BODY COMPOSITION, NEUROMUSCULAR FUNCTION, AND PHYSICAL ACTIVITY AMONG ADOLESCENT AFRICAN-AMERICAN FEMALES

by

RICHARD HADLEY WILLIAMS

(Under the direction of Dr. Gary Alton Dudley)

ABSTRACT

Problem: American adults are facing two major lifestyle-related problems that have surfaced during the previous two-to-three decades: an epidemic of increasing adiposity and a deteriorating pursuit of physical activity. These lifestyle traits, which emerge prior to adolescent growth and development, are culturally linked. The literature suggests that this “weight plague” and “inactivity lifestyle” both have a gender bias and are ethnically prevalent. In particular, the African-American race and the female gender are associated with propensity for this combination. Additionally, the literature suggests that risks for various debilitating diseases are more pronounced as fat mass increases and activity level decreases. Therefore, what consequence, if any, do these trends have on the neuromuscular characteristics of adolescent African-American females?

Procedures: Thirty-two subjects were randomly selected to participate in a seven week protocol that encompassed analysis of body composition, indices of skeletal muscular strength, and questionnaires which quantified time spent in leisure, occupational, and/or structured physical activity endeavors. In order to illustrate comparisons, subjects were grouped as “low-risk” or “high-risk,” depending upon their body mass index (BMI<22.5= “low-risk” and BMI>22.5= “high-risk,” respectively).

Results: There was no sound evidence that suggests lessening of neuromuscular function among subjects. Although possessing significantly greater total body fat-free-mass (p=0.029), leg fat-free mass (p=0.041), arm fat-free mass (p=0.025), and thigh extensor absolute-strength (p=0.013), the “high-risk” individuals demonstrated less attributable variance in their muscular strength and size indices. Surprisingly, the “high-risk” subjects were more active (kcal/d, p=0.042 and 5 day pedometer readings, p=0.0001) than their “low-risk” counterparts according to self-report measures of physical activity. However, the pursuit of hard-to-vigorous physical activities was almost non-existent between both groups (1.88 and 2.56 hrs/wk for “low-risk” and “high-risk” respectively).

Conclusion: Although groups differed in body composition, muscular strength, and activity durations, altered neuromuscular function among subjects were not present. Given the minimal pursuit of hard-to-vigorous activities, more time engaging in these activities may be the critical element in offsetting premature neuromuscular disorders, although not observed. Moreover, more research in needed that focuses on adolescent skeletal muscular characteristics and their relation to physical activity durations.

Additionally, developing ways to enhance hard-to-vigorous activities is strongly encouraged.

INDEX WORDS: African-American Females, Adolescence, Neuromuscular Function, Body Composition and Mass, Physical Activity, Upper Arm Flexors, Thigh Extensors, Isometric Torque, Absolute Strength, Specific Tension, MR-imaging, DEXA, Pedometer/step counter, and 7-day Physical Activity Recall.

BODY COMPOSITION, NEUROMUSCULAR FUNCTION, AND PHYSICAL ACTIVITY AMONG ADOLESCENT AFRICAN-AMERICAN FEMALES

by

RICHARD HADLEY WILLIAMS

B.S. Ed., The University of Georgia, 1995
M.Ed., The University of Georgia, 1997

A Dissertation Submitted to the Graduate Faculty of The University of Georgia in
Partial Fulfillment of the Requirement for the Degree

DOCTOR OF EDUCATION

ATHENS, GEORGIA
2002

BODY COMPOSITION, NEUROMUSCULAR FUNCTION, AND PHYSICAL ACTIVITY AMONG ADOLESCENT AFRICAN-AMERICAN FEMALES

by

RICHARD HADLEY WILLIAMS

Approved:

Major Professor:	Gary A. Dudley
Co-Major Professor:	Kevin McCully
Committee:	Kirk Cureton Billy Hawkins Caroline Lehr Patrick O'Connor

Electronic Version Approved:

Gordhan L. Patel
Dean of the Graduate School
The University of Georgia
August 2002

DEDICATION

This work is dedicated to my Heavenly Father, who has granted me numerous gifts and talents that I am grateful for. I also dedicate this document to HIS only son, Jesus Christ, who died for all of our sins.

This manuscript is also dedicated to my forefathers, who paved the way for my educational success through the toils and snares of hard work and racial inequality. I thank you for your vision of achievement.

I also dedicate this work to my parents (Morris and Frances E Williams), grandparent (Princetta H. Greene), siblings (Morris III, Dr. Brian, Roderick, Robert and Stephanie), nephews, nieces, uncles, aunts, in-laws, cousins and friends. Your prayers are greatly appreciated.

To my deceased great grandparents (John and Lula Chandler, Lula Hadley), grandmother (Mary O' Neal), grandfathers (John Frank Greene, Morris Eugene Williams, Rev. James N. Greene), aunt (Eva O'Neal), and uncles (Richard Hadley, Paul Williams, Roosevelt Williams), thank you for guidance along this journey.

To Dr. Gary Alton Dudley, thanks for giving me inspiration as well as insight.

Most emphatically, to my wife, Demetria Nicole, thank you for your love and support throughout the past 12 years. You are truly a blessing from GOD.

PHI NU PHI

ACKNOWLEDGMENTS

I am grateful to my Heavenly Father and HIS son, Jesus Christ. I thank you for the remission of my sins.

I thank my wife and family for their endless love and support; my graduate committee, for their support and encouragement of this manuscript. Dr. Dudley thanks for being my mentor and more importantly my friend. Thanks for the "talks" we shared; your love for science and compassion for others is unparallel. Dr McCully thanks for stepping in and providing immediate assistance, you love for science and teaching is expressed daily. Dr. Hawkins and Dr. Rose Thompson, thanks for your support, truly we all share similar experiences and while igniting the torch of wisdom.

I especially would like to thank Charlie Monroe, Dr. Reginald Jackson, Cassandra Barnes RN, Dr. Jessica Decuir, Mike and Regina Middlebrooks, the Cedar Shoals High School administrators, teachers, and coaches, The Boys and Girls Club of Athens Clarke-County, Dr. Chris Gregory, Dr. Chris Modlesky, Derrick Bray, Ashley, Samantha Jones, Deirdre Kyle, Marlee Steward, Jeremy Nicholas, Willie Jennings, Dr. Corey Moore, Eric Wiggins, Shan Daniels, Wiley Cook, Rico Adkins, Damon Evans, The Zeta Iota Chapter of Kappa Alpha Psi, The Shepherd Spinal Center's Clinical Research Team and patients, and most of all, the subjects and their parents, who dedicated numerous hours, support and effort toward this project.

I would also like to thank the crew of the "BIG DAWG'S" Muscle Biology Lab and all of the past and current graduate students for their friendship, interest, and dedication towards academic excellence; you all have truly encouraged me.

PHI NU PHI

TABLE OF CONTENTS

Page

CHAPTER I

INTRODUCTION

The United States is at war with a weight epidemic that fosters premature death, sickness, and suffering for millions of Americans. Increases in obesity and overweight have occurred in all groups, irrespective of age, ethnicity, race, or socioeconomic status (Booth et al., 2000). Customarily, *obesity/overweight* is defined as having a high percentage of body fat, usually greater than 25% for men and greater than 32% for women. This corresponds to a body mass index, BMI (weight-to-height^2), value of 27-31 for men and 27-32 for women (Department of Health and Human Services, 1998). Within the last fourteen years, the combined prevalence of obesity and overweight in America has increased from 46% to 55% of the adult population (CDC, 1999). Similarly, the adolescent incidence of obesity and overweight has risen rapidly. The number of overweight or obese children age 6-17 years old has doubled within the last three decades (Troiano and Flegal, 1995). Today, approximately one in five children in the US are overweight or obese (Troiano and Flegal, 1998).

This "weight plague" is particularly prevalent among African-American women. Accordingly, 66% of African-American women are obese and/or overweight (Flegal et al., 1998). Although African-American women are not more likely to be overweight during infancy and childhood than other women, during adolescence and adulthood, body mass index and the prevalence of being overweight increases more in African-American women than in other groups (Kumanyika, 1987; Gillum, 1987; Gourtmaker et al., 1987;

Melnyk and Weinstein, 1994; CDC, 999). Accordingly, Troiano et al. (1995) report that African-American females demonstrate the largest increase in the prevalence of overweight. The factors that contribute to the propensity of being overweight and to obesity in adolescent are not well understood. However, one area of concern is a lack of physical activity. Low levels of physical activity have been reported for African-American women; this is correlated to their higher rates of obesity (Folsom et al., 1991; Lasco et al., 1989; Kumanyika and Charleston, 1992; Pleas, 1988; Melnyk and Weinstein, 1994; CDC, 1999). The 1990 Youth Risk Behavior Survey found that African-American females exhibit the largest age-related decline in the percentage of girls reporting three or more vigorous exercise sessions per week (Heath et al., 1994). Furthermore, the National Center for Health Statistics reports that the percentage of 9th to 12th graders undergoing daily physical education in U.S. schools has declined from 42% to 27% between the 1991--1997 school terms.

With this combination of decreased physical activity and increased adiposity in adolescence, multiple medical complications can be theorized to develop. Epidemiological data have established that physical inactivity increases the incidence of at least 17 unhealthy conditions, almost all of which are chronic diseases or considered risk factors for chronic diseases (Booth et al., 2000). For example, cardiovascular disease, hypertension, gallbladder disease, diabetes mellitus, atherosclerosis, gout, arthritis, and certain cancers have all been associated with obesity and decreased physical activity in adults (Greenwood and Pittman-Waller, 1988; Williamson et al., 1990; Manson et al., 1990; Williamson et al., 1991; Melnyk and Weinstein, 1994; and Booth et al., 2000). Furthermore, Wei et al. (1999) found low fitness to be an independent predictor of all causes of mortality but found that the risk of death due to low fitness rises from approximately two-fold to three-fold as obesity increases. For instance, of the 2.1

million deaths in the U.S. each year, roughly one-half result from preventable causes (McGinnis and Foege, 1993). Therefore, the disproportionate levels of obesity, decreased physical activity, and greater risk for certain diseases observed in female African-American adults and adolescents underscore the urgency to better understand and combat this serious health dilemma.

Published literature concerning the neuromuscular complications associated with decreased physical activity and obesity within the adolescent population is scarce. We are aware of the graded cardiovascular risk; however, neuromuscular function, in terms of muscle activation, strength, power, force production, and fatigue, has not been examined. Is neuromuscular function altered with the increase in adiposity and inactivity? Intrinsically, this could lead to future neuromuscular disorders or impending complications associated with muscular abnormalities such as, sarcopenia, peripheral vascular disease, muscle-specific atrophy, altered muscular reaction to stimulation, a decrease in tension per unit cross-sectional area, or muscle-nerve degeneration. Is there any protective neuromuscular effect associated with being non-overweight/obese and physically active compared to being an inactive-overweight adolescent? Can the phenomena of obesity, inactivity, and associated diseases be altered if detected earlier in life? If so, these findings will provide additional information that can be used to encourage such individuals to become more active and reduce their body fat percentage, while improving quality of life.

Therefore, the purpose of this investigation is to determine if increasing adiposity and decreasing physical activity pursuits compromise neuromuscular function of the upper arm flexors and thigh extensors in adolescent African-American females. In order to draw conclusions, participants were categorized into two groups relative to their weight and height. The 95th-percentile BMI cutoff points calculated at 6-months age intervals was the criterion utilized for adolescent overweight status, derived respectively from National Health Examination Survey, cycles 2 and 3. Thus, teens were grouped as "high-risk," if they had a BMI greater than 22.5, and as "low-risk," if they had a BMI less than 22.4.

Specific Aims of the Study

1) To recruit adolescent African-American females who fit into 2 categories, "low-risk" and "high-risk."

2) To evaluate body composition

3) To record neuromuscular function

4.) To document physical activity durations

Hypothesis

1.) Although fatter, the "high-risk" group will have greater lean tissue in the extremities.

2.) The "high-risk" group will have greater muscular strength in the lower extremity but not in the upper extremity.

3.) The "high-risk" group will have impaired neuromuscular characteristics.

4.) The "low-risk" group will have greater time engaging in physical activity.

Assumptions and Limitations of the Study

Similar to most studies that investigate muscular performance, major assumptions are that subjects elicit maximal effort during muscular testing, that subjects were internally motivated, and that subjects give honest answers when questioned.

Notwithstanding, this study is limited in that it did not take into account individuals whose race was non-African-American, cited limitations of body composition methodology, and individuals who met the subject criteria but were not able to participate due to equipment limitations (DEXA scanning table width capacity, MRI field of view and size capacity). The subjects consisted of adolescent Athens-Clarke County, GA citizens.

Delimitations

In the proposed study, participants who had previously given birth, were pregnant, or had prior injuries (broken extremities, ACL-tears) were excluded. In addition to racial makeup and medical history, the selection of participants was made from the group of students who participated in the year's previous high school sports program, school sponsored organizations, and after school programs sponsored by the Athens Clarke-County Boys and Girls Club. Therefore, the findings of this study solely represent this adolescent population.

Study Scope

The study protocol examined 32 African-American female students within the Athens community who were between the ages of 14-18 years. The majority of the students were recruited from Cedar Shoals High School and the Athens Clarke County Boys and Girls Club. Participants took part in a seven-week protocol that included the analysis of body composition, the mapping of skeletal musculature extremity contours, neuromuscular strength testing procedures, and assessment of physical activity pursuits.

CHAPTER II

REVIEW OF LITERATURE

Adolescent Obesity and Its Genetic Influence

Obesity is considered a common chronic disease amongst children, adolescents, and adults. Recent advances in medical science have provided admirable information that has broadened our understanding of its origin (Bar-Or et al., 1998). Previously, obesity was considered to result from over-eating, or as a result of psychological problems with food: using food to deal with depression, anxiety, boredom, or even happiness (Cassell, 1994). The prevailing theory was that in order to lose weight; one had to just eat less. However, the identification of mutant genes that foster obesity and of metabolic factors such as variations in energy expenditure and fuel utilization have allowed researchers to better understand the complexities of obesity (Weinsier et al., 1998). Today, obesity is considered a complex, multi-factorial trait that involves the interaction of influences from the social, behavioral, physiological, metabolic, cellular, and molecular domains (Bar-Or et al., 1998). Although there are several constituents of obesity, metabolic factors, diet, and physical activity are the three major culprits that contribute to the etiology of adolescent obesity (Weinsier et al., 1998).

A number of studies that include both cross-sectional and longitudinal data report that obese children frequently have obese physical activity (Vogler et al., 1995; Fabsitz et al., 1994). The evidence suggests that 40% of obese 7-year old children and 70% of obese adolescents become obese adults (Mossberg, 1989; Stark et al., 1981). A study comparing adult fraternal (dizygotic) and identical (monozygotic) twins found that the body weights of the identical twins were much closer together than the body weights of fraternal twins (Strunkard et al., 1986). Another study revealed that when monozygotic twins were reared apart, their body mass indexes were nearly as close as those of monozygotic twins reared together (Strunkard et al., 1990). Likewise, a study of adults who had been adopted before the age of 1 year revealed that despite being brought up by their adoptive parents, their body weights were still similar to those of their birth parents (Strunkard et al., 1986).

These studies demonstrate the genetic link of obesity, in which shared genes are more important than shared living environments. However, not all researchers believe that genetic factors are paramount in obesity related issues. A study that ascertained 1,698 members of 109 families (including spouses, foster-degree cousins, uncles/aunts-nephews/nieces, parents-natural children, full siblings, dizygotic twins, and monozygotic twins**)** revealed that biological inheritance, lifestyle and environment, and cultural factors accounted for 45%, 30% and 25% of the variance respectively (Bouchard et al., 1988). Thus, non-genetic influences (taken together) are deemed just as important as genetic influences.

Body Image Attitudes and the Behaviors of African-American Women

The continual quest to be accepted is a universal theme throughout every nation, culture, and race. In today's Western world, we live in a society obsessed with thinness. Our culture dictates that you cannot be too thin. However, our racial differences suggest different weight ideals. Attitudes toward physical appearance and standards of beauty and desirability have varied over time as well as from culture-to-culture. Cultural identification is the foundation that constructs an individual’s attitude and beliefs regarding body image. Body image has been described as a multidimensional construct, comprising affective, attitudinal, and behavioral domains (Butters & Cash, 1987; Cash et al., 1989; Keeton et al., 1990). The conceptualization of body image as a multifaceted construct is particularly important in understanding the inconsistencies in the literature related to the body attitudes of African-American women. An investigation of cultural differences provides insight into what is acceptable within certain cultures

Thinness is indisputably the paramount of beauty in today's society. However, a thin figure was not always considered to be ideal. In fact, the desire for thinness is a relatively new phenomenon. Throughout history, a large body size represented abundance and wealth and indicated physical and political power (Cassidy, 1991; Sobal et al., 1991). In Greek and Roman representations of the ideal body image, sculpted gods and goddesses often have ample thighs, hips, waists, and buttocks. During the Renaissance era, full-bodied women were also considered to be the ideal. Not only was plumpness admired, but it was also considered an appealing sexual characteristic in some cultures; this is true even today. For example, the Nomadic Moors of Mauritania and the Annang of Nigeria regard beauty in women according to their adiposity. In their culture, a woman who is so portly that she is unable to work or move about easily is considered the supreme type of beauty (Cassidy, 1991). As a consequence, stoutness becomes a symbol of wealth, for only an affluent man can afford to lose the potential productivity of a wife or daughter. Additionally, in much of Western Africa the term "fat" is viewed as an accolade, implying power, vigor, strength, attractiveness, and beauty (Cassidy, 1991).

Today, American society considers that a thin look denotes self-control and success. Fear of being fat, fear of losing control over eating, and fear of not being as slim as possible are major social concerns. Nevertheless, this social concern is not shared or viewed in the same regard among cultures. For instance, some African-Americans consider a "full-figured" body as ideal. In addition, studies have revealed that although African-American women are, on average, heavier than Caucasian women (Rand & Kaldau, 1990), fewer African-American women exhibit problematic eating behavior (Abrams et al, 1993; Gray et al., 1987). The literature also suggests that African-Americans report more positive feelings toward their bodies and possess greater body satisfaction than Caucasians (Harris, 1994; McCarthy, 1990; White et al., 1985). Additionally, African-Americans' positive attitudes are associated with less concern for body weight (Rosen & Gross, 1987). For example, adolescent African-American females view themselves as "just right" and desire to gain weight more frequently than their Caucasian female peers (Wardle & Marsland, 1990). African-American females also have less of a discrepancy between their perceived and ideal body size (Rucker & Cash, 1992). The relative importance of thinness and appearance in women are the result of variations in culture-bound values (Rucker & Cash, 1992; Bowe et al., 1991; Garner et al., 1980).

Socioeconomic Factors that Contribute to Obesity in African-American Women

The term *obesity* is difficult to precisely define because different criteria and methods have been offered. This partly explains why scientists have difficulty establishing an ideal level of adipose tissue. Customarily, *overweight/obesity* is defined as having a high percentage of body fat, usually greater than 25% for men and greater than 32% for women. This corresponds to a body mass index (weight-to-height^2) value of 27-31 for men and 27-32 for women (Department of Health and Human Services, 1998). According to this scale, increases in body weight are of epidemic proportion among African-American women. Reports have identified that 66% of African-American women in the U.S. are obese or overweight (Fegal et al, 1998). However, today's criteria used to define obesity are based solely on quantifiable measures, ignoring the importance of socio-cultural and socio-economic elements.

Over the past several decades, population-based research has evaluated the impact of a wide range of biological, behavioral, environmental, and other potential risk factors on the adverse health outcomes associated with being overweight or obese. When one sorts through this vast collection of studies, the relationships among low socioeconomic status, cultural differences, low physical activity, and poor health rise to the top of the list (Garalnik & Leveille, 1997; Young, 1996). The strength and consistency of these relationships have been remarkable; nevertheless, it has been difficult to fully explain obesity, even after taking into account these considerations (Garalnik & Leveille, 1997; Young, 1996). Thus, being overweight or obese is not just a quantifiable variable, but also a multifaceted paradigm (Cassell, 1994; Weinsier et al., 1998; Bar-Or et al., 1998). It is also perhaps remarkable that these differences, which can have a large impact on morbidity and mortality (Booth et al., 2000; Melnyk and Weinstein, 1994), are not considered a major public concern; thus possibly justifying the lack of more recent minority research.

Differences in rates of disease among ethnic and racial subgroups of the population have been well documented (Booth et al., 2000; Flegal et al., 1998). Because many African-Americans in the U.S. are economically disadvantaged, researchers who find higher rates of particular diseases in this subgroup often evaluate whether they can be explained by socio-economic differences. The results of these investigations have been mixed (Adler et al., 1993; Kington and Smith, 1996), with some racial differences in disease rates not explained by socio-economic status. However, the interrelationship of race and socio-economic status may be too complex to unravel, even with the traditional adjustments for current income and education (Guralnik & Leveille, 1997).

Although the precise casual pathways producing racial and ethnic differences in weight status have not been clearly delineated, racial and ethnic groups that experience increasing body weights generally have a lower socio-economic status. Literature suggests an inverse relationship between socio-economic status and body weight in the U.S. (Sobal and Stunkard, 1989). Thus, people with lower socio-economic status have higher body weights. In addition, lower socio-economic status may also lead to such factors as reduced access to health care services, lower quality of medical care, post-pone diagnosis and treatment, which transform into greater severity of illness. Moreover, lower socio-economic status allows for a higher prevalence of many common chronic conditions via complex pathways linking behavioral, psychological, social, biological, and genetic factors (Kamanyika et al., 1993).

