

**Resource Guide for  
Predictive Factors and Methods of Assessing Physical Activity  
and Adiposity in Children**

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## **Resource Guide Overview**

The purpose of this report is three-fold. First, it provides a detailed review of literature regarding the predictive factors for overweight/adiposity and physical activity in children. Second, it is to serve as a resource guide in determining what methods are available to measure both adiposity and physical activity in children, identify which methods are most suitable for use in communities and which are more useful in research settings, and to provide a discussion of the values and limitations of each of the methods identified. Lastly, the guide provides quick reference resource charts for health professionals/health educators to use in making evidence-based decisions when either developing or reviewing any proposed projects. The guide enables a comparison between methodologies in order to determine which is most suited for the purpose of future proposed programs.

## **Introduction: Predictive Factors for Obesity in Children**

The epidemic of childhood overweight is gaining prevalence and requires attention. The National Center for Health Statistics reported that between 1999 and 2000, 15% of children (aged 6-11 years) were overweight. The American Obesity Association (2005) reported that approximately 30.3 % of children (aged 6-11) are at risk for overweight and 15.3% are overweight. As of 2004, over 9 million children were considered to be overweight (Institute of Medicine, 2004). In the last thirty years, the percentage of overweight children has doubled (National Institutes of Health (NIH), 2002). An estimated 61% of overweight young people have at least one additional risk factor for heart disease, such as high cholesterol or high blood pressure (Centers for Disease Control (CDC), 2005). In addition, children who are overweight are at greater risk for bone and joint problems, sleep apnea, and social and psychological problems such as stigmatization and poor self-esteem (CDC, 2005). Overweight children are more likely to become overweight adults, and thus have a greater risk of developing health problems, including heart disease, Type 2 diabetes, stroke, cancer, and osteoarthritis (CDC, 2005). Overweight adolescents have a 70% probability of maturing into the overweight

or obese category as adults (NIH, 2002). It is important, then, to examine predictive factors and methods of assessing physical activity and adiposity in the child population.

## **Predictive Factors**

Multiple factors exist in influencing the likelihood of a child becoming at risk for overweight or obesity. These can be broken down into categories of biological, environmental, and behavioral factors.

### **Biological Factors**

Motor development during the fundamental motor skills period is critical for children's development of gross motor skills. Acquisition of these skills has the potential to either encourage or discourage engagement in physical activity for the rest of a child's life (Du Toit & Pienaar, 2003).

### ***Motor Development***

An important question exists regarding differences in gross motor skills between at risk and overweight children versus normal weight children. It remains unclear as to which component begins the cycle of overweight: 1) an increased body weight that leads to inactivity thereby leading to weight gain, or 2) a lack of gross motor skills that impedes participation in physical activity. Graf and colleagues (2004) propose that the child begins an inactive lifestyle, which leads to motor deficits, which begins the cycle of inactivity and a sedentary lifestyle, and eventually causes the child to become at risk for and then overweight.

Overweight has been shown to have a negative effect on gross motor acquisition among four year old children, but no statistical difference between overweight and normal weight three year olds (Du Toit & Pienaar, 2003). This implies that skill acquisition is age-related and not age-determined. Children who are overweight show more deficits in constructs such as balance, agility, perceptual and spatial abilities than do non-overweight children (Du Toit, & Pienaar, 2003).

Controls have been established for sex and at risk for or overweight versus normal weight children to explain the differences in motor deficits. Boys have displayed significantly higher scores than girls when tested for motor skill performance (Graf et al.,

2004). This could be due to the musculature of the male body, motivation, joint compression, or additional factors. When focusing on strictly at risk and overweight versus normal children, Graf and colleagues (2004) found that the motor quotient for the obese group fell in the moderate motor disorder category while the overweight group fell near the normal range. This suggests that sex and age should both be included when discussing the effects of at risk and overweight on motor skill development.

### **Psychosocial Behaviors**

At risk for overweight and overweight children are at risk for developing psychological disorders such as depression. A significant association exists between adolescent obesity and depression (Sjoberg, Nillson, & Leppert, 2005). Children who are at risk for or overweight are often the subject of teasing and bullying (Hayden-Wade et al., 2005), and possess lower levels of self-esteem. Decreased self-esteem is pronounced in the female population, possibly because the physical appearance of girls' bodies changes so dramatically during puberty while they concurrently experience great hormonal changes (Sweeting, Wright, & Minnis, 2005) and social pressures to adhere to an ideal body image.

Another possible cause for an increase in body weight is excessive stress. Children who experience high amounts of interpersonal stress decrease the amount of exercise they attain (Roemmich, Gurgol, & Epstein, 2003). Additionally, eating as a coping strategy is quite common among at risk and overweight children, which perpetuates the cycle of weight gain.

### **Environmental Factors**

Environmental factors affecting childhood overweight include socioeconomic status, familial contributions, dietary intake, and maternal smoking and have been proposed, by some, to be the main cause for the increase in childhood overweight (Tremblay & Willms, 2003).

#### ***Socioeconomic Status***

Research studies have investigated socioeconomic status (SES) and the impact on child and adolescent overweight. It is known that low SES is a risk factor for

adolescent overweight (Janssen, Boyce, Simpson, & Pickett, 2006). At the individual level, SES includes areas of wealth, whereas area level SES includes unemployment rate, income, and percentage of adults with less than a high school education.

Adolescent overweight has been found to have an inverse association with both individual and area levels of SES (Janssen et al., 2006). A positive association exists between unhealthy eating and the less educated as well as physical inactivity and decreasing levels of wealth. Neighborhood safety impacts physical activity of children (Molnar, Gortmaker, Bull, & Buka, 2004). Low neighborhood safety and lack of available safe recreational areas significantly reduce youth physical activity, thereby increasing the risk for overweight during adolescence and into adulthood.

### ***Familial Contributions***

Parents influence food choices of their children through active and passive practices. Parents are role models and influence children through teaching and encouraging self-regulation and healthy behavioral practices (Golan & Crow, 2004). Parents also control the food that is in the home, thus deciding what foods the child consumes.

The environment surrounding a child or adolescent regarding food ingestion is an area to consider when addressing the childhood obesity epidemic. Children are more likely to consume healthier foods, such as fruits and vegetables, when regularly eating together with other family members. In families where eating together is unimportant, adolescents have been found to have a significantly greater risk of being overweight (Mamun, Lawlor, O'Callaghan, Williams, & Najman, 2005).

### ***Dietary Intake***

Dietary intake is an integral part of predicting adiposity in children. The type and quantity of food can impact a child's health and body composition. The availability and consumption of energy-dense snacks such as chips and sodas have increased among children. These foods are highly appealing to children and often contain as many calories as a meal. The increased frequency of snack consumption among children may increase daily caloric intake to levels above that which children are expending, thus leading to weight gain.

The energy intake from foods in the form of carbohydrates, fats, and proteins are also important for analyzing childhood obesity. The dietary intake of children is composed mainly of carbohydrates and fats with minimal protein. Protein is known to have a greater thermal effect and to produce a greater feeling of satiety than fats and carbohydrates (Tanaka et al., 2004). High protein diets (greater than twenty percent of energy intake) have proven to increase weight loss at a greater rate than low fat, high carbohydrate diets, although the long-term effects are controversial (Tanaka et al., 2004).

