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A Comparison of Measures in Physical Fitness and Biological Maturity Between Female Gymnasts and Females Not Involved in Organized Sport

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A Comparison of Measures in Physical Fitness and

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(TITLE)

not Involved in Organized Sport

BY

Cara Kokenes

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THESIS

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ABSTRACT

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Cara Kokenes

The purpose of this study was to investigate differences in physical fitness and biological development between two groups of twelve year old females. One group consisted of idividuals who had been involved in competitive sport for at least two years while the other group was not involved in organized sport. Two groups of 20 subjects were examined in terms of height, weight, flexibility, strength, body composition, maturation, eating attitudes, and cardiorespiratory endurance. The results indicated that the gymnasts were significantly ($p<.05$) shorter, lighter, stronger in regard to left hand grip strength, lower in percent body fat, less biologically mature, and had greater cardiorespiratory fitness than the non-gymnasts. No significant differences were observed in right hand grip strength or eating attitudes. It was concluded that maturation level as well as gymnastic training played a major role in influencing values obtained through measurements of physical fitness.

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DEDICATION

I would like to dedicate this masters thesis to my parents, Lynn and James Kokenes, who have provided continuous support throughout my entire academic career.

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CHAPTER I

INTRODUCTION

Identification of the problem

Adolescence is a time of rapid change and growth. Between the ages of nine and seventeen, most children become biologically mature adults. It has been documented that motor performance, total body fat, and maximal oxygen consumption (L/min) tend to increase as adolescents mature (Kemper, Verschur, and Ritmaster, 1987; Bale, Mathew, Piper, Bale, and Williams, 1992; Post and Kemper, 1993). The time it takes for these changes to occur, and the rate of change, varies among individuals and is dependent on both environmental and genetic factors.

Environmental factors that often affect normal growth and onset of puberty include outside factors such training affects. Two different studies conducted by Kemper, Post, and Twisk (1997) and Post and Kemper (1993) show a relationship between late maturing adolescents and a greater consumption of foods high in energy and protein, with a slightly higher activity pattern than early maturing adolescents. A study conducted by Theintz, Howald, Weiss, and Sizenko (1993) showed how environmental factors can alter growth potential of adolescent female athletes. The authors concluded that the effects of exercise training such as lifting heavy weights before puberty can alter growth rate to such an extent that full adult height may not be reached. In the prepubescent child, the area of bone surrounding the growth plate has not yet achieved its mature strength and is, therefore predisposed to injury (Priest and Holshouser 1987). The authors also found that biological factors contributing to delayed onset of puberty are possibly due to exercise which may cause an inhibition of the hypothalamic-pituitary-gonadal axis (Grumbach, Roth, Kaplan, and Kelch 1974). This reaction may be negatively affected by poor nutrition and insufficient caloric intake. If the body expends more calories than are taken in, the normal growth spurt may be delayed or growth may be retarded. The duration and severity of caloric restriction can determine whether the predicted peak height of the individual is ever achieved (Theintz, Howald, Weiss, and Sizenko, 1993).

Biological maturity in females is most frequently determined by age at menarche, development of secondary sex characteristics, and skeletal maturation. A study conducted by Theintz, Ladame, Kenner, Plinchta, Howald, and Sizenko (1994) compared moderately trained swimmers with highly trained gymnasts to determine whether differences in height, weight, and age of menarche were apparent between the two groups. The results revealed the twenty-seven highly trained gymnasts (12.7 +/- 1.1 years old) to be shorter and lighter with only 7.7% having reached menarche while fifty percent of the taller, heavier, sixteen moderately trained swimmers (13.0 +/- .9 years old) had reached menarche at the time of the study. Graber, Brooks, and Warren (1995) found a trend for maternal age at menarche to predict adolescent age at menarche. The latter study suggests a genetic relationship to the onset of menarche while the former suggests intense exercise with diet restrictions are environmental aspects which can delay the onset of puberty. It is difficult to determine whether this actually affects the normal biological rate of maturation or if later maturing girls excel in certain sports that tend to favor the smaller, more flexible athlete.

Gymnastics is one sport in which the population tends to include more late maturing girls. The sport began to be criticized by the public after the death of world class gymnast Kristy Henreich due to anorexia. Merrel Noden claims gymnasts are stunted in growth, have poor nutritional habits, and have a greater chance of developing primary amenhorrea due to anorexic behaviors resulting in low levels of body fat as well as other nutritional factors (1994). Gymnasts, as well as many other athletes tend to develop "athlete's amenhorrea" a result of hypothalamic inhibition which causes low pituitary secretion of gonadatropic hormones (Apter, 1978). Because gonadatropic hormones play a role in controlling the menstrual cycle, it's inhibition can cause irregularities in the athlete.

Many studies show gymnasts tend to be leaner than most other groups of athletes, but few show long term damaging affects due to the leanness of the girls. A study performed in 1995 by Lindholm, Hagenfeldt, and Ringertz found former gymnasts to have reached menarche at a later chronological age than a control group, but they had no difference in total body fat or body mass index (BMI) later in life. This supports the idea that gymnasts are late maturing but eventually catch up to other females. Other studies show that although bone growth may be stunted, there is an increase in bone mass due to high impact loading strains on the skeleton. This high impact may be osteotropic (beneficial) for women later in life (Taaffe, Robinson, Snow, and Marcus, 1997).

By measuring some basic components of physical fitness, comparisons can be made between sixth and seventh grade children not engaged in organized sports and their gymnast counterparts. Fitness testing can serve both groups by tracking progress, creating an understanding of the effects of physical training, evaluating specific programs, motivating children and fitness leaders to improve scores, and promoting physical education (Safrit, 1995). Problems documented in the literature concerned with the increased inactivity of American youth have been pinpointed through fitness testing and comparisons (Ross and Gilbert 1985; Ross and Pate 1987). Children need encouragement and education about physical fitness from the home, community, and school.

Researchers who study the differences among certain athletic and non-athletic groups have become concerned with the lack of physical fitness in sedentary individuals as well as overtraining in certain athletes, especially gymnasts. Because a gymnast's career is short, she has usually reached her peak by age 18 (Swift 1995). Intense training at a young age is therefore crucial to the development of the young gymnast. Lindholm, Hagenfeldt, and Ringertz (1995) support the idea that intense physical exercise could result in delayed puberty and have a negative influence on the acquisition of peak bone mass.

With decreased emphasis on physical education, a message is being sent to children and adolescents that their bodies are relatively unimportant. By teaching children the importance of movement at an early age, they can develop active lifestyles they will carry into adulthood. Fat children tend to be more likely to be overweight and obese as adolescents and adults (Zack, Harlan, Leaverton, and Coroni-Huntley, 1995). Because of this tendency, proper lifestyle changes early in life can be beneficial.

Millstein and Litt (1990) performed a study in which they found children to view themselves as "healthy" if they were capable of performing physical, mental, and social and social tasks with moderate intensity. According to Ratliffe and Ratliffe (1994), being healthy (physically fit) is defined as a state of well being that allows people to perform daily activity with vigor and reduce their risks of health problems. Children's perceptions can be changed if enough evidence can be documented to encourage fitness leaders to change current programs to emphasize healthy lifestyles.

The prevalence of obesity as indicated by triceps skinfold measurements higher than the eighty-fifth percentile, has risen 39 percent over the past two decades (Chicoye, Jacobson, Landry, and Starr 1997).This significant change is partially due to an increase in the number of children who spend the majority of their free time watching television and playing video games (Dietz and Gortmaker, 1985), an increase in inactivity (Groves, 1988), and the failure of physical educators to develop current and future healthy lifestyle habits in today's youth (Sallis et al, 1992).

Lacy and LaMaster (1990) found junior high school students were involved in fitness activities for fewer than five minutes in their thirty-four minute physical education class period in 75 percent of their classes. Another study completed by Ross and Pate (1987) showed that one half of all children between ten and 17 years old are involved in vigorous exercise three or more times a week at an intensity accepted by ACSM guidelines for adults. This statistic is encouraging except for the fact that these guidelines have been criticized by some as being weak and insufficient (Blair, 1992).

Purpose of the Study

The purpose of this study was to compare measures of physical fitness between a group of 12 year old females who had not participated in organized athletics with a group of highly trained gymnasts who had been involved in competitive gymnastics for at least four years.

Hypotheses

It was hypothesized that there would be no difference in cardiorespiratory fitness, height, or weight among twelve-year-olds not involved in organized sport and highly trained gymnasts of the same age. It was also hypothesized, however, that the gymnasts would have greater muscular strength, be more flexible, have a lower percent body fat, have more symptomatic responses on an eating attitude test, and would be biologically less mature than the group not involved in organized sport.

Delimitations

1. This study was limited to subjects from the Chicagoland area. The subjects were not randomly selected. Therefor, the findings of this study are not necessarily representative of all children of this age range.
2. Body fat estimates were made using measurements of skinfold thickness. Although it is one of the best techniques available for field research, other methods such as underwater weighing have been shown to be more accurate.
3. Accurate assessment of axillary hair may have been slightly ambiguous because it was recorded according to self reports from the children.

Definitions of Terms

Body Composition. The relative amounts of body constituents (fat, water, and minerals) in the body. Body composition is usually divided into fat and lean body. (Howley and Franks, 1992, page 357).

Biological Maturation. Refers to achievement of development or growth in terms of sexual maturation from birth and peak adult status.

Cardiorespiratory Endurance. Refers to heart and respiration. Cardiorespiratory endurance is the enhancement of the heart and circulatory function produced by regular vigorous aerobic training (Strand and Reeder, 1993, page 89).

Flexibility. Includes adduction, abduction, and rotation of joints. It is the ability to move a joint through the full range of motion without pain or discomfort. (Harvey and Tanner, 1991, page 402).

Strength. The maximal amount of force that can be exerted by a muscle group against a resistance. (Howley and Franks, 1992, page 374)

VO2 max. Maximal oxygen uptake. A measurement of aerobic capacity which is expressed in liters per minute or ml per kilogram of body weight. (Borms, 1986, page 6).

Menarche. The establishment of menstruation.

CHAPTER II

LITERATURE REVIEW

Statement of the Purpose

The purpose of this study was to compare measurements of physical fitness and assess biological maturity in a group of 12 year old girls who had not participated in organized sport with a group of highly trained gymnasts who had been involved in competitive gymnastics for at least two years. This review of literature will discuss each of the following components: flexibility, strength, body composition, maturation, eating attitudes, and cardiorespiratory fitness.

Introduction

The youth of today is often criticized for being inactive and lazy. According to two National Children and Youth Fitness Studies, however, today's youth is not as inactive as most people think. Ross and Pate found one half of all ten to 17 year olds exercise three or more times per week (1987). Although this meets the 20 minute, three-day a week recommended requirements for exercising adults, a more intense program is suggested for adolescents. Because of controversies such as this, the American College of Sports Medicine's (ACSM) guidelines in this area have been criticized as being weak and insufficient (Blair, 1993). Corbin, Pangrazi, and Welk (1994) suggest that daily activity at a moderate intensity level might be sufficient exercise for children. One way to accomplish this is to challenge physical educators to emphasize skill development while enhancing physical fitness.

They should include activities designed specifically to increase the amount of time students are involved in moderate-to-vigorous activity (Strand and Reeder, 1996).

If the activity levels of the adolescent population are re-evaluated keeping this criticism in mind, our adolescent population does appear to have low activity levels. These low activity levels can relate to the development of increased body fat and decreased flexibility. Many factors have contributed to this recent decline: physicians are not doing enough to teach children about the causes of diseases associated with inactivity such as obesity (Groves, 1988), increased numbers of latch-key kids spend the majority of their free time watching television and playing video games (Dietz and Gortmaker, 1985), and physical education programs may also fail to develop current and future healthy lifestyle habits in our youth (Sallis et al., 1992). Lacy and LaMaster (1990) found grade school students were involved in fitness activities for fewer than 5 minutes in their 34 minute physical education class period in 75% of their total classes. It is findings such as this that makes fitness testing important and necessary to help benefit those children who consider physical education their main form of exercise.

Flexibility

Flexibility can be seen from an aesthetic aspect for certain sports as well as an important component of physical fitness in adolescents. It is required for skilled movement in a variety of different settings, but is particularly important in gymnastics. Because demonstration of flexibility is part of the scoring system, gymnasts need to have an optimal level of flexibility in order to create an appearance of smoothness of movement, graceful coordination, and self control (Alter, 1996). The range of motion of joints is limited with increased amounts of body tissue around them, thus explaining in part, why it is important to keep body fat low to achieve optimal flexibility (Laubach and McConville, 1966).

The greatest critical period for the development of flexibility occurs between the ages of seven and eleven (Sermeev, 1966). For many females, puberty usually begins with a major growth spurt and the gradual development of secondary sex characteristics. It has been hypothesized that because the bones are growing faster than the muscle can stretch, there is an increase in muscle tendon tightness about the joint (Leard, 1984). This theory would explain the reason flexibility increases until puberty and then decreases from about age 12 to 15. After age 17, flexibility increases once again in young adults because muscles eventually grow to catch up to the bones.

Flexibility can be defined as the capacity to move a limb or body part throughout its range of motion (ROM); since flexibility is joint specific, it is important to emphasize ROM in all joints (Liemohn, 1988). Normal static flexibility is defined for each joint, and involves the anatomic components of each joint: muscle-tendon units, ligaments, joint capsules, muscles, bones and connective tissue. Heredity, age, body temperature, gender, and activity affect flexibility and therefore must be taken into account when testing subjects for specific areas of flexibility (Purcell and Hergenroeder, 1994).