Adolescent Obesity and Its' Health Risks

There is a mountain of evidence associating increased adiposity with various health risks. In fact, the numbers of illnesses, some potentially fatal, are displayed with increasing body weight (Must et al., 1999). Consequently, obesity is considered a co-morbidity factor of some of the most prevalent diseases of modern society (Booth et al., 2000). For example, cardiovascular disease, hypertension, gallbladder disease, diabetes mellitus, atherosclerosis, gout, arthritis, and certain cancers have all been associated with obesity in adults (Booth et al, 2000; Melnyk and Weinstein, 1994). The risk of coronary heart disease is increased 86% by a 20% rise in body weight in men, whereas this risk is increased 3.6-fold in obese women (Jung, 1997). The adverse health effects of obesity affect not only the adult population, but may also begin in adolescence. Some cardiovascular risk factors may become established even in childhood, among them increased serum total cholesterol, altered lipoprotein subtraction concentrations, and hypertension (Colditz and Coakley, 1997). In addition, racial differences in health risk and obesity are also noted. Of particular concern is the location of excess adipose tissue in African-American females (Kumanyika, 1987; Gillum, 1987; Gortmaker et al., 1987; Folsom et al., 1991; Wienphal et al., 1990; Stevens et al., 1992). In obese African-American females, fat deposition occurs in the body's central regions, coined "trunkal fat" (Greenwood and Pittman-Waller, 1988; Kumanyika, 1987; Folsom et al., 1991). The early accumulation of fat in the intra-abdominal region is significantly related to the development of adverse health effects. For example, rates of hypertension, stroke, coronary heart disease, elevated blood lipids, and diabetes among African-American women are reported to be 1.5-2.5 times the rates among Caucasian women (Kumanyika, 1987; Gillum, 1987). Low levels of physical activity have been reported for African-American females, which are theorized to correlate well to their higher rates of overweightness and obesity (Folsom et al., 1991, Lasco et al., 1989; Kumanyika and Charleston, 1992; Pleas, 1988; Melnyk and Weinstein, 1994).

Adolescent Obesity and Its' Physical Activity Associations

African-American females are facing two major lifestyle-related dilemmas that have surfaced over the last two decades -- an epidemic of inactivity and an epidemic of obesity. Troiano et al. (1995), using data from the NHANES III, reported that African-American females demonstrate the largest increase in the prevalence of overweight, increasing from 18.4% to 30.7% in 6 year-olds to 11 year olds and 18.2% to 29.9% in 12 year-olds to 17 year-olds. In addition, the 1990 Youth Risk Behavior Survey found African-American females to exhibit the largest age-related decline in the percentage of girls reporting three or more vigorous exercise sessions per week, dropping from 21.6% in 9th grade to 9.1% by 12th grade (Heath et al., 1994). Concomitantly, the National Center for Health Statistics reports that students in grades 9th--12th engaging in physical education class in U.S. schools has declined from 42% to 27% during 1991--1997. With this trend, it is estimated that the spiraling decline in physical activity will continue unless direct action is taken.

Multiple interactions exist between lack of physical activity and obesity. Indirect evidence from various national surveys supports this view and suggests that reduced total daily physical activity may be the most important current factor contributing to the increase in body weight (Ward et al., 1997). Furthermore, Kumanyika et al. (1993) found that adolescents who perceived themselves as "too fat" reported fewer days of strenuous activity, fewer hours of strenuous exercise in physical education class, and more hours spent viewing television on school days than fit students. Likewise, Andersen et al. (1998) reported that 20% of U.S. children participate in two or fewer bouts of vigorous physical activity per week. The results pointed out that children who watched 4 or more hours of television each day had a greater body fat and body mass index than those who watched less than 2 hours per day (Andersen et al., 1998).

In summary, the prevalence of adolescent obesity is rising. To prevent this occurrence, regularly physical activity is suggested. Rippe & Hess (1998) suggest targeting physical inactivity by promoting less television viewing, less use of video games, and less automobile usage, as well as encouraging increased vigorous physical exercise, are reasonable measures to ensure good health and prevent obesity in at-risk children.

Influence of Inactivity on Muscular Integrity

Skeletal muscle performs a variety of important functions that allow for efficient daily life activities. Genetics, neural control, metabolic influences, environmental factors, diet, physical activity and exercise are all thought to influence skeletal muscle integrity. However, which factors are most influential is not known.

Being overweight or obese may alter muscular functioning. Preliminary data among obesity-prone women suggest that a higher body weight is associated with greater physiologic stress during exercise and a tendency to spend less time in physical activity (Weinser et al., 1997). Moreover, other investigations have shown that muscle disuse is associated with a decreased muscle fiber type cross-sectional area, (Maunder and Young, 1997; MacDougall et al., 1990) muscular weakness, and fatigue (White and Davies, 1984; Duchanteau and Hainaut, 1987). Thus, inactivity alters muscle power in terms of fiber type recruitment, metabolism, and fatigue. Data examining the effects of inactivity mostly encompasses models of unweighting, injury, and disease. However, no available data are found involving the effect of inactivity on adolescent skeletal muscle. So, the influence of adiposity and decreased physical activity upon muscular integrity in adolescence is still a mystery. Yet, the following section reports that altered muscular functioning in adults' follows even short-term disuse.

There is a wealth of information regarding the effect of short-term disuse on the characteristics of skeletal muscle in human adults. The models of microgravity environments (space flight), immobilization (casting), and bed rest (limb suspension) are often used in investigations of short-term disuse. From these reports, the predominant response is muscle atrophy (wasting). Additionally, the extent to which atrophy appears is related to the duration of unloading, as well to the muscle groups involved (Berg, et al., 1997; Hather et al., 1992).

Studies that investigate skeletal muscle contour suggest that weight bearing and postural control muscles are most at risk during short-term disuse (Gogia et al., 1988; Hather et al., 1992). Thus, the extensor muscle groups of the lower extremities are more susceptible to muscle atrophy. Adams et al (1994) noted that the knee extensors cross-section area (decreased 8%) was more affected than the knee flexors after 16 days of limb suspension. Similarly, Hather et al. (1992) reported a 16% decrease in knee extensor muscle cross sectional area after 6 weeks of lower limb suspension. Moreover, Berg et al. (1997) reported a 14% decrease in the knee extensor cross sectional area after 37 days of bed rest. Therefore, the magnitude of muscle atrophy is directly related to the duration of unloading.

Studies investigating neuromuscular function have also noted the altered muscular effect of short-term disuse (Duvoisin et al., 1989; Gogia et al., 1998; Berg et al., 1997; Dudley et al., 1992; Adams et al., 1994). For example, Berg et al. (1997) observed a 25%-30% decrease in maximum voluntary isometric and concentric knee extensor torque following 6 weeks of bed rest. Duvoisin et al. (1989) reported a 19% decrease in knee extensor strength (torque) following a 30-day bed rest. The decline in extensor muscle group strength is in agreement with a more pronounced decline in the extensor muscle group cross sectional area following short-term disuse. Thus, inactivity influences muscular integrity by suppressing the muscle’s ability to perform work. These data support the theories of “use it” or “lose it.”

In summary, short-term disuse results in muscle wasting, which is directly related to the duration of unloading. Nevertheless, atrophy is more susceptible in weight-bearing and postural muscles (mainly leg extensors). In turn, an altered neuromuscular functioning is noted. It is therefore likely that the atrophy and reductions in neuromuscular functioning are the results of a change in activity status or lack there of. Although it may be questionable to gather inferences from studies in which physical activity is virtually restricted, these studies are noteworthy because they provide the foundation and evidence for a muscular response to decreased physical activity.

Specific tension and Obesity

Specific tension refers to strength per unit of muscle mass. Specific tension is often regarded as a better indication of muscle functioning than strength alone (Dutta et al., 1997). Given that there is no accepted skeletal muscle circumference size, apparent specific tension threshold, or body fat standard available for all ages, data from previous research that examined body composition and strength indices of adults provide insight into the effect adiposity has upon skeletal muscular mass and specific tension.

Muscle strength is reported to reach peak value during the second and third decade of life, is maintained or is slightly lower in the fourth decade, and then diminishes 12-14% per decade after the fifth decade (Lindle et al., 1997; Metter et al., 1997). Although the specific mechanism(s) responsible for this age-related decline in muscle strength has not been identified, the major underlying factor appears to be the decrease in muscle mass with age (Frontera et al., 1991; Reed et al., 1991). Furthermore, the age-associated loss of muscle mass and neuromuscular functioning (sarcopenia) has important health and economic implications (Lynch et al., 1999). Despite the plethora of findings suggesting diminished muscular functioning among elderly individuals, there is no published literature that directly examines the effect adiposity has upon skeletal muscle mass and muscular functioning. We are aware of the debilitating risks associated with elevated adiposity and short-term disuse; however, the relationship, if any, between increasing adiposity and muscle quality in overweight/obese adolescents is currently an unknown.

Going and Davis (1998) proposed that an assessment of body composition is useful in establishing optimal weight for health and performance in athletes, helpful in formulating dietary guidelines and exercise prescriptions for modifying body composition and evaluating efficacy, and critical in monitoring changes in composition with growth, maturation, and aging in order to distinguish "normal" changes from pathology. Although body fat is often the focus of assessment, lean tissue mass and its components (fluid, muscle, and bone) are equally, if not more important (Going and Davis, 1998). Low levels of lean mass and loss of lean tissue contribute directly to metabolic complications and indirectly contribute to diminish functional capacity, reduced physical activity, and altered energy expenditure, and thus, a greater risk of fat gain (Going and Davis, 1998). With this greater risk of fat gain, muscle quality could theoretically be jeopardized.

The data of Lynch et al. (1999) indicate age-related declines in arm and leg muscle quality in men and women. Interestingly, they observe that while arm and leg muscle quality decline at a similar rate with age in men, leg muscle quality decline roughly 20% more than arm muscle quality with increasing age in women. They conclude that although muscle quality is affected by age and gender, the magnitude of any effect depends on the muscle group studied and the type of muscle action (concentric vs. eccentric) used to assess strength.

Although literature was not found examining the effects adiposity plays upon muscle quality during the adolescent years, limited literature on adolescents was found that examines skeletal muscle functioning. Ward et al. (1997) observe that relative to their counterparts, girls with obesity produced a significantly greater absolute strength score involving two isometric strength tests. They conclude that excess adiposity may have little effect on performance during non-weight bearing activities but may have detrimental effects on functional capacity during weight bearing activities such as climbing, jogging, or walking.

In summary, age and gender both affect muscle quality; however, this effect depends upon the muscle group studied and the type of muscle action used to assess strength. Moreover, low muscle strength, but not low muscle mass, is associated with poor physical functioning (Visser et al., 2000; Ward et al. 1997). We are aware of the age-associated decline in muscle mass and muscular function, but data examining muscle quality during adolescent growth is needed. Thus, prospective studies are encouraged that investigate the association between muscle quality and physical functioning during periods of adolescent growth.

References

Abrams K. K., L.R. Allen, and J.J. Gray. Disordered eating attitudes and behaviors, psychological adjustment and ethnic identity: A comparison of Black and White female college students. *International Journal of Eating disorders* 1993; 14: 49-57.

Adams G.R., B.M. Hather, and G.A. Dudley. Effect of short-term unweighting on human skeletal muscle strength and size. *Aviat Space Environ Med* 1994; 65:1116-1121.

Adler N. E., Boyce, T.W., Chesnet, MA et al., Socioeconomic inequalities in health: No easy solution. *JAMA*. 1993; 269:3140-3145.

Andersen R.E., C.J. Crepso, S.J. Bartlett, L.J. Cheskin, and M. Pratt. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the third national health and nutrition examination survey. *JAMA* 1998; 279(12):938-42.

Bar-Or EO, J. Foreyt, C. Bouchard, K.D. Brownell, W.H. Dietz, E. Ravussin, A.D. Salbe, S. Schwenger, S. St Jeor, and B. Torun. Physical activity, genetic, and nutritional considerations in childhood weight management. *Med Sci Sports Exerc* 1998; 30:2-10.

Basset E.J., M.A. Fiatarone, E.F. O'Neil, M. Kelly, W.J. Evans, and A. Lipsitz. Leg extensor power and functional performance in very old men and women. *Clin Sci* 1992; 82:321-327.

Berg H.E., L. Larsson, and P.A. Tesch. Lower limb skeletal muscle function after 6 weeks of bedrest. *J Appl Physiol* 1997; 82:182-188.

Booth F.W., W. Scott, E. Gordon, C.J. Carlson, and M.T. Hamilton. Waging war on modern chronic diseases: Primary prevention through exercise biology. *J Applied Physiology* 2000; 88: 774-787.

Bouchard C., L. Perusse, and C. Leblanc. Inheritance of the amount and distribution of human body fat. *International Journal of Obesity* 1988; 12:205-215.

Bowe, D.J., M. Tomoyasu., and A. Cause. The triple threat: A discussion of gender, class and race differences in weight. *Women & Health* 1991; 17(4): 123-142.

Butters, J.W., and T.E. Cash. Cognitive-behavioral treatment of women's body image dissatisfaction. *Journal of Consulting and Clinical Psychology* 1987; 55:889-897.

Caprio S., L.D. Hyman, S. McCarthy, R. Lange, M. Bronson, and W.V. Tamborlane. Fat distribution and cardiovascular risk factors in obese adolescent girls: importance of the intra-abdominal fat depot. *American Journal of Clinical Nutrition* 1996; 64(1): 12-17.

Cash, T.F., B.A. Winstead, and L.H. Janda. The great American shape-up. *Psychology Today* 1989; 30-37.

Cassell, DK. The encyclopedia of obesity and eating disorders. 1994.

Cassidy C.M. The good body: when big is better. *Medical Anthropology*. 1991; 13:181-213.

Centers for Disease Control and Prevention. *National Center for Health Statistics, Healthy People 2000. Review, 1998-99.* Hyattsville, MD: Public Health Service, 1999.

Colditz G.A., and E. Coakley. Weight, weight gain, activity, and major illnesses: the nurses' health study. *Int J Sports Med* 1997; 3:S162-70.

Differing J, G.J. Welk, J. Hart, and A. Symington. The use of the Digi-Walker step counter to measure levels of physical activity. *Med Sci Sports Exerc* 1998; 30: S11

Dishamn R.K. and M. Steinhardt. Reliability and concurrent validity for a 7-d recall of physical activity in college students. *Med Sci Sports Exerc* 1988: 20:14-25.

Dudley G.A., M.R. Duvoisin, G.R. Adams, R.A. Meyer, A.H. Belew, and P. Buchanan. Adaptations to unilateral lower limb suspension in humans. *Aviat Space Environ Med* 1992; 63: 678-683.

Dutta C., E.C. Hadley, and J. Lexell. Sarcopenia and physical performance in old age: overview. *Muscle Nerve Suppl* 1997; 5: S5-S9.

Duvoisin M.R., V.A. Convertino, P. Buchanan , P.D. Gollnick, and G.A. Dudley. Characteristics and preliminary observations of the influence of electromyostimulation on the size and function of human skeletal muscle during 30 day exposure to simulated microgravity. *Aviat Space Environ Med* 1989; 60:659-663.

Fabsitz R.R., P. Sholinsky, and D. Carmelli. Genetic influences on adult weight gain and maximum body mass index in male twins. 1994; 140:711-720.

Flegal K.M. Overweight and obesity in the United States: Prevalence and trends, 1960-1994. *Int Journal of Obesity* 1998; 22:39-47.

Folsom A.R., T.C. Cook, J.M. Sprafka, G.L. Burke, S.W. Norsted, and J.R. Jacobs. Differences in leisure-time physical activity levels between blacks and whites in population-based samples: the Minnesota Heart Study, *J Behav Med* 1991; 14:1-9.

Frontera W.R., V.A. Hughes, R. De Meersman, D. Sepulveda, and R.N. Baumgartner RN. Appendicular skeletal muscle mass: effect of age, gender, and ethnicity. *J Appl Physiol* 1997; 83: 229-239.

Garner, D.M., P.E. Garfinkjle, D. Schwartz, and M. Thompson. Cultural expectations of thinness in women. *Psychological Reports*, 47; 483-491.

Gillum R.F. Overweight and obesity in black women: a review of published data from the National Center for Health Statistics. *J Natl Med Assoc* 1987; 79:865-871.

Gogia P., V.S. Schneider, A.D. LeBlane, J, Krebs, C. Kasson, and C. Pientok. Bedrest effect on extremity muscle torque in healthy men. *Arch Phy Med Rehabil* 1988; 69: 1030-1032.

Gortmaker S.L., A. Must, and A.M. Sobol. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc* 1996; 150:356-362.

Gortmaker S.L., W.H. Dietz, A.M. Sobal, and C.A. Wehler. Increasing pediatric obesity in the United States. *Am J Dis Child* 1987; 141: 535-540.

Gray, J.J., K. Ford, and L.M. Kelly. The prevalence of bulimia in a black college population. *International Journal of Eating Disorders*, 1987; 6: 733-740.

Greenwood M.R.C., and V.A. Pittman-Waller. Weight control: a complex, various, and controversial problem. In: Frankle RT, Yang M-U, eds. *Obesity and Weight Control.* Rockville, MD: Aspen Publishers; 1988:3-15.

Harris, S.M. Racial differences in predictors of college women's body image attitudes. *Women & Health* 1994; 21(4): 89-103.

Harris, S.M. Family, self, and socio-cultural contributions to body-image attitudes of African-American women. *Psychology of Women Quarterly* 1995; 19:129-145.

Hatano Y. Use of the pedometer for promoting daily walking exercise. *Int Council Health, Physical Educ Recr* 1993; 29: 4-28.

Hather B.M., G.A. Adams, P.A. Tesch, and G.A. Dudley. Skeletal muscle responses to unilateral lower limb suspension. *J Appl Physiol* 1992; 72:1493-1498

Heath G.W., M. Pratt, C.W. Warren, and L. Kann. Physical activity trends in America high school students. *Arch Pediatr Adolesc Med* 1994; 148: 1131-1136.

Henriques, G.R., L.G. Calhoun, and A. Cann. Ethnic differences in women's body satisfaction: An experimental investigation. *The Journal of Social Psychology* 1996; 136 (6): 689-697.

Jung R.T. Obesity as a disease. *Br. Med bull* 1997; 53: 307-321.

Keeton, W.P., T.F. Cash, and T.A. Brown. Body image or body images? Comparative, multidimensional assessment among college students. *Journal of Personality Assessment*. 1990; 54: 213-230.

Kington R., and J.P. Smith. Socioeconomic status and racial and ethnic differences in functional status associated with chronic disease. *American Journal of Public Health* 1996; 87(5): 805-810

Kumanyika S. Obesity in black women. *Epidemiol Rev* 1987; 9:31-50.

Kumanyika S., J.F. Wilson, and M. Guilford-Davenport. Weight-related attitudes and behaviors of black women. *J Am Diet Assoc* 1993; 93: 416-22.

Kumanyika S.K., and J.B. Charleston. Loose weight and win: a church-based weight loss program for blood pressure control among black women. *Patient Educ Counsel*. 1992; 19: 19-32.

Lasco R.A., R.H. Curry, V.J. Dickson, J. Powers, S. Menes, and R.K. Merritt. Participation rates, weight loss, and blood pressure changes among obese women in a nutrition-exercise program. *Public Health Rep* 1989; 104: 640-646.

Lindle R.S., E.J. Meter, N.A. Lynch, J.L. Fleg, J.L. Fozard, J. Tobin, T.A. Toy, and B.F. Hurley. Age and gender comparisons of muscle strength in 654 women and men aged 20-93. *J Appl Physiol* 1997; 83: 1581-15867.

Lynch N.A., E.J. Metter, R.S. Lindle, J.L. Fozard, J.D. Tobin , T.A. Roy, J.L. Fleg , and B.R. Hurley. Muscle quality: Age-associated difference between arm and leg muscle groups. *J Appl Physiol* 1999; 86: 188-194.

Manson J.E., G.A. Colditz, M.J. Stamplfer, W.C. Willet, B. Rosner, R.R. Monson, F.E. Speizer, and C.H. Hennekens. A prospective study of obesity and risk of coronary heart disease in women. *N Eng J Med* 1990; 322: 882-889.

McCarthy, M. The thin ideal, depression and eating disorders in women. *Behavior Research and Therapy* 1990; 28: 205-216.

McGinnis, J. M. and W. H. Foege. Actual causes of death in the United States. *JAMA* 1993; 270: 2207-2212.

Melnyk M.G., and E. Weinstein. Preventing obesity in black women by targeting adolescents: a literature review. *J Am Diet Assoc* 1994; 94:536-40.

Metter E.J., R. Conwit, J. Tobin, and J.L. Fozard. Age-associated loss of power and strength in the upper extremities in women and men. *J Gerontol A Biol Sci Med Sci* 1997; 52: B267-276.

Must A, J. Spandano, E.H. Coakley, A.E. Fiels, G. Colditz, and W.H. Dietz. The disease burden associated with overweight and obesity. *JAMA* 1999; 282:1523-1529.

Paffenbarger L., and S. N. Blair. Relationship between low cardiorespiratory fitness and mortality in normal weight, overweight, and obese men. *JAMA* 282: 1547-1553, 1999.