### ***Maternal Smoking***

It is widely known that smoking has serious health risks such as hypertension, cardiovascular disease, lung cancer, and stroke. Maternal prenatal smoking negatively impacts fetal growth and also affects late childhood blood pressure. Intrauterine exposure to maternal cigarette smoking increases the risk of obesity in childhood or adulthood by 27% (Oken, Huh, Tavera, Rich-Edwards, & Gilman, 2005).

### **Behavioral Factors**

Behavioral factors influencing physical activity in children include uses of multimedia, amount of television viewing, and exercise training.

#### ***Uses of Multimedia***

Multimedia has been found to have positive effects on children's behavior, through increasing physical activity, and to have negative effects on behavior, through decreasing physical activity.

However, most video games do not require that children be active to play. An increase in multimedia use such as video games or computer games is inversely related to the amount of physical activity that children obtain (Stettler, Signer, & Suter, 2004). Stettler et al. (2004) found that the use of electronic games nearly doubled the risk for obesity by the amount of hours per day spent playing them. Tremblay and Willms (2003) concluded that playing video games and watching television for more than two hours a day should be considered a risk factor for childhood overweight. A threshold between at risk, (for one and two hours a day), and overweight, (three hours a day) of video game and television use has been proposed (Tremblay & Willms, 2003).

Positive directions include educational games and games that require physical activity. CD-ROMs and video games have been developed to teach children about diet and exercise. For example, "A Fantastic Voyage" teaches children medical terminology, as well as what a term, like cholesterol, does to one's body (Brown, 2006).

Unfortunately, tools like this are expensive to design because of the large staff that is needed, not only for the designing of the game, but also for the nutrition and exercise portions (Brown, 2006). Games like "Dance Dance Revolution" require children to follow a pattern with their feet that they see on screen. Video game programmers have added the option for parents and/or children to document how many calories have been burned per dance session (Brown, 2006). These video games allow children to become more active through a mode that is appealing to them.

### ***Consumption of Television Viewing***

Multiple studies have shown a positive correlation between consumption of television and childhood obesity; however, no direct association has been shown. Marshall, Biddler, Gorely, Cameron, and Murdey (2004) found a small yet essential relationship between television viewing and body fatness. However, some groups that have high rates of television consumption also have high rates of physical activity. Anderson, Crespo, Bartlett, Cheskin, & Pratt (1998) found that in a group of multiethnic children, (aged 5-16 years) that participated in vigorous physical activity at least 3 times per week, 26% of them watched 4 or more hours of television daily. It is therefore possible that television viewing and physical activity participation are separate phenomena.

### ***Exercise Training***

Two types of exercise training, aerobic and anaerobic, have been explored in the child population. Aerobic exercise refers to repetitive large group muscle exercises that engage the cardiovascular and respiratory systems, such as running, walking, and cycling. Aerobic exercise increases caloric expenditure, which can aid in preventing weight gain or aid in weight loss. Aerobic exercise has been found to decrease body fat in overweight child populations (Gutin et al., 1995; Reybrouck et al., 1990). Anaerobic exercise is defined as high-intensity physical activity performed in short periods of time. The intervals usually last thirty seconds to two minutes in duration. Anaerobic exercise

does not use oxygen as an energy source as aerobic exercise uses, but instead utilizes the phosphagen and lactic acid systems (ASMI) (American Sports Medicine Institute, 2006). Swimming, sprinting, and weight lifting are examples of anaerobic training, in which a maximal level of strength is expended for a short time frame. Resistance training refers to exercise such as weight-lifting that is performed against an external workload (Watts et al., 2005). Resistance training increases lean body (muscle) mass, which leads to an increased amount of calories expended during resting states. Therefore, resistance training has potential for decreasing at risk and overweight in child populations. However, controversy exists regarding use of resistance training in pre-adolescent populations. Opponents of resistance training believe that pre-adolescent children are at an increased risk for injury since growing bones are less resistant to physical stress and damage to the epiphysis may impair normal bone growth (Watts, Jones, Davis & Green, 2005). However, proponents of resistance training believe that appropriately prescribed, properly supervised low to moderate intensity activity can be used safely and effectively in pre-adolescent children (Lillegard & Terrio, 1994). Resistance training combined with dietary modification has been found to decrease body fat in overweight child populations (Woo et al., 2004).

## **Introduction: Adiposity Measurement in Children**

Integral to the study of overweight in children include the capabilities to measure adiposity. These may be broken down into field measures and laboratory measures. A description and discussion of strengths and limitations of each type of measurement, as well as resource charts for quick reference follow.

### **Field Measures**

#### ***Body Mass Index (BMI)***

Body Mass Index, or BMI (sometimes referred to in children and adolescents as “BMI-for Age”), is calculated from measuring the height and weight of an individual then dividing the weight in kilograms by the height, squared in meters:

$BMI = \text{weight}(\text{kg}) / \text{height}_{}^2(\text{m})$ . The resulting number is then plotted on gender specific



growth charts, covering ages 2-20 years. A percentile figure is then found and used to determine a child's range. BMI under the 5<sup>th</sup> percentile is deemed "Underweight;" BMI between the 5<sup>th</sup> and below the 85<sup>th</sup> percentile is considered "Normal;" BMI between the 85<sup>th</sup> and below the 95<sup>th</sup> percentile is "At risk of Overweight;" BMI greater than or equal to the 95<sup>th</sup> percentile is "Overweight" (CDC, 2006).

This simple measure is cost effective (\$2-8 for tape measure, \$10-30 for scale, charts available online free of cost (CDC, 2006)), fast and easy to use, practical, and is the most commonly used measure for screening large populations (Goran, 1998). It is useful for both group comparison as well as pre-post, within subject assessments. BMI also has the capability to retrospectively assess populations in which height and weight records exist (Storlien, Bird, & Silva, 1987).

Limitations of BMI assessment in children have to do primarily with the fact that growing children have a more complex body composition than adults. For example, children's maturation and growth patterns vary, with large inter- and intraindividual variations, causing changes in body composition/BMI (Wang, 2004). Additionally, using BMI is problematic due to the fact that it does not take into account body type or ethnicity (Wang, 2004). For example, a child with an athletic build may be assessed as overweight, though he/she does not possess abnormally high amounts of body fat. Different ethnic groups vary with regards to body type. European Americans are typically a larger population than Asian Americans; using the same charts for both could be problematic. Thus, future research directions should include establishment of body type and ethnicity specific charts. In addition, BMI is insensitive to underweight and overweight individuals possibly underestimating an increase in fatness (Wang, 2004). This measure has also been found to be less accurate in male adolescents (Demerath et al., 2006). In sum, BMI is the most widely used tool in the child population due to its convenience and ability to assess overweight and at risk for overweight.

### ***Skinfolds/ Anthropometry***

Adiposity is frequently assessed through measures of skinfold thickness. Skinfold measures are taken with a skinfold caliper, a handheld tool that measures the thickness of skin as it is pinched by the experimenter. This procedure is designed to measure the layers of fat underneath the skin. Locations of measurement in children

typically include triceps, calf, and subscapular measurements. Prediction models and equations are then used to estimate body fat mass. Examiners must be trained to use skinfold calipers, as accuracy depends upon the skill and interpretation of the examiner. Because accuracy of skinfold measurement is dependent upon practice and experience, large inter-observer variability has been found (Freedman, Ogden, Berenson, & Horlick, 2005). Skinfold measurement assumes the same fat distribution for all subjects, and do not take into account fat deposits not directly under the skin. Due to differences in body types across ethnicities, the need exists for ethnicity-specific equations to calculate body fat. Skinfold measures have also been shown to be inaccurate in overweight child populations due to the fact that, in some cases, skinfold calipers are incapable of capturing the entire skinfold. Advantages of this field measure include low cost, ranging from \$17-30, mobility, quick assessment time, relative ease of use, and thus, usefulness in screening large populations.

