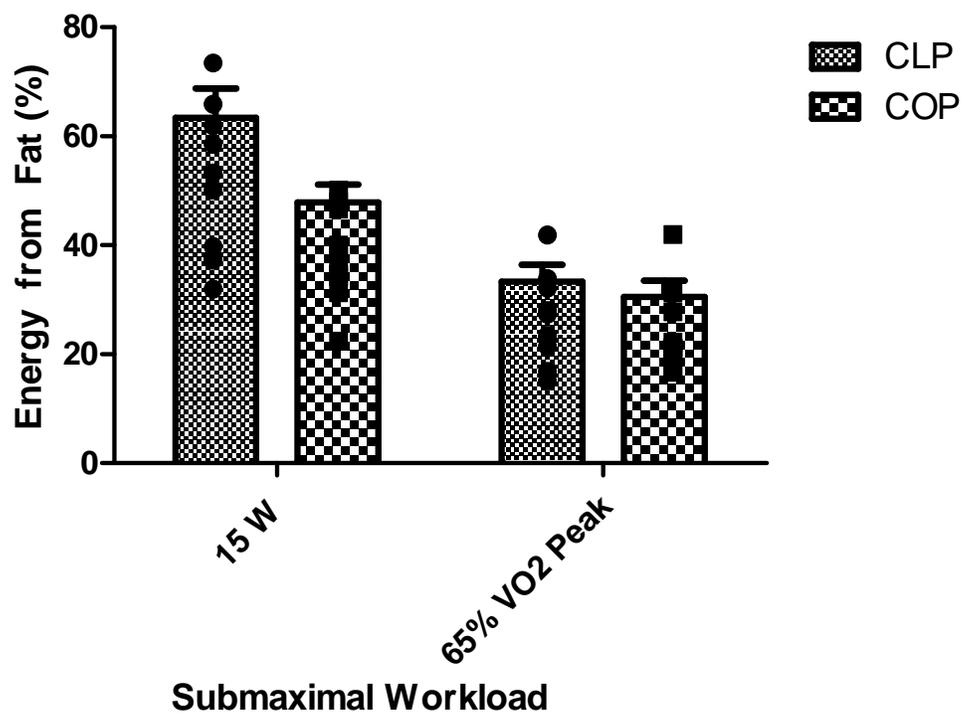


Figure 2: Energy from fat (%) for CLP and COP at an absolute workload of 15 W and a relative workload of 65% VO<sub>2</sub> peak. COP had a significantly lower percent energy from fat at 15 W than the CLP group. There was no significant difference between groups in percent energy from fat at 65% VO<sub>2</sub> peak.

### Weight and Respiratory Exchange Ratio for CLP and COP

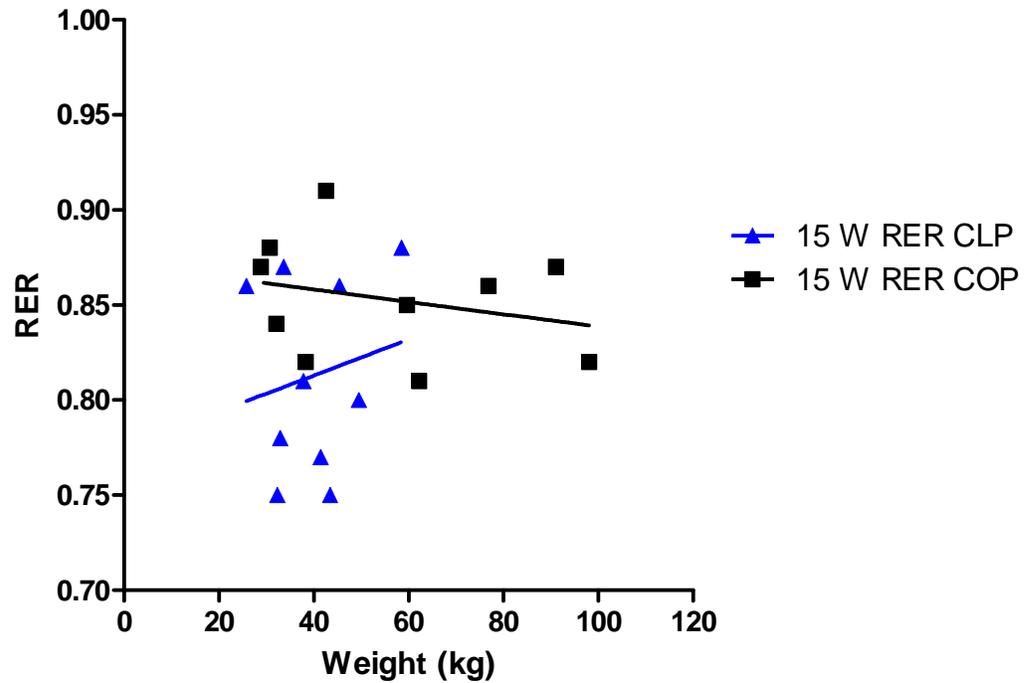


Figure 3: No significant correlations between groups or within groups.  $R = 0.11$  and  $P = 0.63$  for all subjects combined. The CLP group had a  $R$  value of 0.18, and a  $P$  value of 0.62. The COP group had a  $R$  value of 0.27, and a  $P$  value of 0.45.

### BMI and Respiratory Exchange Ratio for CLP and COP

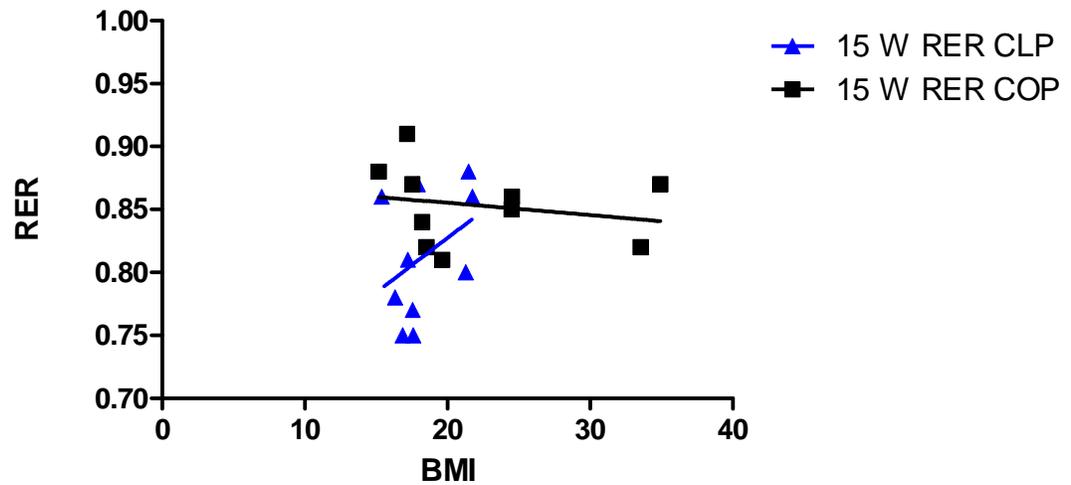


Figure 4: No significant correlations in all subjects combined or within groups.  $R = 0.17$  and  $P = 0.48$  between groups. The CLP group had a  $R$  value of 0.39, and a  $P$  value of 0.26. The COP group had a  $R$  value of 0.22, and a  $P$  value of 0.55.