Pleas J. Long-term affects of a lifestyle-change obesity treatment program among minorities. *J Natl Med Assoc*. 1988; 80:747-752.

Rand, C.W., and J.M. Kaldau. The epidemiology of obesity and self-defined weight problems in the general population: Gender, race, age, and social class. *International Journal of Eating Disorders.* 1990; 9:329-343.

Reed R.L., L. Pearlmutter, K. Yochum, K.E. Meredith, and A.D. Mooradian. The relationship between muscle mass and muscle strength in the elderly. *J Am Geriatr Soc* 1991; 39:555-561.

Rippe J.M., and S. Hess S. The role of physical activity in the prevention and management of obesity. *J A Diet Assoc* 1998; 2: S31-8.

Rosen, J.C., and J. Gross. Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology*. 1987, 6, 131-147.

Rucker C.E., and T.F. Cash. Body image, body size perceptions, and eating behaviors among African-American and White college women. *International Journal of Eating Disorders* 1992, 12(3): 291-299.

Sallis J.F. Seven-day physical activity recall. *Med Sci Sports Exerc* 1997; 29(6 suppl):S89-S103.

Sallis J.F., M.J. Buono, J.J. Roby, F.G. Michael, and J.A. Nelson. Seven-day recall and other physical activity self-reports in children and adolescents. *Med Sci Sports Exerc* 1993; 25: 99-108.

Sobal, J. Obesity and socioeconomic status: a frame work for examining relationship between physical and social variables. Special issue: bigger is better? Biocultural dynamics of body shape. *Medical Anthropology* 1991; 13: 231-247.

Sobal, J. and A.J. Stunkard. Socioeconomic status and obesity: A review of the literature. *Psychological Bulletin, 1989*; 105:260-275

Stark O., E. Atkins, H. Wolff, and J.W.B. Douglas. Longitudinal study of obesity in the National Survey of Health and Development. *Br Med J* 1981; 283:13-17.

Stevens J., J.E. Kiel, P.F. Rust, H.A. Tyroler, C.E. Davis, P.C. Gazes. Body mass index and body girths as predictors of mortality in blacks and white women. *Arch Intern Med.* 1992; 152:1257-1262.

Strunkard A.J., T.A. Sorensen, and C. Hanis. An adoption study of human obesity. *N Eng J Med.* 1986; 314:193-198.

Struckard A.J., T.T. Foch, and Z. Hrubec. A twin study of human obesity. *JAMA* 1986; 256:51-544.

Troiano R.P., K.M. Flegal, R.J. Kuczmarski, S.M. Campbell, and C.L. Johnson. Overweight prevalence and trends for children and adolescents. The Nation Health and Nutrition's Examination Surveys 1963 to 1991. *Arch Pediatr Adolesc Med* 1995; 149:1085-1091

Troiano R.P., and K.M. Flegal. Overweight children and adolescence: Description, epidemiology, and demographics. *Pediatrics* 1998 (suppl); 101(3):497-504.

Visser M., D.J. Deeg, P. Lips, T.B. Harris, and L.M. Bouter. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. *J Am Geriatr Soc* 2000; 48:381-386.

Vogler G.P., T.I.A. Sorensen, and A.J. Stunkard AJ. Influences of genes and shared family environment on adult body mass index assessed in an adoption study by a comprehensive path model. *Int J Obesity* 1995; 19: 40-45.

Ward D.S., G. Stewart, G. Trost, G. Felton, R. Saunders, M. Parsons, M. Dowda, and R.R. Pate. Physical activity and physical fitness in African-American girls with and without obesity. *Obes Res* 1997; 5:72-577.

Wardle, J. and L. Marsland. Adolescent concerns about weight and eating: A social-development perspective. *J Psychosomatic Res*, 1990; 34: 377-391.

Weinsier R.L., G.R. Hunter, A.R. Heini, M.I. Goran, and S.M. Sell. The etiology of obesity: Relative contribution of metabolic factors, diet, and physical activity. *Am J Med* 1998; 105: 145-150.

Whitaker RC, Wright JA, Pepe MS, Seidel KD, and Dietz WH. Predicting obesity in young adulthood from children and parental obesity. *N Eng J Med* 1997; 337(13): 869-873.

White, W.C., Hudson, L., and Campbell, S. Bulimarexia and black women: A brief report. *Psychotherapy*. 1985; 22, 449-450.

Wiepahl J., D.R. Ragland, and S. Sidney. Body mass index and 15-year mortality in a cohort of black men and women. *J Clin Epidemiol* 1990; 43: 949-960.

Williamson D.F., H.S. Kahn, and T. Byers. The 10-year incidence of obesity and major weight gain in black and white US women aged 30-55 years. *Am J Clin Nutr* 1991; 53 (suppl):1515S-1518S.

Williamson D.F., H.S. Kahn, P.L. Remington, and R.F. Anda. The 10-year incidence of overweight and major weight gain in US adults. *Arch Intern Med* 1990; 150: 665-672.

Young T.K. Sociocultural and behavioral determinants of obesity among inuit in the central Canadian artic. *Soc. Sci. Med* 1996; 40: 1665-1671.

CHAPTER III

NEUROMUSCULAR FUNCTION, BODY MASS, AND PHYSICAL ACTIVITY AMONG ADOLESCENT AFRICAN-AMERICAN FEMALES[1]

---

[1] Williams, R.H., Jackson, R., Barnes, C., and Dudley, G.A. To be submitted to *Medicine and Science in Sports and Exercise*

Introduction

There is enormous interest in the health of our nation. The literature has shown that citizens of the United States are increasing their adiposity levels at an alarming rate. Currently, 62% of Americans are overweight [body mass index (BMI) of 25 or greater] (National Center for Health Statistics, 1999). Not only do we observe this epidemic in the adult population (Flegal et al., 1998; Booth et al., 2000; Melnyk and Weinstein, 1994), but also evidence suggests this trend is descending into the adolescent community (Folsom et al., 1991; Lasco et al., 1989; Kumanyika and Charleston, 1992; Pleas, 1988; Melnyk and Weinstein, 1994).

The current adolescent prevalence for overweight/obesity among America's youth is greater than 15% (Troiano and Flegal, 1998; National Center for Health Statistics). This weight plague is particularly prevalent among African-American women. Flegal et al. (1998) reported that 66% of African-American women are obese or overweight. Although African-American women are not more likely than other women to be overweight during infancy and childhood, during adolescence and adulthood, body mass index and the prevalence of overweight begin to increase with age more among African-American women (Folsom et al., 1991; Lasco et al., 1989; Kumanyika and Charleston, 1992; Pleas, 1988; Melnyk and Weinstein, 1994). Accordingly, Troiano et al. (1995) reported that adolescent African-American females demonstrate the largest increase in the prevalence of overweight, increasing from 18%-31% in 6-11 year olds and 18%-30% in 12-17 year olds.

The definition of overweight/obese used in most investigations is a body mass index (BMI) of 25 or greater. A BMI >25 is considered the "basal level" for increases in a plethora of diseases. Among those diseases are diabetes, cardiovascular disease, hypertension, stroke, and certain cancers (Booth et al., 2000; Greenwood and Pittman-Waller, 1988; Williamson et al., 1990; Manson et al., 1990; Williamson et al., 1991; Melnyk and Weinstein, 1994). However, the risks associated with BMI are based upon adult standards; confirmation regarding adolescents' BMI is still ambiguous. The factors that contribute to overweight and obesity in adolescence are not well understood. However, one area of concern is the decreased time engaging in physical activity resulting in decreased energy expenditure. Participation in moderate-to-vigorous physical activity is low among adolescents. The 1990 Youth Risk Behavior Survey found adolescent African American females exhibit the highest age-related decline compared to other students of differing race in the percentage of girls reporting three or more vigorous exercise sessions per week, dropping from 22% during the freshman year to 9% in their senior year of high school (Heath et al., 1994). Furthermore, the National Center for Health Statistics reports that the percentage of 9th-12th graders undergoing daily physical education class in U.S. schools has declined from 47% to 27% between the 1991 to 1997 school terms. Preliminary data among obese-prone women suggest that a higher body weight is associated with a tendency to spend less time pursuing physical activity endeavors (Weiner et al., 1997). Currently, legislation in some states, including Georgia, minimizes and/or eliminates health/physical education classes in post-primary schooling.

Given the combination of increased fat mass and reduced participation in physical activity among adolescents, our interest is drawn to the effect, if any, on skeletal muscular characteristics of adolescent African-American females. We are aware of the graded health risk associated with inactivity and increased body fat; however, neuromuscular function in terms of concentric strength and isometric force has not been examined. Therefore, the aim of this investigation was to evaluate body composition, to record neuromuscular function, and to document physical activity among 2 groups according to their body mass index. The research design was developed to examine a cross-section of the adolescent African-American female population. The hypotheses is that groups differing in body mass index will differ in fat mass and lean tissue mass of the extremities; will differ in muscular strength on the lower extremity, but not of the upper extremity; and will differ in time engaged in physical activity.

Methods and Measurements

Subjects: Those diagnosed with clinical cardiovascular or musculoskeletal disease were excluded. Also, subjects were excluded if they were pregnant, had neck, back, or joint pain, any surgery in the past year, or any other condition that might be aggravated by strength testing. After receiving a complete explanation of the procedures and risks of the study, all subjects and parents/guardians gave their written informed consent. All subjects received a complete medical history and physical examination prior to testing (Dr. Reginald Jackson, MD and Cassandra Barnes, RN).

Twenty-seven African-American adolescent female students (aged 14-18 years) from the Athens, Georgia area participated in a seven-week protocol that included testing of reliable and valid measures of body composition, neuromuscular functioning, and physical activity. The Institutional Review Board for Human Subjects approved the protocol of this study (University of Georgia, Athens, GA).

Weight and Height: Standing height without shoes was measured to the nearest 0.5 cm, using a wall standiometer. Body weight was measured on a balance scale to the nearest 0.5 kg, with the subjects in exercise clothes and no shoes. Body mass index (BMI) was calculated as weight (kg) divided by height (m^2). BMI was utilized as an index of body fatness. Subjects were categorized into two groups relative to their BMI status. The 85th-percentile (gender and age specific) BMI cutoff point calculated at 6-months age intervals was the criterion used for adolescent overweight grouping, derived respectively from National Health Examination Survey, cycles 2 and 3. Teens were grouped as "high-risk" for major health problems if they had a BMI greater than 22.5 and as "low-risk," if they had a BMI less than 22.4.

Body Mass Assessment: Employing the total body scan operation, body mass was measured by dual-energy X-ray adsorptiometry (DEXA) to determine percent body fat, total body fat mass and nonosseous total body fat-free mass, as well as fat mass and nonosseous fat free mass of the extremities (arm and leg).

Arm fat free mass included soft tissue extending from the center of the shoulder joint to the phalange tips, while leg fat free mass consisted of soft tissue extending from an angled line drawn through the femoral neck to the phalange tips. Nonosseous appendicular fat free mass derived from these regional measurements was assumed to be a valid estimation of appendicular skeletal muscle mass of the extremities, based upon the work of Wang et al. (1999). All scans were analyzed, using the Hologic software program (Hologic QDR-1000W enhanced whole body analysis software version 5.71, Waltham, MA) for body composition analyses. The scanner was calibrated daily before testing and DEXA within-subjects standard deviation of duplicate measurements of percent fat roughly one-week apart in five subjects was 0.2% (Modlesky, 1996).

Muscular strength: Muscle strength was measured in two muscle groups (arm flexors and thigh extensors) by two different methods (a one-repetition maximum [1RM] and isometric maximal voluntary contraction [MVC]). Thigh extensor 1RM was performed on a standard leg extension machine (Magnum Leg Extension Fitness System by Bagder Fitness Equipment), where subjects were asked to lift a given weight while seated upright. Additionally, the upper arm flexor 1 RM was also measured. Upper-arm 1RM was performed by raising a weighted dumb-bell while seated upright. 1RM for upper arm flexors and thigh extensors were obtained via three attempts at subjects' 1RM with a 3-minute rest interval between lifts. In order to obtain a reliable and valid strength index of the extremities, subjects were tested weekly for four weeks. During the fifth week, a final neuromuscular strength value was recorded and compared between the four previous weeks. The highest strength value obtained during the fifth week served as the criterion strength value.

The isometric MVC of each subject was recorded using a MacLab A-D converter sampling at 100Hz, interfaced with an Apple MacIntosh computer. A 250--500-millisecond window was utilized to detect peak force over a three-second contraction. Subjects were asked to perform three isometric MVC's, with 1-minute rest intervals for both the upper arm flexor and thigh extensor muscle groups. In order to assess a reliable and valid isometric MVC, subjects were tested weekly for four weeks. During the fifth week, a final neuromuscular strength value was recorded and compared between the four previous weeks. The highest strength value obtained during the fifth week served as the criterion strength value.

Physical Activity Measurement: In order to estimate the subject's time engaged in physical activities over a week, the Seven-Day Physical Activity Recall (PAR) questionnaire was administered. The PAR questionnaire is an assessment tool that assesses daily physical activity components. The number of hours spent in sleep and performing different levels of activity were obtained and given a metabolic equivalent (MET, the expression of the energy cost of activity) value. Although the PAR questionnaire is designed to measure a variety of physical activities, only time spent in physical activities of moderate intensity and greater are summed (Sallis, 1997). From hours spent in moderate (4 METs), hard (6 METs) and very hard (10 METs) intensity physical activity, the energy expenditure in kilocalories/kilogram body weight/day was estimated (Sallis, 1997). Previous studies indicate that the PAR is valid measure of leisure, occupational, and structured physical activity (Sallis et al., 1986; Dishman and Steinhart, 1988; Wallace et al., 1985).

Total steps taken over 5 non-consecutive days (same reference week of PAR questionnaire) was used as an objective measure of physical activity. Subjects were instructed to wear a pedometer or step counter (Digi-Walker 2000 model) on their waist for seven days, as described by Welk et al. (2000). Throughout a one-week period, participants were asked to complete a daily log in which they recorded the times they woke up and went to bed and the times the Digi-Walker was put on and taken off. The Digi-Walker recorded the number of steps taken daily.

Statistical Analyses: Data analysis was performed using the SPSS software (v.10). Standard statistical descriptive methods were employed for calculations of means and standard errors. Relationships between variables were determined by Pearson correlations. A two-way repeated measure analysis of variance (group X time) was performed on all neuromuscular function measures during the four-week practice trial to test for a ”training” effect. Subsequently, a two-sample independent t-test was performed to compare “low-risk” to “high-risk” groups among all measures. Statistical significance was based on an alpha level less than 0.05.

Results

Physical Characteristics: Descriptive characteristics of the two groups are presented in *Table 3.1*. The “low-risk” and “high-risk” groups were similar in age ($p= 0.831$) and height ($p= 0.253$) but significantly different in body weight ($p < 0.0001$) and BMI ($p < 0.0001$).

Body Composition Assessment Measures: Group descriptive statistics for body composition measures are illustrated in *Figures 3.1-3.3*. Results from DEXA whole body scans showed that “high-risk” group had significantly more total body fat (%) ($p< 0.0001$), non-dominant arm fat (%) ($p< 0.0001$) and leg fat (%) ($p < 0.0001$). Hence, the “high risk” group also had greater total body fat mass ($p=0.0001$), non-dominant arm fat mass ($p < 0.0001$) and leg fat mass ($p=0.0001$). Additionally, the “high risk” group had greater total body fat-free mass ($p= 0.029$), non-dominant arm fat free mass ($p = 0.025$) and leg fat-free mass ($p = 0.041$) than their “low-risk” counterparts.

Neuromuscular Strength Measures: Descriptive group statistics for neuromuscular function measures of the upper and lower extremity are given in *Figures*

3.4 and 3.*5* respectively. Even though the “high risk” group produced somewhat greater neuromuscular strength among all extremity measures, there was no statistically significant difference between groups in upper arm flexor 1RM and MVC strength (*Figure 3.4a* and 3.*4b*). Likewise, leg MVC strength (*Figure 3.5b*) was similar among groups. Yet, the “high-risk” group produced significantly more absolute leg 1RM strength (*Figure 3.5a*).

Physical Activity Measures: The physical activity data are presented in *Figure 3.6*. The “high-risk” group spent more time engaging in moderate and hard activities (9.82 and 6.00 hrs/wk respectively) and relatively no time pursuing very hard activities (2.56 hrs/wk) compared to their “low-risk” counterparts (*Figure 3.6a*). Energy expenditure was higher for the “high risk” group during activities of moderate-to-very hard (*Figure 3.6b*, p=0.042). However, the data suggest no significant difference exits between energy expenditure expressed relative to body weight (p = 0.222) or relative to fat-free mass (0.426) between the groups (*Table 3.2*). The “high-risk” group also recorded greater steps taken per day (over 5 non-consecutive days), as determined by pedometer counts (*Figure 3.6c,* p< 0.001).

Discussion

The primary objective of this study was to compare "high-risk" to “low-risk” individuals on body composition, neuromuscular function, and physical activity. Important features of the current study include the use of DEXA to obtain a valid measure of total body fat and fat free mass and area specific fat and fat free mass as well as valid and reliable measures of two indices of neuromuscular function, and the assessment of a direct and indirect measure of physical activity.

Body Composition: Although having 37%, 57%, and 47% greater fat mass in total body, arm and leg fat mass respectively, the "high risk" group had roughly 10%, 11%, and 12% more lean tissue mass measured by DEXA than their "low risk" counterparts. The groups differed significantly in fat and lean tissue. It was hypothesized that the "high risk" group would have greater compensatory lean tissue mass of the extremities. This comes as no surprise since the "high-risk" group had significantly more adipose tissue and thus had to support a greater load. The data are in agreement with published literature which suggests greater lean tissue mass with increasing body weight among adults (Prior et al., 2001). Moreover, limited data exist concerning African-Americans females and their body composition. To date, no data were found examining adolescent African-American females and their body fat and lean tissue masses. The idea of having greater lean tissue mass suggests an enhance ability to develop and maintain force. Hence, the more compensatory lean tissue mass, the greater the potential force value.

Neuromuscular Function: In the present study, data provided evidence of neuromuscular strength in adolescent African-American females. In order to be certain that extremity measures of strength were valid and reliable, four weeks of baseline data were obtain. Most studies allow two-to-three warm up attempts prior to recording a strength measure; however, the current investigation examined five weeks of extremity neuromuscular strength. From the data, there was no significant difference between the first four weekly strength scores and the final strength scores of the extremity. Thus, the data successfully showed that potentially confounding learning and familiarization effects did not play a role in this investigation. Therefore, the final neuromuscular strength measure reflects reliable and valid extremity neuromuscular strength.

Although the “high risk” group recorded greater neuromuscular strength values of the upper extremity, no significant difference was observed between groups in upper arm 1RM or isometric MVC strength. This finding is somewhat of a surprise. Because of the significantly greater fat free mass values in the “high risk” group, you would expect a greater difference in strength score. However, the lack of upper arm loading or its use in weight bearing support is relatively small. Studies that investigate skeletal muscle contour suggest weight bearing and postural control muscles are most at risk during short-term disuse (Gogia et al, 1988: Hather et al, 1992).

Evidence from Ward et al. (1997) also observed similar findings in their investigation of obese and non- obese females. Their authors also report a higher non-significant absolute strength score in elbow flexion for obese females (22.7 ± 3.9 kg) than for non-obese females (21.2 ± 4.5 kg). The data from the current study produced similar results for isometric arm flexion torque (28.83ft/lbs and 25.91ft/lbs for "high-risk" and "low-risk," respectively Figure 4b) and dynamic (1RM) arm flexion force (7.69kg and 7.06kg for "high-risk" and "low-risk," respectively). Ward et al. (1997) observed that when elbow flexion was expressed relative to body weight, girls with obesity were found to exhibit significantly lower levels of upper body strength (Ward et al., 1997). Similarly, the “high-risk” group reported a lower but non-significant value in strength relative to body weight. When strength measures were expressed relative to fat free mass, elbow flexion was significantly lower in girls with obesity (Ward et al., 1997); however, this was not seen in the current study. In conclusion, there was no neuromuscular difference found in the upper extremities of these subjects, primarily because there was no difference observed in either strength index; however, the “high-risk” group possessed a significantly larger arm-FFM value ($p = 0.025$).

In the examination of lower extremity neuromuscular strength, the “high risk” group recorded greater neuromuscular function for all the strength values. Furthermore, a significance difference was observed in the 1RM but not isometric MVC of the thigh extensors between groups. This finding is not suprising given the greater body mass; however, the lack of separation between groups in their isometric MVC extensor strength score is surprising. Although both measures of thigh extensor force were moderately correlated ($r = 0.654$, $p < 0.001$), isometric MVC was similar between groups. Therefore, the authors conclude 1RM thigh extensor strength provides a better separation index of lower extremity strength among varying body weights of adolescent African-American females. However, what effect does the loading characteristics play upon the “high risk” group? The literature suggests that the extensor muscle groups of the lower extremities have a greater risk of muscle atrophy as activity decreases. Adams et al. (1994) noted that the knee extensors cross- section area, CSA (decreased 8%) were more affected than the knee flexors after 16 days of limb suspension. Similarly, Hather et al. (1992) reported a 16% decrease in knee extensor muscle in the cross sectional area after 6 weeks of lower limb suspension. Moreover, Berg et al. (1997) reported a 14% decrease in knee extensors in the cross sectional area after 37 days of bed rest. Therefore, the magnitude of muscle atrophy is directly related to the duration of unloading.