Nearly 80 percent of all people have experienced low back pain at one point in their life, most of which can be attributed to inflexibility or lack of muscular fitness (Liemohn, 1988). Fairbank, Pynsent, vanPoortvliet, and Phillips (1984), further investigated this phenomenon in a sample of 446 students aged 13 to 15 (227 males and 219 females) and found 26% had experienced back pain. Fairbank found back pain incidence to peak at age 14 and it was more common in those who did not participate in athletics. This study showed the anatomic sites of back pain in this population to be in the thoracic area (19%), thoracolumbar area (31%), and in the lumbar area (50%), but did not reveal the detrimental effects on the back for the future. A recent study conducted by Hareby, Neergoard, Hessloe, and Kjer (1995) found, from a 25 year follow-up study of 14 year old children, that the combination of low back pain at the age of 14 years together with a family history of low back pain is highly associated with adult symptoms.

Development of low back pain as a child due to inflexibility can have detrimental effects later in life. If children are assessed early and learn stretching exercises to increase flexibility, chances of low back pain occurrence may decrease as the child/adolescent enters adulthood. Assessing low back flexibility at an early age can also help physical educators promote stretching to decrease chances of future problems with back pain.

Strength

By definition, strength is an expression of muscular force--the capacity to develop tension against external resistance. Static (isometric) strength is the force exerted against an external resistance without any change in muscle length. When measuring static strength, it is important to consider its correlation to motor performance, body size, physique, and body composition.

In girls, strength tends to improve linearly with age through sixteen or seventeen, with no clear evidence of a "spurt", as seen in many boys. Although increases tend to be linear with age, strength patterns are not the same for all tasks. Sol (1987) reported that 80 percent of the performance in women's' gymnastics could be predicted by rope climbing, leg split, standing vertical jump, and hand grip. Rope climbing shows how well one can support their own body weight, leg split measures flexibility, standing vertical jump measures the ability to generate force in a short amount of time (explosiveness), and hand grip relates to upper body strength. Because strength, power, flexibility, power, flexibility, and agility are considered components of successful gymnastic performance, one would expect gymnasts to excel when compared to their non-gymnast counterparts in each of the tests listed above.

Strength training has often been said to place stress on the bones and ligaments, which could hinder the growth process (Berger and O'Shea, 1986). Current studies show strength training to be a benefit rather than a contraindication. Using elite junior Olympic weightlifters and age-matched controls, Conroy et al. (1993) showed that resistance training proportionately increases bone mineral density in relation to the intensity of resistance against which the bone and muscle-tendon unit work. Other sports such as gymnastics include weight training to increase the ability of the athletes to support their own body weight. This training can also serve to increase bone mineral density and decrease risks of premature osteoporosis. Other benefits of weight training have shown a probable increase in ligament strength, improved sport performance, decrease in the rate and severity of sport-related injuries, and an accelerated recovery rate when injuries have occurred in adolescents (Priest and Holhouser, 1987).

In average prepubescent children, muscle weight is about 27% of the total body weight and the effect of muscle hypertrophy from training is so small that strength gains are mainly shown through improved coordination. After sexual maturation, muscular development is influenced by androgenic hormones and the muscle then increases to 40% of total body weight (Rohmert and Priesting, 1968). This may be one reason that explains why early maturing girls tend to excel in strength assessments involving tasks such as throwing, while late maturing girls excel in running and jumping. When done under proper supervision and with proper technique, strength training seems to have benefits that outweigh its risks (Priest and Holshouser, 1987).

Body Composition

Body composition can be assessed through a variety of methods including: measurement of skinfold thickness, bioelectrical impedance analysis, and underwater weighing. Although underwater weighing is considered to be the most accurate, other methods, such as skinfold measurement, can be reliable if the technician is experienced and the equipment is accurate (Dietz and Gortmaker, 1985).

By measuring the "fatness" of a person, we are actually measuring the amount of extractable lipids, adipose, and other tissues (Lohman, 1987). The actual skinfold pinch as measured by the caliper is a measure of the thickness of a double fold of skin with compressed adipose tissue. This measurement is referred to as subcutaneous because it is a measurement of fat directly below the skin (Martin, Ross, Drinkwater, and Clarys, 1985). Because an estimated 20 to 70% of the total body fat is located subcutaneously, basic relationships are assumed when using skinfolds to estimate total body density (from which percent body fat is derived) (Leard, 1984).

As early as 1915, skinfold assessment was used to estimate body fat.

Equations were originally developed from cadaver studies and later perfected by comparing them with more reliable measurements using underwater weighing (Martin et al., 1985). Eventually, researchers sought to decrease prediction error and later developed equations for specific populations such as children and athletes (Slaughter, et al., 1988). When creating this equation in 1988, Slaughter et al based their research on a study conducted in 1984 by Boileau et al. which showed that changes in water, minerals, and protein components in children affects their fat-free body density. Fat free body composition constants are 73.8% water, 19.4% protein, and 6.8% minerals for adults, but differ for children. The fact that children have a higher percentage of water and less minerals than adults must be taken into account when using appropriate prediction equations for specific populations (Heyward and Stalarczyk, 1996). It is also important to note that the internal-external distribution of fat in children is different to that of adults. Slaughter's equation improved concurrent validity of practical field-based estimates of body fat in youth by combining the measurements of underwater weighing with measurement of bone mineral density and total body of water in children. This equation was developed using multi-component model references to predict body fat and has a prediction of error ranging from 3.6 to 3.9% (Heyward and Stalarczyk, 1996).

Obesity can cause both immediate and long-term health consequences for children. Many researchers have attempted to establish norms and national averages as guidelines to assess overfatness. According to calf and triceps measurements, Lohman (1987) concluded that optimal percent body fat in female children ranges from 14 to 25%. Young girls measuring 30% fat or more have higher systolic and diastolic blood pressure, total cholesterol, and lipoprotein cholesterol than those below this level

(Going, Lohman, and Williams, 1992). These potential risk factors, typical of inactive children, can often be carried into adulthood and manifest themselves as serious risks of coronary heart disease. Participating n organized sports, such as gymnastics, can decrease the chances of these risks due to the rigorous training styles of the sport.

A longitudinal study conducted by Zack, Harlan, Leaverton, Cornoni-Huntley, (1979) found that childhood adiposity tends to be carried into adolescence in girls ranging from 12-17 years old. Other studies (Must, Jaques, Dallal, Bajema, Dietz, 1992; Must, 1996; Lechky, 1994) have found that those adolescents who scored in the seventy-fifth to eightieth percentile on a body mass index survey, are forty to ninety percent more susceptible to becoming obese adults. This index was based on scores of nation-wide surveys of adolescents.

Low activity levels can contribute to obesity in children and affect the chances of carrying obesity into adulthood. Children over 30% body fat may also have a greater risk of developing cardiovascular disease (Douthitt and Harver, 1995), abnormal glucose tolerance and hypertension that may possibly lead to non-insulin dependent diabetes mellitus (Must, 1996), and immediate psychosocial consequences which often lead to lasting distorted self-image (Stunkard, 1967). Young female gymnasts tend to average between 12-16% body fat, thus they have a decreased chance becoming obese as adults.

Although it is considered healthy for children to be below 16% body fat, concern rises when postmenarchal females drop below this. It is possible that low levels of body fat lead to significantly lower bone mineral content which can increase susceptibility of stress fractures and possibly premature osteoporosis (Going et al., 1992). This can lead to a negative influence on the accumulation of bone mass which is particularly important during adolescence because the ability of bone to adapt to mechanical loading is much greater during this period than after maturity. This is also the crucial time in which half of the adult bone mass is accumulated (Parfitt, 1994). Although some gymnasts tend to have low body fat percentages which could contribute to low bone mineral content, the high impact loading strains of gymnastic training on the skeleton can have powerful osteotropic benefits on the body. This is why some gymnasts with low levels of body fat do not show evidence of premature osteoporosis (Taafe et al., 1997).

Maturation

"Maturation is often conceived as a series of successive transformations through time leading to the attainment of the adult state" (Taranger, 1976). Children are usually classified according to their chronological age (CA), or the number of years since birth. When discussing a child's maturity status, biological age (BA) takes anatomical, physiological, and or mental measures into consideration (Kemper et al., 1987). Differences in the maturation/size of children may affect fitness test results and their interpretation. It is important to take biological age into account during the pubertal years when children with the same CA show large individual variations in parameters of physical fitness testing such as body composition and flexibility.

Measuring maturity can be accomplished through a variety of means. Single events that have been used frequently are: age of menarche [Duppe, Cooper, Gardshell, Johnell, 1997; Howat, Carbo, Mills, and Wozniak, 1989], age of peak growth velocity (Carron and Bailey, 1974; Mirwald et al., 1981), the Tanner stages of sexual maturation (Duke, Litt, Gross, 1980; Taranger, 1976), and the development of axillary hair according to Malina (Personal communication, 1998).

Biological age can be estimated through a series of calcification stages according to hand/wrist as well as dental x-rays. The Tanner-Whitehouse II method has been used to assess the levels of calcification in the hand and wrist (Kemper et.al., 1987) while x-rays of the teeth and gums can explain the level of biological maturity through the eruption of permanent teeth.

Once BA is determined, children can be categorized as either late maturers (LM) or early maturers (EM). Comparisons can also be made to see whether there are differences in structure (height and weight) or function (VO2 max, strength, and flexibility) in children with different maturation patterns (Kemper et al., 1987). Delayed maturation occurs in 25 out of 1000 children and often interferes with the child's ability to progress effectively within her peer group (Root and Reiter, 1976).

The appearance of secondary sex characteristics and the pubertal growth spurt are the result of complex hormonal processes initiated from the hypothalamus (Taranger, 1976). The onset of pubic hair is usually complete after 1.6 years after its onset. Approximately two years after the onset of pubic hair, axillary hair begins to develop. This relationship allows researchers to assess approximate biological age and maturity status accurately (Taranger, 1976). The appearance of axillary hair can be used as an assessment tool for maturity, and its appearance usually occurs within two years of pubic hair development (Taranger, 1976).

There is a significant correlation between age at menarche, body weight, and body fat. In 99% of females, menarche occurs within five years of the onset of breast growth and is achieved at a mean weight of forty-seven kilograms. A study reviewed in 1996 from an original study conducted annually between 1977 and 1980 in subjects ranging from 13 to 16 years old measured height, weight, skinfold thickness, and sexual maturity (Kemper et al., 1997). Sexual maturation, determined by age at menarche, was used to determine biological maturity of the subjects. Body mass index increased and skinfold measurements increased throughout the study. These findings supported the conclusion that girls who had reached menarche at a relatively young age showed greater percent body fat in trunk-oriented patterns compared to late-maturing girls who achieved menarche at an older age (vanLenthe, Kemper, vanMechelen, 1996). This might infer that menarche is associated with the degree and distribution of body fat.

Physical activity can influence growth, physical development, and biological maturation in childhood and adolescents. Those with high levels of fatness, or adiposity, are not only fatter than peers of the same age and sex, but on average tend to be taller; have increased skeletal dimensions, and fat-free mass; and are advanced in biological maturation (Buenen, Malina, Lefevre, Claessens, 1994). Menarche is delayed in children participating in some activities, especially gymnastics, ballet dancing, and ice-skating. For gymnasts, the delay is about two years, while other athletes, such as swimmers, usually mature at about the same rate as their non-athletic peers (Peltenburg, Erich, Bernink, Zonderland, and Huisveld, 1984). A delay in menarche is most often the result of excessively low amounts of body fat due to training or caloric restriction of the athlete. Kemper et al. (1997) investigated the relationship of food intake and physical activity with biological maturation in 200 boys and girls during adolescence and young adulthood. Subjects were followed over nine years during which biological maturation was repeatedly measured, daily physical activity was assessed, and individual food intake was estimated. The results revealed that late maturation correlated to a higher energetic nutrient intake, a higher activity pattern, and a lower percentage of body fat. The early maturers had a higher fat mass, which resulted in a lower relative VO2 max. Deuk, Matt, Manore and Skinner (1996), reported that cessation of reproductive function (menstrual cycle) that occurs as an energy conserving adaptation can be reversed if the athlete increases their body fat percentage.

Until the age of 12, gymnasts tend to be the same size as other children of the same age. From this age on, sedentary children become taller than gymnasts (Peltenburg, et. al., 1984). Genetic inheritance of height as well as the gene pool of the population influence childhood growth patterns. Possible explanations for why the gymnasts may be shorter than other athletic groups (swimmers, in this case), are that less biologically mature children are usually shorter and more flexible, therefore, they are better suited for the sport of gymnastics.

Because most skeletal growth occurs before menarche, late maturing girls often have a delay in growth (Marshall and Tanner, 1969). The mean height of girls whose epiphyses are still unfused after menarche tends to be lower than that in adolescents with closed epiphyses. The incidence of open epiphyses after menarche decreases as time elapses (Porcu, Venturoli, Fabri, Paradisi, Longhi, Sganga, Flamingi, 1994). Within five years of the onset of menarche, the epiphyses of bones are closed and skeletal growth stops. This means that the onset and progression of puberty is directly related to growth cessation. The hormonal control of skeletal growth and maturation involves many endocrine systems. At puberty, skeletal growth rate shows a sharp acceleration and connection between the action of growth hormone and steroid hormones. In order for the growth spurt, followed by the closing of the epiphyses, to occur, puberty must begin. It is possible then, that gymnasts are not stunted in growth, but delayed due to the late onset of menarche.

Eating Attitudes

A good food plan, especially for young athletes, is a well-balanced, nutrient-dense diet (Sirota, 1991). A well-balanced diet refers to the food pyramid recommended daily allowances (RDA) published by the U.S. Department of Agriculture. Problems can arise when certain minerals such as zinc dip below optimal levels. A study conducted by Brun, Dieu-Cambrezy, Charpait, Fonsc, and Fedou in 1995 found that 11 gymnasts aged 12 to 15 had lower serum zinc levels than a matched control group of sedentary children. Low levels of zinc were correlated with a diet low in milk, seafood, whole grains and nuts, and soybeans. This could play a role in abnormalities of puberty, growth, or muscular performance. Because zinc is an essential component of hormones, insulin, and enzymes insufficient levels of zinc can affect normal growth, onset of puberty, and muscular performance.