### Percent Body Fat and RER for CLP and COP

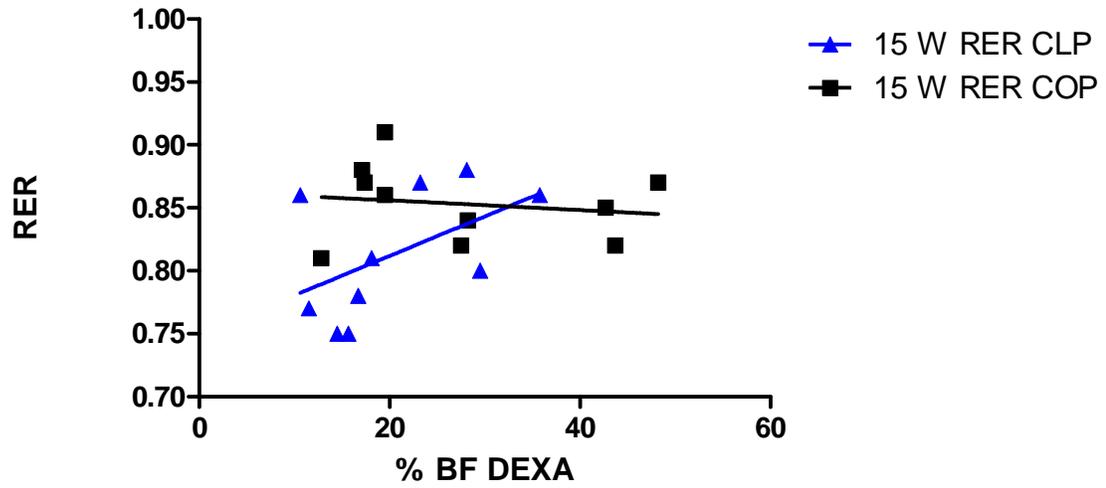


Figure 5: No significant correlations with all subjects combined or within groups.  $R = 0.30$  and  $P = 0.21$  for all subjects. The CLP group had a  $R$  value of 0.52, and a  $P$  value of 0.12. The COP group had a  $R$  value of 0.16, and a  $P$  value of 0.66.

## CHAPTER 5: DISCUSSION

### **Overview**

The purpose of this study was to examine the possibility of reduced lipid oxidation, which may lead to obesity, possibly being a hereditary condition. Previous research has shown that after weight loss from gastric bypass surgery, there was still a reduction in the ability to metabolize fat for energy during submaximal exercise (Guesbeck et al., 2000). Is this observation due to an inherent inability to oxidize fat which may lead to morbid obesity? To test this hypothesis, in the present study children of morbidly obese parents (COP) and children of lean parents (CLP) performed submaximal exercise on a cycle ergometer at an absolute workload of 15W and a relative workload of approximately 65% VO<sub>2</sub> peak. Oxygen consumption and the respiratory exchange ratio (RER) were measured during the exercise session via expired gases. The primary finding from the current study is that there is a significant difference in the children of obese parents (COP) when compared to the children of lean parents (CLP) in terms of fat metabolism at an absolute submaximal workload of 15 W. The children of obese parents (COP) had a significantly lower percentage of energy coming from fat and, therefore, a higher respiratory exchange ratio (RER) at the absolute workload.

### **Participant Characteristics**

The children who participated in this study were divided into two groups depending on the BMI of their parents. Children in the CLP (Children of Lean Parents) group had both biological parents with BMI's less than or equal to 25 kg/m<sup>2</sup>. Children in the COP (Children of Obese Parents) group had at least one parent with a BMI greater than or equal to 40 kg/m<sup>2</sup>. For recruitment of participants in the COP group, adults who had undergone or were scheduled for

gastric bypass or lap band surgeries were contacted by phone, were told about the study, and asked if they had any children who might be interested in participation. Out of the participants in the COP group, 8 children had one parent who had undergone gastric bypass or lap band surgery. The other 2 children in the COP group did have a parent with a BMI greater than or equal to 40 kg/m<sup>2</sup> but were not electing to have any type of weight related surgery. Out of the 10 parents in this study with BMIs greater than or equal to 40 kg/m<sup>2</sup>, 9 were female and only one male. The significant differences seen between groups for mother BMI and weight are easily explained by the recruitment characteristics for each group (Table 1). There was also a significant difference observed between groups for father weight, but not father BMI. This may have been because only one father had a BMI greater than or equal to 40 kg/m<sup>2</sup>.

When recruiting participants groups were matched for age, race, and gender. The characteristics of the groups, as presented in Table 2, indicated no significant differences. When examining the data, there was one subject in the COP group that was considerably heavier than the others (~90 kg); when this subject was excluded from data analyses the characteristics of the groups were more similar (see results), and the reduced capacity for fat oxidation at 15 W remained statistically significant, suggesting a factor other than the body mass of the subjects.

A secondary recruitment goal was to examine children who were not regularly participating in an organized sporting or other physical activity, as exercise training can significantly alter substrate utilization during submaximal exercise (Berggren et al., 2008). When physical activity was measured via accelerometers, there was no significant difference between groups in terms of minutes of sedentary, light, moderate, vigorous, or total active minutes as presented in Table 6. Four subjects in the COP group and two subjects in the CLP group were excluded because too few days of activity data were collected. However, we believe that the

data obtained was representative of the group as there were also no differences in VO<sub>2</sub> peak , maximal workload, or time to exhaustion during the maximal exercise test as presented in Table 3. Numerous cut points for defining sedentary behavior have been suggested. The Avon Longitudinal Study of Parents and Children (ALSPAC) examined physical activity habits in a cohort of 5,434 children using the Actigraph accelerometer (Mitchell, Mattocks, Ness, Leary, Pate, Dowda, Blair, and Riddoch, 2009). The Actigraph accelerometer was also used in the present study. Accelerometer data were reduced using age specific cut-points to categorize each interval as sedentary, light, and moderate to vigorous physical activity (Troost, Pate, Sallis, Freedson, Taylor, Dowda, and Sirard, 2002). Each participant had to have at least 3 days of data to be considered for analysis. A complete day was considered to be at least 10 hours of wear time. Periods of 60 or more consecutive minutes, during which zeroes were recorded, were considered non-wear time and not included as part of the total day (Troost, et al., 2002). Both the CLP and COP groups had average values around 800 cpm over a 24 hour period and were not significantly different from one another. Our findings thus suggest that the children examined were relatively sedentary, and performing little to any moderate to vigorous physical activity, thus minimizing any exercise training effect on our findings. Both the CLP and COP groups likely fall within the light activity range. Overall, the data gathered indicate that both groups were very similar in descriptive characteristics, activity levels, and fitness and were largely sedentary.

### **Submaximal Exercise Responses**

Although the CLP and COP groups were similar in many aspects, we did observe a difference in substrate utilization at the 15 W workload, with the CLP group utilizing more lipid than the COP group (Figure 1 and 2). The 15 W exercise load elicited approximately 35 to 36%

of VO<sub>2</sub> peak; therefore, RER would be expected to be relatively low due to more fat being used for energy at such a light absolute workload. Because both groups were the same in all other respects except for parent's BMI, these findings suggest that there may be a genetic predisposition for a decreased ability to metabolize fat which supports our hypothesis. A study on fat oxidation in formerly obese women found that although fat mobilization from adipose tissue was similar between control and formerly obese women, fat oxidation was significantly lower at rest and during recovery from exercise in the formerly obese despite higher amounts of circulating plasma nonesterified fatty acids (Ranneries, Bulow, Buemann, Christensen, Madsen, and Astrup, 1998). From the results of this study the authors suggested there was an impairment in uptake and utilization of fatty acids in the muscle, which makes these individuals more susceptible to weight gain due to a positive energy balance (Ranneries et al., 1998). This impairment in the use of fatty acids may be linked to the rise in the incidence of obesity. Thus, the current findings are particularly relevant, as they indicate the impairment in the ability to utilize lipid may be expressed at an early age and contribute to the development of obesity.

We expected to also see differences in substrate utilization at 65% VO<sub>2</sub> peak similar to the results from the study by Guesbeck et al. (2000). In the Guesbeck et al. (2000) study formerly morbidly obese females had significantly higher RERs at both an absolute workload of 15 W and a relative workload of 65% VO<sub>2</sub> peak when compared to weight matched controls. However, in the present study there were no significant differences between groups in any of the submaximal exercise responses at 65% VO<sub>2</sub> peak. This could be due to the nature of the exercise intensity as at 65% VO<sub>2</sub> peak both groups utilized more carbohydrate for energy due to the intensity being higher. Also, it is difficult to determine the workload which will elicit 65% VO<sub>2</sub> peak in all subjects, particularly in children where two tests were performed in order to

obtain a valid VO<sub>2</sub> peak. This small amount of variance may have obscured differences between groups.