Studies investigating neuromuscular function also have noted the altered muscular effect of short-term disuse (Duvoisin et al., 1989; Gogia et al., 1998; Berg et al., 1997;

Dudley et al., 1992, Adams et al., 1994). For example, Berg et al. (1997) observed a 25%-30% decrease in maximum voluntary isometric and concentric knee extensor torque following 6 weeks of bed rest. Duvoisin et al. (1989) reported a 19% decrease in knee extensor strength (torque) following a 30-day bed rest. The decline in extensor muscle group strength is in agreement with a more pronounced decline in the extensor muscle group cross sectional area following short-term disuse. Thus, inactivity influences muscular integrity by reducing the muscle's ability to perform work. These data support the idea of "use it" or "lose it."

Physical Activity: The physical activity data suggest that the groups differed in pursuits of physical activity. The "high risk" group reported a significantly greater step count per day (over 5 non-consecutive days) and energy expenditure during activities of moderate-to-very hard than their "low risk" counterparts. The current data argues against other data which suggest overweight and obese individuals spend less time in physical activity (Weinser et al, 1997). The CDC's Youth Risk Behavior Surveillance System (1990) and Behavior Risk Factor Surveillance Survey (1998), suggests African-American females are facing two major lifestyle-related predicaments that have surfaced over the last two decades--a plague of inactivity and an epidemic of increasing adiposity. Multiple interactions exist between the lack of physical activity (decreased energy expenditure) and obesity. Indirect evidence from various national surveys supports this view and suggests that reduced total daily physical activity may be the most important current factor contributing to the increase in body weight (Ward et al., 1997). Furthermore, Kumanyika et al. (1993) found that adolescents who perceived themselves as "too fat" reported fewer days of strenuous activity, fewer hours of strenuous exercise in physical education class, and more hours spent viewing television on school days than fit students. Likewise, Andersen et al. (1998) reported that 20% of U.S. children participate in two or fewer bouts of vigorous physical activity per week. The results also showed that children who watched 4 or more hours of television each day had a greater body fat and body mass index than those who watched less than two hours per day (Andersen et al., 1998). The results of the current study do not support conclusions of altered pursuits of activity with increasing fat mass. Based on our data, the "high-risk" individuals participated in greater pursuits of activity, therefore contradicting Melnyk and Weinstein (1994), Weinser et al. (1997), and Kumanyika et al. (1993), who observed a positive correlation between low levels of physical activity in African-American females and their higher rates of obesity.

Moreover, compared to previous data (Welk et al., 2000; Hatano, 1993; Mathews and Freedson, 1995) groups in the current investigation produced high levels of recorded steps: 10,597 and 13,125 for “low-risk” and “high-risk,” respectively (*Figure 3.6c*). Thus, our data indicate groups were above and beyond the reported traditional public health activity guidelines (e.g., > 30 min of moderate activity and/or > 20 min of vigorous activity); however, studies are needed in order to empirically determine whether these guidelines are appropriate for differing populations. The data are also in agreement with those of Wilde (2002) who observed over 600 adolescents (14-16 year old) who reported values of 11,000-12,000 steps/day. However, these subjects were mostly Caucasian and data regarding African Americans persons are limited. Additionally, evidence suggests that reporting physical activity as energy expenditure makes it appear that the “higher risk” individuals are more active than those who are normal weight (Tudor-Locke and

Myers, 2001). In agreement with this, studies have shown that pedometers are most accurate at measuring steps taken (Bassett et al., 1996; Hendelman et al., 2000), and less accurate at estimating energy expenditure (Bassett et al., 2000). For these reasons, researchers have recommended that steps taken or steps/day be universally adopted as a standard unit of measurement for collecting, reporting, and interpreting pedometer data (Tudor-Locke, 2002).

Even though the present data go against the prevailing theories associated with increasing fat mass and decreasing time in physical activity pursuits, the data are more in agreement with the dwindling of activities involving hard-to-vigorous intensities. In the present study, groups participated in relatively no time in very hard activities (1.88 and 2.56 hrs/wk for “low-risk” and “high-risk” respectively). Therefore, targeting physical inactivity by promoting less television viewing, less use of video games, and less automobile usage, as well as encouraging increased vigorous physical exercise, are reasonable alternatives to ensure good health and prevent obesity in children (Rippe & Hess, 1998).

Conclusion

Obesity displays co-morbidity with of some of the most prevalent diseases of modern society (Booth et al., 2000). For example, cardiovascular disease, hypertension, gallbladder disease, diabetes mellitus, atherosclerosis, gout, arthritis, and certain cancers have all been associated with obesity in adults (Melnyk and Weinstein, 1994). In fact, the number of co-morbidity diseases displayed by an individual rises with increasing body weight (Must et al., 1999). The adverse health effects of obesity not only affect the adult population, but may also manifest during adolescence. Some cardiovascular risk factors begin in childhood, among them increased serum total cholesterol, altered lipoprotein subtraction concentrations and hypertension (Colditz and Coakley, 1997). In addition, racial differences in health risk and obesity are also noted. Of particular concern is the location of the excess adipose tissue in African-American females. In obese African-American females, fat deposition occurs in the body's central regions, coined "trunkal fat" (Greenwood and Pittman-Waller, 1988; Kumanyika, 1987; Folsom et al., 1991). The early accumulation of fat in the intra-abdominal region is significantly related to the development of adverse health effects. Among those, rates for hypertension, stroke, coronary heart disease, evaluated blood lipids and diabetes among African-American women are reported to be 1.5 to 2.5 times the rates among Caucasian women (Melnyk and Weinstein, 1994). Although the present study did not test for any medical abnormalities, preliminary data of the blood glucose-insulin profile among three of the "high-risk" subjects did not demonstrate heightened plasma glucose levels following 2-hour oral glucose ingestion (unpublished data).

The aim of this investigation was to evaluate body composition, to record neuromuscular function, and to document physical activity among 2 groups differing in their body mass index. From the cross-sectional research design, the 2 groups of adolescent African-American females were also found to differ on leg strength (1RM), an objective measure of physical activity (steps per day), and a subjective measure of energy expenditure (kcal/day); but were similar in arm strength and the subjective measure of energy expenditure when it was expressed per kg of body weight (kcal/kg/day). Thus the hypotheses was affirmed regarding group difference in fat mass and lean tissue mass of the extremities; group difference in muscular strength on the lower extremity, but not of the upper extremity; and group difference in energy expenditure, time, and steps taken participating in physical activity. However, the hypothesis suggesting higher physical activity in the “low-risk” group was not supported.

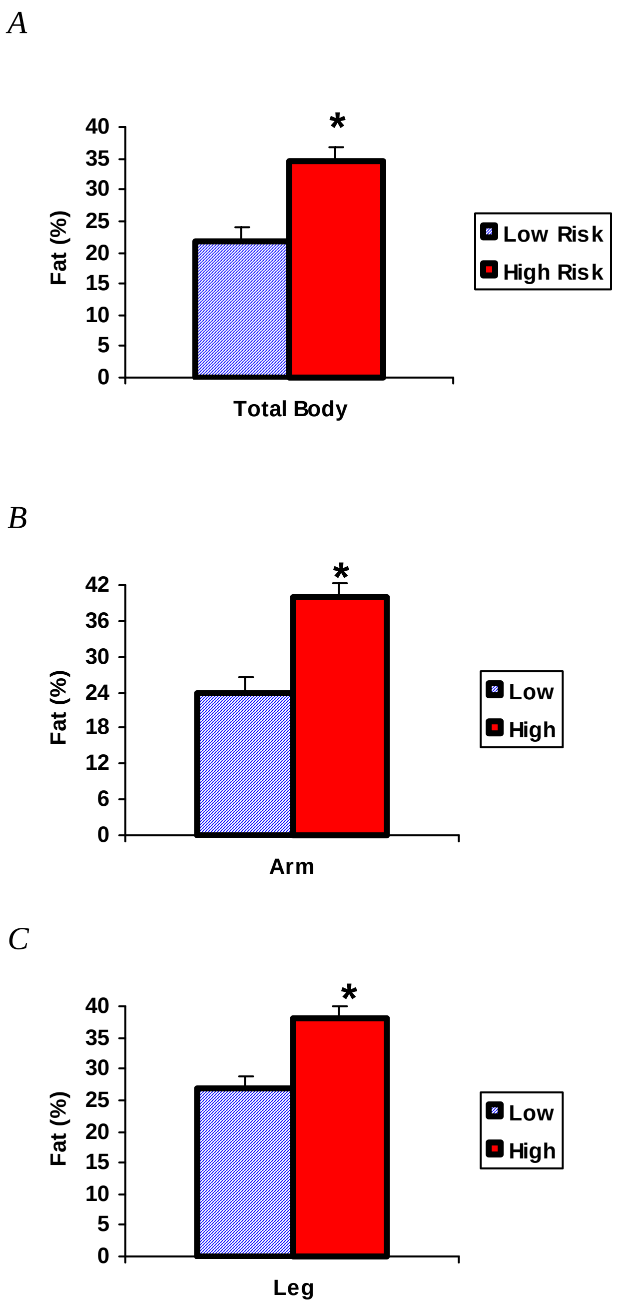

Figure 3.1: The relationship between low and high risk subjects and % fat from DEXA measurements. *a*) total body, *b*) non-dominant arm, *c)* non-dominant leg. Values are means and standard errors. * indicates a significant difference between groups, $p < 0.0001$.

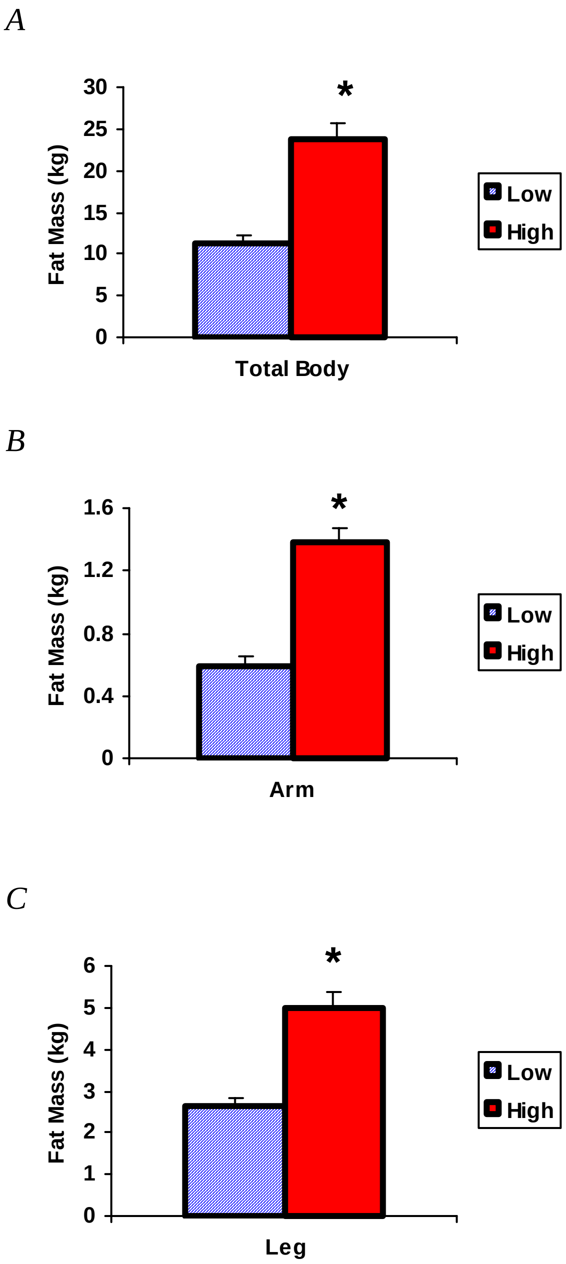

Figure3.2: The relationship between low and high risk subjects and fat mass (kg) from DEXA measurements. *a*) total body, *b*) non-dominant arm, *c*) non-dominant. Values are means and standard errors. * indicates a significant difference between groups, $p < 0.0001$.

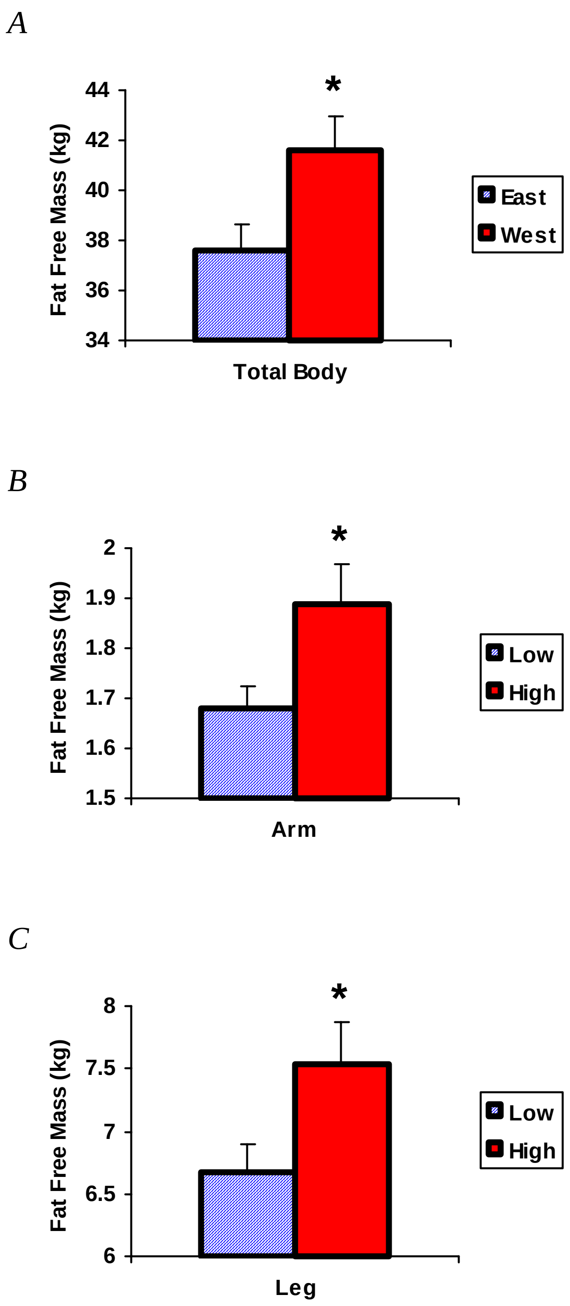

Figure 3.3: The relationship between low and high risk subjects and fat free mass (kg) from DEXA measurements. *a*) total body, *b*) non-dominant arm and, *c*) non-dominant leg. Values are means and standard errors. * indicates a significant difference between groups, $p < 0.05$.

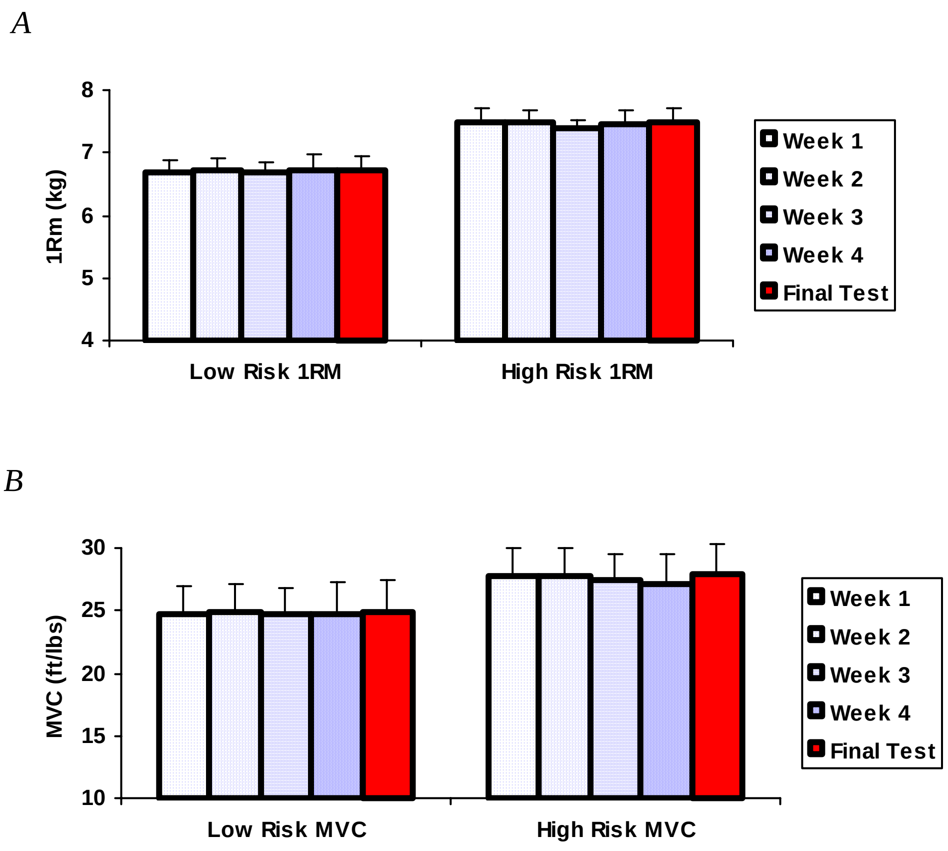

Figure 3.4: The relationship between low and high risk subjects and upper arm flexor strength measures. *a*) non-dominant upper arm flexor 1RM and *b*) non-dominant upper arm flexor isometric MVC over 4 weekly familiarization trials. There was no significance difference between four weekly strength measures and the final arm flexor strength test. There was no significant difference between groups and upper arm flexor strength. Values are means and standard errors.

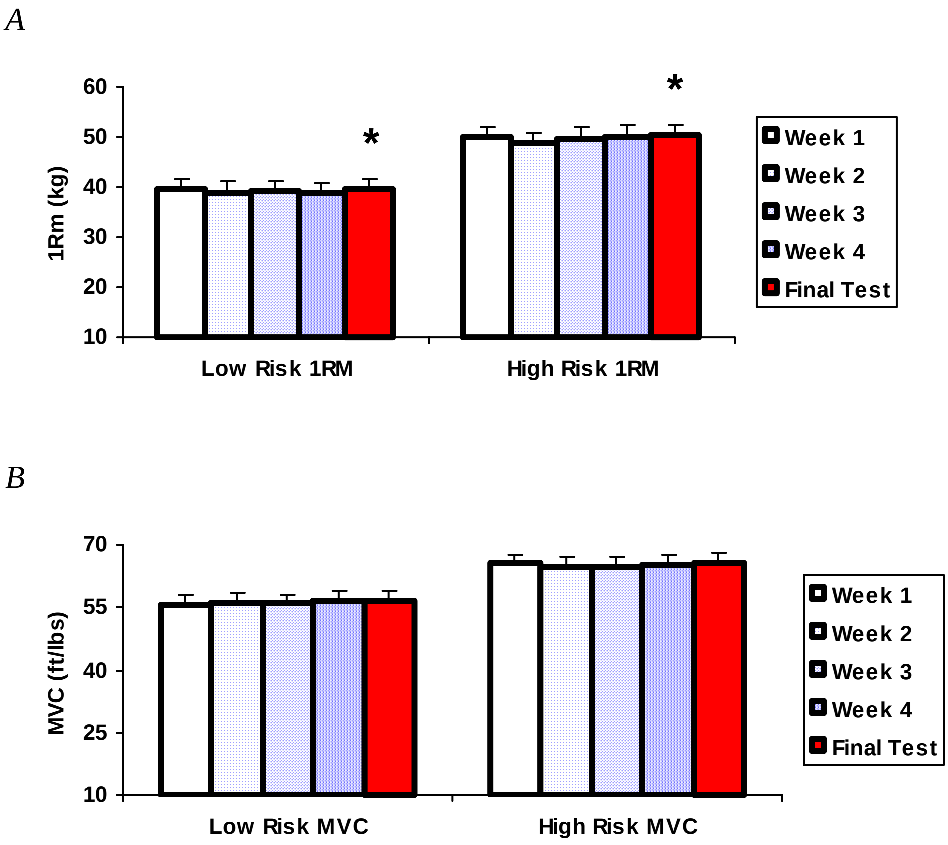

Figure 3.5: The relationship between low and high subjects and thigh extensor strength measures. *a*) non-dominant thigh extensor 1RM and *b*) non-dominant thigh extensor isometric MVC over 4 weekly familiarization trials. There was no significance difference between four weekly strength measures and the final arm flexor strength test. There was a significant difference between groups and non-dominant thigh extensor 1RM strength. Values are means and standard errors.