Vitamin deficiency is often difficult to detect because it takes longer for clinical signs such as fatigue, irritability, and anorexia to appear than it does for enzyme activity to be decreased. Athletes who have an increased requirement for vitamins and do not properly replace them can harm their bodies without even realizing it (Shils, 1973). A study conducted by Reggiani, Arras, Senar, and Chiodini in 1989 showed the caloric intake of a group of twelve year old gymnasts to be lower than that recorded for matched non-gymnast peers, however, their intake was still within standards according to their body weight.

Restriction of food intake has been shown to delay puberty, stunt growth, and induce amenorrhea (Pugliese, Lifschitz, Grad, Marks-Katz, 1987). Delayed menarche is seen with malnutrition as seen with anorexia nervosa and inflammatory intestinal disease (Lindholm et al., 1994). Anorexia nervosa, which has its peak incidence during adolescence, is a syndrome characterized by the fear of becoming fat and extreme weight loss which can be frequently accompanied by amenorrhea (Selzer, Caust, Hibbert, Bowes, Patton, 1994).

Athletes, especially gymnasts, seem to be one of the most vulnerable groups when it comes to inadequate nutritional intake, especially gymnasts. A suboptimal nutrition level can delay growth and development (Root and Reiter, 1976). Since childhood comes to an end with the appearance of physical signs of puberty, many female adolescents try to delay the onset of puberty by starving themselves to keep a boyish looking figure (Sirota, 1991). Often, the body's caloric intake does not match the needs of the body to enable the body to carry out its natural processes, or to allow it to become ready for reproduction (Wiita, 1995).

Various methods are used for the assessment of food selection and intake. Food records, self-reporting eating frequency questionnaires, and direct observation of eating in the laboratory have been used to evaluate dietary intake and consumption. The EAT-26 questionnaire assesses attitudes toward eating and weight, measurements of hunger and satiety, and bodily sensations associated with eating and is important for understanding factors that influence eating behavior. This tool can be used as a tool to assess and predict whether further investigation into a subject's eating attitude is necessary (Hammer, 1992).

Cardiorespiratory Fitness

Cardiorespiratory is the ability to deliver oxygen to tissues during prolonged bouts of continuous exercise. It can be expressed in terms of aerobic power or oxygen uptake (VO2) in either ml/min or ml of O2 consumed per kilogram of body weight (Purcell and Hurgenroeder, 1994). The increase in estimated or measured VO2 max has been commonly used to evaluate the effectiveness of physical activity programs designed to improve this component of fitness (Haskell, Montoye, Orenstien, 1985).

Investigations have shown, however, that children aged ten years and younger do not respond with an increase in VO2 max as one would expect from endurance activities. The data of Schumaker and Hollmann (1974) on 'well trained juvenile athletes' indicated that an endurance-accentuated training program did not increase the VO2 max of subjects before the age of 11. This suggests that there is an increased trainability of the heart and circulatory system with maturity.

To further support the idea of development of VO2 max with biological age, Kobayashi et al (1978) conducted a study comparing the peak height velocity (PHV) to VO2 max. They found that the increase in aerobic capacity was relatively small before PHV, but significant thereafter, especially in trained boys. Trainability of endurance seems to depend on the biological maturity level of growing children. Other studies have also concluded that after puberty, the effects of endurance training are similar to those reported for adults (Borms, 1986).

Although gymnastics is considered more anaerobic than aerobic, it is still important for gymnasts to develop both of these cardiovascular systems because neither functions independently of the other. Additional cardiovascular training is therefore beneficial to all children regardless of whether they are involved in sports that are primarily anaerobic. Lack of cardiorespiratory exercise is a primary risk factor for developing cardiovascular diseases such as obesity, hypercholesterolemia, and hypertension (ACSM Guidelines). A recommended plan for children aged one to fourteen for improving VO2 max consists of maintenance of 60 to 90% of the maximum heart rate for a total of 30 minutes of large muscle, dynamic exercise training done with moderate to vigorous intensity (Haskell et al, 1985).

Aerobic training can also increase the anaerobic threshold and improve the clearance of lactic acid from exercising muscles (Purcell and Hurgenroder, 1994). In normal children and adolescents, peak VO2 (ml/min) increases with growth and maturation, although there are indications that girls' peak VO2 (ml/kg) in females may level off around age 14. It is expressed in relation to body mass (ml/kg/min) in order to achieve meaningful relative values (Armstrong and Welsman, 1994).

The best way to measure cardiorespiratory fitness is to perform a Graded Exercise Test (GXT) to determine maximal oxygen uptake. The more oxygen the body can utilize, the greater the VO2 max. This increase in the amount of oxygenated blood in the body allows the heart and lungs to work with greater efficiency. Therefore, increases in VO2 max can be considered a true estimate of cardiorespiratory fitness. Submaximal testing is often performed to estimate VO2 max because it is inexpensive, less time consuming, and can be administered to large groups of people.

A "Letters to the Editor" regular column- May/June issue of Journal of Physical Education, Recreation and Dance (JOPERD, 1996) gives the opinions of members of the physical education community on the importance of cardiorespiratory fitness vs skill development in adolescence. The following opinions were expressed: "Because of all the changes occurring during adolescence, cardiovascular fitness should be a major aspect in a physical education cirriculum (Klenn); "To ensure adolescents become 'great movers', emphasis should be shifted to include cardiovascular fitness" (Christie); and ". . . this should not be an either/or dichotomy. The focus should be on maximizing cardiovascular fitness while effective skill development is being carried out" (Crawford).

Educators and coaches can evaluate and teach the importance of physical fitness and how to live healthy lives. As young girls enter adolescence, changes take place that either enhance or inhibit them during sport and exercise. Body fat levels tend to increase while resting metabolism and flexibility often decrease. By participating in organized sport, children can enhance fitness levels and recognize its importance.

CHAPTER III

PROCEDURES

Statement of the Purpose

The purpose of this study was to compare measures of physical fitness and maturation between a group of 12 year old girls who had not participated in organized sport and a group of highly trained gymnasts who had been involved in competitive gymnastics for at least two years.

Subjects

Two groups of 20, twelve-year-old female subjects were chosen to participate in this study. Girls who had reached their twelfth birthday, but had not yet reached their thirteenth, were included as subjects. The group of girls not involved in organized sport were selected from Westmont Jr. High while the group of trained gymnasts were members of The Naperville Gymnastics Club. Both of these institutions were located in the southwest suburbs of Chicago. The gymnasts had competed for two to four years and had practiced an average of five days per week for a total of twenty hours. Based on United States Association of Gymnastics (USAG) recommendations, Naperville Gymnastics Club requires each girl to participate in practice according to set guidelines. The participants selected from the junior high (non-gymnasts) had not been involved in an organized sport program for at least two years, at the time of testing. To ensure these subjects were inactive, they were asked to fill out a questionnaire at the time of testing which asked if they had been involved in any sports in the past two years, if the activities were school-based or club-based outside of school, and whether they participated year round or seasonally. An introduction to the study (Appendix A) including an explanation of the study and a release form (Appendix B) were sent to each participant prior to enrollment. Both the participant and a parent were required to read, sign, and return the information to either the junior high or to the gym.

Procedures

The non-gymnast subjects were tested on a balcony above the main gym for privacy while the gymnasts were tested in a locker room attached to the main gym. An adult research assistant was thoroughly trained in the proper performance of test procedures prior to data collection. The assistant was responsible for administering the step test only. The testing session began with a brief introduction to the researchers and an explanation of what each girl would be asked to do. In order to obtain the most accurate representation of their physical fitness level, subjects were encouraged to put forth a maximum effort where required and to perform to the best of their ability.

Before beginning the battery of tests, each subject was asked to fill out a form which identified them by their name and subject number. The form included questions concerning current sport participation, menarche status, and an axillary hair assessment (Appendix C). Test data was associated with the subject number only and it was matched with their name only for purposes of providing test result feedback to participants. Testing stations were set up to make the testing time as efficient as possible. Each subject followed the same testing order.

Measurements

Height and Weight

Height was measured to the nearest quarter of a centimeter by means of a portable stadiometer. Weight was measured to the nearest tenth of a pound with a strain gauge scale (A & D model UC 300). Subjects were clothed in either shorts and a T-shirt or a leotard. No shoes were worn.

Flexibility

The sit and reach test was used to determine hamstring and lower back flexibility. The sit and reach box was twelve inches high with a measuring stick positioned so the 22.86 (cm) mark was at the front edge of the box. Each subject was asked to remove their shoes and place the soles of their feet flat against the front edge of the box. They kept their legs extended in front of them with their hips parallel to the box. One hand was placed on top of the other with the fingers extended as far as possible. Each subject was instructed to bend at the hips while they pulled their chest toward their knees without bouncing. They were allowed four non-ballistic attempts with five seconds of rest between each trial, to reach forward as far as they could. The greatest distance touched by the fingertips was recorded to the nearest quarter inch (Safrit, 1995). The validity of this test compared with a hamstring flexor strength test and a lower back flexor strength test had a correlation of 0.60 to 0.73 and 0.27 to 0.30 respectively. The reliability of this test has 0.70 or higher (Jackson and Baker, 1986).

The Physical Best sit-and-reach test was designed specifically for children and can therefore be seen as a relevant measurement to assess hip and/or low back musculature tightness which can increase an individual's susceptibility to low back pain caused by inflexibility (Liemohn, 1988).

Strength

A hand grip dynomometer was measure hand grip strength. (Instruments, Lafayette, IN). This is a spring devise, that when squeezed, measures static strength according to the needle indicator which shows the compression of the springs. The dynamometer was held parallel to the side with the dial facing away from the body. The hand grip size was adjusted to a position that was comfortable for each subject. The subject squeezed the dynamometer as hard as possible without moving the arm. Three trials were administered, alternating between, with a ten-second rest in between trials (Heyward 1991). A strong grip has been correlated with a strong upper body strength. The hands are used when performing most arm and chest activities, hence a high hand grip score relates to a strong upper body.

Body Composition

A Lange skinfold caliper was used to measure skinfold thickness. Measurements were taken from two sites on the right side of the body: one at the calf and the other at the triceps. The calf measurement was taken as a vertical fold at the maximal circumference on the medial aspect of the leg with the knee flexed at approximately 90 degrees while seated with the sole of the foot on the floor. The tricep skinfold site was measured as a vertical fold half way between the lateral projection of the acromial process and the inferior margin of the olecranon process on the posterior aspect of the arm. The arm hung loosely at the side (Harrison, Burskirk, Lindsay, Johnston, Lohman, Pollock, Roche, and Wilmore, 1988). Three non-sequential measurements were obtained at each site with the reading recorded four seconds after the application of the caliper. Three measurements were averaged unless one value differed by greater than three mm from the other two. In this case, a fourth measurement was taken and the outlyer was discarded. An equation for females of this specific age group developed by Slaughter et al (1988) was used to estimate the percent fat from the skinfold measurement as follows:

Percent Body Fat = .610 (sum of calf and triceps skinfolds) +5.1. *(1)*

The prediction error of the above equation was reported to be 3.3-3.9 percent. Fat free body (FFB) was also measured and compared between the two groups. An equation from Martin was used to estimate FFB to estimate lean body mass:

Fat Free Body = Body Weight x (1 – percent body fat decimal) *(2)*

Maturation Level

Maturity was assessed using two different criteria: a self-report of the development of axillary hair and the onset of menarche with the best estimate of the date of onset. Axillary hair was measured on a three-stage scale: 1=none present; 2=sparse growth; 3=adult distribution (Bouchard and Malina, 1991). Written descriptions of each stage were given, and each subject was asked to evaluate and rate themselves (Appendix C). The month and year menarche was achieved was recorded through a self-reported questionnaire. The height of each parent was obtained from the parents and used in the following equation to predict the final height of their daughter.

Eating Attitude Evaluation

An Eating Attitudes Test (EAT-26) (Appendix D) was used to measure symptoms and concerns of eating disorders (Garner, 1993). Previous use of this test indicates that out of those who have scored above 20 out of a possible 80 points, one third had clinically significant eating concerns or weight preoccupations. Therefore, anyone scoring above a 20 on this test should be referred for a follow-up evaluation (King, 1991).

Participants rated whether each item applied “always,” “usually,” “often,” “sometimes,” “rarely”, or “never.” Responses for each item were weighted from zero to three, with a score of three assigned to the responses furthest in the symptomatic direction (“always” or “never” depending on whether the item was keyed in the positive or negative direction) (Garner and Garfinkel, 1979). The total EAT-26 score consisted of the sum of all items. A zero through three scale was used rather than a one through six because the test rests on the assumption that item scaling on the EAT-26 is continuous only for the responses weighted up to three. With a one through six scale, it is possible for two nonsymptomatic responses to receive the same weight.

Cardiorespiratory Endurance

A submaximal step test was performed to estimate maximal oxygen uptake (VO2 max). This test utilizes the assumption that a linear relationship exists between heart rate, oxygen uptake, and work intensity. The standard error in estimating VO2 max from a submaximal heart rate, due to variability in the maximal rate, is ten to twenty percent (McArdle, Katch, and Katch, 1981). The VO2 max is often overestimated in untrained, sedentary individuals with this method (Heyward, 1991). The McArdle, Pechar, Jacobson, and Ruck (1972) step test was used to predict VO2 max.

Subjects were asked to step at twenty-two steps per minute for three minutes on a bench that was 16.25 inches high. A tape recorded cadence was used to ensure each subject stepped at the same rate. After three minutes of stepping was completed, heart rate was recorded every five seconds during a fifteen-second interval.

The heart rate was measured using a telemetric heart rate monitor

(Polar, Port Washington, NY). This device consists of two parts: a moistened band which was strapped around the lower margin of the thoracic cage, approximately at the xyphoid process, which sends a signal to a wrist monitor that displays the heart rate. By using a 15 second recovery heart rate, maximal oxygen uptake was predicted through an equation developed by McArdle et. al (1972).

$$VO2\ max = 65.81 - (0.1847 \times heart\ rate) \qquad (3)$$

The standard error of prediction using this equation is +/- 16% of the actual VO2 max.