Overall the most important and interesting finding from this study is that there was a decrease in fat metabolism in children whom had at least one morbidly obese parent, despite the fact that the children in the COP group were matched in all other respects to the CLP group except for parental BMI.

### **RER and Obesity**

While body mass may not be a strong predictor of substrate metabolism, who your parents are might be (Zurlo, Lillioja, Puente, Nyomba, Raz, Saad, Swinburn, Knowler, Bogardus, and Rauvussin, 1990). A study conducted by Zurlo et al. (1990) examined the 24 hour respiratory quotient (RQ) and possible determinants for the RQ in 111 adult Pima Indian subjects. 66 of the subjects were siblings from 28 different families. All subjects were fed a standard diet for at least two days prior to measuring RQ via a respiratory chamber. This study found that those with higher 24 hour RQ had a 2.5 greater risk of gaining greater than or equal to 5 kg of body weight. Possible determinants examined in this study were changes in body weight, 24 hour energy balance, sex, percent body fat, and family membership. These determinants, excluding family membership, were found to collectively account for 18% of the variance in RQ ( $P \leq 0.001$ ). However, in the siblings studied, family membership alone attributed to 28% of the variance in RQ ( $P \leq 0.05$ ). Out of the determinants of RQ studied, family membership was the strongest predictor of RQ. The authors concluded that family membership is the key determinant of the ratio of fat to carbohydrate oxidation (Zurlo, Lillioja et al, 1990). In another study, Larson et al. (1990) demonstrated that differences in resting muscle metabolism accounts for variance in metabolic rate and may play a role in obesity. Furthermore, another

study done within the Pima Indian population concluded that a low resting metabolic rate is a risk factor for weight gain (Tataranni, Harper, Snitker, Parigi, Bunt, Bogardus, and Ravussin, 2003). To our knowledge our present study is one of the first to show a similar effect of family on respiratory exchange ratio in children during submaximal exercise.

### **Obesity – A hereditary condition?**

Is body mass a hereditary characteristic much like height or eye color? The relationship between adoptee weight and the weight of their biological parents or adoptive parents was examined in a sample of 540 adult adoptees in a study by Stunkard et al. (Stunkard, Sorensen, Hanis, Teasdale, Chakraborty, Schull, and Schulsinger, 1986). This study found a highly significant positive correlation between adoptee weight and the weight of the biological parents with a P value 0.0001 for the mothers and a P value of 0.02 for the fathers. This relationship held true for those classified as obese as well. Furthermore, there was no significant correlation between adoptee weight and adoptive parent weight (Stunkard et al., 1986). Another study looked at similarities within families for body fat and fat distribution using measures of BMI, skinfolds, and waist circumference (Katzmarzyk, Malina, Perusse, Rice, Province, Rao, and Bouchard, 2000). From their results they found a heritability range of 45 to 60% for fatness and from 29 to 48% for fat distribution. These findings thus suggest that the causes of obesity are more complicated than simply overeating. Genetics may be a strong indicator for obesity; however, it is also important to note that environment does also play a role and may affect gene expression for obesity (Speakman, 2004).

### **Practical Applications**

If a genetic link to an impaired use of fat for energy, leading to obesity, does exist, this could have implications for the treatment of obesity and other underlying conditions. If a cause

of obesity is a decreased ability for the muscle uptake and use of fat for energy, medications could be developed to increase the body's use of fat for energy. Also if obesity truly is hereditary, the genes that code for obesity may be identified.

Even if a decreased ability to oxidize fat is a hereditary trait that may lead to obesity, this does not mean that there is no hope of children of morbidly obese parents maintaining a normal weight. In a study by Berggren, Boyle, Chapman, and Houmard (2008), muscle fatty acid oxidation was compared in lean, morbidly obese, and formerly obese women. Fatty acid oxidation was lower in the muscle of the morbidly obese and formerly obese subjects in comparison to the lean subjects. However, after acute exercise training, which consisted of cycling at 70% V<sub>O2</sub> peak for 1 hour for 10 days, fatty acid oxidation was increased in the morbidly obese and formerly obese subjects to a level similar to that of the lean subjects (Berggren et al., 2008). If children at high risk for obesity were to engage in regular moderate to vigorous activity, they may avoid being overweight or obese.

### **Summary**

In summary we found that children of obese parents compared to children of lean parents have a higher respiratory exchange ratio and decreased utilization of fat during a submaximal exercise bout of 15 W. The children in the COP group and CLP group were similar in all descriptive characteristics, activity levels, and fitness. The only attributable difference was parental body mass.

### **Future Studies**

This current study provides evidence that a predisposition to being obese may be, at least in part, a hereditary trait. To increase support for this argument future research must be done. In our current study children of the COP group qualified as long as one parent was

morbidly obese. However, it would be interesting to examine fat oxidation in children with two morbidly obese parents; perhaps, fat oxidation would be even lower in these children. It also would be beneficial to obtain blood samples from children with morbidly obese parents and lean parents to see if differences exist in the amount of circulating fatty acids in the blood. The effects of exercise on children predisposed to obesity could also be examined. Regular physical activity starting at a young age for children with morbidly obese parents may decrease their risk of being obese themselves. It is difficult to pinpoint a decrease in fatty acid utilization as a cause of obesity since the observation cannot be made prior to obesity. Studies in children who have an increased risk of obesity are imperative to learn more about the causes of obesity.

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## APPENDIX A: UMCIRB APPROVAL



**University and Medical Center Institutional Review Board**  
East Carolina University  
Ed Warren Life Sciences Building • 600 Moye Boulevard • LSB 104 • Greenville, NC 27834  
Office 252-744-2914 • Fax 252-744-2284 • [www.ecu.edu/irb](http://www.ecu.edu/irb)  
Chair and Director of Biomedical IRB: L. Wiley Nifong, MD  
Chair and Director of Behavioral and Social Science IRB: Susan L. McCammon, PhD

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TO: Joseph Houmard, PhD, Human Performance Lab, ECU  
FROM: UMCIRB   
DATE: November 17, 2008  
RE: Full Committee Approval of a Study  
TITLE: "Fat Metabolism in Children During Exercise"

### UMCIRB #08-0542

The above referenced research study was initially reviewed by the convened University and Medical Center Institutional Review Board (UMCIRB) on **10/8/08 & 11/12/08**. The research study underwent a review and approval of requested modifications on 11/14/08 by Dr. W. Nifong. The UMCIRB deemed this **HPL** sponsored study **more than minimal risk** requiring a continuing review in **12 months**. Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The investigator must adhere to all reporting requirements for this study.