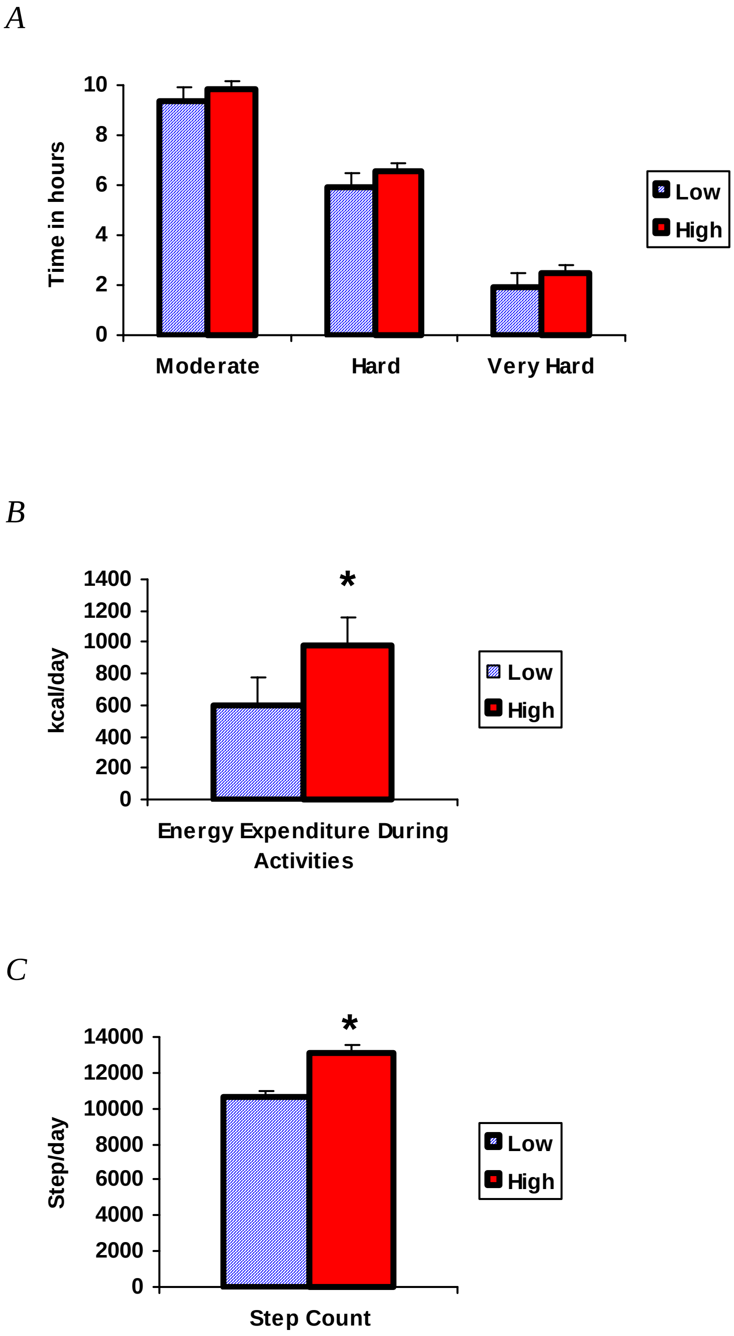

Figure 3.6: Physical activity data for the high and low risk groups. *a*) time in hours in moderate, hard, and very hard weekly activities, *b*) energy expenditure during weekly activities involving moderate-to-very hard, *c*) steps with pedometer (5 non-consecutive days). Values are means and standard errors. * indicates a significant difference between groups, $p < 0.05$.

Table 3.1: Group Statistics

	Risk Group	N	Mean	Std. Error	P-value
Age (yrs)	Low	14	15.1	0.305	0.831
	High	13	15.2	0.222	
Height (m)	Low	14	1.63	0.018	0.253
	High	13	1.60	0.197	
Body Weight (kg)	Low	14	52.50	1.965	**< 0.0001**
	High	13	68.94	3.247	
Body Mass Index (kg/m^2)	Low	14	19.7	0.496	**< 0.0001**
	High	13	27.0	1.220	

In *Table 3.1*, **bold-type** indicates a significant difference between groups among physical characteristics.

Table 3.2: Energy expenditure associated with moderate, hard, and very hard physical activities

	Risk Group	N	Mean	Std. Error	P-value
kcal / day	Low	14	598.90	89.43	**0.042**
	High	11	974.66	161.04	
Kcal / kg-body weight / day	Low	14	11.44	1.702	0.426
	High	11	13.41	1.69	
kcal / kg-ffm body / day	Low	14	433.53	65.92	0.222
	High	11	563.14	80.89	
Step count	Low	14	10597.5	392.32	**< 0.0001**
	High	13	13125.4	465.30	

In *Table 3.2*, **bold-type** indicates a significant difference between groups among physical activity measures.

References

Adams G.R., B.M. Hather, and G.A. Dudley. Effect of short-term unweighting on human skeletal muscle strength and size. *Aviat Space Environ Med* 1994; 65:1116-1121.

Andersen R.E., C.J. Crepso, S.J. Bartlett, L.J. Cheskin, and M. Pratt. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the third national health and nutrition examination survey. *JAMA* 1998; 279(12):938-42.

Bassett, D.R., B.E. Ainsworth, S.R. Leggett, C.A. Mathien, J.A. Main, D.C. Hunter, and G.E. Duncan. Accuracy of five electronic pedometers for measuring distance walked. *Med Sci Sports Exerc* 1996; 28(8): 1071-1077.

Berg H.E., L. Larsson, and P.A. Tesch. Lower limb skeletal muscle function after 6 weeks of bed rest. *J Appl Physiol* 1997; 82:182-188.

Booth F.W., W. Scott, E. Gordon, C.J. Carlson, and M.T. Hamilton. Waging war on modern chronic diseases: Primary prevention through exercise biology. *J Applied Physiology* 2000; 88: 774-787.

Centers for Disease Control and Prevention. *National Center for Health Statistics, Healthy People 200. Review, 1998-99.* Hyattsville, MD: Public Health Service, 1999.

Colditz G.A., and E. Coakley. Weight, weight gain, activity, and major illnesses: the nurses' health study. I*nt J Sports Med* 1997; 3:S162-70.

Differing J, G.J. Welk, J. Hart, and A. Symington. The use of the Digi-Walker step counter to measure levels of physical activity. *Med Sci Sports Exerc* 1998; 30: S11

Dishman R.K. and M. Steinhardt. Reliability and concurrent validity for a 7-d recall of physical activity in college students. *Med Sci Sports Exerc* 1988; 20:14-25.

Dudley G.A., M.R. Duvoisin, G.R. Adams, R.A. Meyer, A.H. Belew, and P. Buchanan. Adaptations to unilateral lower limb suspension in humans. *Aviat Space Environ Med* 1992; 63: 678-683.

Duvoisin M.R., V.A. Convertino, P. Buchanan , P.D. Gollnick, and G.A. Dudley. Characteristics and preliminary observations of the influence of electromyostimulation on the size and function of human skeletal muscle during 30 day exposure to simulated microgravity. *Aviat Space Environ Med* 1989; 60:659-663.

Easton R.G., A.V. Rowland, and D.K. Include. Validly of heart rate, pedometer, and accelerometer for predicting the energy cost of children's activities. *J Appl Physiol* 1998; 84:362-371.

Flegal K.M. Overweight and obesity in the United States: Prevalence and trends, 1960-1994. *Int Journal of Obesity* 1998; 22:39-47.

Folsom A.R., T.C. Cook, J.M. Sprafka, G.L. Burke, S.W. Norsted, and J.R. Jacobs. Differences in leisure-time physical activity levels between blacks and whites in population-based samples: the Minnesota Heart Study, *J Behav Med* 1991; 14:1-9.

Gillum R.F. Overweight and obesity in black women: a review of published data from the National Center for Health Statistics. *J Natl Med Assoc* 1987; 79:865-871.

Gogia P, V.S. Schneider, A.D. LeBlane, J. Krebs, C. Kasson, and C. Pientok C. Bed rest effect on extremity muscle torque in healthy men. *Arch Phy Med Rehabil* 1988; 69:1030-1032.

Gortmaker S.L., W.H. Dietz, A.M. Sobal, and C.A. Wehler. Increasing pediatric obesity in the United States. *Am J Dis Child* 1987; 141: 535-540.

Gortmaker S.L., A. Must, and A.M. Sobol. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc* 1996; 150:356-362.

Hather B.M., G.A. Adams, P.A. Tesch, and G.A. Dudley. Skeletal muscle responses to unilateral lower limb suspension. *J Appl Physiol* 1992; 72:1493-1498

Hatano Y. Use of the pedometer for promoting daily walking exercise. *Int Council Health, Physical Educ Recr* 1993; 29: 4-28.

Heath G.W., M. Pratt, C.W. Warren, and L. Kann. Physical activity trends in America high school students. *Arch Pediatr Adolesc Med.* 1994; 148: 1131-1136.

Hendelman, D., K. Miller, C. Baggett, E. Debold, and P Freedson. Validity of accelerometry for the assessment of moderate intensity physical activity in the field. *Med Sci Sports Exerc* 2000; 32(9): S442-S450.

Jung RT. Obesity as a disease. *Br. Med bull* 1997; 53: 307-321.

Kumanyika S., J.F. Wilson, and M. Guilford-Davenport. Weight-related attitudes and behaviors of black women. *J Am Diet Assoc* 1993; 93: 416-22.

Kumanyika S. Obesity in black women. *Epidemiol Rev.* 1987; 9:31-50.

Kumanyika S.K., and J.B. Charleston. Loose weight and win: a church-based weight loss program for blood pressure control among black women. *Patient Educ Counsel.* 1992; 19: 19-32.

Lasco R.A., RH. Curry, V.J. Dickson, J. Powers, S. Menes, and R.K. Merritt. Participation rates, weight loss, and blood pressure changes among obese women in a nutrition-exercise program. *Public Health Rep* 1989; 104: 640-646.

Lynch N.A., E.J. Metter, R.S. Lindle, J.L. Fozard, J.D. Tobin , T.A. Roy, J.L. Fleg , and B.R. Hurley. Muscle quality: Age-associated difference between arm and leg muscle groups. *J Appl Physiol* 1999; 86: 188-194.

Mathews C.E., and P.S. Freedson. Field trial of a three-dimensional activity monitor: comparison with self report. *Med Sci Sports Exerc* 1995: 27:1071-1078.

McGinnis, J. M. and W. H. Foege. Actual causes of death in the United States. *JAMA* 1993; 270: 2207-2212.

Melnyk M.G., and E. Weinstein. Preventing obesity in black women by targeting adolescents: a literature review. *J Am Diet Assoc* 1994; 94:536-40.

Metter E.J., R. Conwit, J. Tobin, and J.L. Fozard. Age-associated loss of power and strength in the upper extremities in women and men. *J Gerontol A Biol Sci Med Sci* 1997; 52: B267-276.

Modlesky, C.M., K.J. Cureton, R.D. Lewis, B.M. Prior, M.A. Sloniger, and D.A. Rowe. Density of the fat-free mass and estimates of body composition in male weight trainers. *J Appl Physiol* 1996; 80:2085-2096.

Must A, J. Spandano, E.H. Coakley, A.E. Fiels, G. Colditz, and W.H. Dietz. The disease burden associated with overweight and obesity. *JAMA* 1999; 282:1523-1529.

Must, A., J. Spandano, E. H. Coakley, A. E. Field, G. Colditz, and W.H. Dietz. The disease burden associated with overweight and obesity. *JAMA* 282: 1523-1529, 1999.

Pleas J. Long-term affects of a lifestyle-change obesity treatment program among minorities. *J Natl Med Assoc*. 1988; 80:747-752.

Paffenbarger L., and S. N. Blair. Relationship between low cardiorespiratory fitness and mortality in normal weight, overweight, and obese men. *JAMA* 282: 1547-1553, 1999.

Pocock N., J. Eisman, T. Gwinn, P. Sambrock, P. Kelly, J. Freund, and M. Yeates. Muscle strength, physical fitness, and weight but not age predict femoral neck bone mass. *J Bone Min Res* 1989; 4: 441-447.

Rand, C.W., and J.M. Kaldau. The epidemiology of obesity and self-defined weight problems in the general population: Gender, race, age, and social class. *International Journal of Eating Disorders.* 1990; 9:329-343.

Rantanen T, and J. Avela. Leg extension power and walking speed in very old people living independently. *J Gerontol A Biol Sci Med Sci* 1997;5 2:M22-M231.

Ryan A.S., and J. Nicklas. Age-related changes in fat deposition in mid-thigh muscle in women: relationships with metabolic cardiovascular disease risk factors. 1998.

Reed R.L., L. Pearlmutter, K. Yochum, K.E. Meredith, and A.D. Mooradian. The relationship between muscle mass and muscle strength in the elderly. *J Am Geriatr Soc* 1991; 39:555-561.

Rippe J.M., and S. Hess. The role of physical activity in the prevention and management of obesity. *J A Diet Assoc* 1998; 2: S31-8.

Rosen, J.C., and J. Gross. Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology*. 1987, 6, 131-147.

Sallis J.F., M.J. Buono, J.J. Roby, F.G. Michael, and J.A. Nelson. Seven-day recall and other physical activity self-reports in children and adolescents. *Med Sci Sports Exerc* 1993; 25: 99-108.

Sallis J.F. Seven-day physical activity recall. Med Sci Sports Exerc 1997; 29 (6 suppl):S89-S103.

Stark O., E. Atkins, H. Wolff, and J.W.B. Douglas. Longitudinal study of obesity in the National Survey of Health and Development. *Br Med J* 1981; 283:13-17.

Struckard A.J., T.A. Sorensen, and C. Hanis. An adoption study of human obesity. *N Eng J Med.* 1986; 314:193-198.

Troiano R.P., K.M. Flegal, R.J. Kuczmarski, S.M. Campbell, and C.L. Johnson. Overweight prevalence and trends for children and adolescents. The Nation Health and Nutrition's Examination Surveys 1963 to 1991. *Arch Pediatr Adolesc Med* 1995; 149:1085-1091

Troiano R.P., and K.M. Flegal. Overweight children and adolescence: Description, epidemiology, and demographics. *Pediatrics* 1998 (suppl); 101(3):497-504.

Tudor-Locke, C. Taking steps toward increased physical activity; using pedometers to measure and motivate. *Research Digest: President's council on physical fitness and sports* 2002; 17(3):1-8.

Visser M., D.J. Deeg, P. Lips, T.B. Harris, and L.M. Bouter. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. *J Am Geriatr Soc* 2000; 48:381-386.

Ward D.S., G. Stewart, G. Trost, G. Felton, R. Saunders, M. Parsons, M. Dowda, and R.R. Pate. Physical activity and physical fitness in African-American girls with and without obesity. *Obes Res* 1997; 5:72-577.

Wallace J.P., T.L. McKenzie, and P.R. Nader. Observed vs. recalled exercise behavior: a validation of a seven day exercise recall for boys 11to 13 years old. *Res Q Exerc Sport* 1985; 56: 161-165.

Wardle, J. and L. Marsland. Adolescent concerns about weight and eating: A social-development perspective. *Journal of Psychosomatic Research*, 1990; 34: 377-391.

Wei, M., J. B. Kampert, C. E. Barlow, M. Z. Nichaman, L. W. Gibbons, R. S. Modern chronic diseases: Primary prevention through exercise biology. *J Appl Physiol* 2000; 88: 774-787.

Weinsier R.L., G.R. Hunter, A.R. Heini, M.I. Goran, and S.M. Sell. The etiology of obesity: Relative contribution of metabolic factors, diet, and physical activity. *Am J Med* 1998; 105: 145-150.

Widle, B.E., C.L. Sidman, and C.B. Corbin. A 10,000 step count as a physical activity target for sedentary women. *Research Quartley for Exercise and Sport*, 2001; 72(4): 411-414.

Widle, B.E. Activity patterns of high school students assessed by a pedometer and a national activity questionnaire. 2002 Arizona State University, Mesa, AZ

CHAPTER IV

SKELETAL MUSCLE PROFILES AMONG ADOLESCENT AFRICAN-AMERICAN FEMALES: MUSCULAR STRENGTH, SPEED AND FATIGE CHARACTERISTICS[1]

---

[1] Williams, R.H. and Dudley, G.A. To be submitted to *Journal of Applied Physiology*

Introduction

Skeletal muscle performs a variety of important functions that allow for efficiency in daily life activities. Genetics, neural control, metabolic influences, environmental factors, diet, physical activity and exercise all greatly influence the skeletal muscles' ability to exert force. Although the factor(s) that mostly influence muscles' ability to generate force is not known, one heightened area found within the literature is neuromuscular strength testing. The literature suggests that adult skeletal muscle mass is highly correlated with dynamic strength and/or isometric power among men and women (Overend et al., 1992; Viitasalo, 1985; Lindle et al., 1997;Young et al., 1985; Kallman et al., 1990; Reed et al., 1991). Furthermore, numerous models of skeletal muscle characteristics and profiles of strength have been published as well (Dutta et al., 1997; Kallman et al, 1990; Reed et al., 1991). Among these, Llynch et al. (1999) provides evidence that specific tension (strength/unit muscle mass) is a superior marker of neuromuscular ability in the aged rather than skeletal muscle size or muscular strength and power alone. Although no difference in specific tension between younger and older women has been reported (Young et al., 1984), ambiguities exist within the adolescent female population. Therefore, the purpose of this investigation was to examine skeletal muscle function in adolescent African-American females and their profiles in regard to skeletal muscularity. Specifically, does increasing body fat affect muscular characteristics of the extremity in terms of muscular strength, muscular speed, and muscular fatigue. Additionally, the relationship between skeletal muscular strength and size was investigated.

Methods

Subjects: Those diagnosed with clinical cardiovascular or muscle-skeletal disease were excluded. In addition, subjects were excluded if they had active neck and back pain, frequent and severe joint pain, any surgery in the past two-years, non-ambulatory, orthopedic impairments, pregnancy, or any other condition that might be aggravated by strength testing. After receiving a complete explanation of the procedures and risks of the study, all subjects and parents/wards gave their written informed consent. All subjects received a complete medical history and physical examination prior to testing.

A total of 23 African-American adolescent female students (ages 14-18 years) from the Athens, Georgia area participated in a seven-week protocol that included measures of body composition, neuromuscular function, and skeletal muscular contour. The Institutional Review Board for Human Subjects at the University of Georgia, Athens, GA, approved the experimental protocol.

Standing height (cm) without shoes was measured using a standiometer. Body weight (kg) was determined using an electronic scale with subjects in exercise clothing and no shoes. Body mass index (BMI) was calculated as weight (kg) divided by height (m) squared and was utilized as an index of body fatness, independent of body composition and contour described below. In order to draw conclusions, subjects were categorized into two groups relative to their BMI status. The 95th-percentile (gender and age specific) BMI cutoff point calculated at 6-months age intervals was the criterion used for adolescent overweight grouping, derived respectively from National Health Examination Survey, cycles 2 and 3. Thus, teens were grouped as “high-risk,” if they had a BMI greater than 22.5, and as “low-risk,” if they had a BMI less than 22.4.

Dual-energy X-ray Absorptiometry (DEXA): Body composition was determined from whole-body scans by DEXA (Hologic QDR-1000W enhanced whole body analysis software version 5.71, Walthham, MA) to assess percent body fat (%BF), total body and area specific fat mass (total body-FM, arm-FM, leg-FM) and nonosseous total body fat-free and fat-free arm (arm-FFM) and leg mass (leg-FFM) of the limb. Arm-FM and arm-FFM encompassed soft tissue extending from the center of the arm socket to the phalange tips. Leg-FM and leg-FFM consisted of soft tissue extending from an angled line drawn through the femoral neck to the phalange tips. Nonosseous appendicular FFM derived from these regional measurements was then assumed to be a valid estimation of appendicular skeletal muscle mass for the extremities based on the work performance of Wang et al. (1999). The scanner was calibrated daily before testing and DEXA within-subjects standard deviation of duplicate measurements of percent fat roughly one-week apart in five subjects was 0.2% (Modlesky, 1996).

Magnetic Resonance Imaging: Magnetic resonance imaging (MR-imaging) was performed with a 1.5T/64 MHz scanner (General Electric, Milwaukee, WI) with a transmitter/receiver body coil. T1-weighted spin-echo, axial-plane imaging was performed with the following variables: TR 500ms; TE 15ms; number of excitations, two; matrix 256 x 192; field of view 18-20 cm (arms) and 26-30 cm (legs); slice thickness 10mm; inter-slice gap 10 mm; and a scan time of 3.20 minutes. These variables were selected to optimize image quality, to clearly delineate the border of each muscle and bone, and to identify fat and connective tissue. T1- weighted images are typically used for the determination of anatomy, as well as to provide a good soft tissue contrast between fat/muscle interfaces.

For thigh imaging, the subjects were imaged in a prone position with the ankle and knee held at roughly 120º and 180º, respectively, with 180º being full extension at each joint. Although no padding or support was utilized, the subject's feet were held in position with a rubber strap. For upper arm imaging, the subjects were imaged in a prone position with the shoulder and elbow joint held roughly at 180º, with 180º being full extension. Padded support at the elbow joint was utilized to insure a proper alignment with the shoulder, while the subjects' hands were internally rotated against the thigh. A landmark of six inches was used for spatial reference on the extremity. For the thigh, a mark was placed 6 inches above the top of the patella. For the upper arm, a mark was placed 6 inches above the lateral epicondyle.

No active muscle contraction was apparent during measurement. Contiguous, axial 10 mm sections of the thigh and upper arm were measured. The outline of each muscle or muscle group was digitized using NIH Image public domain software and the anatomical cross-sectional area (CSA) was determined by summing each MR-image integrated pixel [each pixel = 0.422μm (thigh) and 0.184μm (arm)]. For the thigh measurements, 9-10 images inferior to the gluteal musculature were utilized for the thigh anatomical cross-sectional area (thigh-CSA). For the upper arm measurements, 6-8 images inferior to the deltoid muscle were used for the upper arm anatomical cross-sectional area (arm-CSA). The total number of images obtained for the thigh and the upper arm was 19 (although not the entire extremity area but a consistent fraction)
The muscles investigated were as follows: thigh extensor (quadriceps) CSA incorporated the three vastus muscles (lateralis, medialis, and intermedius) and the rectus femoris muscle; thigh flexor (hamstrings) CSA consisted of the adductor group (brevis, longus,

and magnus), the biceps femoris (short and long head), sartorius, gracillis, semimembranosus, and semitendinosus. The upper-arm extensor CSA was comprised of the triceps brachii (short, long and lateral head), while the upper-arm flexor CSA were used to obtain the biceps brachii (long and short heads) and the brachialis.