### ***Girth/Circumference Measurements***

Girth or circumference measurements are field measures designed to estimate body fat by measuring circumference of an individual's waist, hips, chest, arm, and thigh, typically with a simple tape measure. Equations are then used to estimate body fat.

Anyone can use this simple method; it is cost effective, about \$2-8 for a tape measure, fast and easy, and therefore useful in screening large populations. This measurement is also useful in assessing change in fat distribution, which is particularly useful as a motivational tool for those participating in an intervention or weight loss program. Girth measurements are often used in concert with skinfold measurements to increase accuracy (Goran, 1998). Additionally, waist circumference is a useful measure in predicting insulin resistance, a risk factor for diabetes.

However, girth measurements are perhaps the least accurate method, with even lower accuracy in underweight and overweight populations. Furthermore, central fat distribution is greater in children of African, Mexican, and Native American descent, as girth measurement is insensitive to ethnic differences (Goran, 1998).

### ***Bioelectrical Impedance Analysis (BIA)***

Estimations of total body water, fat free mass and percent body fat can be deduced by the subject's height (cm), weight (kg), and resistance to small electric currents circulated through one's body. There are many different types of BIA machines, but most are typically "tetra polar," having four electrodes: two that emit an electrical current and two others that detect the current as it passes through the body. To ensure that the composition of the whole body is accurately determined, electrodes are applied at both the wrists and the feet. BIA measures the impedance or resistance to the signal as it travels through the water that is found in muscle and fat. The more muscle an individual's body contains, the more water the body can hold. The greater the amount of water, the easier it is for the current to pass through. Greater fat results in greater resistance to the current. After a resistance measure is found, formulas are used to determine total body water, fat-free mass, fat mass, and percent body fat.

The following is the Kushner formula for determining total body water.

$$\text{Total Body Water} = (0.593 \cdot \text{Ht}^2 / \text{R}) + (0.065 \cdot \text{W}) + 0.04$$

Ht = height in cm

R = resistance in ohms

W = weight in kg

(Beertema, Van Hezewijk, Kester, Forget, & Van Kreel, 2000)

For the calculation of fat-free mass, a hydration constant must be chosen. A hydration constant of .76 is a fairly accepted value for children around twelve years of age.

$$\text{Fat Free Mass} = \frac{\text{Total body water}}{.76} ; \text{ Fat Mass} = \text{Weight} - \text{Fat Free Mass}$$

$$\% \text{ Fat} = \frac{\text{Fat Mass}}{\text{Body Weight}} \times 100$$

Bioelectrical impedance analysis is an easy, inexpensive, and quick way to determine body fat percentage in individuals. Bioelectrical impedance, like other assessment tools, faces many unique challenges when describing body composition of children. Changes in the relative lengths of limbs and trunk during growth may influence the relation between total body water and  $\text{height}^2/R$ ; therefore, the use of different age ranges may introduce incompatibility (Wells et al., 1999). Furthermore, the large variation of growth and maturation patterns among boys and girls before the approximate age of fifteen makes it difficult to develop a formula for total body water that is sensitive to gender and maturational differences. Growth also limits the ability to gather accurate pre-post assessments among children. The Kushner equation for determining total body water, as shown above, is generally recommended for young children despite its lack of validation in children of different ethnic groups (Goran, 1998). Some machines, such as those with an appearance similar to bathroom scales, are inaccurate because they neglect to measure all compartments of the body. Impedance analyzers, furthermore, vary in measurement values according to their manufacturer, even after calibration (Houtkooper, Going, Lohman, Roche, & Loan, 1992). Despite these limitations, bioimpedance machines are widely used because of their mobility, ease of use, and relatively low cost.

## **Laboratory Measures**

### ***Dual Energy X-Ray Absorptiometry (DEXA)***

Dual energy x-ray absorptiometry (DEXA or DXA) is a laboratory measure of fat mass, lean tissue mass, and bone (mineral) mass through an x-ray scan of an individual's body. The scan usually lasts about ten minutes. Software computation is used to determine body composition, factoring in variables such as age, weight, height, and sex. DEXA machines are expensive to purchase (approximately \$70,000), and require technician training, (usually about \$800). Due to its high cost, DEXA is impractical for screening large populations but, because of its high accuracy, has been used extensively in cross-validation studies. However, questions do exist regarding the reliability of DEXA software in computing data for child populations (Goran, 1998).

### ***Hydrostatic/ Underwater Weighing***

Hydrostatic or underwater weighing is a laboratory method used to measure body density. This is accomplished by total submersion of an individual in a tank of water following the expulsion of all air from his lungs. Underwater weight and water displacement are measured and compared with the individual's "dry weight" to determine body density through use of a series of calculations. Because fat is less dense than muscle, this technique can provide an accurate estimate of body fat. A trained operator is required, and experience is necessary for maximal accuracy. From a practical standpoint, this method is suboptimal for use among small children, as they are required to hold their breath and stay underwater for several seconds in an unfamiliar laboratory environment. In addition, hydrostatic weighing is relatively inaccurate in young children due to the lack of established equations for this population (Wells et al., 1999). Hydrostatic units are costly, upwards of \$30,000. Hydrostatic weighing holds relatively high accuracy in older children, but due to its nature, is impractical in screening young children and large populations.

### ***Air-displacement Plethysmography (ADP)***

Established on the idea of determining total body volume for further body composition inferences, air displacement plethysmography has become increasingly popular because of its growing practicality. ADP is one of the more accurate measures of body composition in people of all ages and all ranges of body fatness (Fields & Goran, 2000). ADP measures total body volume and then equations are used to determine body density and body fat percentage.

An individual enters an airtight, "podlike" chamber and breathes into a tube connected to the unit. Total body volume is derived by measuring small changes in pressure between the test chambers in which subjects sit with that of a reference chamber. In the past, this technique relied heavily on conditions that made it difficult to duplicate testing due to the required maintenance of a constant temperature (Fields, Goran, & McCrory, 2002). However, these setbacks have been overcome with the most recent design in ADP known as the "Bod Pod."