The above referenced research study has been given approval for the period of **11/12/08 to 11/11/09**. The approval includes the following items:

- Internal Processing Form (modified, received 10/17/08)
- Protocol Summary (received 9/17/08)
- Informed consent (version 8/20/08, received 11/14/08)
- Minor Assent (version 9/9/09, received 10/17/08)
- Adult Questionnaire of Child Health & Physical Activity Habits (received 9/17/08)
- Personal History Form (received 9/17/08)
- Tanner Staging Form (received 9/17/08)
- Advertisement (received 9/17/08)

The following UMCIRB members were recused for reasons of potential for Conflict of Interest on this research study: R. Hickner

NOTE: The following UMCIRB members with a potential Conflict of Interest did not attend this IRB meeting: None

**The UMCIRB applies 45 CFR 46, Subparts A-D, to all research reviewed by the UMCIRB regardless of the funding source. 21 CFR 50 and 21 CFR 56 are applied to all research studies under the Food and Drug Administration regulation. The UMCIRB follows applicable International Conference on Harmonisation Good Clinical Practice guidelines.**

**UMCIRB HIPAA Authorization Checklist/Approval Form**

UMCIRB #: 08-0542 PI: Joseph Staumard PhD  
 Title of study (full or abbreviated): Fat Metabolism in Children During Exercise

**Check one of the boxes below:**

- Use of ECU "Research Participant Authorization to Use and Disclose Information for Research"  
 Use of a sponsor/granting agency or other alternative HIPAA Patient Authorization  
 Use of research informed consent document form with required elements of the HIPAA Patient Authorization

**Designated UMCIRB reviewer has reviewed the substitute HIPAA Patient Authorization for Research or proposed research consent form and found that it is written in plain language and contains:**

- | Yes                                 | No                       |                                                                                                                                                                                                                                                                       |
|-------------------------------------|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | A specific and meaningful description of the information to be used or disclosed                                                                                                                                                                                      |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | The name or identification of persons or class of persons authorized to make requested use/disclosure of PHI                                                                                                                                                          |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | The name or identification of persons or class or persons who will use PHI for research-related purposes                                                                                                                                                              |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | A description of each purpose of the use or disclosure                                                                                                                                                                                                                |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | The individual's signature (or that of his/her authorized representative) and the date.                                                                                                                                                                               |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | An expiration date or event, or a statement "end of research study" or "none" when appropriate                                                                                                                                                                        |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | A statement that the individual may revoke the authorization in writing;                                                                                                                                                                                              |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | Any exceptions to the right to revoke (e.g. researcher may continue to use and disclose, for research integrity and reporting purposes any PHI collected from the individual pursuant to such Authorization before it was revoked).                                   |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | A statement that information disclosed under the Authorization could potentially be re-disclosed by the recipient and would no longer be protected under HIPAA.                                                                                                       |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | A statement of the ability or inability to condition treatment, payment, enrollment or eligibility for benefits on the authorization by stating either stating the applicable conditions or the consequences to the individual for refusal to sign the authorization. |
| <input checked="" type="checkbox"/> | <input type="checkbox"/> | <b>All the above elements are present, HIPAA AUTHORIZATION document is APPROVED</b>                                                                                                                                                                                   |
| <input type="checkbox"/>            | <input type="checkbox"/> | <b>All the above elements are <u>not</u> present; HIPAA AUTHORIZATION document is NOT APPROVED</b>                                                                                                                                                                    |

Susan McCannan

Designated UMCIRB Reviewer

SMC  
10-23-08  
~~9-19-08~~

Date

**Principal Investigator: Present this signed form at the time PHI is requested from custodians of records. By signing this document, I acknowledge and affirm that all enrolled subjects have signed a valid HIPAA Authorization Form.**

Principal Investigator

Date

\*\*\*\*\*IMPORTANT INFORMATION\*\*\*\*\*

**Continuing Review/Closure Obligation**

As a investigator you are required to submit a continuing review/closure form to the UMCIRB office in order to have your study renewed or closed before the date of expiration as noted on your approval letter. This information is required to outline the research activities since it was last approved. You must submit this research form even if you there has been no activity, no participant s enrolled, or you do not wish to continue the activity any longer. The regulations do not permit any research activity outside of the IRB approval period. Additionally, the regulations do not permit the UMCIRB to provide a retrospective approval during a period of lapse. Research studies that are allowed to be expired will be reported to the Vice Chancellor for Research and Graduate Studies, along with relevant other administration within the institution. The continuing review/closure form is located on our website at [www.ecu.edu/irb](http://www.ecu.edu/irb) under forms and documents. The meeting dates and submission deadlines are also posted on our web site under meeting information. Please contact the UMCIRB office at 252-744-2914 if you have any questions regarding your role or requirements with continuing review.  
<http://www.hhs.gov/ohrp/humansubjects/guidance/contrev0107.htm>

**Required Approval for Any Changes to the IRB Approved Research**

As a research investigator you are required to obtain IRB approval prior to making any changes in your research study. Changes may not be initiated without IRB review and approval, except when necessary to eliminate an immediate apparent hazard to the participant. In the case when changes must be immediately undertaken to prevent a hazard to the participant and there was no opportunity to obtain prior IRB approval, the IRB must be informed of the change as soon as possible via a protocol deviation form.  
<http://www.hhs.gov/ohrp/humansubjects/guidance/45cfr46.htm#46.103>

**Reporting of Unanticipated Problems to Participants or Others**

As a research investigator you are required to report unanticipated problems to participants or others involving your research as soon as possible. Serious adverse events as defined by the FDA regulations may be a subset of unanticipated problems. The reporting times as specified within the research protocol, applicable regulations and policies should be followed.  
<http://www.hhs.gov/ohrp/policy/AdvEvtGuid.htm>

## APPENDIX B: INFORMED CONSENT

**Fat metabolism in children during exercise****INFORMED CONSENT**

**Principal Investigator: Joseph A. Houmard, Ph.D.**  
**Institution: Human Performance Laboratory**  
**Address: 371 Ward Sports Medicine Building**  
**Telephone Number: (252) 737-4617**

**TITLE OF PROJECT:** Fat metabolism in children during exercise

**INTRODUCTION**

Your child has been asked to participate in a research study being conducted by Joseph A. Houmard and colleagues. This research is designed to determine how children utilize fuels (fat and carbohydrate) during exercise. Two groups of children will be selected: One group of children will have a parent that is or has been overweight and the other group will have parents that are not as overweight. 8 to 10 children will be enrolled for each group with a total of 16 to 20 children participating in this study.

Studies will take place in the Human Performance Laboratory of East Carolina University.

**PLAN AND PROCEDURES**

Prior to testing, you, as a guardian(s) will read and sign this Informed Consent for research, as well as fill out a medical history questionnaire pertaining to you and your child. Participation in this study will require medical history such as body weight, height, and history of diabetes from at least one biological parent; the child will not be able to participate in this research if such information cannot be obtained for at least one biological parent. Participation in this study will require 4 visits to the FITT building over a 1 to 2 month period. Each visit will last approximately an hour.

After the initial screening, if your child is still eligible for enrollment, their participation will involve:

- You will fill out a **personal history forms (Visit 1)** that pertain to you and your child. Your child will fill out forms relating to their health status and physical activity.
- Determination of **body composition (Visit 1)** using body mass index (BMI) and skinfolds will be conducted at the Human Performance Laboratory. To calculate BMI, height and weight will be measured. Seated height and minimum waist girth will also be measured. Skinfold thickness of the tricep and calf will be taken on the right side of the body, in duplicate, with a skinfold caliper. Body composition will also be determined using something called a DEXA which is like an x-ray of your child's entire body. During this test your child will be asked to wear minimal clothing (e.g., swimsuit, or shorts and a shirt, or a gown), and to remove all jewelry. He/she will lie still on a padded table for the length of the scan (approximately 6 minutes). A scanner on the table will move across and up and down to scan his/her body. Your child will not feel anything and can breathe normally during the scan. If your child has metal in his/her body, then your child will not be able to participate in the DEXA scan. A person trained for the use of the DEXA will perform all testing. One benefit of this test is that it provides the most accurate assessment of body composition available.
- Determination of **aerobic capacity (Visits 2 and 3)**. A maximal test on a stationary cycle (cycle ergometer) will be completed to evaluate aerobic capacity. For this test, your child will cycle on the stationary bicycle for approximately 10-15 minutes. During this test, your child will wear a

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 TO

**Fat metabolism in children during exercise**

mouthpiece so the air they breathe out can be collected for analysis of oxygen. At first, your child will cycle at a very low resistance (low workload) but the resistance will become harder until your child can no longer continue. Your child will perform two (2) of these tests to insure that the measurements are correct. If the measurements the researchers obtain indicate that the effort was not maximal, a third test may be performed.