Absolute Muscular Strength: A one-repetition maximum (1RM) was used to indicate the maximal amount of weight each subject was able to raise. The 1RM was utilized as an isotonic (free weights) measure, examining the thigh extensor and upper arm flexor strength. 1RM for upper arm flexors and thigh extensors were obtained via three attempts at subjects' 1RM with a 3-minute rest interval between lifts. In order to assess a reliable and valid strength index, subjects were tested weekly for four weeks prior to final muscular strength testing.

***Isometric Muscular Strength and Speed*:** For the thigh isometric maximal voluntary contraction [(MVC), the best out of three trials with a 1-min interval rest between] was measured at 70º before full knee extension (180º), with the pelvis, trunk, and lower leg tightly secured to an experimental chair. The chair was constructed to analyze thigh torque (ft-lbs) and speed (ms) of contraction via a load cell attached to an (0.05 mm thick) iron rod 0.5 meters away. For the upper arm, isometric MVC [the best out of three trials with a 1-min interval rest between] was measured between 75º-85º of the arm flexion. Upper arm torque (ft-lbs) and speed (ms) of contraction was measured via a load cell linked to a (0.5mm thick) link chain attached to a metal hand-grip. The subject's chair position and chain link number was recorded to ensure proper alignment and placement for each testing session.

The force and speed indexes were measured using a MacLab A-D converter sampling at 100Hz interfaced with an Apple MacIntosh computer. A 250-500ms window was used to detect peak force over a three-second contraction. Subjects were asked to perform three isometric MVC's, with 1-min rest intervals for both the arm flexor and leg extensor muscle groups. In order to assess a reliable and valid force and speed index, subjects were tested weekly for four weeks prior to final neuromuscular testing.

In addition to examining isometric MVC, indices of neuromuscular speed involving rate and the rise in force development were also determined. Time from 20% to 80% of the peak recorded MVC was analyzed to provide data regarding skeletal muscle rate of force development. Additionally, the fall from 80-20% of peak-measured MVC was determined as an index of skeletal muscle relaxation time.

Muscular Fatigue: In order to test upper-arm flexor and thigh extensor fatigue characteristics, 5 sets X 10 reps of 65% of their 1RM was used. Subjects were allowed a one-minutes rest between each set. Additionally after each set, subject's relative perceived exertion (RPE) was recorded. Immediately after performing the fifth set, subjects quickly performed a maximal voluntary contraction (MVC). A percent change score in peak isometric MVC force was utilized as an index of relative fatigue (MVC-post-MVC/MVC X 100)

Specific tension: Relative strength for body extremities was determined by two neuromuscular strength indexes (1RM and MVC) and two measures of body-mass (DEXA and MR-imaging). Thus, four indices describing specific tension for the arm and leg extremity were calculated. The following measurements of specific tension were obtained.

Specific tension for the upper extremity

Flexor MVC/flexor CSA- upper arm flexor MVC torque (ft/lbs) divided by upper arm flexor cross-sectional area (cm^2)

Flexor 1RM/flexor CSA- upper arm flexor 1RM (kg) divided by upper arm flexor cross-sectional area (cm^2)

Flexor MVC/arm-FFM- upper arm flexor MVC torque (ft/lbs) divided by arm fat-free mass (kg)

Flexor 1RM/arm-FFM- upper-arm flexor 1RM (kg) divided by upper arm fat-free mass (kg)

Specific tension for the lower extremity

Extensor MVC/extensor CSA- thigh extensor MVC torque (ft/lbs) divided by thigh extensor cross-sectional area (cm^2)

Extensor 1RM/Extensor CSA- thigh extensor 1RM (kg) divided by thigh cross-sectional area (cm^2)

Extensor MVC/leg FFM –thigh extensor MVC torque (ft/lbs) divided by leg fat-free mass (kg)

Extensor 1RM/leg FFM- thigh extensor 1RM (kg) divided by leg fat-free mass (kg)

Data Analysis

Data analysis was performed using the SPSS software package version 10. Standard statistical descriptive methods were employed for the calculation of means and standard errors among subjects. Relationships between variables were determined by linear regression analysis and Pearson correlations among the subjects' body weight, height, neuromuscular functioning, and body composition measures. A two-way repeated measure analysis of variance (group X time) was performed on all neuromuscular function measures during the four-week practice trial to test for a ”training” effect. In addition, multiple linear regressions were utilized to explain the variation of strength indexes to size indices among all subjects and between groups, as based on BMI (Group 1, BMI $\leq$ 22.4; Group 2, BMI $\geq$ 22.5). The regression model took the following forms:

$$\Upsilon = b_o + b_1 X_{smi}$$

and

$$\Upsilon = b_o + b_1 X_{smi} + b_2 G$$

where Υ is the dependent variable (strength indices), X_{smi} is the independent variable (skeletal muscle indexes), and G is the grouping variable (1 or 2, depending on BMI). Careful attention was given to detect multicolinearity between variables.

Results

Subject Characteristics: The groups were similar in age ($p = 0.684$) and height ($p = 0.513$), but significantly different in the body weight ($p < 0.0001$) and body mass index ($p < 0.0001$) variables (*Table 4.1*).

Groups also differed between the two indices of muscular composition with the “high risk” group having a greater DEXA fat free mass value. *Table 4.2* provides group statistics of DEXA measured fat free mass. In *Table 4.2*, body and leg lean tissue mass was significantly different ($p = 0.012$ and 0.023 for body and leg respectively), but arm lean tissue mass was not ($p = 0.058$).

Similarly, *Table 4.3* provides information regarding upper arm muscle CSA measured from MRI scans. From *Table 4.3*, upper arm muscle (extensor and flexor) CSA (p = 0.048) was the only muscular size measure to be significantly different between the groups.

Upper-arm analysis: In *Table 4.4,* correlations between the 2 measurements of upper arm skeletal muscle mass, DEXA and MR-imaging are presented. A significant correlation was observed between DEXA and MR-imaging (arm-FFM: CSA of upper arm flexors, r = 0.479, p = 0.021; arm-FFM: CSA upper arm, r = 0.417, p = 0.048).

Table 4.5 provides correlations among DEXA and MRI of the upper extremity size, and strength indices of the 2 groups of adolescent African-American females.

In *Figure 4.2a*, the graph depicts the weekly measure of upper arm flexor strength of the “low risk ” and “high risk” subjects. There was no significance difference between the four weekly strength measures and the final strength measure of upper arm flexor strength. Likewise, there was no significant difference between groups and the strength in the non-dominant upper arm flexor.

Figure 4.3a shows the relationship between the “low risk” and “high risk” groups and specific tension measures of the upper arm. Specific tension of the non-dominant upper arm flexors is similar between groups. The upper arm flexor rate and the rise in force characteristics did not show a significant difference between groups. In addition, group means of 80%-20% relaxation time was not significantly different (*Figure 4.4a*). Additionally, there was no observed statistical difference in the fatigue characteristics of the upper extremity (*Figure 4.5*).

Leg /Thigh analysis: In *Table 4.6,* the two measures of thigh skeletal muscle mass, DEXA and MR-imaging, were found to have a moderately strong statistical significant correlation (thigh extensor CSA, r = 0.580, p = 0.004; total body-FFM: thigh muscle CSA, r = 0.451, p = 0.31; leg-FFM: thigh extensor CSA, p = 0.580, p = 0.004).

Table4. 7 provides information regarding the correlation among DEXA and MRI lower extremity size and strength indices of the 2 groups. In *Figure4.2,* the relationship between low and high risk subjects and thigh extensor strength is expressed. There was no significance difference between four weekly strength measures and the final leg extensor strength test. However, there was a significant difference between groups and their non-dominant thigh extensor 1RM strength.

Figure 4.43b suggests that the relationship between the groups and specific tension of the lower extremity is similar with the "high risk" group developing a higher non significant strength per CSA value. Similar to the upper arm flexors, the speed characteristics of the thigh extensors' 20-80% rise time and 80%-20% relaxation time were non-significant between groups (*Figure 4.4b*). Additionally, there was no observed statistical difference in the fatigue characteristics of the lower extremity (*Figure 4.5*).

Discussion

In the present study, neuromuscular function and body composition analysis was performed on the upper and lower extremity of 23 adolescent African-American females to investigate various indices of muscular size and force. Skeletal muscle was analyzed by using two of the best available clinical methodologies of body composition--MR-imaging and DEXA analysis. From this viewpoint, we examined the utility of both measures. Not only were both measures highly significant between the extremities, but also, each portrayed the body in a compartmental fashion. For example, the DEXA measure allows the body to be distinguished as a whole (total body-FFM) and as a part (arm/leg-FFM), while MR-imaging provides measurements of a specific region (thigh/upper-arm-CSA) and a more defined area (arm flexor/leg extensor-CSA). This was done to examine the different aspects of the skeletal muscles and their ability to develop force.

Within the literature, MR-imaging is regarded as a supportive reference method for appendicular skeletal muscles and interstitial and subcutaneous adipose tissue measurement in vivo (Castro et al, 1999). Additionally, DEXA is regarded as a superior estimate of total body and regional FM and FMM (Wang et al., 1999). Thus, DEXA and MR –imaging technology provides a great non-invasive measure of body composition.

The current study also examined neuromuscular function in a multi-facet paradigm. Neuromuscular functioning was described in three different ways regarding muscular strength, specific tension, muscular speed and muscular fatigue. Again, this allowed for a more in-depth examination of skeletal muscle strength and/or power.

Thus, it was hypothesized that the “high risk” group would have altered neuromuscular characteristics of the extremities, such that the “high risk” group would record lower specific tension, decreased rise time, increased relaxation time, and a higher fatigue percentage. The following sections will provide evidence regarding profiles of skeletal muscle characteristics between two groups of adolescent African-American females.

The data suggest no indications of altered neuromuscular function among the upper and lower extremities between 2 groups. This was observed for muscular specific tension, speed, and fatigue characteristics of the upper extremity. Additionally, there also was no evidence to support altered neuromuscular characteristics of the lower extremity in specific tension, speed and fatigue characteristics. Several authors have suggested that circulatory factors (Pirnay et al., 1972; Terjung et al., 1985), muscle fiber type proportion (Komi et al., 1977; Thorstensson et al., 1976), and the capacity of the energy metabolism related pathways (Fox et al., 1982; Komi et al, 1977; Thorstensson, 1976) may alter muscular function. Moreover, literature suggests a negative association between increases in adiposity and muscle fiber size and enzymatic capacity. Some studies have reported that obesity is related to relative reductions in oxidative muscle fibers (type I) (Kriketos et al., 1996, Lithell et al., 1987) and/or a relative increase in glycolytic muscle fibers (type IIb) (Kriketos et al., 1997; Kriketos et al., 1996, Lithell et al., 1987). However, no such relationships were found in some studies (Toubro et al., 1994). As for enzyme activities, the activity of citrate synthase, malate dehydrogenase, and oxoglutarate dehydrogenase, all oxidative key enzymes in the tricarboxylic acid cycle (i.e. markers of muscle aerobic-oxidative capacity), was found to be negatively related to body fat or weight gain (Kriketos et al., 1997; Simomeau, 1994; Simomeau, 1995). Together, these studies indicate that muscle morphology and oxidative capacity are important in the etiology of obesity. Furthermore, if literature demonstrates key factors in skeletal musculature changes as a function of body adiposity, what can be said regarding the muscular strength of overweight/obese adolescents? In the current investigation, there was no substantial proof of altered neuromuscular function as body weight increase in adolescent African-American females.

The author also investigated the relationship between measures of muscle size and strength in adolescent African-American females. To provide insight regarding the relationship of muscle size and strength, the variance in muscular strength among differing fat mass was questioned. It was hypothesized that the "high risk" subjects would have decreased attributable variance in their strength score. The following section provides information regarding the relationship between skeletal muscle strength and size.

Upper-Arm Analysis: The most interesting finding in the investigation of the muscularity profiles of the upper arm in adolescent African-American females is that skeletal muscle mass measured by DEXA analysis is strongly related to skeletal muscle strength in absolute terms while muscle mass acquired via MR-imaging analysis is related to skeletal strength, relatively. From multiple linear regression analysis, the results yield the following: In the "low-risk" group, the variance in upper arm flexor1 RM was attributed to total arm-FFM (36.36%). In the "high-risk" group, the variance in specific tension-upper arm flexor MVC/flexor CSA was significantly explained by upper arm flexor CSA (45.43%) and upper arm muscle CSA (55.85%), whereas upper arm-FFM (53.88%) explained a significant portion of the variance in specific tension-upper arm flexor MVC/arm-FFM.

In summary**,** interesting conclusions from the data can be inferred about the neuromuscular function of the upper-arm with increasing adiposity. As previously stated, a positive relation was observed between the upper extremity DEXA and MR-imaging analyses. Moreover, the "high-risk" group possessed a significantly greater total body-FFM and arm-FFM value compared to the "low-risk" group. However, the strength indices were similar. Intuitively, most would associate a greater arm skeletal muscle mass value to a more pronounce strength outcome. Hence, relatively less skeletal muscle mass would be needed to perform work. Consequently, the “high-risk” group attributed more of it’s’ variance in arm strength to muscular mass. Therefore, “lessening” of upper arm neuromuscular functioning in the “high-risk” group was not concluded given its’ small although significant variance.

Thigh/Leg Analysis: Statistical analysis performed on the leg/thigh variable produced numerous interesting observations regarding skeletal muscular characteristics. Since human locomotion is dependent among the lower extremities (in most cases), leg/thigh neuromuscular functioning is exceptionally imperative. The data revealed a robust correlation among the measures of skeletal muscle mass and skeletal muscle strength indexes. However, the relationship between muscle size and strength is kindred to DEXA muscle mass analysis and strength products in absolute and isometric terms only. [Skeletal muscle mass measured by MR-imaging or other relative strength alliances did not correlate.] Although skeletal muscle mass obtained through DEXA is significantly correlated with absolute/isometric strength indexes, force measured isometrically ($p = 0.007$) provided a more significant relationship than absolute strength ($p = 0.034$).

In the “low-risk” group, 45.97% of the variance in specific tension-thigh extensor 1RM/extensor CSA was suggested attributed thigh extensor-CSA. Additionally, thigh extensor CSA (45.43%) was also instrumental in the variance of specific tension-thigh extensor MVC/extensor CSA. In the “high-risk” group, 41.47% of the variance in thigh extensor MVC is explained by leg-FFM.

As previously mentioned, within the “low-risk” group, two indexes of muscular strength (specific tension-thigh extensor 1RM/extensor CSA, and thigh extensor MVC/extensor CSA) were found to be highly predictive of skeletal muscle size (thigh flexor-CSA) while only one strength measure (thigh extensor MVC) was independent of skeletal muscular size. Although our data suggest the “high-risk” group was significantly greater among all DEXA muscular parameters and body weight, thus having more FFM availability for work, “lessening” of thigh extensor neuromuscular functioning in the “high-risk” group was not concluded given its’ small although significant variance.

Conclusion

The properties of contracting skeletal muscles have been studied from two aspects--force and velocity. Although the velocity aspect of skeletal muscle is extremely important, the aim of this research centered more on force-generation and its relationship to muscular characteristics of the extremity. It was shown that “high risk” adolescent African American females do not posses altered muscular characteristics (in strength, speed, or fatigue). It was shown that the major determinant of skeletal muscle force-generating potential is muscle size.

The major objective of this investigation was to disseminate knowledge regarding skeletal muscular characteristics among adolescent African American females. More importantly, evidence was provided that the major determinant of skeletal muscle force is muscle size

Our findings clearly demonstrate that DEXA and MR-imaging provides accurate measurements of skeletal muscle mass and CSA throughout a wide range of values typical of the appendicular region. In addition, DEXA and MR-imaging are suggested methods that may also serve as a criterion measure for appendicular and whole body adipose tissue distribution.

To date, no known literature has examined the aspects of neuromuscular function and skeletal muscle size in this synergistic manner. Moreover, it is novel that these muscular characteristics were inspected in adolescent African-American females. Taken together, these factors make direct comparisons with our observations difficult. Hence, it is not possible to accurately compare the results of the present study with previous observation.

Table 4.1: Subject Characteristics

	RISK	N	Mean	Std. Error Mean	p- value
Age (yrs)	Low	13	15.07	0.32	0.684
	High	10	14.90	0.23	
Body Weight (kg)	Low	13	50.95	1.31	0.000
	High	10	68.65	4.20	
Height (m)	Low	13	1.61	0.01	0.513
	High	10	1.60	0.01	
Body Mass Index (kg/m^2)	Low	13	19.53	0.50	0.000
	High	10	26.65	1.35	

Table 4.2: Group Statistics of DEXA Measured Fat-Free Mass

	RISK	N	Mean	Std. Error Mean	p- value
Body Fat-Free Mass (kg)	Low	13	36.87	0.79	0.012
	High	10	41.33	1.55	
Leg Fat-Free Mass (kg)	Low	13	6.50	0.16	0.023
	High	10	7.49	0.40	
Arm Fat-Free Mass (kg)	Low	13	1.65	0.04	0.058
	High	10	1.86	0.10	

Table 4.3: Group Statistics of MRI Extremity Cross-Sectional Area

	RISK	N	Mean	Std. Error Mean	p- value
Thigh Extensor CSA (cm^2)	Low	13	50.43	1.74	0.150
	High	10	54.31	2.00	
Thigh Flexor-Extensor CSA (cm^2)	Low	13	92.93	3.52	0.093
	High	10	102.29	3.97	
Upper Arm Flexor CSA (cm^2)	Low	13	10.51	0.48	0.062
	High	10	12.05	0.63	
Upper Arm Extensor-Flexor CSA (cm^2)	Low	13	21.81	1.01	0.048
	High	10	25.30	1.36	

Table 4.4: Correlation between DEXA and MRI measures of Arm Muscularity

		FFM-body	FFM-arm	Flexor-CSA	Muscle-CSA
DEXA Body Fat-Free Mass (kg)	Pearson Correlation	1	.793**	.449*	.383
	Sig. (2-tailed)	.	.000	.032	.071
	N	23	23	23	23
DEXA Arm Fat-Free Mass (kg)	Pearson Correlation	.793**	1	.479*	.417*
	Sig. (2-tailed)	.000	.	.021	.048
	N	23	23	23	23
MRI- Arm Flexor CSA (cm^2)	Pearson Correlation	.449*	.479*	1	.906**
	Sig. (2-tailed)	.032	.021	.	.000
	N	23	23	23	23
MRI- Arm Extensor/ Flexor CSA (cm^2)	Pearson Correlation	.383	.417*	.906**	1
	Sig. (2-tailed)	.071	.048	.000	.
	N	23	23	23	23

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Table4.5: Upper Extremity Neuromuscular Function Correlation Measures

		MVC/ CSA	1RM/CSA	MVC/ FFM	1RM/ FFM	1RM ARM	Arm MVC
Flexor MVC/ Flexor CSA	Pearson Correlation	1	.707**	.707**	.590**	.441*	.657**
	Sig. (2-tailed)	.	.000	.000	.003	.035	.001
	N	23	23	23	23	23	23
Flexor 1RM/ Flexor CSA	Pearson Correlation	.707**	1	.244	.819**	.782**	.380
	Sig. (2-tailed)	.000	.	.263	.000	.000	.074
	N	23	23	23	23	23	23
Flexor MVC/ Fat Free Mass	Pearson Correlation	.707**	.244	1	.543**	.309	.828**
	Sig. (2-tailed)	.000	.263	.	.007	.152	.000
	N	23	23	23	23	23	23
Flexor 1RM/ Arm Fat-Free Mass	Pearson Correlation	.590**	.819**	.543**	1	.884**	.619**
	Sig. (2-tailed)	.003	.000	.007	.	.000	.002
	N	23	23	23	23	23	23
Arm Flexor 1RM (kg)	Pearson Correlation	.441*	.782**	.309	.884**	1	.639**
	Sig. (2-tailed)	.035	.000	.152	.000	.	.001
	N	23	23	23	23	23	23
Arm Flexor MVC (ft/lbs)	Pearson Correlation	.657**	.380	.828**	.619**	.639**	1
	Sig. (2-tailed)	.001	.074	.000	.002	.001	.
	N	23	23	23	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.6: Correlation between DEXA and MRI measure of Leg Muscularity

		FFM-body	FFM-leg	Muscle-CSA	Extensor CSA
DEXA Body Fat-Free Mass (kg)	Pearson Correlation	1	.903**	.503*	.451*
	Sig. (2-tailed)	.	.000	.015	.031
	N	23	23	23	23
DEXA Leg Fat-Free Mass (kg)	Pearson Correlation	.903**	1	.580**	.580**
	Sig. (2-tailed)	.000	.	.004	.004
	N	23	23	23	23
MRI-Thigh Flexor-Extensor CSA (cm^2)	Pearson Correlation	.503*	.580**	1	.954**
	Sig. (2-tailed)	.015	.004	.	.000
	N	23	23	23	23
MRI-Thigh Extensor CSA (cm^2)	Pearson Correlation	.451*	.580**	.954**	1
	Sig. (2-tailed)	.031	.004	.000	.
	N	23	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Table 4.7: Lower Extremity Neuromuscular Function Correlations