Following calibration, a subject can step into the test chamber and have his/her raw body volume ( $V_{brow}$ ) and thoracic gas volume ( $V_{tg}$ ) measured. Thoracic gas

volume is attained by breathing into a tube and filter that connect to the reference chamber in the rear of the Bod Pod. These measurements are then used in an equation to calculate body density. The following is the Lohman equation for calculating body density, which uses age-dependent constants for changes in the density of the fat-free mass and hydration status (Fields & Goran, 2000).

$$D_b = M / (V_{b \text{ raw}} + 0.40V_{tg} - SAA)$$

$D_b$  = body density

$M$  = mass of the subject (Kg)

$V_{b \text{ raw}}$  = Raw body volume (L)

$V_{tg}$  = Thoracic gas volume

$SAA$  = Surface area artifact

Body fat percentage is then estimated from body density:

$$\% \text{ fat} = (C_1/D_b - C_2) \times 100$$

Age, yr	Boys		Girls	
	$C_1$	$C_2$	$C_1$	$C_2$
9-10	5.30	4.80	5.35	4.95
11-12	5.23	4.81	5.25	4.84
13-14	5.07	4.64	5.12	4.69

(Fields & Goran, 2000)

Limitations do exist in regards to the Bod Pod. Some researchers suggest that smaller children are not measured as accurately because of the high ratio of test compartment volume to body volume, but the development of smaller machines has eliminated much skepticism. Though the small spaces are usually not as intimidating to children as the procedure of underwater weighing, children must be able to stay still for

a significant amount of time for the results to be accurate. Additionally, clothing worn in the Bod Pod must be regulated, as excess clothing can cause underestimation of body volume; thus, individuals should wear tight fitting swimsuits for optimal measurement accuracy. Bod Pod is expensive, ranging from \$30,000-\$40,000.

Though a paucity of research exists in the cross-validation of Bod Pod among the child population, Fields and Goran (2000) found the Bod Pod to correlate with a four-compartment model ( $R^2 = 0.97$ ). It was also found to be the most accurate, precise, and unbiased technique in measuring fat mass in 9 to 14 year olds, compared with DEXA, Hydrostatic weighing, and Total Body Water. High accuracy, quick measurement time, and unbiased measurements are the strengths of Bod Pod.

### ***Densitometry***

Densitometry involves the measurement of body composition through a combination of different laboratory techniques. Body composition is broken up into the basic components of: fat mass, lean (protein) tissue mass, bone (mineral) mass, and water mass. The most thorough assessment, known as the four-compartment model and widely considered to be the “gold standard” of body composition assessment, measures all of these components. The three-compartment model and the two-compartment model divide body composition into the components of 1) fat mass, water, and fat free dry mass; and 2) fat mass and fat free mass, respectively (Wells et al., 1999). Methods used to derive these measures include DEXA to measure bone mass, hydrostatic weighing or Bod Pod to measure lean body mass and fat mass, and Bioelectrical Impedance Analysis (BIA) or Isotope Dilution methods to measure total body water content.

Densitometry is expensive. It involves the use of several costly machines requiring skilled technicians to operate, and it is inaccessible to the general population, as these methods are available only in research settings. The need to conduct several tests on each individual makes it impractical for large populations.

However, because the four-compartment model is considered to be the most accurate of the body composition assessments, it is useful in cross-validation studies of other measures of body composition (Houtkooper, et al., 1992).

### ***Magnetic Resonance Imaging (MRI)***

Computer assisted diagnosis (CAD) techniques have made the use of whole body Magnetic Resonance Imaging (MRI) very useful in identifying total body fat and its three-dimensional location in the body. This technique has become increasingly common, with the growing availability of MRI technology. A contributing factor to the increased usage of MRI lies within the decreased usage of CT scans (computed tomography) due to its high radiation doses (Brennan et al., 2005).

MRI works by scanning the body into a set of overlapping coronal cross sections. The sections further divide the body into small three-dimensional cubes called voxels that label fatty tissue by specific tones of grey. Before scanning an individual, however, the predetermined coronal section and voxel size must be determined according to the experimenter's desire for specificity. Accordingly, smaller slice thickness and voxel values result in greater specificity (Brennan et al., 2005). Once these parameters are determined according to the size and specificity of the subject, scans can be taken. Because of wide variation of gray among cross sections, it is necessary to use an intensity histogram to algorithmically identify the peaks characteristic of soft tissue. Combined with coordinate information, these gray-scale peaks are aligned to match the distribution across all sections.

Calculation of the total body fat (TBF) is performed using the following formula:

$$\text{TBF} = (\text{Nfat voxels})(\text{Voxel\_Dim})(\text{Fat\_Density})$$

Nfat voxels = total number of fat voxels contained in the data set

Voxel\_Dim = voxel dimension (cm<sup>3</sup>)

Fat Density = density of the fat tissue

Then

$$\% \text{ Fat} = \frac{\text{Fat Mass}}{\text{Body Weight}} \times 100$$

(Brennan et al., 2005)

When using MRI for children, especially young children, it must be considered that movement can cause disturbances in the images, causing difficulty in interpretation.



Because conditions in the MRI machine can be cold from the liquid helium or liquid nitrogen in the superconducting magnet, small children especially infants should be wrapped in blankets to keep them warm (Shen, Lui, Punyanitya, Chen, & Heymsfield, 2005). In addition, complications with the loud noise and small spaces must be accounted for with the use of earplugs and a diversion like music to keep them at ease. Despite the increase in MRI facilities, this technology is still very expensive to maintain and to use.

### ***Computed Tomography (CT or CAT Scan)***

Computed tomography is similar to MRI in the way that it scans multiple slices of the body. Multiple x-rays circle the body creating computerized cross-sectional images of body tissues and organs that are used to determine the volume of different body compartments. CT images of the abdomen allow computerized measurement of total fat area, and also enable the differentiation of subcutaneous fat from intra-abdominal fat (Borkan et al., 1982). However, due to radiation exposure, CT is now considered unethical to use in assessment of child populations.

### ***Isotopic Dilution***

Isotopic dilution measures total body water, which is then used in a series of equations to determine fat-free mass, fat mass, and body fat percentage. Total body water is measured using stable isotopes such as Oxygen 18 or Deuterium Oxide, based on the assumption that isotope distribution and exchange is similar to that of water. Although Oxygen 18 is typically more accurate, Deuterium Oxide is typically used because of its significantly lower cost.

The procedure requires one of the isotopes to be administered orally or intravenously. Pre and post-dose (at 3-5 hours) measures of plasma, saliva, or urine are taken. A mass spectrometer is then used to determine isotope ratio measurements of the samples. The results are reported as a delta relative to a reference gas.

$$\text{Delta D} = [(\text{Ratio of Sample} - \text{Ratio of Reference}) / (\text{Ratio of Reference})] \times 1000$$

Calculation of total body water, according to the back extrapolation method, requires the experimenter to figure out the delta values for the pre-dose (dpre) and post-dose (dpost)

samples (Wells et al., 2005). Furthermore, the amount of dose diluted and water used is recorded. The Deuterium content of the tap water (dtap) and diluted dose (ddose) are measured. Total body water in moles is calculated from the dilution of heavy isotopes using the following:

$$\text{TBW (moles)} = ((\text{ddose} - \text{dtap}) / (\text{dpost} - \text{dpre})) \times (\text{WA} / 18.02a)$$

W = amount of water used to dilute the dose

A = amount of dose (g) administered to subject

a = amount of dose (g) diluted for analysis

To convert to TBW in Kg:

$$\text{TBW (kg)} = \text{TBW (moles)} \times 18.02 / 1000\text{g/kg}$$

It has been determined experimentally that Deuterium Oxide overestimates total body water by 4%, while Oxygen 18 overestimates total body water by 1% (Metabolic Solutions, 2006). Overestimation occurs because both Deuterium and Oxygen18 binds to acidic amino acids of body proteins or other non-exchangeable sites. Consequently, formulas have been derived to correct these problems:

$$\text{Deuterium dilution: Corrected TBW (kg)} = \text{TBW (kg)} / 1.044$$

$$\text{Oxygen 18: Corrected TBW (kg)} = \text{TBW (kg)} / 1.01$$

(Wells et al., 2005)