- Your child will wear a **physical activity monitor (between Visits 3 and 4)** (RT3 Triaxial Accelerometer) for seven days. The purpose of this test is to determine how much physical activity your child is performing. The parent or an adult may need to assist the child in recording the data, resetting the monitors and other similar procedures. You/your child can elect to not perform this aspect of the study.
- Your child will perform a **submaximal exercise test (Visit 4)** which will consist of cycling for 20 min at two relatively low resistances. For this test, your child will warm-up on the cycle for 3-5 min. After the warm-up, your child will cycle at 10 minutes at one resistance. After this 10 minute period, your child will rest for 5-10 min and then perform another 10 min exercise session. During this test, your child will wear a mouthpiece so the air they breathe out can be collected for analysis of oxygen. This test will take place in the morning after your child has fasted for 8-12 hours (overnight fast). Your child can drink all the water they want prior to the test but cannot consume any foods and drinks containing energy (calories).

**RISKS AND DISCOMFORTS**

There are certain risks and discomforts that may be associated with this research. They include:

- Risks associated with the maximal exercise are dizziness, ventricular arrhythmia (odd heart beats), and in very rare instances death. These risks are very small, with an incidence of fewer than 1 in 10,000 deaths in patients who are known to, or suspected of, having heart disease. The risk is expectedly much smaller a group of young, healthy subjects such as in the present study. To further minimize the risk, faculty and students that have been extensively trained in administering maximal exercise tests will administer the assessments. If during a test a subject complains of dizziness, chest discomfort or other signs of exercise intolerance, the test will be promptly stopped. In the event of loss of consciousness, breathing or heart beat, appropriate CPR and AED administration will be initiated and Greenville Fire/Rescue will be notified via 911.
- The risk associated with DEXA is minimal. The radiation received is less than 1% of the radiation received in one year from normal background sources. More radiation is received from a cross-country airline trip (60 uSv) or at a one-week ski vacation at a high altitude city (i.e. Denver Colorado) (15 uSv) than from a DEXA scan (0.6 uSv).
- Your child should be aware that there are unforeseen risks involved with this and all research studies.

**POTENTIAL BENEFITS**

Your child will be exposed to exercise testing and training which may encourage an active lifestyle. Data gathered may aid in determining if alterations in how carbohydrate and fat are utilized during exercise are a function of parental characteristics.

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 TO 11-11-09

**Fat metabolism in children during exercise**

**TERMINATION OF PARTICIPATION**

Your child's participation in this research study may be terminated without your consent if the investigators believe that these procedures will pose unnecessary risk to your child. Your child may also be terminated from the participation if your child does not adhere to the study protocol.

**COST AND COMPENSATION**

Your child will be paid \$40 for his/her time and inconvenience for completion of the study. If your child elects to not complete the study he/she will be compensated for \$10 for each visit completed (body composition, maximal exercise test (2), submaximal exercise testing).

The policy of East Carolina University does not provide for the compensation or medical treatment for subjects because of the physical or other injury resulting from this research activity. However, every effort will be made to make the facilities of Brody School of Medicine, Pitt County Memorial Hospital available for treatment in the event of such physical injury.

**CONFIDENTIALITY**

Only the investigators associated with this study will have access to the data obtained. No identifying information will be released. Numeric coding, which only the primary investigator will have access to, will protect the identity of your child and other subjects. Data will be secured in a locked filing cabinet in the office of the primary investigator in the Human Performance Laboratory. The data will be kept for approximately 2 to 4 years.

**VOLUNTARY PARTICIPATION**

Your child understands that his/her participation in this study is voluntary. Refusal to participate will involve no penalty or loss of benefits to which your child is otherwise entitled. Furthermore, your child may stop participating at any time he/she chooses without penalty, loss of benefits, or without jeopardizing his/her continuing medical care at this institution.

**RESEARCH PARTICIPANT AUTHORIZATION TO USE AND DISCLOSE PROTECTED HEALTH INFORMATION**

The purpose of the information to be gathered for this research study is to better understand fat metabolism in children during exercise. The individuals who will use or disclose your identifiable health information for research purposes include Joseph Houmard, Ph.D. and Audrey Eaves. The type of information accessed for this research study includes medical history, cardiorespiratory fitness, energy usage during exercise, and body composition. The information will be used and disclosed in such a way as to protect your identity as much as possible; however, confidentiality cannot be absolutely guaranteed. Someone receiving information collected under this Authorization could potentially re-disclose it, and therefore it would no longer be protected under the HIPAA privacy rules (federal rules that govern the use and disclosure of your health information). There is not an expiration date for this Authorization.

You may not participate in this study if you do not sign this Authorization form. You may revoke (withdraw) this Authorization by submitting a request in writing to Joseph Houmard, Ph.D. However, the research team will be able to use any and all of the information collected prior to your request to withdraw your Authorization.

To authorize the use and disclosure of your health information for this study in the way that has been described in this form, please sign below and date when you signed this form. A signed copy of this Authorization will be given to you for your records.

UHC/CRB  
APPROVED  
FROM 11-12-08  
TO 11-11-09

**Fat metabolism in children during exercise****PERSONS TO CONTACT WITH QUESTIONS**

If you have questions related to the sharing of information, please call Joe Houmard at 252-737-4617 (days) or 252-353-4482 (nights or weekends). You may also telephone the University and Medical Center Institutional Review Board at 252-744-2914. If you have a question about injury related to this research, you may call the ECU Risk Management Office at 252-328-2010. In addition, if you have concerns about confidentiality and privacy rights, you may phone the Privacy Officer at Pitt County Memorial Hospital at 252-847-6545 or at East Carolina University at 252-744-2030.

**TITLE OF PROJECT:** Fat metabolism in children during exercise

**CONSENT TO PARTICIPATE**

As parent or legal guardian I have read all of the above information, asked questions, and received answers concerning areas I did not understand, and have received satisfactory answers to these questions. I willingly consent for the participation of my child in this research study. (A copy of this consent form will be given to the person signing as the subject or as the subject's authorized representative.)

Please contact me concerning similar studies in the future concerning myself/my child.

Please **do not** contact me concerning similar studies in the future.

\_\_\_\_\_  
Participant's Name (Print)

\_\_\_\_\_  
Authorized Representative's Name (Print) – Parent/Guardian #1      (Day)      (Night)  
Phone numbers in case of injury

\_\_\_\_\_  
Signature of Authorized Representative – Parent/Guardian #1      Date

\_\_\_\_\_  
Authorized Representative's Name (Print) – Parent/Guardian #2      (Day)      (Night)  
Phone numbers in case of injury

\_\_\_\_\_  
Signature of Authorized Representative – Parent/Guardian #2      Date

AUDITOR WITNESS: I confirm that the contents of this consent/assent form were orally presented.

\_\_\_\_\_  
Auditor's Name (Print)

\_\_\_\_\_  
Signature of Auditor      Date

\_\_\_\_\_  
Principal Investigator's Name (Print)

\_\_\_\_\_  
Signature of Principal Investigator      Date

Version: 8/20/08

Page 4 of 4

Subject's Initials \_\_\_\_\_

UNCLINICAL  
 APPROVED  
 FROM 11-19-08  
 TO 11-11-09

## APPENDIX C: ASSENT

**ASSENT DOCUMENT FOR CHILDREN****Title of project: Fat metabolism in children during exercise****Principal Investigator:** Joseph A. Houmard, Ph.D.**Institution:** East Carolina University**Address:** Human Performance Laboratory, Ward Sports Medicine Building**Telephone Number:** 252-737-4617**Why is this study being done?**

We are trying to learn what happens when kids exercise. During exercise people burn fat and sugar for energy. The reason for this study is to find out how you use fat for energy when exercising.

Read about what will happen during this exercise study and make sure you want to be in the study. You do not have to participate in this study. You can ask questions at any time.