Data Analysis

Statistical analysis was performed using Statview 512+ for a Macintosh personal computer. Descriptive statistics including mean and standard deviation were computed for all variables within each group. An Analysis of Variance (ANOVA) was used to test for significant differences between the two groups.

CHAPTER IV

RESULTS

Introduction

The purpose of this study was to compare measurements of physical fitness and biological maturity in a group of 12 year old girls who had not participated in organized sport and a group of highly trained gymnasts who had been involved in competitive gymnastics for at least two years.

Descriptive statistics were used to describe each group for fitness and maturational variables. Analysis of variance was used to compare the differences between each group. Anthropomorphic and physical fitness variables (Table 1) included: weight, height, hip and low back flexibility (sit-and-reach test), grip strength, estimates of VO2 max (sub-max step test), percent body fat (skinfolds), and fat free body. Maturity was assessed by age at menarche and the presence and development of axillary hair. In addition, an eating attitude screening assessment was performed to reveal eating disorder characteristics.

The presentation of results will be organized as follows: 1) description of subjects, 2) a comparison of the two groups for each fitness variable, 3) a comparison of maturation between the groups, and 4) a comparison of eating disorder tendencies between groups.

Table 1. Descriptive statistics for physical fitness variables.

Measure	Group 1 n=20 Mean +/- SD	Group 2 n=20 Mean +/- SD
	Gymnast	Non-gymnast
Age	12.32+/-.22	12.35+/-.24
Height (centimeters)	142.46+/-8.18	165.85+/-8.18
Weight (kg)	37.19+/-.6.05	47.35+/-9.38
Body Composition (percent)	14.69+/-2.56	22.68+/-5.45
Resting Heart Rate (bpm)	87.90+/-10.94	117.3+/-18.0
VO2 max (ml/kg/min)	41.32+/-2.77	33.87+/-7.85
Flexibility (inches)	24.68+/-2.06	15.79+/-3.70
Right Hand-Grip Strength (kg)	13.33+/-3.36	16.98+/-5.95
Right Hand Grip Strength/Weight	.364+/-.068	.352+/-.111
Left Hand-Grip Strength (kg)	14.00+/-2.39	14.93+/-5.86
Left Hand Grip Strength/Weight	.380+/-.055	.307+/-.096
Eating Disorder Evaluation (points)	4.05+/-3.30	10.85+/-15.54
Fat Free Body (kg)	31.65+/-4.77	36.33+/-6.20

significant difference between groups ($p<.05$)

Height and Weight

Values for height (p=.0001) and weight (p=.0002) were significantly higher for the non-gymnasts compared to the gymnasts (156.462+/-9.219 vs. 142.47+/-7.876; 47.35+/- 9.381 vs. 37.185+/-6.053). Height and weight were measured on the same equipment for both groups by means of a gauge scale and portable stadiometer for weight and height respectively). (Table 1 and figures 1 and 2.)

Flexibility

Values for flexibility were significantly higher (p=.0001) for the gymnasts compared to the non-gymnasts (24.7±2.057 vs. 15.8±3.704). Values were taken from a sit-and–reach test for which a higher value indicates a greater amount of flexibility. (Table 1 and figure 3.)

Strength

Values for hand-grip strength of the right hand were significantly higher (p=.022) for the non-gymnasts compared to the gymnasts (16.9±5.9 vs. 13.3±3.4). Left hand values, however were not significantly different (p=.5172) for the gymnasts at 14±2.4 kg compared to the 14.9±5.8 kg.

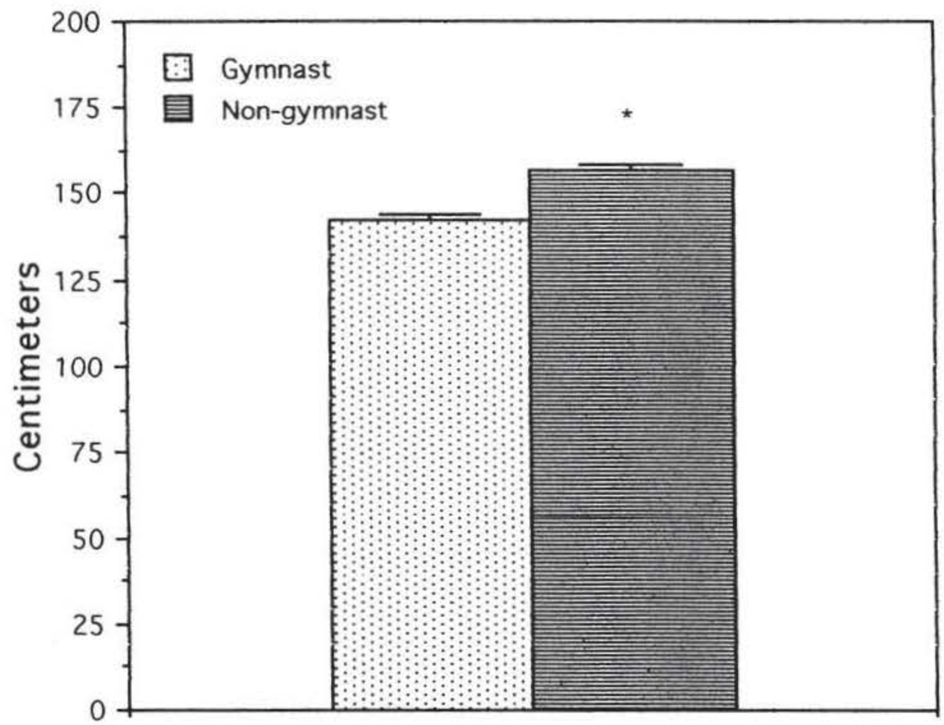

Figure 1. A comparison of the height between gymnasts (n=20) and non-gymnasts (n=20). * symbolizes significance (p<.05).

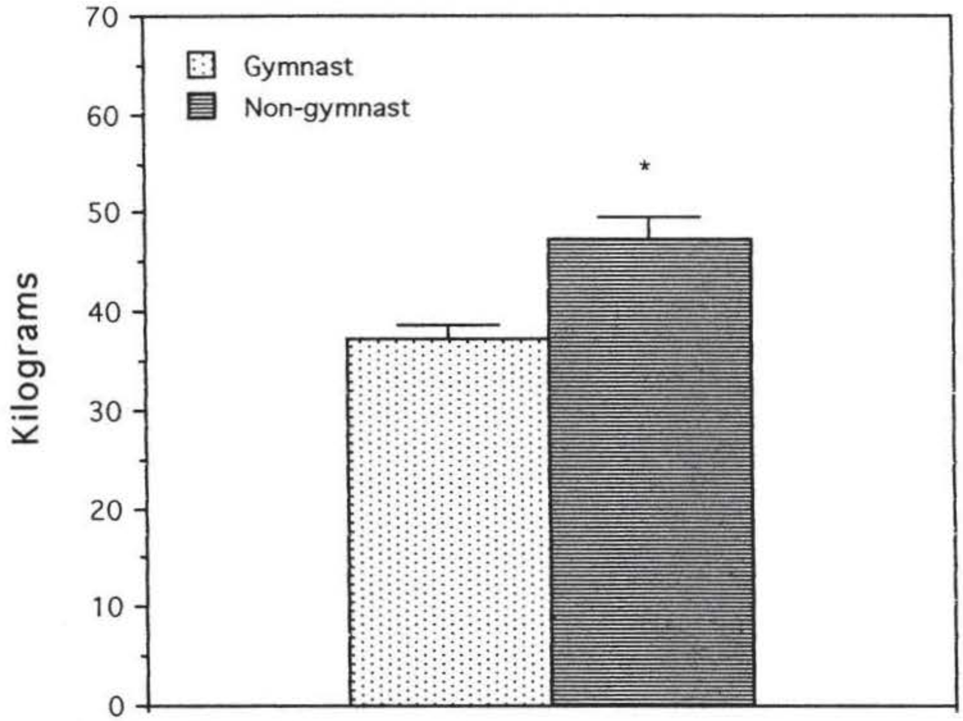

Figure 2. A comparison of weight between gymnasts (n=20) and non-gymnasts (n=20).
* symbolizes significance ($p<.05$).

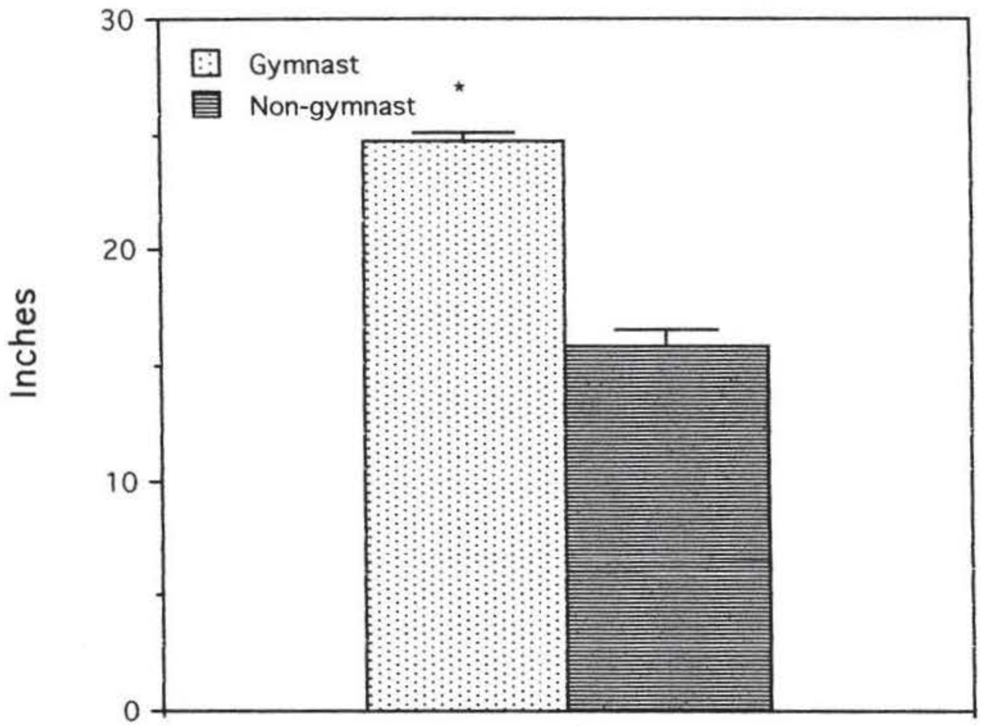

Figure 3. A comparison of sit-and-reach scores between gymnasts (n=20) and non-gymnasts (n=20). * symbolizes significance (p<.05).

(Table 1 and figures 4, 4b, 5, and 5b.)

Body Composition

Percent body fat was significantly higher (p=.0001) for the non-gymnasts compared to the gymnasts (x=22.7+/-5.5 vs. x=14.7+/-2.6). Percent fat was estimated through the sum of triceps and calf measurements. (Table 1 and figures 6 and 7.) The non-gymnasts had significantly higher FFB (x=36.33+/-6.20) compared to the gymnasts (x=31.65+/-4.77).

Maturity Assessment

Maturity was assessed using two different criteria. More of the non-gymnasts had achieved menarche (12 out of 20) compared to the gymnasts (two out of 20). There was no significant difference (p=.3032) in age menarche was reached 11.9+.247 years compared to the non-gymnasts 11.5+.54 years. The presence and development of axillary hair was also used to assess maturity. The non-gymnasts showed a significantly higher value (p=.0497) compared to the gymnasts. Axillary hair was estimated on a three point scale. (Table 1 and figure 8.)

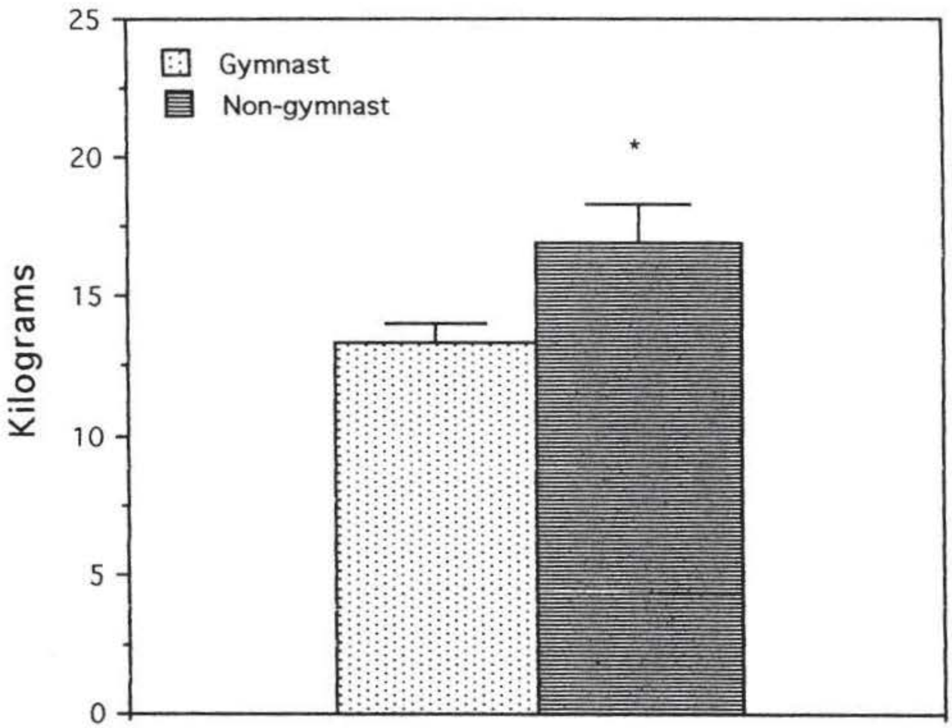

Figure 4. A comparison of right hand grip strength between gymnasts (n=20) and non-gymnasts (n=20). * symbolizes significance (p<.05).