Based on the understanding of the percent water in fat-free mass, one is able to determine the total fat-free mass in kilograms. The hydration fraction, however, is known to decrease into adulthood where it seems to level off at around 73% at about 22 years of age (Eckhardt et al., 2003). According to some studies, 76% is a good value to use for children around 12 years of age (Wells et al., 1999; Eckhardt, 2003).

$$\text{FFM (kg)} = \text{corrected TBW (kg)} / 0.76$$

Then,

$$\text{Fat Mass (kg)} = \text{Body weight (kg)} - \text{FFM (kg)}; \text{ \% Body Fat} = \frac{\text{Fat Mass}}{\text{Body Weight}} \times 100$$

One study that compared isotope dilution to a four-compartment model for twelve year-old children had a correlation of .95, a specificity of .94, and a sensitivity of .93 (Bray, DeLany, Volaufova, Harsha, & Champagne, 2002). Furthermore, one study showed that age and sex-specific differences in hydration of fat-free mass are rather minor (Eckhardt et al., 2003). The long duration and the added expense, however, have kept this procedure from being used widely in clinical practice. Furthermore, it may be unethical to require small children to fast between the administration of the isotopes and the post-dose sample.

The following resource charts provide a summary of the methods of adiposity measurement and assessment in children for quick reference.

	<b>BMI</b>	<b>Skinfolds</b>	<b>Girth Measurements</b>	<b>DEXA</b>	<b>Underwater/ Hydrostatic Weighing</b>	<b>Densitometry</b>
<b>Description</b>	Determined by measuring height and weight, then calculating a BMI that is then plotted on norm-referenced charts.	Skinfold calipers used to measure body fat at select locations on body. Prediction models and equations are then used to estimate body fat mass.	A tape measure is used to measure circumference around waist, hip, chest, arm, and thigh. Equations then used to estimate body fat.	Machine that performs an X-ray scan of body and then computer software used to determine fat mass, lean tissue mass, and mineral mass.	Individual submerged in a tank of water. Underwater weight is measured and used to calculate body density and then body fat percentage.	Combined usage of various lab techniques to formulate the most accurate assessment of body composition. Usage of DXA, Underwater weighing or ADP/Bod Pod, BIA or DH20.
<b>Type</b>	Field	Field	Field	Lab	Lab	Lab
<b>Age Issues</b>	Less accurate in male adolescents.	N/A	Males have greater amounts of intraabdominal fat than females in adolescence, but not in prepubescence.	Reliability issues regarding software for children's body composition. See below.	Relatively low precision; difficult to perform in young children	Difficult to perform in young children.
<b>Gender Issues</b>	Less accurate in male adolescents.	N/A	See above.	N/A	N/A	See DXA, BIA, and Isotope Methods.
<b>Accessibility</b>	Anyone can use.	Must be trained in usage.	Anyone can use.	Available in research facilities. Requires skilled technicians.	Available in research facilities. Requires skilled technicians.	Requires use of several machines/methods. Available only in research settings.
<b>Accuracy</b>	Low	Dependent upon skill of examiner. Large inter-observer variability.	Low accuracy, especially for individuals very low or very high in fat.	High	High	Highest Four-compartment model considered the "gold standard."
<b>Cost</b>	Low \$2-\$8 for tape measure, \$10-50 for scale	Low \$30 for skinfold caliper	Low \$2-\$8 for tape measure	High \$70,000+	High \$30,000+	High
<b>Strengths</b>	Fast and easy. Useful for large populations. Retrospective assessment capabilities.	Fast and easy. Useful for screening large populations.	Fast and easy. Useful for large populations. Waist circumference predicts insulin resistance.	Provides measurement of fat mass, lean tissue mass, and mineral mass.	Accuracy	Highest accuracy. Provides measurement of fat mass, lean tissue mass, and mineral mass.
<b>Limitations</b>	Need for ethnicity-specific charts. Low sensitivity for over and underweight.	Less accurate in overweight populations. Need for ethnicity-specific equations.	Central fat distribution is greater in children of African, Mexican, and Native-American descent.	Software for child populations. Impractical for large populations.	Uncomfortable for children. Impractical for large populations.	Time consuming. Impractical for screening large populations.

	<b>Bioelectrical Impedance Analysis (BIA)</b>	<b>ADP/ Bod Pod</b>	<b>Isotopic Dilution</b>	<b>Magnetic Resonance Imaging (MRI)</b>	<b>Computed Tomography (CT, CAT Scan)*</b>
<b>Description</b>	Based on the body's resistance to an electrical current circulated through the body. Estimates total body water, fat-free mass, and body fat percentage.	Involves an airtight chamber that measures body volume relative to pressure changes. Body density and body fat are then calculated.	Involves the ingestion of a stable isotope in conjunction with pre-dose and post-dose urine, saliva, or plasma samples. An estimate of total body water is derived and used to calculate fat-free mass, fat mass, and body fat percentage.	Whole body scans or compartment scans can determine the location and volume of total fat.	Scans body to create a computerized image that can show be used to determine total fat area.
<b>Type</b>	Field	Lab	Lab	Lab	Lab
<b>Age Issues</b>	Validity issues of total body water formulas due to growth and maturation.	Useful for all age groups. Infant-specific models available.	Ethical concerns for use in children due to requirement of child to fast between measurements.	Whole body scans difficult for young children due to loud noises, cold temperature, small spaces, and requirement of child to remain still.	No longer used on children because of radiation exposure.
<b>Gender Issues</b>	N/A	N/A	Sex specific ethnic differences in hydration of the FFM are rather minor.	N/A	N/A
<b>Accessibility</b>	Easily transportable.	Available in research facilities.	Requires lab work to process samples.	Available in research and healthcare facilities. Requires skilled technicians.	Available in research facilities. Requires skilled technicians.
<b>Accuracy</b>	Medium Dependent upon machine used and total body water equation used.	High	High	High	High
<b>Cost</b>	Moderate \$100-400	High \$30,000-40,000	Moderate	High	High
<b>Strengths</b>	Fast Limited training required.	Accuracy Fast measurement time.	Accuracy	Accuracy Measures adiposity location.	Accuracy
<b>Limitations</b>	Lack of validation in children of different ethnic groups.	Small, enclosed space. Requires child to remain still. Baggy clothing can disrupt calculations.	Requires extensive lab work. Time consuming. Requires children to fast between samples.	Small, enclosed space is loud and cold. Requires child to remain still.	*No longer used in children due to radiation exposure.

## **Physical Activity Measurements in Children**

The measurement of physical activity can be broken down into two groups, electronic devices and paper form. Each group can be broken into further sub categories of measurement apparatuses and techniques. There are pros and cons associated with the sub categories as well as the groups as a whole.

The electronic devices explored include pedometers, accelerometers, the IDEEA device and heart rate monitors. The pros and cons will be discussed for each device as well as a description of which features are available and which features should be considered when purchasing these electronic devices.