**What will happen during this study?**

1. You will complete four (4) visits over about 1 to 2 months. Each visit will last about an hour.
2. At the first visit you will answer some questions about your health and how much you exercise. You will then have your height, seated height, weight, waist, skinfolds, and percent body fat measured. Skinfolds are measured by pinching different areas on your body. You may feel a very light pinch. You will then go to another room where we will do a test called a DEXA scan. It is like an x-ray of your entire body. During this test you will wear shorts and a shirt, or a gown, and you will take off any jewelry. You will then lie still on a padded table for about 6 minutes. The table will move across and up and down to scan your body, but you do not feel anything and can breathe normally during the scan. This test will determine how much muscle and fat your body has.
3. At the second and third visits you will perform an exercise test on a bicycle that does not move. During the bike test we will place nose clips on your nose, and you will breathe through a small mouthpiece. You will be able to breathe through the mouthpiece like you normally do. When you breathe through the mouthpiece, you will pedal on a bicycle and it will be fairly easy. As you ride the bike, the pedals will become harder and harder to push until you cannot turn the pedals (about 8 – 12 minutes). You will need to ride the bike with the mouthpiece on two different days. If the two tests are not the same, a third test may be needed. It is important you give a very good effort for the bike test and do not stop too early.
4. At the last visit you will do another type of exercise test on the same bicycle. This bike test will take place in the morning. You can drink all the water you want before the test but you cannot eat for 8-12 hours before this test, which means you will not eat breakfast on the morning you do your last bike test. You will wear nose clips and a mouthpiece. For this bike test you will warm-up on the bike for 3-5 minutes. After you warm up, you will bicycle for 10 minutes, but during this bike test the pedals will not get harder to push, but will stay the same. This should feel fairly easy. After you finish your 10 minutes of bicycling, you will take a rest break for 5-10 minutes. After the rest break, you will bicycle for another 10 minutes. The pedals may feel easier or a little bit harder than your first 10 minutes but should still be fairly easy. The pedals will not get harder as you exercise.
5. We will provide an activity monitor called an accelerometer for you to wear. These activity monitors are light weight and about the size of a pager and are worn on the waist. They keep track of the physical activity you do, and then it is measured by a computer. You will wear the monitors for 7 days, except when bathing, swimming, or sleeping. You will write down the time you put on and take off the activity monitors every day. You will also write down the number of steps, and what type of activity you did the most each day in a physical activity log book. You can choose not to participate in this part of the study.

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 APPROVED  
 FROM 11-12-08  
 TO 11-11-09

### ASSENT DOCUMENT FOR CHILDREN

- 6. Your personal information will be kept safe and private at the Human Performance Laboratory. Only the people working on the study can see your information. You can choose at any time to not participate in this study.

**What are the bad things that might happen?**

Sometimes things happen to people in research studies that may make them feel bad. These are called risks. The risks in this study are:

- 1. Sometimes people feel sick (for example like throwing up) for a short period of time when they exercise hard.

To make sure you do not get sick during exercise, we will watch how your heart responds to the exercise and will stop the exercise if you feel sick.

**What are the good things that might happen?**

People may also have good things happen to them when they are in research studies. These are called benefits. Here are some benefits that you might have from this study.

- 1. You will get to do some fun tests.
- 2. You will learn more about exercise and physical activity.
- 3. You will learn about your body and how healthy you are.

**Will you get any money for being in this study?**

You will receive \$40 for being in this study. If you choose to stop the study, you will get \$10 for every time you came to the lab and finished a test.

**What happens if you change your mind about being in the study?**

Participating in this study is your choice. You may stop at any time during the study. No one will be upset with you if you decide not to participate.

**Who can answer any question that you might have later on?**

You can talk to Dr. Joseph Houmard 252-737-4617 if you have more questions at any time during the study. You can also call the university office at 252-744-2914 if you are concerned about how you have been treated in the study.

If you put your name at the end of the form it means that you agree to be in this study. You and your parents will be given a copy of this form to keep after you sign it.

\_\_\_\_\_  
Child's Name (print)

\_\_\_\_\_  
(Date)

\_\_\_\_\_  
Child's signature

\_\_\_\_\_  
(Date)

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 FROM 11-12-08  
 TO 11-11-09

## APPENDIX D: TANNER STAGING

**Tanner Staging**

Please read the descriptions below and circle the stage that best describes the development of your child.

**I. Girls**

| Tanner Stage | Stage of development | Pubic Hair              | Breasts                                |
|--------------|----------------------|-------------------------|----------------------------------------|
| Stage 1      | Early adolescence    | Preadolescent           | Preadolescent                          |
| Stage 2      |                      | Sparse, straight        | Small mound                            |
| Stage 3      | Middle adolescence   | Dark, curl              | Bigger; no contour separation          |
| Stage 4      |                      | Coarse, curly, abundant | Secondary mound of areola              |
| Stage 5      | Late Adolescence     | Triangle; medial thigh  | Nipple projects; areola part of breast |

**I. Boys**

| Tanner Stage | Stage of development | Pubic Hair           | Penis           | Testes        |
|--------------|----------------------|----------------------|-----------------|---------------|
| Stage 1      | Early adolescence    | None                 | Preadolescent   | Preadolescent |
| Stage 2      |                      | Scanty               | Slight increase | Larger        |
| Stage 3      | Middle adolescence   | Darker, curls        | Longer          | Larger        |
| Stage 4      |                      | Adult, coarse, curly | Larger          | Scrotum dark  |
| Stage 5      | Late adolescence     | Adult - thighs       | Adult           | Adult         |

Adapted from Medical College of Georgia Department of Pediatrics  
<http://www.mcg.edu/pediatrics/CCNotebook/chapter3/tanner.htm>

## APPENDIX E: ACTIVITY QUESTIONNAIRE

**Adult Questionnaire of Child Health and Physical Activity Habits**

- Adapted from BRFSS

Child Name: \_\_\_\_\_ ID \_\_\_\_\_  
Date: \_\_\_\_\_

**This survey should be completed by the adult in the home who is most familiar with this child's daily activities.**

This survey will help us understand physical activity and other health habits of children and teenagers. Your answers are very valuable. Please take a few minutes to complete the survey, and then return it immediately to the administrator of the survey. Feel free to ask any questions.

**All the questions on this survey are about the child whose name is at the top of this page.**

\_\_\_\_\_  
Adult's signature

**GENERAL INFORMATION ABOUT THIS CHILD**

Q1. What is this child's birth date? \_\_\_\_\_ month \_\_\_\_\_ day \_\_\_\_\_ year

Q2. What was this child's birth weight? \_\_\_\_\_ lbs \_\_\_\_\_ oz

Q3. Was this child born preterm? (circle one)      **No**              **Yes** - How many weeks \_\_\_\_\_

Q4. What is this child's gender? (circle one)      Male              Female

Q5. What is this child's height? \_\_\_\_\_ feet \_\_\_\_\_ inches

Q6. What is this child's weight? \_\_\_\_\_ pounds

Q7. Does this child have any medical conditions or disabilities that limit his or her physical activity? (circle one number)

0. No                      1. Yes, please specify: \_\_\_\_\_

Q8. How do you identify your child's racial or ethnic background? (circle one number only)

1. Asian Pacific Islander
2. African American
3. Native American Indian
4. Latino/Hispanic
5. Caucasian
6. Multi-racial/ Multi-ethnic
7. Other (please specify) \_\_\_\_\_

**THIS CHILD'S ACTIVITIES**

**Circle the number of the answer that you feel is correct for this child.**

Q9. On how many of the past 7 days did this child exercise or participate in sports activities for at least 20 minutes that made him/her sweat and breathe hard, such as basketball, jogging, swimming laps, tennis, fast bicycling, or similar aerobic activities? **Circle one number**

0      1      2      3      4      5      6      7

Q10. On how many of the past 7 days did this child do exercises to strengthen or tone his/her muscles, such as push-ups, sit-ups, or weight lifting? **Circle one number**