		MVC/CSA	1RM/CSA	MVC/FFM	1RM/FFM	Thigh 1RM	Thigh MVC
Extensor MVC/ Extensor CSA	Pearson Correlation	1	.711**	.793**	.558**	.577**	.798**
	Sig. (2-tailed)	.	.000	.000	.006	.004	.000
	N	23	23	23	23	23	23
Extensor 1RM/ Extensor CSA	Pearson Correlation	.711**	1	.418*	.904**	.870**	.471*
	Sig. (2-tailed)	.000	.	.047	.000	.000	.023
	N	23	23	23	23	23	23
Extensor MVC/ Fat Free Mass	Pearson Correlation	.793**	.418*	1	.517*	.360	.700**
	Sig. (2-tailed)	.000	.047	.	.011	.091	.000
	N	23	23	23	23	23	23
Extensor 1RM/ Fat Free Mass	Pearson Correlation	.558**	.904**	.517*	1	.847**	.398
	Sig. (2-tailed)	.006	.000	.011	.	.000	.060
	N	23	23	23	23	23	23
Thigh Extensor 1RM (kg)	Pearson Correlation	.577**	.870**	.360	.847**	1	.654**
	Sig. (2-tailed)	.004	.000	.091	.000	.	.001
	N	23	23	23	23	23	23
Leg Extensor MVC (ft/lbs)	Pearson Correlation	.798**	.471*	.700**	.398	.654**	1
	Sig. (2-tailed)	.000	.023	.000	.060	.001	.
	N	23	23	23	23	23	23

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

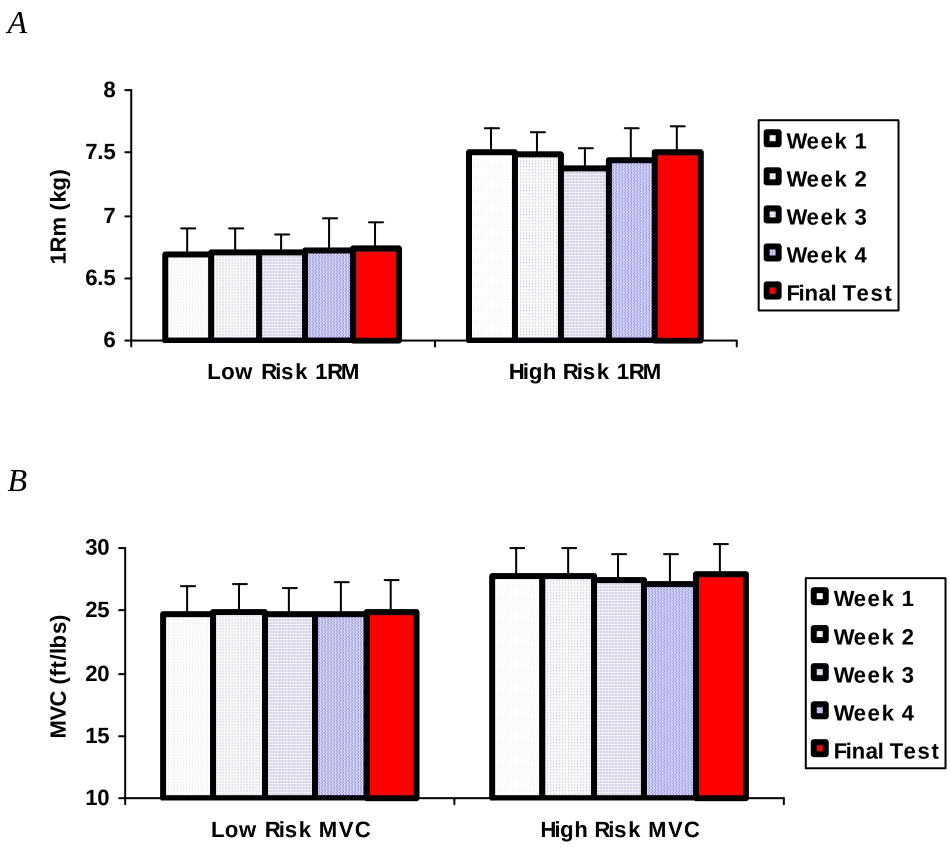

Figure 4.1: The relationship between low and high risk subjects and upper arm flexor strength measures. *a*) non-dominant upper arm flexor 1RM and *b*) non-dominant upper arm flexor isometric MVC over 4 weekly familiarization trails. There was no significance difference between four weekly strength measures and the final arm flexor strength test. There was no significant difference between groups and upper arm flexor strength. Values are means and standard errors.

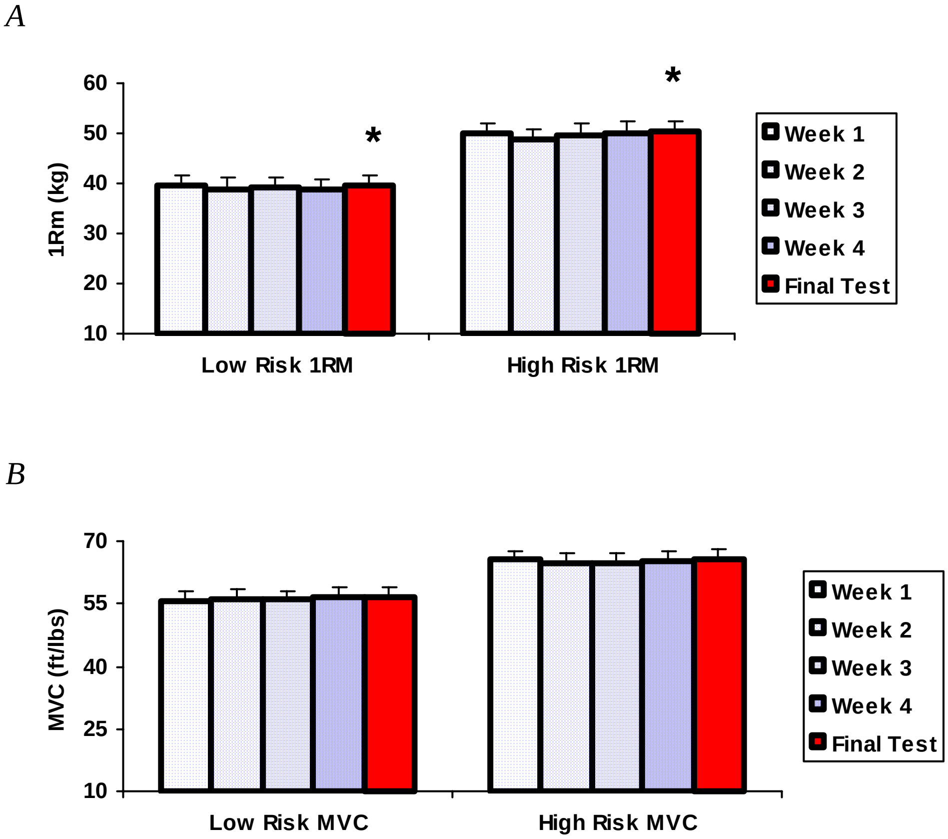

Figure 4.2: The relationship between low and high subjects and thigh extensor strength measures. *a*) non-dominant thigh extensor 1RM and *b*) non-dominant thigh extensor isometric MVC over 4 weekly familiarization trails. There was no significance difference between four weekly strength measures and the final arm flexor strength test. There was a significant difference between groups and non-dominant thigh extensor 1RM strength. Values are means and standard errors.

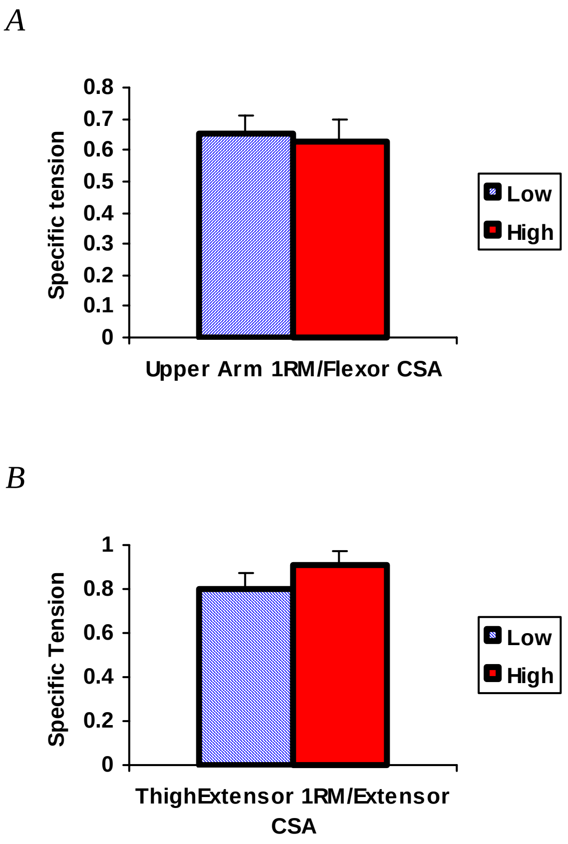

Figure 4.3: Relationship between low and high risk groups and specific tension measure. *a*) non-dominant upper arm flexor and *b*) non-dominant thigh extensor specific tension. Values are means and standard error.

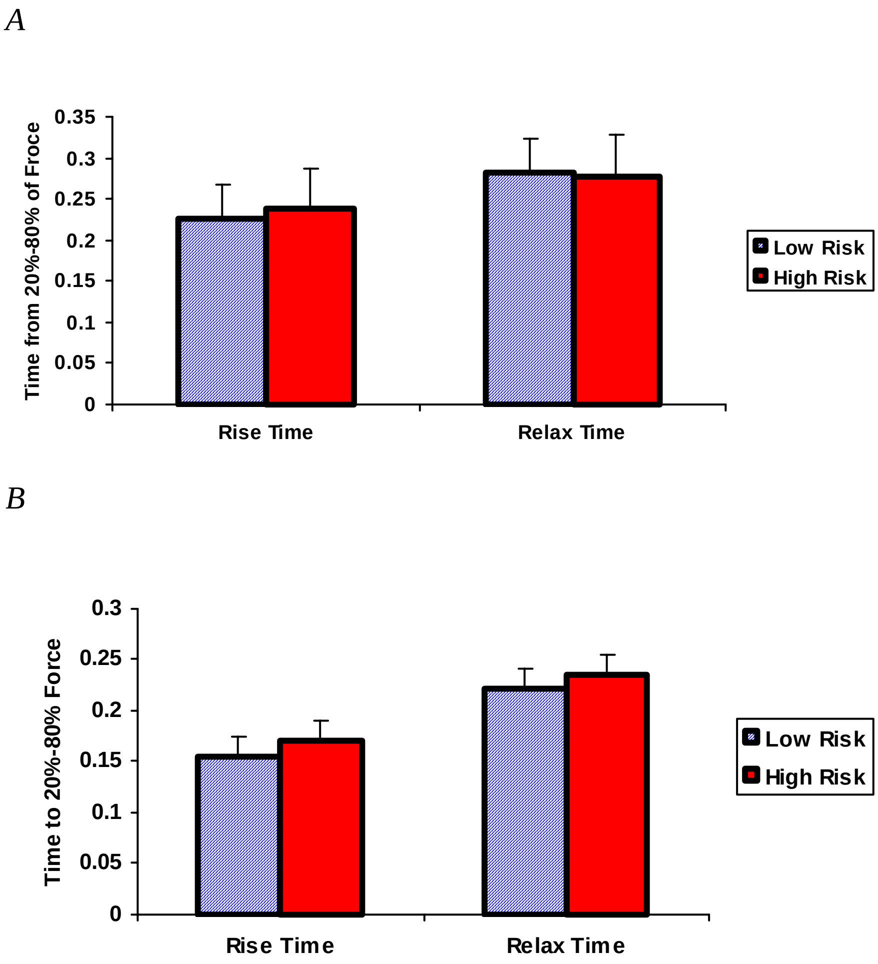

Figure 4.4: Relationship between low and high risk groups and 20%-80% of MVC rise and relaxation times. *a*) non-dominant upper arm flexor and *b*) non-dominant thigh extensor speed characteristics. Values are means and standard error.

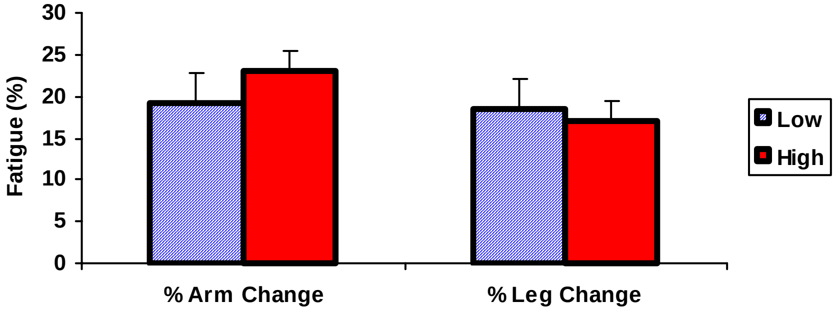

Figure 4.5: Relationship between low and high risk groups and fatigue (%). A change score in upper arm flexor and thigh extensor MVC after 3 sets- 10 reps of 65% of 1RM. Fatigue (%) value = (pre MVC- post MVC/pre MVC) x (100). Values are means and standard error.

References

Fox, A. D., R. Billeter, and H. Howald. Anaerobic muscle enzyme changes after interval training. *Int. J. Sports Med* 1982; 3:18-21.

Kallman, D. A., C. C. Plato, and J. D. Tobin. The role of muscle loss in the age-related decline of grip strength: cross-sectional and longitudinal perspectives. *J. Gerontol. A Biol. Sci. Med. Sci.* 1990; 45:M82-M88..

Komi, P. V., H. Rusko, J. Vos and Vihko. Anaerobic performance capacity in athletes. *Acta Physiol. Scand. Suppl.* 1977; 100: 107-114.

Komi, P.V., and J. Karlsson. Physical performance, skeletal muscle enzyme activities, and fiber types in monozygous and dizygous twins of both sexes. *Acta Physiol. Scand. Suppl. 1979;* 462: 1-28.

Kriketos, A. D., L. A. Baur, J. O' Connor, D. Carey, S. King, I. D. Caterson , and L. H. Storlien. Interrelationships between muscle morphology, insulin action, and adiposity. *AM. J. Physiol*. 270 (*Regulatory Integrative Comp. Physiol*. 39): 1996; R1332-R1339.

Kriketos, A. D., L. A. Baur, J. O'Connor, D. Carey, S. King, I. D. Caterson, and L. H. Storlien. Muscle fiber type composition in infant and adult populations and relationships with obesity. *Int. J. Obes*.1997; 21: 796-801.

Lithell, S., A. A. Young, C. L. Culter, J. L. Ivy, W. G. H. Abbott, J. K. Zawadzki, H. Yki-Jarvinen, L. Christin, T. W. Secomb, and C. Bogards. Skeletal muscle capillary density and fiber type are possible determinants of in vivo insulin resistance in man. *J. Clin. Invest*. 1987; 80: 415-424.

Lindle, R. S., E. J. Metter, N. A. Lynch, J. L. Fleg, J. L . Fozard, J. Tobin, T. A. Roy, and B.F. Hurley. Age and gender comparisons of muscle strength in 654 women and men aged 20-93. *J. Appl. Physiol.* 1997; 83:1581-1587.

Lithell, H., and H. Boberg. Determination of lipoprotein-physical activity in human skeletal muscle tissue. *Biochem. Biophys. Acta* 1978; 5287: 58-68

Lortie, G., J. A. Simoneau, M. R. Boulay, and C. Bouchard. Muscle fiber composition and enzyme activities in brothers and monozygotic twins. *Sport and Human Genetics*, edited by R. M. Malina and C. Bouchard. Champaign, IL: Human Kinetics, 1986;147-153.

Modlesky, C.M., K.J. Cureton, R.D. Lewis, B.M. Prior, M.A. Sloniger, and D.A. Rowe. Density of the fat-free mass and estimates of body composition in male weight trainers. *J Appl Physiol* 1996; 80:2085-2096.

Overend, T.J., D. A. Cunningham, J. F. Kramer, M. S. Lefcoe, and D. H. Paterson. Knee extensor and knee flexor strength: cross-sectional area ratios in young and elderly men. *J. Gerontol. A. Biol. Sci. Med. Sci.* 1992; 47:M204-M210.

Pirnay, G., R. Marechal, R. Radermecker, and J. M. Petit. Muscle blood flow during submaximum and maximum exercise on a bicycle ergometer. *J. Appl. Physiol*. 1972; 32: 210-212.

Reed, R. L. , L. Pearlmutter, K. Yochum, K. E. Meredith, and A. D. Mooradian. The relationship between muscle mass and the muscle strength in the elderly. *J. Am. Geriatr. Soc*. 1991; 39:555-561.

Simomeau, J.A., and C. Bouchard. Skeletal muscle metabolism and body fat content in men and women. *Obes. Res*. 1995; 3: 23-29.

Simoneau, J.A., A. Tremblay, G. Theriault, and C. Bouchard. Relationships between the metabolic profile of human skeletal muscle and body fat gain in response to overfeeding (Abstract). *Med Sci. Sports Exerc*. 1994; 5: S159.

Terjung, R. L., G. A. Dudley, and R. A. Meyer. Metabolic and circulatory limitations to muscular performance at the organ level. *J. Exp. Biol*. 1985; 115: 307-318.

Thorstensson, A. Muscle strength, fiber types and enzyme activities in man. *Acta Physiol. Scand. Suppl.* 1976; 443: 1-45.

Thorstensson, A., G. Grimby , and J. Karlsson. Force Velocity relations and fiber composition in human knee extensor muscles. *J. Appl. Physiol*. 1976; 40: 12-16.

Toubro, S., P. Western, J. Bulow, I. MacDonald, A. Raben, N. J. Christensen, J. Madsen, and A. Astrup. Insulin sensitivity in post obese women. *Clin. Sci. (Colch.*) 1994; 87: 407-413.

Viitasalo, J. T. Muscular strength profiles and anthropometry in random samples of men aged 31-35, 51-55, and 71-75 years. *Ergonomics* 1985; 28:1563-1574.

Wang W, Wang Z, Faith MS, Kotler D, Shih R, and Heymsfield SB. Regional skeletal measurement: evaluation of new dual-energy X-ray absorptiometry model. *J. Appl Physiol* 1999; 87:1163-1171.

Wang Z, Visser M, Ma R, Baumgartner RN, Kotler D, Gallagher D, and Heymsflied SB. Skeletal muscle mass: evaluation of neutron activation and dual-energy X-ray absorptiometry methods. *J Appl Physiol* 1996: 80:824-831.

Young A., M. Stokes, and M. Crowe. The size and strength of quadriceps muscles of old and young women. *Eur. J. Clin.* Invest. 1984;14: 282-287.

Young A., M. Stokes, and M. Crowe. The size and strength of quadriceps muscles of old and young men. *Clin. Physiol.* 1985; 5:145-154.

CHAPTER V

CONCLUSION

The major objective of this research was to provide knowledge regarding adolescent African-American females and their profiles of body composition, neuromuscular function, and physical activity. The research obtained findings that both agree and disagree with previous literature.

It was observed that the major determinant of skeletal muscle force-generating potential during adolescence is muscle size; however, the muscle group, muscular action, and measuring analysis all greatly influence the results. Thus, careful attention must be observed when examining these parameters.

In addition, the results suggest that maximum muscle force normalized to muscle CSA or skeletal muscle mass are both valid measures of intrinsic muscle strength, specific tension in adolescence. Our findings clearly demonstrate that DEXA and MR-imaging provides accurate measurements of skeletal muscularity and adiposity throughout a wide range of values typical of the appendicular regions and adolescence growth.

The findings also suggest no proof of altered neuromuscular functioning of the extremities increases with increasing adiposity. Although the “at-risk” group was more massive, in terms of muscle mass and fat mass, more variance in strength was not attributable to their skeletal muscular size. Hence, we conclude that neuromuscular functioning of the extremities is not “lessened” as adiposity increases.

The results also indicate that “high-risk’ and “low-risk” adolescent African-American females are physical active. Based upon behavioral targets, subjects were within the reported traditional public health activity guidelines (e.g., > 30 min of moderate activity and/or > 20 min of vigorous activity). However, more studies are needed to attempt to empirically determine whether these guidelines are appropriate for other populations. Additionally, it was found that increasing adiposity does not necessarily mean a concomitant decrease in physical activity.

BIBLIOGRAPHY

Abrams K. K., Allen, L. R., and Gray, J. J. Disordered eating attitudes and behaviors, psychological adjustment and ethnic identity: A comparison of Black and White female college students. *International Journal of Eating disorders* 1993; 14: 49-57.

Adams G.R., B.M. Hather, and G.A. Dudley. Effect of short-term unweighting on human skeletal muscle strength and size. *Aviat Space Environ Med* 1994; 65:1116-1121.

Adler N. E., Boyce, T.W., Chesnet, MA et al., Socioeconomic inequalities in health: No easy solution. *JAMA*. 1993; 269:3140-3145.