### **Pedometers**

#### ***Benefits***

Compared to the other electronic devices, pedometers are generally the most inexpensive, ranging from \$15-30 ( Tudor-Locke, Ainsworth, Thompson, & Matthews, 2002a; Tudor-Locke Williams, Reis, & Pluto, 2002b; Tudor-Locke et al., 2004). They have a user-friendly output (steps taken, steps/day) that can easily be understood by the novice record keeper when compared to the outputs of accelerometers and heart rate monitors.

#### ***Limitations***

A limitation with pedometers is that they do not have the capability to discriminate between different modes of physical activity or even the intensity of that activity. A child riding a bicycle would not achieve step counts. A child running might not be interpreted differently than a child walking if proper measurement care is not taken. This problem of walk/run can be fixed with some pedometers that have different walk/run modes programmed into the device itself (Bassett et al., 1996; Le Masurier, Lee, & Tudor-Locke, 2004; Sirard & Pate, 2001; Trost, 2001; Tudor-Locke, et al., 2002a; Tudor-Locke et al., 2002b, 2004; Weston, Petosa, & Pate, 1997).

## **Features**

The features on pedometers range from brand to brand and expand beyond the scope of this paper, but included is a breakdown of some important items to think about when purchasing a pedometer.

### *Counting Mechanism*

Most pedometers function similarly in the respect that they all have some sort of an onboard computer “counting” the steps. Precautions must be taken with older pedometers that utilize a mechanical counting device (physical numbers that move with each step), since large errors are associated with these devices.

### *Calibration*

Calibrating pedometers requires one to either measure stride length or to walk a specified number of steps, counting as the steps are taken, and then reconciling personal step count with that of the pedometer reading. If the pedometer records more steps than what one actually takes, the sensitivity needs to be reduced; if however, it reads less steps than actually taken, the sensitivity switch needs to be moved towards a more sensitive level. An important mention is that using a pedometer requires a calibration that will be specific to each individual being tested. The calibration allows the pedometer to output the distance walked. Some pedometers on the market do not give this distance output and hence do not need to be calibrated in this manner.

### *Variable Sensitivity Switch*

When it comes to working with children of different age ranges, a variable sensitivity switch might be necessary to differentiate between the ages. A small child will not elicit the same response from the pedometer’s lever arm as a larger child or adult will. The sensitivity switch takes this into account. One thing to note is that with increased sensitivity, the error in picking up unwanted movements increases as well. Proper care must be taken to follow the manufacturer’s directions on how to set this sensitivity level otherwise the data collected will be inaccurate.

### *Walk/Run Modes*

Some pedometers have a switch that allows a distinction to be made between running and walking. Without this distinction, step counts can be falsely construed, as the body does not generate the same vertical movements while walking and running.

### *Plastic Cover*

While this feature does not seem as important as the electronics of the device, absence of a plastic cover can confound data collection. During physical activity, a hand or other object can easily press a 'reset' or other button if a plastic shield is not on the device to keep the buttons covered.

### *Usage Time*

Pedometers have varying amounts of memory ranging from 99.9 miles to 99,999 steps or by number of days of recording possible. The amount needed depends on the use of the pedometer.

### *Output Data*

Output data includes information measured by the pedometer made available to the user. Individuals must choose a pedometer that gives them the data that they want. Omron makes pedometers that show step counts, distance in miles, kilocalorie counts, as well as the time of day. Others show only step counts (Bassett et al., 1996).

### ***Final Note***

With regard to pedometers, the more funds spent on a pedometer, typically the more accurate the pedometer. In the world of pedometers, Yamax is a highly regarded brand by researchers and has the data to back up its claims. In a comparison between some less expensive models, Yamax performed with 1% error of the true distance walked while the other models were within 11%. Yamax was the only pedometer to perform well at slow (walking) speeds while all brands performed similarly at fast speeds (Bassett et al., 1996). Le Masurier, Lee, & Tudor-Locke (2004) make the claim that Yamax is the most accurate under controlled and free-living conditions. Other well-known brands include Omron and Accusplit.

A word of caution must be noted that it is not recommended to compare step counts between brands, as the between results are not reliable (Bassett et al., 1996).

### **Accelerometers**

#### ***Benefits***

Some accelerometers have the capability of reading movement in more than one plane, and up to three planes. The additional planes allow for a broader spectrum of physical activity to be recorded beyond just walking and running as in a pedometer.



Accelerometers also possess the capacity to distinguish between varying intensities of physical activity.

### ***Limitations***

Despite the benefit of the three planes of motion, accelerometers cannot assess physical activity associated with cycling. In addition, when compared with pedometers, accelerometers are more complicated in terms of learning to operate the hardware and software. Accelerometers require a computer and cables to download the data and specific software to interpret this data. For this reason, accelerometers are ideal for use in research projects that need to examine differences in the intensity of physical activity achieved rather than just measuring amount of physical activity.

The primary limitation regarding accelerometers is the cost. They are expensive, ranging from \$50-450 per unit. It becomes a trade off of cost and accuracy when compared to pedometers (Puyau, Adolph, Vohra & Butte, 2002; Sirard & Pate, 2001; Trost, 2001; Trost, McIver, & Pate, 2005; Tudor-Locke et al., 2002a; Tudor-Locke et al., 2002b, 2004).

### ***Features***

#### *Type*

There are three different types of accelerometers: uniaxial, biaxial, and triaxial. Accuracy of measurement increases as the number of planes being measured increases, and so does the cost.

#### *Plastic Cover*

As with the pedometers, the issue of a plastic cover is just as critical with accelerometers. The cover protects the buttons from accidental contact and thus confounding data collection.

#### *Memory*

A key component of any accelerometer is the amount of memory that it contains. With up to three transducers and the number of readings taken per second varying, the amount of memory needed to handle this data can be large. Another factor to consider is the time in which measurements will be taken and to plan accordingly for enough memory to handle your purpose in using accelerometers.

#### *User Friendliness*

Since accelerometers require some know-how in order to operate them, user friendliness can be an important feature. Some companies offer customer support to help with the function of the device while others offer support for the software analysis. It might be worth additional cost if help is available in person instead of just over the phone or email. Included in this category is the flexibility of the software as well. Some software packages offer a robust array of analysis tools allowing the user to create customized reports such as graphic representations of the activity achieved each hour throughout the entire day while others are straight forward and limited in this aspect. If these limited packages provide all of the analysis that is needed, they might be the better choice (Troost, McIver, & Pate, 2005).

### ***Final Note***

One consideration when looking at the price of accelerometers is to determine the cost per unit. The accelerometer itself is just part of the required package of computer interface, software, belts, pouches, repair, and maintenance all or none of which could be included with the accelerometer. A well-known brand in the uniaxial category is Caltrac. For the triaxial variety, Tritrac is commonly used by researchers (Troost et al., 2005).

## **Intelligent Device for Energy Expenditure and Activity (IDEEA)**

### ***Benefits***

The IDEEA device contains the ability to discriminate 45 different movement activities ranging from running to sitting and lying to step climbing. It quantifies the duration, frequency, intensity and energy expenditure for each activity, which is much more information than the pedometers or accelerometers are capable of producing. The accuracy and reproducibility of the data is unparalleled, with values in the 96-98% range. The device is capable of collecting data for up to seven days straight.

The IDEEA device comes with a robust software package that allows for the formation of charts, animations, tables, curves, and histograms for time periods that are selected by the user. The company will provide assistance in the data collection, archiving, analysis, and database setup.