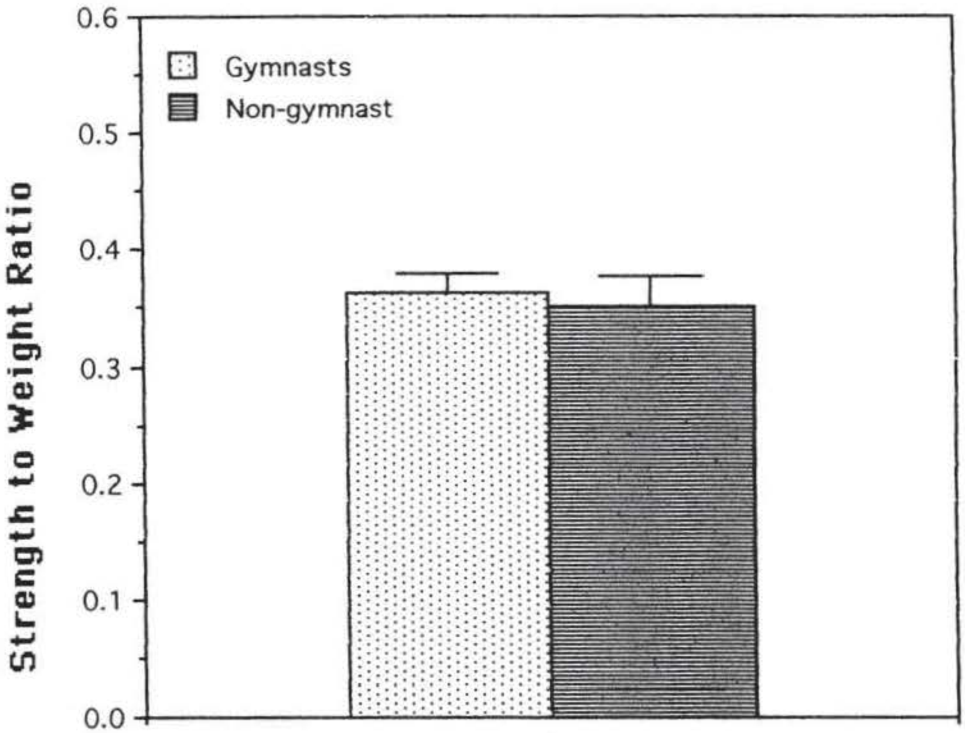

Figure 4b. A comparison of right hand grip strength to weight between gymnasts (n=20) and non-gymnasts (n=20).
* symbolizes significance (p<.05).

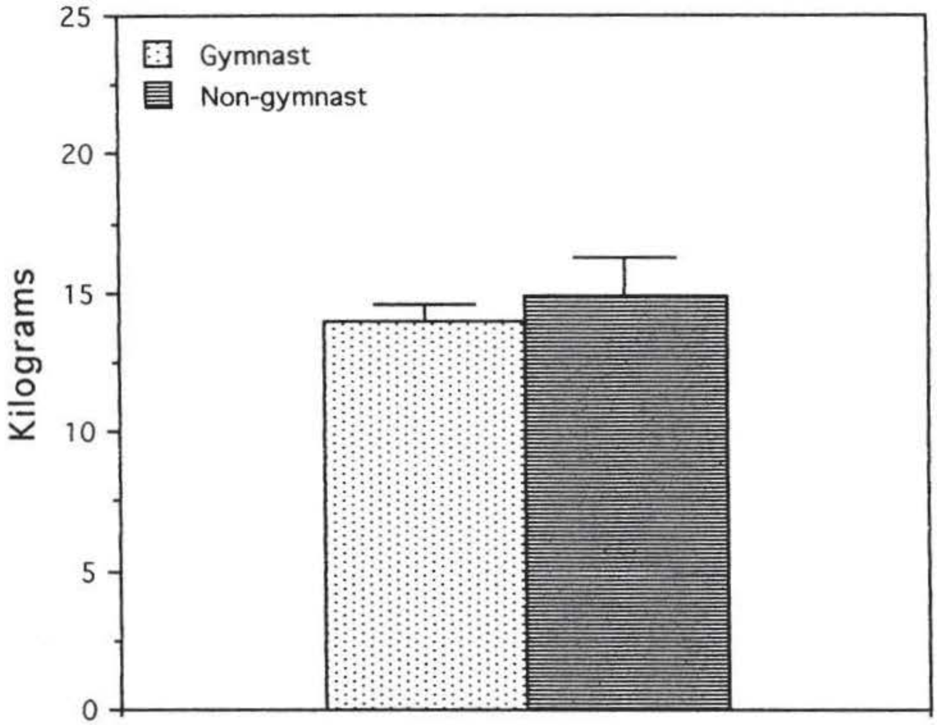

Figure 5. A comparison of left hand grip strength between gymnasts (n=20) and non-gymnasts (n=20).

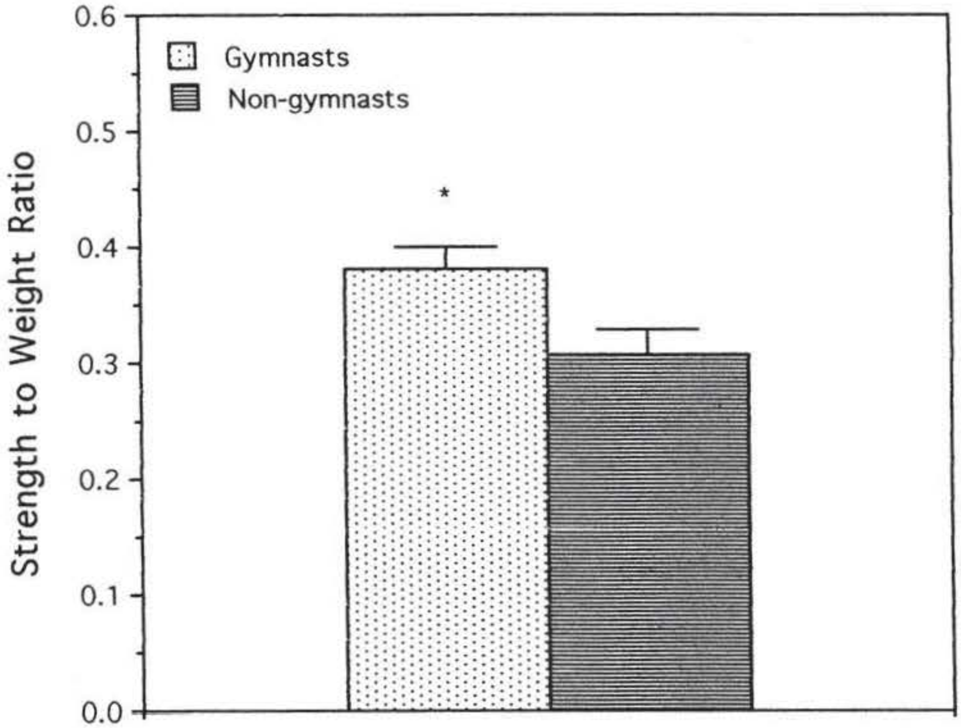

Figure 5b. A comparison of left grip strength to weight between gymnasts (n=20) and non-gymnasts (n=20).
* symbolizes significance (p<.05).

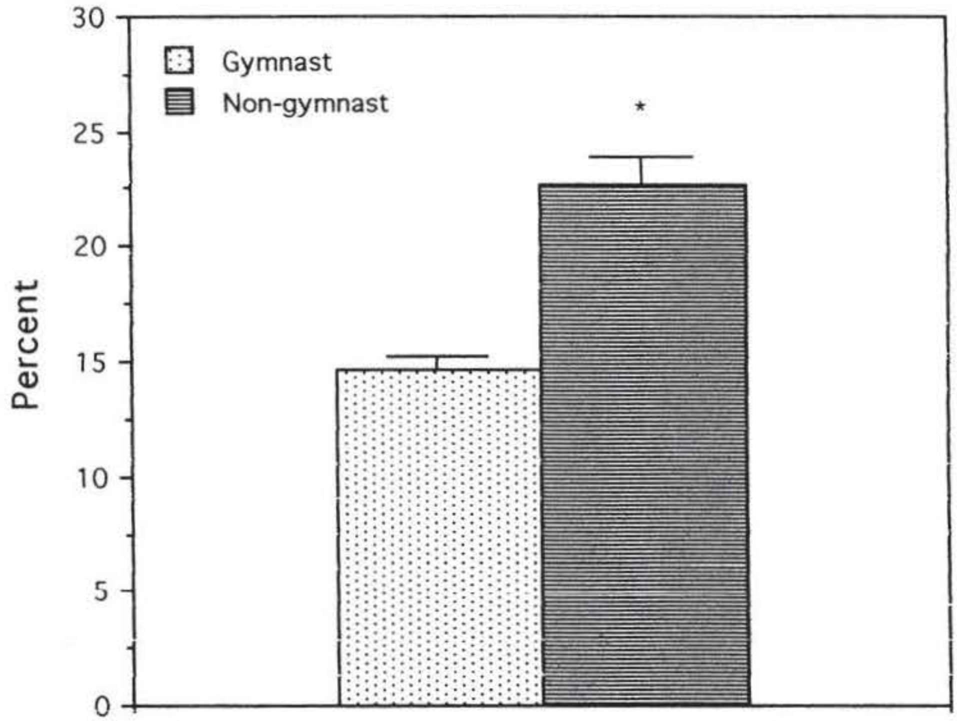

Figure 6. A comparison of body composition of gymnasts (n=20) vs. non-gymnasts (n=20).
* symbolizes significance (p<.05).

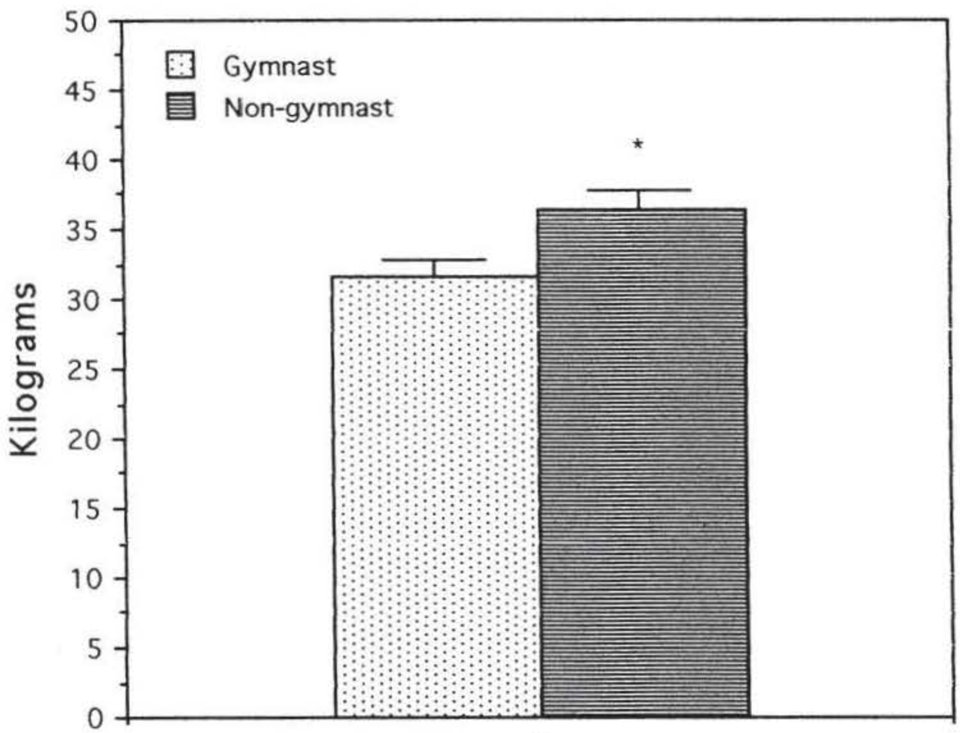

Figure 7. A comparison of fat free body mass between gymnasts (n=20) and non-gymnasts (n=20).
* symbolizes significance ($p<.05$).

Eating Attitude Evaluation

The EAT-26 score was significantly higher (p=.0261) for the non-gymnasts (7.6+/-6.03) compared to the gymnasts (4.05+/-3.3). Although the non-gymnasts' average score was higher, neither group included a member who scored above 20 points which is the criterion for further investigation of an eating disorder. (Table 1 and figure 8.)

VO2 Max

VO2 max was estimated from a submaximal step-test using recovery heart rate, for the non-gymnasts was significantly higher (p=.0001) compared to the gymnasts (117.3±18 vs. 87.9±10.9). Estimated VO2 max was significantly higher (p=.0003) for the gymnasts compared to the non-gymnasts (41.3±2.8 vs. 33.8±7.9). (Table 1 and figure 9.)