Andersen R.E., C.J. Crepso, S.J. Bartlett, L.J. Cheskin, and M. Pratt. Relationship of physical activity and television watching with body weight and level of fatness among children: results from the third national health and nutrition examination survey. *JAMA* 1998; 279(12):938-42.

Bar-Or EO, J. Foreyt, C. Bouchard, K.D. Brownell, W.H. Dietz, E. Ravussin, A.D. Salbe, S. Schwenger, S. St Jeor, and B. Torun. Physical activity, genetic, and nutritional considerations in childhood weight management. *Med Sci Sports Exerc* 1998; 30:2-10.

Basset E.J., M.A. Fiatarone, E.F. O'Neil, M. Kelly, W.J. Evans, and A. Lipsitz. Leg extensor power and functional performance in very old men and women. *Clin Sci* 1992; 82:321-327.

Berg H.E., L. Larsson, and P.A. Tesch. Lower limb skeletal muscle function after 6 weeks of bedrest. *J Appl Physiol* 1997; 82:182-188.

Booth F.W., W. Scott, E. Gordon, C.J. Carlson , and M.T. Hamilton. Waging war on modern chronic diseases: Primary prevention through exercise biology. *J Applied Physiology* 2000; 88: 774-787.

Bowe, D.J., M. Tomoyasu., and A. Cause. The triple threat: A discussion of gender, class and race differences in weight. *Women & Health* 1991; 17(4): 123-142.

Butters, J.W., and T.E. Cash. Cognitive-behavioral treatment of women's body image dissatisfaction. *Journal of Consulting and Clinical Psychology* 1987; 55:889-897.

Caprio S., L.D. Hyman, S. McCarthy, R. Lange, M. Bronson, and W.V. Tamborlane. Fat distribution and cardiovascular risk factors in obese adolescent girls: importance of the intra-abdominal fat depot. *American Journal of Clinical Nutrition* 1996; 64(1): 12-17.

Cash, T.F., B.A. Winstead, and L.H. Janda. The great American shape-up. *Psychology Today* 1989; 30-37.

Cassell, DK. The encyclopedia of obesity and eating disorders. 1994.

Cassidy C.M. The good body: when big is better. *Medical Anthropology*. 1991; 13:181-213.

Centers for Disease Control and Prevention. *National Center for Health Statistics, Healthy People 2000. Review, 1998-99.* Hyattsville, MD: Public Health Service, 1999.

Colditz G.A., and E. Coakley. Weight, weight gain, activity, and major illnesses: the nurses' health study. *Int J Sports Med* 1997; 3:S162-70.

Differing J, G.J. Welk, J. Hart, and A. Symington. The use of the Digi-Walker step counter to measure levels of physical activity. *Med Sci Sports Exerc* 1998; 30: S11

Dishamn R.K. and M. Steinhardt. Reliability and concurrent validity for a 7-d recall of physical activity in college students. *Med Sci Sports Exerc* 1988: 20:14-25.

Dudley G.A., M.R. Duvoisin, G.R. Adams, R.A. Meyer, A.H. Belew, and P. Buchanan. Adaptations to unilateral lower limb suspension in humans. *Aviat Space Environ Med* 1992; 63: 678-683.

Dutta C., E.C. Hadley, and J. Lexell. Sarcopenia and physical performance in old age: overview. *Muscle Nerve Suppl* 1997; 5: S5-S9.

Duvoisin M.R., V.A. Convertino, P. Buchanan , P.D. Gollnick, and G.A. Dudley. Characteristics and preliminary observations of the influence of electromyostimulation on the size and function of human skeletal muscle during 30 day exposure to simulated microgravity. *Aviat Space Environ Med* 1989; 60:659-663.

Easton R.G., A.V. Rowlands, and D.K. Ingledeu. Validly of heart rate, pedometry, and accelorometry for predicting the energy cost of children's activities. *J Appl Physiol* 1998; 84:362-371.

Fabsitz R.R., P. Sholinsky, and D. Carmelli. Genetic influences on adult weight gain and maximum body mass index in male twins. *Med Sci Sports Exerc* 1994; 140:711-720.

Flegal K.M. Overweight and obesity in the United States: Prevalence and trends, 1960-1994. *Int Journal of Obesity* 1998; 22:39-47.

Folsom A.R., T.C. Cook, J.M. Sprafka, G.L. Burke, S.W. Norsted, and J.R. Jacobs. Differences in leisure-time physical activity levels between blacks and whites in population-based samples: the Minnesota Heart Study, *J Behav Med* 1991; 14:1-9.

Fox, A. D., R. Billeter, and H. Howald. Anaerobic muscle enzyme changes after interval training. *Int. J. Sports Med* 1982; 3:18-21.

Frontera W.R., V.A. Hughes, R. De Meersman, D. Sepulveda, and R.N. Baumgartner RN. Appendicular skeletal muscle mass: effect of age, gender, and ethnicity. *J Appl Physiol* 1997; 83: 229-239.

Garner, D.M., P.E. Garfinkjle, D. Schwartz, and M. Thompson. Cultural expectations of thinness in women. *Psychological Reports*, 47; 483-491.

Gillum R.F. Overweight and obesity in black women: a review of published data from the National Center for Health Statistics. *J Natl Med Assoc* 1987; 79:865-871.

Gogia P, V.S. Schneider, A.D. LeBlane, J. Krebs, C. Kasson, and C. Pientok C. Bedrest effect on extremity muscle torque in healthy men. *Arch Phy Med Rehabil* 1988; 69:1030-1032.

Gortmaker S.L., A. Must, and A.M. Sobol. Television viewing as a cause of increasing obesity among children in the United States, 1986-1990. *Arch Pediatr Adolesc* 1996; 150:356-362.

Gortmaker S.L., W.H. Dietz, A.M. Sobal, and C.A. Wehler. Increasing pediatric obesity in the United States. *Am J Dis Child* 1987; 141: 535-540.

Gray, J.J., K. Ford, and L.M. Kelly. The prevalence of bulimia in a black college population. *International Journal of Eating Disorders*, 1987; 6: 733-740.

Greenwood M.R.C., and V.A. Pittman-Waller. Weight control: a complex, various, and controversial problem. In: Frankle RT, Yang M-U, eds. *Obesity and Weight Control.* Rockville, MD: Aspen Publishers; 1988:3-15.

Harris, S.M. Racial differences in predictors of college women's body image attitudes. *Women & Health* 1994; 21(4): 89-103.

Harris, S.M. Family, self, and socio-cultural contributions to body-image attitudes of African-American women. *Psychology of Women Quarterly* 1995; 19:129-145.

Hatano Y. Use of the pedometer for promoting daily walking exercise. *Int Council Health, Physical Educ Recr* 1993; 29: 4-28.

Hather B.M., G.A. Adams, P.A. Tesch, and G.A. Dudley. Skeletal muscle responses to unilateral lower limb suspension. *J Appl Physiol* 1992; 72:1493-1498

Heath G.W., M. Pratt, C.W. Warren, and L. Kann. Physical activity trends in America high school students. *Arch Pediatr Adolesc Med* 1994; 148: 1131-1136.

Henriques, G.R., L.G. Calhoun, and A. Cann. Ethnic differences in women's body satisfaction: An experimental investigation. *The Journal of Social Psychology* 1996; 136 (6): 689-697.

Jung R.T. Obesity as a disease. *Br. Med bull* 1997; 53: 307-321.

Kallman, D. A., C. C. Plato, and J. D. Tobin. The role of muscle loss in the age-related decline of grip strength: cross-sectional and longitudinal perspectives. *J. Gerontol. A Biol. Sci. Med. Sci.* 1990; 45:M82-M88.

Keeton, W.P., T.F. Cash, and T.A. Brown. Body image or body images? Comparative, multidimensional assessment among college students. *Journal of Personality Assessment*. 1990; 54: 213-230.

Kington R., and J.P. Smith. Socioeconomic status and racial and ethnic differences in functional status associated with chronic disease. *American Journal of Public Health* 1996; 87(5): 805-810

Komi, P. V., H. Rusko, J. Vos and Vihko. Anaerobic performance capacity in athletes. *Acta Physiol. Scand. Suppl.* 1977; 100: 107-114.

Komi, P.V., and J. Karlsson. Physical performance, skeletal muscle enzyme activities, and fiber types in monozygous and dizygous twins of both sexes. *Acta Physiol. Scand. Suppl. 1979;* 462: 1-28.

Kriketos, A. D., L. A. Baur, J. O' Connor, D. Carey, S. King, I. D. Caterson , and L. H. Storlien. Interrelationships between muscle morphology, insulin action, and adiposity. *AM. J. Physiol*. 270 (*Regulatory Integrative Comp. Physiol*. 39): 1996; R1332-R1339.

Kriketos, A. D., L. A. Baur, J. O'Connor, D. Carey, S. King, I. D. Caterson, and L. H. Storlien. Muscle fiber type composition in infant and adult populations and relationships with obesity. *Int. J. Obes*.1997; 21: 796-801.

Kumanyika S. Obesity in black women. *Epidemiol Rev*. 1987; 9:31-50.

Kumanyika S., J.F. Wilson, and M. Guilford-Davenport. Weight-related attitudes and behaviors of black women. *J Am Diet Assoc* 1993; 93: 416-22.

Kumanyika S.K., and J.B. Charleston. Loose weight and win: a church-based weight loss program for blood pressure control among black women. *Patient Educ Counsel*. 1992; 19: 19-32.

Lasco R.A., R.H. Curry, V.J. Dickson, J. Powers, S. Menes, and R.K. Merritt. Participation rates, weight loss, and blood pressure changes among obese women in a nutrition-exercise program. *Public Health Rep* 1989; 104: 640-646.

Lindle, R. S., E. J. Metter, N. A. Lynch, J. L. Fleg, J. L . Fozard, J. Tobin, T. A. Roy, and B.F. Hurley. Age and gender comparisons of muscle strength in 654 women and men aged 20-93. *J. Appl. Physiol.* 1997; 83:1581-1587.

Lithell, H., and H. Boberg. Determination of lipoprotein-lipase activity in human skeletal muscle tissue. *Biochem. Biophys. Acta* 1978; 5287: 58-68

Lithell, S., A. A. Young, C. L. Culter, J. L. Ivy, W. G. H. Abbott, J. K. Zawadzki, H. Yki-Jarvinen, L. Christin, T. W. Secomb, and C. Bogards. Skeletal muscle capillary density and fiber type are possible determinants of in vivo insulin resistance in man. *J. Clin. Invest.* 1987; 80: 415-424.

Lortie, G., J. A. Simoneau, M. R. Boulay, and C. Bouchard. Muscle fiber composition and enzyme activities in brothers and monozygotic twins. *Sport and Human Genetics*, edited by R. M. Malina and C. Bouchard. Champaign, IL: Human Kinetics, 1986;147-153.

Lynch N.A., E.J. Metter, R.S. Lindle, J.L. Fozard, J.D. Tobin , T.A. Roy, J.L. Fleg , and B.R. Hurley. Muscle quality: Age-associated difference between arm and leg muscle groups. *J Appl Physiol* 1999; 86: 188-194.

Manson J.E., G.A. Colditz, M.J. Stamplfer, W.C. Willet, B. Rosner, R.R. Monson, F.E. Speizer, and C.H. Hennekens. A prospective study of obesity and risk of coronary heart disease in women. *N Eng J Med* 1990; 322: 882-889.

Mathews C.E., and P.S. Freedson. Field trial of a three-dimensional activity monitor: comparison with self report. *Med Sci Sports Exerc* 1995: 27:1071-1078.

McCarthy, M. The thin ideal, depression and eating disorders in women. *Behavior Research and Therapy* 1990; 28: 205-216.

McGinnis, J. M. and W. H. Foege. Actual causes of death in the United States. *JAMA* 1993; 270: 2207-2212.

Melnyk M.G., and E. Weinstein. Preventing obesity in black women by targeting adolescents: a literature review. *J Am Diet Assoc* 1994; 94:536-40.

Metter E.J., R. Conwit, J. Tobin, and J.L. Fozard. Age-associated loss of power and strength in the upper extremities in women and men. *J Gerontol A Biol Sci Med Sci* 1997; 52: B267-276.

Must A, J. Spandano, E.H. Coakley, A.E. Fiels, G. Colditz, and W.H. Dietz. The disease burden associated with overweight and obesity. *JAMA* 1999; 282:1523-1529.

Overend, T.J., D. A. Cunningham, J. F. Kramer, M. S. Lefcoe, and D. H. Paterson. Knee extensor and knee flexor strength: cross-sectional area ratios in young and elderly men. *J. Gerontol. A. Biol. Sci. Med. Sci.* 1992; 47:M204-M210.

Paffenbarger L., and S. N. Blair. Relationship between low cardiorespiratory fitness and mortality in normal weight, overweight, and obese men. *JAMA* 1999; 282: 1547-1553, 1999.

Pirnay, G., R. Marechal, R. Radermecker, and J. M. Petit. Muscle blood flow during submaximum and maximum exercise on a bicycle ergometer. *J. Appl. Physiol*. 1972; 32: 210-212

Pleas J. Long-term affects of a lifestyle-change obesity treatment program among minorities. *J Natl Med Assoc*. 1988; 80:747-752

Pocock N., J. Eisman, T. Gwinn, P. Sambrock, P. Kelly, J. Freund, and M. Yeates. Muscle strength, physical fitness, and weight but not age predict femoral neck bone mass. *J Bone Min Res* 1989; 4: 441-447.

Rand, C.W., and J.M. Kaldau. The epidemiology of obesity and self-defined weight problems in the general population: Gender, race, age, and social class. *International Journal of Eating Disorders.* 1990; 9:329-343.

Rantanen T, and J. Avela. Leg extension power and walking speed in very old people living independently. *J Gerontol A Biol Sci Med Sci* 1997;5 2:M22-M231.

Ryan A.S., and J. Nicklas. Age-related changes in fat deposition in mid-thigh muscle in women: relationships with metabolic cardiovascular disease risk factors. 1998.

Reed R.L., L. Pearlmutter, K. Yochum, K.E. Meredith, and A.D. Mooradian. The relationship between muscle mass and muscle strength in the elderly. *J Am Geriatr Soc* 1991; 39:555-561.

Rippe J.M., and S. Hess S. The role of physical activity in the prevention and management of obesity. *J A Diet Assoc* 1998; 2: S31-8.

Rosen, J.C., and J. Gross. Prevalence of weight reducing and weight gaining in adolescent girls and boys. *Health Psychology*. 1987, 6, 131-147.

Rucker C.E., and T.F. Cash. Body image, body size perceptions, and eating behaviors among African-American and White college women. *International Journal of Eating Disorders* 1992, 12(3): 291-299.

Sallis J.F. Seven-day physical activity recall. *Med Sci Sports Exerc* 1997; 29(6 suppl):S89-S103.

Sallis J.F., M.J. Buono, J.J. Roby, F.G. Michael, and J.A. Nelson. Seven-day recall and other physical activity self-reports in children and adolescents. *Med Sci Sports Exerc* 1993; 25: 99-108.

Simomeau, J.A., and C. Bouchard. Skeletal muscle metabolism and body fat content in men and women. *Obes. Res.* 1995; 3: 23-29.

Simoneau, J.A., A. Tremblay, G. Theriault, and C. Bouchard. Relationships between the metabolic profile of human skeletal muscle and body fat gain in response to overfeeding (Abstract). *Med Sci. Sports Exerc.* 1994; 5: S159.

Sobal, J. Obesity and socioeconomic status: a frame work for examining relationship between physical and social variables. Special issue: bigger is better? Biocultural dynamics of body shape. *Medical anthropology* 1991; 13: 231-247.

Sobal, J. and A.J. Stunkard. Socioeconomic status and obesity: A review of the literature. *Psychological Bulletin, 1989*; 105:260-275

Stark O., E. Atkins, H. Wolff, and J.W.B. Douglas. Longitudinal study of obesity in the National Survey of Health and Development. *Br Med J* 1981; 283:13-17.

Stevens J., J.E. Kiel, P.F. Rust, H.A. Tyroler, C.E. Davis, P.C. Gazes. Body mass index and body girths as predictors of mortality in blacks and white women. *Arch Intern Med.* 1992; 152:1257-1262.

Struckard A.J., T.A. Sorensen, and C. Harris. An adoption study of human obesity. *N Eng J Med.* 1986; 314:193-198.

Struckard A.J., T.T. Foch, and Z. Hrubec. A twin study of human obesity. *JAMA* 1986; 256:51-544.

Terjung, R. L., G. A. Dudley, and R. A. Meyer. Metabolic and circulatory limitations to muscular performance at the organ level. *J. Exp. Biol.* 1985; 115: 307-318.

Thorstensson, A. Muscle strength, fiber types and enzyme activities in man. *Acta Physiol. Scand. Suppl.* 1976; 443: 1-45.

Thorstensson, A., G. Grimby , and J. Karlsson. Force Velocity relations and fiber composition in human knee extensor muscles. *J. Appl. Physiol.* 1976; 40: 12-16.

Toubro, S., P. Western, J. Bulow, I. MacDonald, A. Raben, N. J. Christensen, J. Madsen, and A. Astrup. Insulin sensitivity in postobese women. *Clin. Sci. (Colch.*) 1994; 87: 407-413.

Troiano R.P., and K.M. Flegal. Overweight children and adolescence: Description, epidemiology, and demographics. *Pediatrics* 1998 (suppl); 101(3):497-504.

Troiano R.P., K.M. Flegal, R.J. Kuczmarski, S.M. Campbell, and C.L. Johnson. Overweight prevalence and trends for children and adolescents. The Nation Health and Nutrition's Examination Surveys 1963 to 1991. *Arch Pediatr Adolesc Med* 1995; 149:1085-1091

Troiano R.P.., and K.M. Flegal. Overweight children and adolescence: Description, epidemiology, and demographics. *Pediatrics* 1998 (suppl); 101(3):497-504.

Viitasalo, J. T. Muscular strength profiles and anthropometry in random samples of men aged 31-35, 51-55, and 71-75 years. *Ergonomics* 1985; 28:1563-1574.

Visser M., D.J. Deeg, P. Lips, T.B. Harris, and L.M. Bouter. Skeletal muscle mass and muscle strength in relation to lower-extremity performance in older men and women. *J Am Geriatr Soc* 2000; 48:381-386.

Vogler G.P., T.I.A. Sorensen, and A.J. Stunkard AJ. Influences of genes and shared family environment on adult body mass index assessed in an adoption study by a comprehensive path model. *Int J Obesity* 1995; 19: 40-45.

Wallace J.P., T.L. McKenzie, and P.R. Nader . Observed vs. recalled exercise behavior: a validation of a seven day exercise recall for boys 11to 13 years old. *Res Q Exerc Sport* 1985; 56: 161-165.

Wang W, Wang Z, Faith MS, Kotler D, Shih R, and Heymsfield SB. Regional skeletal measurement: evaluation of new dual-energy X-ray absorptiometry model. *J. Appl Physiol* 1999; 87:1163-1171.

Wang Z, Visser M, Ma R, Baumgartner RN, Kotler D, Gallagher D, and Heymsflied SB. Skeletal muscle mass: evaluation of neutron activation and dual-energy X-ray absorptiometry methods. *J Appl Physiol* 1996: 80:824-831.

Ward D.S., G. Stewart, G. Trost, G. Felton, R. Saunders, M. Parsons, M. Dowda, and R.R. Pate. Physical activity and physical fitness in African-American girls with and without obesity. *Obes Res* 1997; 5:72-577.

Wardle, J. and L. Marsland. Adolescent concerns about weight and eating: A social-development perspective. *Journal of Psychosomatic Research*, 1990; 34: 377-391.

Wei, M., J. B. Kampert, C. E. Barlow, M. Z. Nichaman, L. W. Gibbons, R. S. Modern chronic diseases: Primary prevention through exercise biology. *J Applied Physiology* 2000; 88: 774-787.

Weinsier R.L., G.R. Hunter, A.R. Heini, M.I. Goran, and S.M. Sell. The etiology of obesity: Relative contribution of metabolic factors, diet, and physical activity. *Am J Med* 1998; 105: 145-150.

Whitaker RC, Wright JA, Pepe MS, Seidel KD, and Dietz WH. Predicting obesity in young adulthood from children and parental obesity. *N Eng J Med* 1997; 337(13): 869-873.

White, W.C., Hudson, L., and Campbell, S. Bulimarexia and black women: A brief report. *Psychotherapy*. 1985; 22, 449-450.

Wiepahl J., D.R. Ragland, and S. Sidney. Body mass index and 15-year mortality in a cohort of black men and women. *J Clin Epidemiol* 1990; 43: 949-960.

Williamson D.F., H.S. Kahn, and T. Byers. The 10-year incidence of obesity and major weight gain in black and white US women aged 30-55 years. *Am J Clin Nutr* 1991; 53 (suppl):1515S-1518S.

Williamson D.F., H.S. Kahn, P.L. Remington, and R.F. Anda. The 10-year incidence of overweight and major weight gain in US adults. *Arch Intern Med* 1990; 150: 665-672.

Young A., M. Stokes, and M. Crowe. The size and strength of quadriceps muscles of old and young women. *Eur. J. Clin.* Invest. 1984;14: 282-287.

Young A., M. Stokes, and M. Crowe. The size and strength of quadriceps muscles of old and young men. *Clin. Physiol.* 1985; 5:145-154.

Young T.K. Sociocultural and behavioral determinants of obesity among inuit in the central Canadian artic. *Soc. Sci. Med* 1996; 40: 1665-1671.