### ***Limitations***

The biggest drawback of the IDEEA is the price. For small numbers, each complete system costs between \$2,000-\$4,000, but for large quantities, the cost per unit can be a few hundred dollars. As mentioned earlier, there is a trade off between cost and accuracy, which holds true for the IDEEA as well. Additionally, the device is much more cumbersome than wearing a pedometer or accelerometer. While the box itself is worn on the waist like the other devices, five sensors must be placed on the body with medical tape on the chest, thighs, and feet.

### ***Features***

IDEEA is currently the only device of its kind (made by MiniSun); therefore, no features can be noted between competing companies.

### ***Final Note***

This device has not yet been validated in children. The IDEEA device is by far the most costly, but shows the most accurate results for true daily living energy expenditure (Zhang et al., 2004; Zhang et al., 2003).

## **Heart Rate Monitors**

### ***Benefits***

Heart rate monitors follow the notion that heart rate and energy expenditure are linear in relation during steady state exercise. Each heart rate monitor can be calibrated to the individual subject for estimated counts of free-living energy expenditure. With this in mind, patterns of activity can be tweaked out from the data such as a child going to recess as opposed to sitting in a classroom.

Heart rate monitors require minimal knowledge to use and are relatively unobtrusive, requiring a band to be wrapped around one's chest to measure heartbeats. Whether this is less obtrusive than pedometers and accelerometers depends upon personal preference.

### ***Limitations***

The greatest issue to consider with heart rate monitors is the fact that physical activity is not the only thing that affects heart rate. Age, anxiety level, temperature of surroundings, and body size are some of the factors that can increase heart rate due to

non-physical activity related issues. The heart rate tends to remain elevated after bouts of exercise as well, longer for obese people, providing a possible false increased length of time for the physical activity event (Crouter et al., 2004; Rice & Howell, 2000; Sirard & Pate, 2001; Trost, 2001; Weston et al., 1997).

Heart rate monitors are of moderate cost. Priced similarly to accelerometers, heart rate monitors range from below \$100 to around \$400, depending upon the features. As with the other devices mentioned, cost increases with features.

### **Features**

#### *Programmability*

Heart rate monitors can be programmed to be subject-specific based on calculations of actual subject  $VO_{2max}$  and  $HR_{max}$ . These measurements require additional techniques to obtain the values, but provide a more accurate result for energy expenditure.

#### *Software*

A software package is required to properly analyze the heart rate data, which is not provided with all brands (even models within brands do not provide the software), (Crouter et al., 2004; Rice & Howell, 2000; Sirard & Pate, 2001; Trost, 2001; Weston et al., 1997).

### **Final Note**

Polar is a reputable brand of heart rate monitor that carries several different models for several different uses. It would be most advantageous to determine the necessary qualities of the heart rate monitor in terms of ease of use, functionality, and user interface and find the best fit based on price (Crouter et al., 2004; Weston et al., 1997).

### **Self-Report Instruments**

“Self-Report Instruments” are one of the most popular methods for use in children and adults when trying to assess physical activity performance. There are some discrepancies in the research, however, because children are not always the most reliable subjects. Children engage in activities sporadically. Because they are less developed in their cognitive abilities, they are not a reliable source to report their

own activities. Two assessment instruments that have proven useful are the Previous Day Physical Activity Recall (PDPAR) and the Activity Gram.

### **Previous Day Physical Activity Recall (PDPAR)**

#### *Description*

PDPAR is a pencil and paper exam that contains a time-based grid. This assessment targets the hours after school exclusively, during which children are to report the activities according to intensity-level for every 30 minute block of time. A list of the most common activities that children participate in daily is provided to the children as they complete the PDPAR. Children are asked to select a specific activity on the list, record its assigned number within the time block, and then rate the level of the activity according to its intensity (very light, light, medium, and hard). This test is helpful in determining the amount and type of activity that a child does in a specific time period (Welk & Wood, 2000).

#### ***Benefits***

The PDPAR is easier for children to recall activities from the day before in comparison to activities from the week before. This test also has specific categories which help the user choose what kind of activity and at what level they are performing at, such as, type, intensity and duration of the activity. The PDPAR has a relatively low cost (Xerox copying); one of the most inexpensive assessment tests.

#### ***Limitations***

The results of these tests may not be specifically made for a child's activity level. Since the test may not be completely valid for children it is recommended that the test be used for three consecutive days (two week days and one weekend day) to show typical activity (Welk & Wood, 2000).

### **ACTIVITYGRAM / FITNESSGRAM**

#### *Description*

ACTIVITYGRAM / FITNESSGRAM is the most recent version of the PDPAR in a software form. This assessment has a similar time-based grid, but is a computerized assessment of physical activity. A student version of the exam is also available.

Students can complete the assessment individually in a P.E. class or in a computer lab. The program is designed for children to do with little or no assistance. A paper form is also available to be used as a practice test and to aid in data entry. The structure of the ACTIVITYGRAM is very similar to the PDPAR. This assessment is more accommodating, however, because it is cooperative for use in school and on weekends at home. Similar to the PDPAR, children pick an activity and activity level for a 30-minute block of time. They can state if they are active all of the time or some of the time for each 30-minute block. One advantage over the PDPAR is that the computer program forces the child to make a choice for each block of time and prompts the child to complete the intensity of activity prior to moving on to the next block of time; unlike the PDPAR where children may leave cells blank or fail to rate intensity correctly.

### ***Benefits***

The ACTIVITYGRAM provides a detailed amount of information for the level of intensity and the type of activity that is performed, as well as information about the time that the activity occurred. This software provides considerable compensation over the pencil and paper form of the PDPAR. The settings in the software help children complete the assessment with ease and give more accurate results. For instance, if a child enters watching television as an activity, the computer will automatically categorize this activity as a rest activity. A big advantage of this test is that a detailed report can be printed and given out to parents of the subjects; this will inform parents of the child's physical activity level (Welk & Wood, 2000).

### ***Limitations***

A weakness for the ACTIVITY GRAM is the high cost of software required for the assessment. FITNESSGRAM software ranges from \$250-\$1500, while student report forms can be as expensive as \$55.

### **Physical Activity Journals/Diaries**

Physical activity journals or diaries are potential methods of tracking physical activity, but have limited practicality for use in the child population. The participant has to be committed to recording their activities regularly or their records may distort the normal pattern of physical activity (Howell & Rice, 2000).

### ***Benefits***

Data for this assessment can be reported in different ways (time or caloric expenditure). Data from Activity Diaries is very similar to reports from other direct observation assessments.

### ***Limitations***

This assessment has been shown to have little uniformity across different instrument studies. Children must be cognizant enough to be able to remember to record their data regularly at the designated times. Without proper training of how to find and record physical activity levels, diaries and journals may be only marginally helpful in monitoring activity levels (Howell & Rice, 2000).

### **Parent or Teacher Report Measures**

These observations are done by either a parent or a teacher who has experience assessing physical activity (Howell & Rice, 2000).

### ***Benefits***

This assessment can be used with young children who are not able to fill out their own assessment or respond to a self-report.

### ***Limitations***

Parent or teacher reports have limited reliability and validity with direct or indirect measures of assessment. Neither the teacher nor parent is able to be with the child all day, so it is impossible to give a complete assessment of the child's physical activity. Parents and teachers are also not necessarily experienced enough to give specifics such as type, frequency, duration and intensity for each child (Howell & Rice, 2000). Additionally, parents or teachers may be biased in their observations.