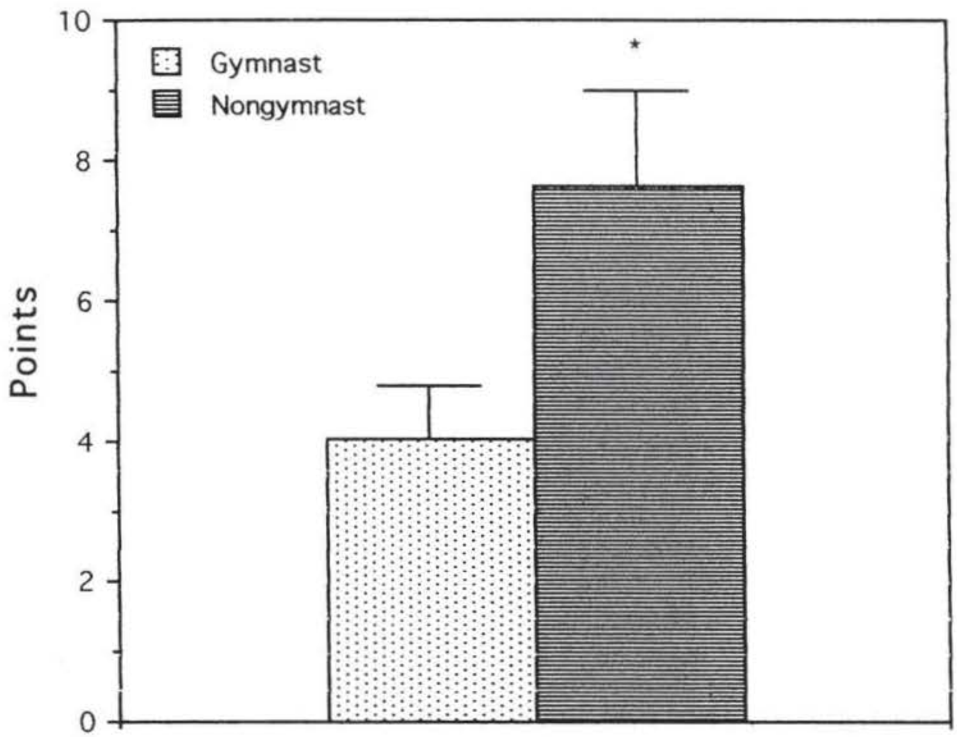

Figure 8. A comparison of an eating attitude evaluation between gymnasts (n=20) and non-gymnasts (n=20). * symbolizes significance ($p<.05$).

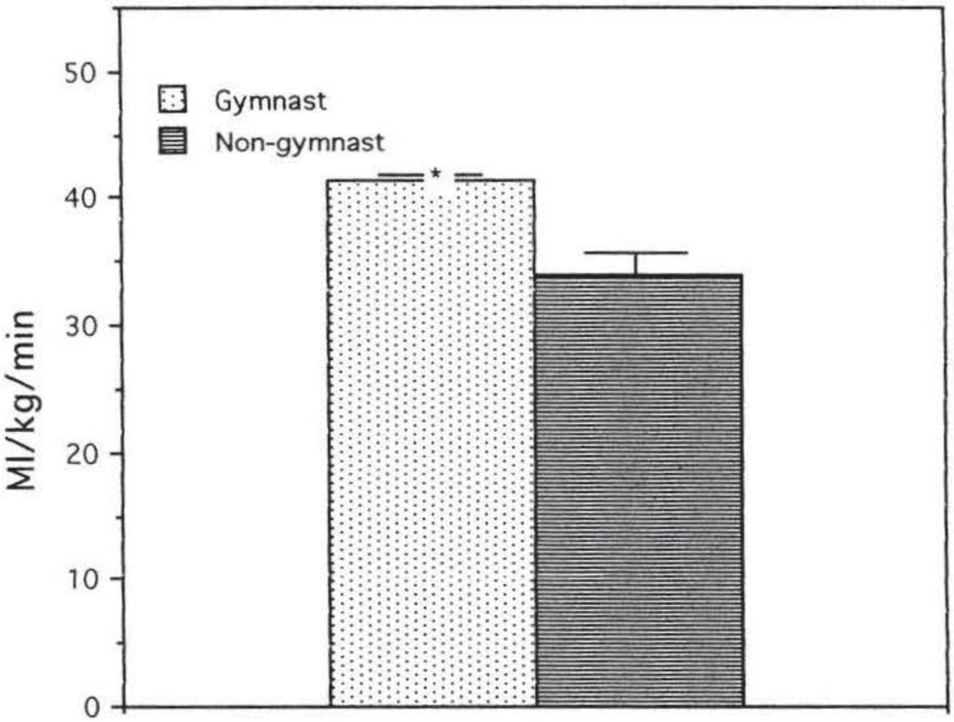

Figure 9. A comparison of estimated VO2 max between gymnasts (n=20) vs. non-gymnasts (n=20). * symbolizes significance ($p<.05$).

Statistical Analysis of Differences Between Groups

An analysis of variance (ANOVA) was used to determine differences between groups with an alpha level set at 5%. Table 2 shows the dependent variables along with the F-test and P values.

Table 2. Summary of one-factor ANOVA.

Variable	F-test	P
Age	1.61	.6907
Height	26.63	.0001
Weight	16.58	.0002
Flexibility	88.01	.0001
Right Grip Strength	5.71	.0220
Left Grip Strength	.427	.5172
Percent Body Fat	35.11	.0001
Fat Free Body	7.13	.0111
VO2 Max	16.01	.0003
Recovery Heart Rate	15.93	.0003

Summary

The results of this study show that the gymnasts were more flexible, had lower right hand grip-strength, lower body fat levels, lower resting heart rates, and higher estimated VO2 max than the non-gymnasts. The gymnasts scored fewer points on the eating disorder evaluation (although neither group surpassed the 20 point indication marker of an eating disorder). They were less biologically mature according to achievement of menarche and axillary hair development than their 12 year old non-gymnast counterparts. No significant differences were found between groups for age and left hand grip strength.

CHAPTER V

SUMMARY, DISCUSSION, AND RECOMMENDATIONS

Summary

Two groups of twenty 12 year old girls were recruited to compare height, weight, flexibility, body composition, hand grip strength, cardiorespiratory endurance, maturation level, and prevalence of disordered eating. One group consisted of highly trained gymnasts who had been involved in competitive gymnastics for at least two years while the other group had not been involved in organized sport for at least two years. Results showed significant differences between the two groups ($p<.05$). The gymnasts were shorter, weighed less, had higher sit-an-reach scores (more flexible), had lower percent body fat, scored lower in the left hand grip-strength test, had higher estimated VO2 max scores, and were less biologically mature then the girls not involved in organized sport. There was not a significant difference found between the groups for the right hand grip-strength test or age.

DISCUSSION

The two groups of girls selected to participate in the study were from similar socio-economic backgrounds, tested using the same experimenters, and under similar conditions. Any differences found between the two groups should be due to actual differences in the subjects.

Height

The results from this study indicate that the gymnasts (x=56.1 inches) were shorter than the non-gymnasts (x=61.4 inches). The short stature of the gymnasts is consistent with other studies investigating height. A study conducted in 1983 comparing 12-year-old gymnasts, swimmers, and controls showed the heights of the girls to be 58 inches, 62 inches, and 62 inches respectively (Bernink, Erich, Peltenburg, Zonderland, and Huisveld). Bale, et al. (1992) found that increased height and body mass is a major contributor to increased motor performance. The structural and physiological changes that relate to height and weight resulted in increases in speed, strength, power, and physical work capacity. Determining whether height differences between the two groups is due to exercise-induced growth retardation, nutritional intake, or self-selection of the sport of gymnastics is virtually impossible within this study.

Weight

The gymnasts (x=37.2 kg) weighed significantly less than the non-gymnasts (x=47.4 kg). Bernink et al. (1983) discovered similar trends. Their study indicated that the 12-year-old gymnasts (x=39 kg) had a lower body weight compared to the non-gymnasts (x=50 kg). This lower weight in the gymnasts could be attributed to characteristics such as higher exercise levels or shorter stature. The prevalence of eating disorders (nutritional deficit) was not considered to be a contributing factor to low weights in this study because no subjects in either group scored high enough on the eating attitude evaluation (EAT-26) to be considered symptomatic. Other studies have shown, however, that a low fat, high protein diet, typical of many athletes trying to stay thin, can explain low body weights (Benardot and Czerwinski, 1991). Due to study design differences, nutritional intake could not be considered as a reason for lower body weights in the gymnasts.

A height to weight ratio was calculated to determine if the greater weight in non-gymnasts was a factor of their greater height alone. The results from this comparison indicate that the non-gymnasts had greater body weight per unit height (x=.302 kg/cm) compared to the gymnasts (x=.261 kg/cm). This suggests the non-gymnasts have more mass per centimeter. This extra mass is probably due to excess body fat rather than muscle weight because the non-gymnasts scored higher in terms of percent body fat.

Flexibility

Lack of physical activity is a major contributor to inflexibility. It is well documented that inactive people tend to be less flexible than active people

(McCue, 1953) and that exercise increases flexibility (Hartley-O'Brien, 1980). This idea was supported from data collected in the sit-and-reach test in this study. Gymnasts (x=24.7 inches) were shown to have more hamstring and lower back flexibility than non-gymnasts (x=15.8 inches). The lower levels of physical activity in the non-gymnasts may have contributed shortening of the connective tissue, which restricts joint mobility. Flexibility of a joint is increased by performing exercises which stretch the appropriate muscle group. To improve range of motion at that joint, the muscle group must be overloaded by stretching muscles beyond their normal length (Malina and Bouchard, 1991). Gymnastics emphasizes flexibility as one of its major training components, and therefore could explain why adolescent gymnasts tend to be more flexible than their sedentary counterparts.

Body Composition

The percent body fat of the gymnasts (x=14.9%) was significantly lower (p=.0001) compared to the non-gymnasts (x=15.8%). These findings are consistent with other studies which have found that post-pubescent girls average 21 to 23% fat while prepubescent average 13 to 15% (Lohman, 1987). Studies have shown that because highly trained gymnasts tend to mature late, their percent body fat averages to be between 13 and 16%, which is similar to that of all prepubescent children (Sinning, 1978).

In addition, FFB differences between the gymnasts (x=31.65+/-4.77) compared to the non-gymnasts (x=36.33+/- 6.20) was significant. The non-gymnasts had a greater FFB but they also had higher percent body fat and overall weight. This would indicate that the significantly higher weight of the non-gymnasts was due to increased body fat rather than muscle mass.

Other factors may have contributed to the differences in body fat percentages between the two groups. Most gymnasts participate in strength and cardiovascular training in addition to the usual gymnastics training which helps keep their body fat levels low.

Strength

Gymnasts tend to have upper body muscle hypertrophy, small hips and broad shoulders (Haywood, Clark, and Mayhew, 1986). It might be assumed that the typical physique of successfully trained gymnasts would allow them to excel in most upper body strength tests. However, this was not the case in the current study. The non-gymnasts had a significantly stronger right hand grip-strength (x=17 kg) compared to the gymnasts (x=13.3 kg). There were no significant differences in the left hand grip-strength between the groups. Grip strength tests are used as an index of forearm and hand strength, but because strength is known to vary with body mass, the lower weight in the gymnasts may have been a factor contributing to the gymnasts poor scores. Bale et al. (1992) found athletes aged 13 to18 to have lower grip strength scores in their left hand compared to their right. This difference may be due to dominance of right-handed people in society. Sport specific tests such as chin-up and press handstand tests have been used to measure gymnastic potential (Ho, 1987) and might be a better indication of true upper body strength for gymnasts. This type of testing was not possible for the study at hand.

Although the non-gymnasts scored higher in terms of absolute right hand grip strength, when body weight was taken into consideration, there was no significant difference between the two groups. In addition, the gymnasts scored significantly higher in terms of left hand grip strength compared to the non-gymnasts. These findings indicate that the gymnasts were just as strong if not stronger when their body weights were taken into account.

VO2 Max

This study used a 15 second recovery heart rate from a submaximal step-test to estimate VO2 max. The estimated VO2 max scores (x=41.3 ml/kg/min) of the gymnasts were significantly higher compared to the non-gymnasts (x=33.9 ml/kg/min) and were calculated relative to their body weight to avoid underestimating scores for the smaller girls.

A study conducted in 1977 by Novak, Woodward, Bestit, and Mellerowicz found a group of highly trained gymnasts to have a mean VO2 value of 42.5 ml/kg/min. These values are very similar to those of the gymnasts in the present study. Malina and Bouchard (1991) state that the average VO2 values for twelve-year-old girls is approximately 48 ml/kg/min. The difference in average VO2 levels could be due to the fact that gymnastics is an anaerobic sport. This would infer that the lack of aerobic training would cause VO2 scores to be lower. The values for the non-gymnasts in this study may not have been consistent with other studies because they were sedentary 12 year olds while average values reported in the literature tend to include children from various activity backgrounds.

Gymnasts in this study may have had higher estimated VO2 values because they have higher fat free body values (FFB) than the non-gymnasts. This is relevant to VO2 max values because as the percent body fat increases, percent of FFB levels decrease during and after puberty. Due to this physiologic response adolescents and adults no longer have the same potential to extract oxygen from the blood (Malina and Bouchard, 1991). Decreased oxygen potential can therefore decrease VO2 max values.

The non-gymnast group in this study had a greater number of post-pubescent subjects as well as higher body fat percentages and lower estimated VO2 max when compared to the gymnasts. This agrees with the findings of Bale et al. that higher percent body fat and ectomorphic shape can be associated with poorer VO2 performance (1991). Adolescent females tend to have an increase in body fat percentage as they mature into adults. The extent to which they rise can be directly related to activity patterns; the more sedentary they are, the higher their body fat percentages tend to rise.

Therefore, it would be expected to see higher scores for the gymnasts who were more active compared to the sedentary non-gymnasts

Maturation

Maturation was assessed using two different criteria: achievement of menarche and the presence of axillary hair. Only two of the 20 (10 percent) gymnasts had achieved menarche compared to 12 of the 20 (60 percent) of the non-gymnasts. Self-assessment of axillary hair showed eight gymnasts and 16 non-gymnasts had scored more than one. This indicated that axillary hair was had begun its initial growth, and in some cases had reached full adult growth. Because more non-gymnasts achieved menarche and had a higher prevalence of axillary hair, it can be inferred that onset of these two factors indicate advanced biological maturity.

Lindholm, et al. (1994), found age at menarche to be associated with social and genetic factors, nutritional intake, and chronic diseases such as anorexia nervosa. He found gymnast age at menarche to be 14.5 +/- 1.4 years compared to the non-gymnasts 13.2 +/- .9 years. The difference was partially attributed to the higher energetic nutrient intake and the higher activity pattern of late maturing girls.

The data collected for the present study shows that gymnasts tend to be less biologically mature possibly due to higher activity patterns and in turn lower body fat percentages. These factors may relate to the observation that late maturing girls tend to choose gymnastics because of the relative ease of acrobatic performance for those who are short and relatively light (Lindholm et al., 1994).