0      1      2      3      4      5      6      7

Q11. On how many of the past 7 days did this child walk, jog, or bicycle for at least 30 minutes at a time? **Circle one number**

0      1      2      3      4      5      6      7

Q12. On an average WEEK day, how many hours **per day** did this child watch television and videos or play computer or video games? **Circle one number**

0      1      2      3      4      5      6      7

Q13. On an average WEEKEND day (Saturday and Sunday), how many hours **per day** does this child watch television and videos or play computer or video games? **Circle one number**

0      1      2      3      4      5      6      7

Q14. Compared to others of the same age and sex how much physical activity does this child get? **Circle one number**

|                          |   |                       |   |                          |
|--------------------------|---|-----------------------|---|--------------------------|
| 1                        | 2 | 3                     | 4 | 5                        |
| Much less<br>than others |   | The same<br>as others |   | Much more<br>than others |

Q15. Compared to others of the same age and sex how do you rate this child's athletic coordination? **Circle one number**

|                                         |   |                       |   |                                         |
|-----------------------------------------|---|-----------------------|---|-----------------------------------------|
| 1                                       | 2 | 3                     | 4 | 5                                       |
| Much less<br>coordinated<br>than others |   | The same<br>as others |   | Much more<br>coordinated<br>than others |

Q16. How much does this child enjoy physical activity? **Circle one number**

1                      2                      3                      4                      5  
 very unenjoyable                      Neutral                      very enjoyable

Q17. How much does this child enjoy physical education classes at school? **Circle one number**

1                      2                      3                      4                      5  
 very unenjoyable                      Neutral                      very enjoyable

Q18. In your opinion, how often is this child physically active? **Circle one number**

1. Frequently
2. A moderate amount
3. Rarely

Q19. What does this child do when she or he has a choice about how to spend recreational time? **Circle one number**

1. Almost always chooses activities like TV, reading, listening to music, computers
2. Usually chooses activities like TV, reading, listening to music, computers
3. Just as likely to choose active as inactive recreation
4. Usually chooses activities like bicycling, dancing, outdoor games or active sports
5. Almost always chooses activities like bicycling, dancing, outdoor games or active sports

Q20. Within the past year, how many organized sports and/or physical activities did this child participate in? **Circle one number**

0                      1                      2                      3                      4 OR MORE

Q21. Within the past year, how often did this child participate in organized sports and/or physical activities? **Circle one number**

1. Never
2. 1-2 times per month
3. 3-7 times per month
4. 8-14 times per month
5. 14 or more times per month

Q22. Where does this child go most often after school?

1. After-school program at school
2. After-school program at another location
3. Home, with supervision
4. Home, without supervision
5. Home of a relative or friend
6. Other, please specify: \_\_\_\_\_

Q23. In the past seven (7) days, how many days did this child do physical activity or sports at these locations?

|                                                                | <i>Number of Days in the Past Week</i> |   |   |   |   |   |   |
|----------------------------------------------------------------|----------------------------------------|---|---|---|---|---|---|
| A. School grounds (after-school only)                          | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| B. Park or playground                                          | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| C. Neighborhood                                                | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| D. After-school care                                           | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| E. Commercial Facility (YMCA, B&GC, health club, dance studio) | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| F. Public recreation Center                                    | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |
| G. Other, Please specify:<br>_____                             | 1                                      | 2 | 3 | 4 | 5 | 6 | 7 |

#### FAMILY HISTORY FOR THIS CHILD

Please check any of the conditions that a family member of this child has been diagnosed to have by a physician.

| CONDITION              | YES            | NO | RELATION TO CHILD |
|------------------------|----------------|----|-------------------|
| High Blood Pressure    |                |    |                   |
| Type 2 Diabetes        |                |    |                   |
| Heart Disease          | Please specify |    |                   |
| Bone or Joint Problems | Please specify |    |                   |
| Asthma                 |                |    |                   |
| Stroke                 |                |    |                   |
| High Cholesterol       |                |    |                   |

The following questions ask about **your own** health and physical activity habits.

Q1. What is **your** height? \_\_\_\_\_ feet \_\_\_\_\_ inches

Q2. What is **your** weight? \_\_\_\_\_ pounds

Q3. On how many of the past 7 days did **you** exercise or participate in sports activities for at least 20 minutes that made you sweat and breathe hard, such as basketball, soccer, running, swimming laps, fast bicycling, fast dancing, or similar aerobic activities? **Circle one response**

0 days                  1 day                  2 days                  3 days                  4 days  
5 days                  6 days    7 days

Q4. On how many of the past 7 days did **you** participate in physical activity for at least 30 minutes that did NOT make you sweat or breathe hard, such as fast walking, slow bicycling, skating, pushing a lawn mower, or mopping floors? **Circle one response**

0 days                  1 day                  2 days                  3 days                  4 days  
5 days                  6 days    7 days

Q5. On how many of the past 7 days did **you** do exercises to strengthen or tone your muscles, such as push-ups, sit-ups, or weight lifting? **Circle one response**

0 days                  1 day                  2 days                  3 days                  4 days  
5 days                  6 days                  7 days

Q6. When you are at work, which of the following best describes what you do? **Circle one number**

1. Mostly sitting or standing
2. Mostly walking
3. Mostly heavy labor or physically demanding work

| During a typical week how often do you:                                             | Never | Once | Sometimes | Almost daily | Daily |
|-------------------------------------------------------------------------------------|-------|------|-----------|--------------|-------|
| Encourage your child to do physical activity or play outside?                       | 1     | 2    | 3         | 4            | 5     |
| Play outside or do physical activity with your child?                               | 1     | 2    | 3         | 4            | 5     |
| Provide transportation to a place where he or she can do physical activity or play? | 1     | 2    | 3         | 4            | 5     |
| Watch your child participate in physical activities or outdoor games?               | 1     | 2    | 3         | 4            | 5     |
| Tell your child that physical activity is good for his or her health?               | 1     | 2    | 3         | 4            | 5     |

## APPENDIX F: PERSONAL HISTORY FORM

**PERSONAL HISTORY FORM**

Please read each of the following questions and circle YES or NO regarding your child.

- |         |    |                                                                                                                                                                       |
|---------|----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1. YES  | NO | Does your child ever have pains in his/her heart and chest?                                                                                                           |
| 2. YES  | NO | Does your child often feel faint or have any spells of severe dizziness?                                                                                              |
| 3. YES  | NO | Has your child's doctor ever said his/her blood pressure was too high?                                                                                                |
| 4. YES  | NO | Has your child's doctor ever told you he/she has a bone or joint problem such as arthritis that has been aggravated by exercise or might be made worse with exercise? |
| 5. YES  | NO | Does your child have asthma?                                                                                                                                          |
| 6. YES  | NO | Does your child have Diabetes or any other metabolic disease?                                                                                                         |
| 7. YES  | NO | Is there a good physical reason not mentioned here why your child should not participate in an activity program even if he/she wanted to?                             |
| 8. YES  | NO | In the past two weeks, has your child followed a normal and regular sleep pattern?                                                                                    |
| 9. YES  | NO | Is your child currently taking any medication?                                                                                                                        |
| 10. YES | NO | Has your child undergone surgery?                                                                                                                                     |

If you answered YES to any of the following questions (with exception to #8), please explain:

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In case of an emergency, please contact:

Name: \_\_\_\_\_

Address: \_\_\_\_\_

Phone Number: \_\_\_\_\_

## APPENDIX G: DATA COLLECTION SHEET

**Fat Metabolism in Children Data Collection Sheet**

Study # 08-0542

Check offs

 Informed Consent Assent Tanner Staging QuestionnaireSubject Identifier \_\_\_\_\_ Group **E** **C** (Circle one)