### **Direct Observation Measures**

For this assessment the observer doing the assessment can watch frequency and type of physical activity and record these activities first hand.

### ***Benefits***

An observer can be in the exact environment for the observation where the activity is occurring. These instruments were developed to accommodate ages 20 months to 11 years.

### ***Limitations***

Direct observation is impractical for assessment of a large group. In addition, presence of an observer may influence the child's behavior. The observer is able only to observe children who have consented to the assessment. The behavior of these children may differ from behavior of the population without consent. Direct observation is time consuming; much more than parent/teacher report. It is costly to train observers and observers may be required to attend several training sessions (Howell & Rice, 2000).

### **Presidential Challenge**

Participants record their activities and are then eligible for earning awards. Points are based upon the amount of energy burned at each activity. A computer-based activity log is provided with easy pull-down menus, and children select the date and description of their activity and time spent engaging in the activity. Using a pedometer to record steps is another alternative.

### ***Benefits***

The ability to record the activities that the subject participates in, as often as he/she wants and in increments as small as five minutes, is a useful tool (Rice and Howell, 2000). In addition, subjects are able to go back up to fourteen days to enter forgotten activity. A printable version is also available for children to record their activities. Every time they enter an activity, they can review their progress toward their goal. The computerized log keeps track of the child's activities and gives them an option to print their progress or compare their progress to others taking the challenge. Their log will also update them when they have reached their goal and earned a reward ("The President's Challenge," 2006).

### ***Limitations***

Self-report in children is often sub-optimal in regards to accuracy.



The following resource charts summarize the various methods for assessing physical activity in children.

	<b>Pedometers</b>	<b>Accelerometers</b>	<b>IDEAA</b>	<b>Heart Rate Monitors</b>
<b>Description</b>	Small device, worn on waist, that records the number of steps an individual takes over a period of time.	Small device, worn on waist, that records both amount and intensity of activity that an individual takes over a period of time.	Small device with sensors (worn on waist, with sensors placed throughout body) that records body movements, physical activity, motor patterns, and can estimate energy expenditure throughout a 24 hour period for up to 7 days.	2-component device (chest strap & wrist receiver) that tracks heart rate while exercising.
<b>Type</b>	Electronic	Electronic	Electronic	Electronic
<b>Age Issues</b>	Variable sensitivity switch may be necessary to differentiate b/w ages.		Has not yet been validated in children.	
<b>Gender Issues</b>				
<b>Accessibility</b>	Anyone can use.	Must be trained in usage.	Requires skilled technicians.	Anyone can use.
<b>Accuracy</b>	Low	High Accuracy of measurement increases as number of planes being measured increases.	Highest 96-98%. Most accurate results for true daily living energy expenditure.	Low Many factors affect heart rate.
<b>Cost</b>	Low \$15-\$30	Moderate \$50-\$450	High A few hundred dollars for large quantities; \$2,000-\$4,000 for small quantities	Moderate Below \$100-\$400
<b>Strengths</b>	Inexpensive. User-friendly output that can be easily understood.	Movement readings in up to three planes, allows for broader spectrum of physical activity to be recorded. Has capacity to distinguish b/w varying intensities of physical activity. Software has analysis tools.	Can discriminate b/w 45 different movement activities. Quantifies the duration, frequency, intensity, and energy expenditure for each activity. Can collect data for up to 7 days. Software package allows for formation of charts, animations, tables, curves, histograms, etc.	Use requires minimal knowledge. Relatively unobtrusive.
<b>Limitations</b>	Unable to discriminate b/w different modes or intensity of physical activity.	Can't assess activity associated w/ cycling. Need to learn hardware/software. Requires a computer and cables to download the data and specific software to interpret this data.	Very expensive. Device is cumbersome. Box is worn on waist, five sensors must be placed on the body with medical tape on the chest, thighs, and feet. Not yet validated in children.	Heart rate remains elevated after bouts of exercise, longer for obese people, providing a possible false increased length of time for the physical activity event.

	<b>PDPAR</b>	<b>Activitygram/Fitnessgram</b>	<b>Physical Activity Journals/Diaries</b>	<b>Parent or Teacher Report Measures</b>	<b>Direct Observation Measures</b>	<b>Presidential Challenge</b>
<b>Description</b>	Exam w/ time-based grid. Children report after school activities according to intensity-level for every 30 minute block of time.	The most recent version of the PDPAR in a software form. This assessment has a similar time-based grid, but is a computerized assessment of physical activity.	Individual records activities regularly in a journal or diary.	Observations are done by either a parent or a teacher who has experience assessing physical activity.	The observer can watch frequency and type of physical activity and record these activities first hand.	Participants record their activities and are then eligible for earning awards. Points are based upon the amt. of energy burned at each activity.
<b>Type</b>	Paper	Paper/Computer	Paper	Paper	Paper	Paper/Computer
<b>Age Issues</b>	Results may not be made for a child's activity level.		Limited practicality for use in children.	N/A	Developed to accommodate ages 20 months to 11 years.	
<b>Gender Issues</b>						
<b>Accessibility</b>	Paper form accessible to everyone.	Designed for children to do w/ little or no assistance. Cooperative for use in school and at home. Paper form is available to be used as practice test and to aid in data entry.	Accessible to everyone.	Accessible to everyone.		
<b>Accuracy</b>	Increases w/ # of days used.	More accurate than paper form.		Limited		Low
<b>Cost</b>	Low	High \$250-\$1500 for software; up to \$55 for student report forms	Low	Low		
<b>Strengths</b>	Helpful in determining amount and type of activity that a child does in a specific time period.	Provides detailed amount of information for level of intensity and type of activity that is performed, and information about the time that the activity occurred. Software helps children complete assessment w/ ease and gives more accurate results. Report can be printed and given to parents of subjects.	Data for assessment can be reported in different ways (time or caloric expenditure). Data from Activity Diaries is similar to reports from other direct observation assessments.	Can be used w/ young children who are unable to fill out their own assessment or respond to a self-report.	Observer can be in the exact environment for the observation where the activity is occurring.	Ability to record activities that subject participates in as often as wanted. Subjects able to go back up to 14 days to enter forgotten activity.
<b>Limitations</b>	Not completely valid for children, recommended that it be used for 3 consecutive days to show typical activity.	Expensive software.	Little uniformity across different instrument studies. Requires proper record keeping in order to be useful.	Parent/teacher reports have limited reliability and validity w/ direct/indirect measures of assessment.	Impractical for assessment of large group. Presence of observer may influence child's behavior. Costly and time consuming.	Low accuracy

## **Summary of Resource Guide**

Various factors must be examined in order to predict and explain childhood adiposity and physical activity. Biological factors, environmental factors, and behavioral factors must be addressed in order to most accurately determine the causes of childhood overweight and inactivity. Coupled with the predictive factors discussed, the measurement of both adiposity and physical activity in children is a complex issue. In order to determine the best method(s) to use for a prospective project or study one must take into account the research evidence available for each type of assessment. By examining all potential assessments, health professionals/educators can make more informed decisions as to which methodology will produce the best assessment within the confines of type of setting, budget available, and age-group examined.

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