Eating Attitude Evaluation

Neither group of subjects were prone to eating disorders according to the EAT–26 test assessment tool. The non-gymnasts did appear to score a little higher (x=7.6 points) compared to the gymnasts (x=4.1 points). This may support the findings of other studies that show pre-adolescent children are less prone to have signs or symptoms of disordered eating attitudes. One non-gymnast was dropped from the analysis in this section because it appeared she had reversed the directions. These findings are consistent with the literature which concludes that eating disorder prevalence tends to occur with the onset of puberty and not in childhood (Bryant-Waugh, Knibbs, Fossen, Kaminski, and Lask, 1992).

The literature concentrates on young girls and teenagers who are so dissatisfied with their bodies that they tend to engage in behaviors that group them in disordered eating and body image distortion categories. Maloney et al. reported 45% of the children in grades three through six they surveyed wanted to be thinner, 37% had already tried to lose weight, and according to the EAT test, 6.9% scored sufficiently to be considered symptomatic of eating disorders (1989). Moore (1988) found 8.5% of the 12 to 22 year olds in his study used vomiting as a form of weight control, 9.5% used stimulants, 3.3% used laxatives, and 6.2% used diuretics.

Other factors may have contributed to the fact that this study had one group with higher scores, but not high enough to be considered symptomatic. Health-risk behaviors, especially eating disorders in young females may be accompanied by shame and embarrassment. This could contribute to decreased likelihood that the subjects would divulge information about their eating habits. Computerized tests rather than traditional surveys have been shown to increase honest responses (Gaines, 1993). This might be valuable for other studies to consider in the future.

CONCLUSIONS

The findings of this study support the hypotheses that the 20 female gymnasts focussed upon were more flexible, had lower percent body fat and were less biologically mature than the 20 non-gymnasts tested. Several reasons have been proposed in an attempt to explain these findings.

The gymnasts tested were less biologically mature according to their menarchial status. Regardless of whether this difference in maturational development was linked to gymnastic training demands or natural sport selection, it appears that this in itself is responsible for many of the differences between the two groups. Of the 20 gymnasts tested, only two had achieved menarche; the remaining 18 being considered prepubescent. This is of significance because prepubescent children tend to have lower percent body fat, are shorter, and often weigh less than post-pubescent children. In addition, the relative inflexibility of the non-gymnasts may by attributed to higher percentage body fat levels and a reduced likelihood of regular involvement in stretching exercises.

Delayed maturation of the gymnasts may have been due to the high activity patterns and intense training endured by these children at such a young age. If this was the case, studies have shown that gymnasts tend to "catch up" later in life with little or no adverse effects on their reproductive systems. A study conducted in 1995 by Lindholm et al. concluded that former gymnasts achieved menarchial status at a later age than a control group, but following this event no deficiencies in body fat, later in life, were observed. Additional studies have shown that, although bone growth may be stunted due to high impact loading on the skeleton, bone mass tends to be increased, thus resulting in positive osteotropic adaptations thereby decreasing the risk of debilitative osteoporotic fractures (Taafe, Robinson, Snow, and Marcus, 1997).

The hypotheses that there would be no difference in cardiorespiratory fitness, height, and size between the groups was not supported by this study. Although gymnastics is considered a predominantly anaerobic sport, these active individuals were being compared to a group of children who abstained from getting involved in any kind of organized sport. The rigorous cardiorespiratory training undertaken by this particular group of gymnasts as a supplemental form of training may have also contributed to their enhanced performance with regard to this particular area of interest.

Additionally, it was hypothesized that the gymnasts would be more susceptible to abnormal eating attitudes compared to the non-gymnasts. This study found neither group to show signs of distorted attitudes according to the EAT-26 test used. This may have been due to the fact that since the gymnasts were still prepubescent, body fat levels had not yet reached the point of affecting performance or image.

In summary, the results of this study indicate that the benefits of gymnastic training outweigh the costs that may be incurred as a result of regular participation in this sport. More specifically, the gymnasts were more flexible, had higher levels of cardiorespiratory fitness, and had lower percent body fat. The pattern of involvement in physical fitness that has been established during childhood often provides a solid foundation for continued involvement during adulthood, thereby reiterating the overriding importance attached to early experiences in physical activity and sport.

Recommendations for Future Studies

1. Because axillary hair development occurs late in puberty, future studies might consider using percent mid-parental height achieved as a supplement to menarche status when establishing estimated biological age. If circumstances allowed, Tanner ratings of secondary sex characteristics would be most beneficial to estimating maturational status.

2. Studies should compare a variety of athletes to the sedentary adolescent to establish the benefits of sport participation to increase physical fitness.

3. A diet analysis performed with a computer questionnaire to supplement an eating attitude evaluation might give more accurate, honest responses.

4. Future studies could expand on types of flexibility tests and relate them to current and future low back pain.

REFERENCES

Alter, Michael (1996). Science of Flexibility (2nd ed. pp. 140-143). Champaign, IL: Human Kinetics.

Apter, D., Vinikka, L., and Vinko, R. (1978). Hormonal pattern of adolescent menstrual cycles. Journal of Clinincal Endocrinology Metabloism, 47 (5), 944-954.

Armstrong, N., and Welsman, J.R. (1994). Assessment and interpretation of aerobic fitness in children and adolescence. Exercise and Sport Science Review, 22, 435-476.

Bale, P., Mayhew, J.L., Piper, F.C., Ball, T.E., William, M.K., (1991) Biological and performance variations in relation to age in male and female adolescent athletes. Journal of Sports Medecine and Physical Fitness, 32(2).

Bember, D.A., Boileau, R.A., Horswill, C.A., Slaughter, M.H., Stillman, R.J., (1988). Skinfold equations for estimations of body fatness in children and youth. Human Biology, 709-734.

Bennett, J.G. and Murphy, D.J. (1995). Sit-ups and push-ups-Are We Heading for Muscular Imbalance? Journal of Physical Education, Recreation and Dance, 66(1), 67-68.

Berger, S.M. and O'Shea, M. (1986). Focus on fitness: is it safe for children to Weight train? Parade Magazine, July, 17.

Bernardot, D. and Czerwinsk, C. (1991) Selected body composition and measures of junior elite gymnasts. Journal of Sports Medecine and Physical Fitness, 91(1).

Blair, S.N. (1992). Are American Children and Youth Fit? The need for better research data. Research Quarterly for Exercise and Sport, 63, 120-123.

Borms, J. (1986). The child an exercise: an overview. Journal of Sports Science Review, 4(1), 3-20.

Brun, J.F., Charpait, A., Dieu-Cambrezy, C., Fons, C., and Fedau, C. (1995). Serum zinc levels in highly trained adolescent gymnasts. Biological Trace Element Research, 47, 273-278.

Bryant-Waugh, R.J., Knibbs, J., Fossen, A.,Kaminski, Z., Lask, B., (1992). Long-term follow-up of patients with early onset of anorexia nervosa. Archives of Diseases in Childhood, 63, 5-9.

Buenen, GP., Claessens, A.L., LeFevre, J.A., and Malina, R.M., Renson, R., Vanreusal, B. (1994). Adiposity and biological maturation in girls age 6-16 of age. International Journal of Obesity and Related Disorders, 18(8), 542-546.

Carron, A.V. and Bailey, D.A. Strength development in boys from 10 through 16 years. Monographs of the Society for Research in Child Development, 39(4), 157, 1974.

Chicoye. L.S., Jacobson, M.S., Landry, G.L., and Starr, C. (1997). Getting teens fit and well-nourished: shaping the future. Patient Care, 12(1), 72.

Corbin, C.B. and Pangrazi, R.P. Are American children and youth fit? Research Quarterly for Exercise and Sport, 63(2), 96-106, 1992.

Conroy, B.P., Kraemer, W.J., Maresh, C.M., Fleck, S.J., Stone, M.H., Fry, A.C., Miller, P.D., and Dalsky, G.P. (1993). Bone mineral density in elite junior olympic weight lifters. Medecine and Sports Exercise, 25, 1103-1109.

Dietz, W.H., and Gortmaker, S.L. (1985). Do we fatten our children at the television set? Obesity and television viewing in children and adolescents. Pediatrics, 75(5), 807-812. In Douthitt, V.L., Harvey, M.L. (1995). Exercise Counseling-How Physical Educators Can Help. Journal of Physical Education, Recreation and Dance, 66(5) 1995, 31-35.

Douthitt, V.L., Harver, M.L. (1995). Exercise Counseling-How Physical Educators Can Help. Journal of Physical Education, Recreation and Dance, May/June, 31-35.

Duke, P.M., Litt, I.F., and Gross, R.T., (1980). Adolescents' self-assessment of sexual maturation. Pediatrics, 66(6), 918-920.

Duppe, H., Cooper, C., Gardshell, P., Johneli, O. (1997). The relationship between childhood growth, bone mass, and muscle strength in male and females adolescence. Calcification Tissue International, 60(5), 405-409.

Fairbank, J.C.T., Pynsent, P.B., VanPoortvliet, J.A., and Phillips, H. (1984). Influence of anthropometric factors and joint laxity in the incidence of adolescent back pain. SPINE, 9, 461-464. In Liemohn, Wendell. Flexibility and Muscular Strength. Journal of Physical Education, Recreation and Dance, 58(8), 37-40.

Gaines, D.M. (1993). Self-report measures for eating disorders. Social and

Behavioral Sciences, 25 (8), 8.

Gaines, D.M. and Garfinkel, P.E. (1979). The eating attitudes test: An index of Symptoms of anorexia nervosa. Psychological Medicine, 9, 273-279.

Garner, D.M. Pathogenesis of anorexia nervosa. Lancet, Jun 26, 341(8861), 1631-5, 1993.

Going, S.B., Lohman, T.G., and Williams, D.P. (1992). Setting Standards for Health Related Fitness Tests-Determining Critical Body Fat Levels. Journal of Physical Education, Recreation and Dance, 62(10), 19-24.

Graber, J.A., Brooks, J., and Warren, M.P. (1995). The antecedents of menarcheal age: heredity, family environment, and stressful events. Child Development, 66(2), 346-359.

Groves, D. (1988). Is Childhood Obesity Related to T.V. Addiction? Physician and Sportsmedecine, 16(11), 117-122.

Grumbach, M.M., Roth, S.C., Kaplan, S.L., Kelch, R.P. (1974). Hypothalamic-pituitary regulation of puberty in man: Evidence of concepts derived from clinical research. In M.M. Grumbach, G.G. Grave and F.E. Mayer (Eds.) The Control of the Onset of Puberty. New York: John Wiley & Sons, pp. 115.

Hailey, E.T. and Franks, B.D. The effects of static stretching and warm-up on prevention of delayed onset muscle soreness. Research Quarterly for Exercise and Sport, 60(4), 357-361, 1989.

Hammer, L.D. (1992). The development of eating behavior in children. Pediatrics Clinics of North America, 39(3), 379-394.

Harreby, M., Hesseloe, G., Kjer, J., and Neergaard, K. (1995). Are radiologic changes in the thoracic and lumbar spine of adolescents risk factors for low back pain in adults? A twenty-five year prospective and cohort study of 640 school children. Spine, 20, 2298-2302.

Harrison, G.G., Burskirk, E.R., Lindsay Carter, J.E., Johnston, F.E. Lohman, T.G., Pollock, M.L., Roche, A.F. and Wilmore, J.H. (1988). Skinfold thicknesses and measurement technique. In T.G. Lohman, A.F. Roche, and R. Mortorell (Eds.), Anthropomorphic standardization reference manual (pp.55-70). Champaign, IL: Human Kinetics.

Hartley-O,Brien, S.J. (1982). Six mobilization exercises for active range of hip flexion. Research Quarterly for Exercise and Sport, 51, 625-635.

Haskell, W.L., Montoye, H.T., Orenstein, D. (1985). Physical activity and exercise to achieve health-related physical fitness components. Public Health Reports, 100(2), 202-212.

Haywood, K.M., Clark, B.A., and Mayhew, J.L. (1986) Differential effects of age group gymnastics and swimming on body composition, strength, and flexibility. Journal of Sports Medecine and Physical Fitness, 26, 416-420.

Heyward, V.H. (1991). Advanced Fitness Assessment and Exercise Prescription. Second ed. Champaign, IL: Human Kinetics.

Ho, R. Talent identification in China. In Petiot, B et al. (Eds). World Identification Systems for Gymnastics Talent. Sports Psyche Editions: Greeley, CO, 1987.

Hoeger, W.W.K. (1989). Lifetime Physical Fitness and Wellness. Englewood, CO: Morton.

Howat, P.M., Carbo, M.L., Mills, G.Q., and Wozniak (1989). The influence of diet, body fat, menstrual cycling, and activity upon bone density of females. Journal of the American Dietetics Association, 89(9), 1305-1307.

Issues (1996). In K-12 physical education classes, should more time be spent on cardiovascular fitness than on skill development? Journal of Physical Education, Recreation and Dance, 67(5), 18-21.

Jackoson, A.W., and Baker, A.A. (1986). The relationship of the sit-and-reach test to criterion measures of hamstring and back flexibility in youth females. Research Quarterly for Exercise and Sport, 57, 183-186.

Kemper, H.C. (1995). Educational growth, health and fitness of teenagers: Longitudinal research in international perspective. Medicine and Sports Science, 20. Basel, Switzerland: Kanger.

Kemper, H.C., Post, G.B., and Twisk, J.W., (1997). Rate of maturation during the teenage years: nutrient and physical activity between ages 12 and 22. International Journal of Sport Nutrition, 7(3), 229-240.

Kemper, C.G., Ritmeester, J.W., and Verschur, R. (1987). Longitudinal development of growth and fitness in early and late maturing teenagers. Pediatrition, 14(4), 219-25.

King, M.B. (1991). The natural history of eating pathology in attenders to primary Medical care. International Journal of Eating Disorders, 10, 379-387.