Name \_\_\_\_\_

Age: \_\_\_\_\_ years Date of Birth \_\_\_\_\_

Height \_\_\_\_\_ cm

Weight \_\_\_\_\_ lbs \_\_\_\_\_ kg

Umbilicus \_\_\_\_\_ cm

Seated Height \_\_\_\_\_ cm Leg Length \_\_\_\_\_ cm **Chair Height is**

Peak Height Velocity \_\_\_\_\_

**Skinfold Measurements**

|             | Measurement 1 | Measurement 2 | Average |
|-------------|---------------|---------------|---------|
| Tricep      |               |               |         |
| Medial Calf |               |               |         |

% Body Fat from Skinfolds \_\_\_\_\_

% Body Fat from DEXA \_\_\_\_\_

Check Offs

 DEXA Scan Introduction to metabolic cart equipment and bike Instructions for next visit**Scheduled dates and times for next visits**

Max Test 1 \_\_\_\_\_

Max Test 2 \_\_\_\_\_

Submax Test \_\_\_\_\_  
Data on Parents

**Mother**

Age \_\_\_\_\_ Date of Birth \_\_\_\_\_

Height \_\_\_\_\_ cm

Weight \_\_\_\_\_ lbs

BMI \_\_\_\_\_ kg/m<sup>2</sup>

Gastric Bypass or other            Y            N

**Father**

Age \_\_\_\_\_ Date of Birth \_\_\_\_\_

Height \_\_\_\_\_ cm

Weight \_\_\_\_\_ lbs

BMI \_\_\_\_\_ kg/m<sup>2</sup>

Gastric Bypass or other            Y            N

## APPENDIX H: MAXIMAL EXERCISE PROTOCOL

Study # 08-0542 Maximal Exercise Protocol**\*\* COPY OF VO2 PRINT OUT**

Name: \_\_\_\_\_

Subject ID: \_\_\_\_\_

Date: \_\_\_\_\_

DOB: \_\_\_\_\_ Age: \_\_\_\_\_ Predicted Max HR: \_\_\_\_\_ 85% HR: \_\_\_\_\_

Height: \_\_\_\_\_ (cm) Weight: \_\_\_\_\_ lb = \_\_\_\_\_ kg

Medications: \_\_\_\_\_

Supine - BP: \_\_\_\_\_ HR: \_\_\_\_\_

Standing - BP: \_\_\_\_\_ HR: \_\_\_\_\_

Start at 20W if  $\leq 30$  kg

| Minute | Watts | Watts | HR | BP | RPE | Comments |
|--------|-------|-------|----|----|-----|----------|
| 1      | 20    | 25    |    |    |     |          |
| 2      | 20    | 25    |    |    |     |          |
| 3      | 20    | 25    |    |    |     |          |
| 4      | 40    | 50    |    |    |     |          |
| 5      | 40    | 50    |    |    |     |          |
| 6      | 40    | 50    |    |    |     |          |
| 7      | 60    | 75    |    |    |     |          |
| 8      | 60    | 75    |    |    |     |          |
| 9      | 60    | 75    |    |    |     |          |
| 10     | 80    | 100   |    |    |     |          |
| 11     | 80    | 100   |    |    |     |          |
| 12     | 80    | 100   |    |    |     |          |
| 13     | 100   | 125   |    |    |     |          |
| 14     | 100   | 125   |    |    |     |          |
| 15     | 100   | 125   |    |    |     |          |
| 16     | 120   | 150   |    |    |     |          |
| 17     | 120   | 150   |    |    |     |          |
| 18     | 120   | 150   |    |    |     |          |
| 19     | 140   | 175   |    |    |     |          |

Total Exercise Time: \_\_\_\_\_ Max HR: \_\_\_\_\_ Max BP: \_\_\_\_\_

VO2 max \_\_\_\_\_ ml/kg/min Max RER \_\_\_\_\_

### APPENDIX I: MAXIMAL EXERCISE PROTOCOL FOR OLDER CHILDREN

Study # 08-0542 Maximal Exercise Protocol

\*\* COPY OF VO2 PRINT OUT

Name: \_\_\_\_\_

Subject ID: \_\_\_\_\_

Date: \_\_\_\_\_

DOB: \_\_\_\_\_ Age: \_\_\_\_\_ Predicted Max HR: \_\_\_\_\_ 85% HR: \_\_\_\_\_

Height: \_\_\_\_\_ (cm) Weight: \_\_\_\_\_ lb = \_\_\_\_\_ kg

Medications: \_\_\_\_\_

Supine - BP: \_\_\_\_\_ HR: \_\_\_\_\_

Standing - BP: \_\_\_\_\_ HR: \_\_\_\_\_

Boys - 15

| Minute | Watts | HR | BP | RPE | Comments |
|--------|-------|----|----|-----|----------|
| 1      | 50    |    |    |     |          |
| 2      | 50    |    |    |     |          |
| 3      | 50    |    |    |     |          |
| 4      | 100   |    |    |     |          |
| 5      | 100   |    |    |     |          |
| 6      | 100   |    |    |     |          |
| 7      | 150   |    |    |     |          |
| 8      | 150   |    |    |     |          |
| 9      | 150   |    |    |     |          |
| 10     | 200   |    |    |     |          |
| 11     | 200   |    |    |     |          |
| 12     | 200   |    |    |     |          |
| 13     | 250   |    |    |     |          |
| 14     | 250   |    |    |     |          |
| 15     | 250   |    |    |     |          |
| 16     | 300   |    |    |     |          |
| 17     | 300   |    |    |     |          |
| 18     | 300   |    |    |     |          |
| 19     | 350   |    |    |     |          |

Total Exercise Time: \_\_\_\_\_ Max HR: \_\_\_\_\_ Max BP: \_\_\_\_\_

VO2 max \_\_\_\_\_ ml/kg/min Max RER \_\_\_\_\_

## APPENDIX J: SUBMAXIMAL EXERCISE PROTOCOL

Study # 08-0542 Submaximal Exercise Protocol

\*\* COPY OF VO2 PRINT OUT

Name: \_\_\_\_\_

Subject ID: \_\_\_\_\_

Date: \_\_\_\_\_ Time: \_\_\_\_\_ Fasted: Y N

DOB: \_\_\_\_\_ Age: \_\_\_\_\_

Height: \_\_\_\_\_ (cm) Weight: \_\_\_\_\_ lb = \_\_\_\_\_ kg

Medications: \_\_\_\_\_

Supine - BP: \_\_\_\_\_

HR: \_\_\_\_\_

Standing - BP: \_\_\_\_\_

HR: \_\_\_\_\_

| Minute | Watts | HR | BP | RPE | Comments |
|--------|-------|----|----|-----|----------|
| 1      | 15    |    |    |     |          |
| 2      | 15    |    |    |     |          |
| 3      | 15    |    |    |     |          |
| 4      | 15    |    |    |     |          |
| 5      | 15    |    |    |     |          |
| 6      | 15    |    |    |     |          |
| 7      | 15    |    |    |     |          |
| 8      | 15    |    |    |     |          |
| 9      | 15    |    |    |     |          |
| 10     | 15    |    |    |     |          |

\*5 to 10 minute break

VO2 max \_\_\_\_\_ ml/kg/min 65% VO2 max \_\_\_\_\_ ml/kg/min = \_\_\_\_\_ W

| Minute | Watts | HR | BP | RPE | Comments |
|--------|-------|----|----|-----|----------|
| 1      |       |    |    |     |          |
| 2      |       |    |    |     |          |
| 3      |       |    |    |     |          |
| 4      |       |    |    |     |          |
| 5      |       |    |    |     |          |
| 6      |       |    |    |     |          |
| 7      |       |    |    |     |          |
| 8      |       |    |    |     |          |
| 9      |       |    |    |     |          |
| 10     |       |    |    |     |          |

**Recovery:**

|    | HR    | BP    |
|----|-------|-------|
| 1. | _____ | _____ |
| 2. | _____ | _____ |
| 3. | _____ | _____ |
| 4. | _____ | _____ |

Comments: \_\_\_\_\_

\_\_\_\_\_