Kobayashi, K., Kitmura, K., Matuan, H., Miura, M., Miyioshita, M., Murase, Y., and Sodeyama, H. (1978). Aerobic power as related to body growth and training in Japanese boys: a longitudinal study. Journal of Applied Physiology, Respiratory, Environmental and Exerphysiology, 45, 666-672.

Lacy, A.C., and LaMaster, K.J. (1990). Analysis of fitness activities in junior high school physical education. The Physical Educator, 47, 176-179.

Laubach, L.C. and McConville, J.T. (1966). Muscle strength, flexibility, and bone size of adult males. Research Quarterly, 37(3), 384-392.

Leard, J.S. (1984). Flexibility and Conditioning in the Young Athlete. In L.J. Michael (ed.), Pediatric and Adolescent Sports Medecine (pp.194-210). Boston:Little, Brown. In Alter, Michael (1996). Science of Flexibility (2nd ed. pp. 140-143). Champaign, IL: Human Kinetics.

Lechky, O. (1994). Epidemic of childhood obesity may cause major public health problems, doctor warns. Canadian Medical Association Journal, 150(1), 78-81.

Liemohn, Wendell (1988). Flexibility and Muscular Strength. Journal of Physical Education, Recreation and Dance, 58(8), 37-40.

Lindholm, C., Hagenfeldt, K. and Ringertz, H. (1995). Bone mineral content of Young female former gymnasts. Acta Paediatricia, 84(10), 1109-1112.

Lohman, T.J., (1987). The use of skinfolds to establish body fatness of children and youth. Journal of Physical Education, Recreation and Dance, 58, 98-102.

Malina, R.M. (1983). Human Growth, Maturation, and Regular Physical Activity. Acta Medica Auxologica, 15, 5-23.

Malina, R.M. and Bouchard, C. (1991) Growth, Maturation and Physical Activity. Champaign, IL: Human Kinetics.

Maloney, M.J., McGuire, J., Daniels, S.R., (1989). Dieting behavior and eating attitudes in children. Pediatrics, 84, 482-489.

Marshall, W.A. and Tanner, J.M. (1969). Variations in pattern of pubertal changes in girls. Archives of Disease in Childhood, 44, 291-301.

Martin, A.D., Ross, W.D., Drinkwater, D.J., and Clarys, J.P. (1985). Prediction of body fat by skinfold caliper:assumptions and cadaver evidence. International Journal of Obesity, 9 Supplement (1), 31-39.

McArdle, W.D., Katch, F.I. and Katch, V.L. (1981). Exercise physiology: Energy, nutrition and human performance. Philadelphia: Lea and Febiger.

McArdle, W.D., Katch, F.I.,Pechar, G.S., Jacobson,L. and Ruck, S. (1972). Reliability of inter-relationships between maximum oxygen uptake, Physical working capacity and step-test scores in college women. Medicine of Science in Sports and Exercise, 4, 182-186.

McCue, B.F. (1953). Flexibility of college women. Research Quarterly, 24, 316-324.

Mirwald, R.L., Bailey, D.A., Cameron, N. and Rasmussen, R.L. Longitudinal comparison of aerobic power in active and inactive boys aged 7.0 to 17.0 years. Annals of Human Biology, 8(5), 405-414, 1981.

Moore, D.C. (1988). Body image and eating behavior in adolescent girls. American Journal of Diseases in Children, 142, 1114-1118.

Must, A. (1996). Morbidity and mortality associated with elevated body weight in children and adolescents. American Journal of Clinical Nutrition, 63 Supplement (3), 4555-4475.

Must, A., Jaques, P.F., Dallal, G.E., Bajema, C.J., and Dietze, W.H. (1992). Long-term morbidity and mortality of overweight adolescents. A follow up of the Harvard Growth Study of 1922-1935. New England Journal of Medicine, 327(19), 1350-1355.

Nodem, M. (1994). Dying to Win. Sports Illustrated, 81(6), 52-58.

Novak, L.P., Woodward, W.A., Bestit, C., Mellerowicz, H. (1977) Working capacity, body composition, and anthropometry of Olympic female athletes. Journal of Sports Medicine and Physical Fitness, 17, 275-284.

Parfit. A.M. (1994). The two faces of growth: benefits and risks to bone integrtiy. Osteoporosis International, 4(6), 382-98.

Peltenburg, A.L., Erich, W.B.M., Bernink, M.J.E., Zonderland, M.L., and Huisveld, I.A. (1983) Body composition, biological maturation, and training in relation to socio-economic status in girl gymnasts, swimmers, and controls. Growth, 47(1).

Porcu, E., Venturoli, S., Fabri, R., Paradisi, R., Longhi, M., Sganga, E., and Flamingi, C. (1994). Skeletal maturation and hormonal levels after menarche. Archives of Gynecological Obstetrics, 225(1), 43-46.

Post, G.B. and Kemper, H.C. (1993). Nutritional intake and biological maturation during adolescence: The Amsterdam growth and health longitudinal. European Journal of Clinical Nutrition, 47(6), 400-408.

Priest, J.W. and Holshouser, R.S. (1987). Prepubescent strength training-some considerations. Journal of Physical Education, Recreation and Dance, October, 68-70.

Pugliese, M., Lifshitz, F., Fort, P., Recker, B. and Ginsberg, L. Pituitary-hypothalmic response in adolescents with growth failure due to fear of obesity. Journal of American College of Nutrition, 6(2), 113-120, 1987.

Purcell, J.S., Hergenroeder, A.C. (1994). Physical conditioning in adolescents. Current Opinion in Pediatrics, 6(4), 373-378.

Ratliffe, T., and Ratliffe, L.M. (1994). Teaching children fitness: Becoming a master teacher. Champaign, IL: Human Kinetics.

Reggiani, E., Arras, G.B, Senar, A.D., and Chiodini, G. (1989). Nutritional status and body composition of adolecent female gymnasts. Journal of Sports Medicine and Fitness, 29(3), 285-288.

Robergs, R.A. and Roberts, S. (1997). Exercise Physiology: Exercise, Performance and Clinical Applications. St. Louis, MI: Mosby.

Rohment, W. and Presing, M. (1968). Rechts-links – Vergliech bei Isometriachem Armmastkel training mit verschiedenem trainingareic. Sportantz und Sportmedicin, 43, 433-455. In Borms, J. (1986) The child and exercise: an overview. Journal of Sports Science Review, 4(1), 3-20.

Root, A.W. and Reiter, E.D. (1976). Evaluation and management of the child with delayed pubertal development. Fertility and Sterility, 27(7), 745-755.

Ross, J.G., and Gilbert, G.C. (1985). The National Children and Youth Fitness Study: A Summary of Findings. Journal of Physical Education, Recreation and Dance, 56(1) 45-50.

Ross, J.G., and Pate, R.R. (1987). The National Children and Youth Fitness Study II: A Summary of Findings. Journal of Physical Education, Recreation and Dance, 58(9) 51-56.

Rowland, T.W., (1990). Exercise and Children's Health. Champaign, IL: Human Kinetics.

Safrit, Margaret J. (1995). Complete Guide to Youth Fitness Testing. Champaign, IL: Human Kinetics.

Sallis, J.S., Simons-Martin, B.G., Stone, E.J., Corbin, C.B., Epstein, L.H., Faucette, N., Ianotti, R.J., Killen, J.D., Klesgres, R.C., Petray, C.K., Rowland, T.W., and Taylor, W.C., (1992). Determinants of physical activities and interventions in youth. Medicine and Science in Sports and Exercise, 24 (6) Supplement, 248-257.

Schumaker, B. and Holloman, W. (1974). The aerobic capacity of trained athletes from 6-7 years on. In Children and Exercise (edited by J. Borms and M. Hebbelinck), Acta Paediatricia Belgica, Supplement, 28, 92-101.

Shils, M.E., (1973). Food and nutrition relating to work and environmental stress. In R.S. Goodhart and M.E. Shils (Eds.), Modern nutrition in health and disease (5th ed. pp. 711-729). Philadelphia: Lea and Febiger.

Seermeev, B.V. (1966). Development of mobility in the hip joint in sportsmen. Yessis Review, 2(1) 16-17. In Alter, Michael (1996). Science of Flexibility (2nd ed. pp. 139-145). Champaign, IL: Human Kinetics.

Selzer, R., Caust, J., Hibbert, M., Bowes, G., and Patton, G. (1994). The association between secondary amenhorrea and common eating disordered practices in an adolescent population. Journal of Adolescent Health, 19(1), 56-61.

Sinning, W.E. (1978). Anthropomorphic estimations of body density, fat, and lean body weight in women's gymnastics. Medicine and Sport Science in Exercise, 10, 243-249.

Sirota, Lorraine (1991). Vitamin Requirements and Deficiencies:Theoretical and Practical Considerations for Athletes. Journal of Physical Education, Recreation and Dance, 61(10), 57-78.

Sol, J.M.B. (1987). The Bisadom/Sol aptitude test for female gymnasts. In Petiot, B. (Eds) World identification systems for gymnastic talent. Greeley, Co: Sports Psyche Editions.

Slaughter, M.H., Lohman, T.G., Boileau, R.A., Horswill, C.A., Stillman, R.J., vanLoan, M.D., and Bemster, D.A. (1988). Skinfold equations for estimated body fatness in children and youth. Human Biology, 60, 709-723.

Strand, B. and Reeder, E.D. (1966). Inreasing physical activity through fitness integration. Journal of Physical Education, Recreation and Dance, 67(3), 41-45.

Stunkard, B.A., (1967). Obesity and the body image: age at onset of disturbances in the body image. American Journal of Psychiatry, 123, 1443-1447.

Swift, E.M., (1995). Growing Pains. 82(10), 40-42.

Taffe, D.R., Robinson, T.L., Snow, C.M. and Marcus, R. (1997). High impact Exercise promotes bone gain in well-trained female athletes. Journal of Bone Mineral Research, Feb, 12(2), 255-260.

Taranger, J. (1976). Evaluation of biological maturation by means of maturity criteria. Acta Paedtricia Scandinavian Supplement (ILX), 258, 79-82.

Theintz, G.E., Howald, H., Weiss, V. and Sizonenko, P.C. (1993) Evidence for a Reduction of growth potential in adolescent female gymnasts. Journal of Pediatrics, Feb, 122(2), 306-313.

Theintz, G., Ladame, F., Kenrer, E., Plinchta, C., Howald, H., and Sizonenko, C. (1994). Prospective study of psychological development of adolescent female athletes; Initial assessment. Journal of Adolescent Health, 15(3), 258-262.

vanLenthe, F.G., Kemper, C.G., and vanMechelen, W. (1996). Rapid maturation in adolescence results in greater obesity in adulthood: the Amsterdam growth and health study. American Journal of Clinical Nutrition, 54(1), 18-24.

Wiita, B., Stombaugh, I., and Buch, J.(1995). Nutrition Knowledge and Eating Practices of Young Female Athletes. Journal of Physical Education, Recreation and Dance 66(3), 36-41.

Zack, P.M., Harlam, W.R., Leaveston, P.E. and Cori-Huntley,J. (1995). A Longitudinal study of body fatness in children and adolescents. Journal of Pediatrics, 95(1), 126-130.

Appendix A
Introduction to the study

Eastern Illinois University

Physical Fitness Assessment of Competitive Gymnasts vs. Non-gymnasts

Introduction to the Study

My name is Cara Kokenes and I am once again asking permission to have your daughter participate in a research project which will be used to complete my Master's Thesis in Exercise Science/Cardiac Rehabilitation at Eastern Illinois University. I would like to give you and your daughter a brief explanation of the study I am asking her to participate in. Each subject who volunteers will be asked to participate only once, and there will be no follow-up participation requested.

Objective

Each subject will be asked to complete the following battery of tests:
Descriptive Questionaire: Each subject will be asked to reveal their name, birthdate, and physical activity background.

Body Compostition:This is a procedure in which a skinfold measurement will be taken on the calf and upper arm to estimate total body fat.

Flexibility: A sit and reach test will be used to determine low back and hamstring flexibility. Each subject will place her feet against a box with a measuring stick positioned at the edge. Four attempts of stretching as far forward in front of them will be made.

Strength: A hand-grip strength test will be used to estimate upper body strength. A device known as a dynamometer will measure how many pounds each subject can squeeze while her hand is flat at her side.

Cardiovascular Assessment: A three minute step test will be performed to estimate cardiorespiratory endurance. Each participant will be asked to step up and down on a 16 inch bench in time to a pre-recorded beat. A heart rate will be taken from a monitoring devise worn around the midsection of each participant.

Maturity Assessment: In order to assess biological maturity of the subjects, a short questionaire will be given to each girl. This form will ask each participant to assess their own development of axillary (under arm)hair as well as report on when/if menarch (onset of the first menstrual period) has been achieved. These are the least physically revealing questions to determine biological maturity.

Diet screening: A brief one page questionairre will be used to assess eating behaviors.

Appendix B
Consent Form

The risks of participation in this study are minimal although some participants may experience some mild physical or psychological discomfort. For example, subjects may experience slight discomfort associated with pinching of the skin during skinfold measurement.

The benefits of this study to participants include written feedback about their personal fitness status.

Participating in this study is completely voluntary and data will be confidentially handled.

My daughter and I have read the preceeding description and understand the nature of the proposed research activity in which she is to be involved. My child and I hereby consent to voluntarily perform the battery of tests explained on the previous page. In choosing to paticipate, it is understood that a maximal effort is necessary in performing each test.

We understand the information obtained will be treated as privileged and confidential and will not be released or revealed to anyone else. The information obtained, however, may be used for statistical or scientific purposes with our rights to privacy retained.

My child and I understand that she has the right to withdraw from the study at any time, especially if she feels dizzy or disoriented, develops extreme shortness of breath, stops sweating, or has intense feelings of nausea.

In, addition, we understand that there are some risks, as with any sort of physical activity. The risks, however, are no greater than those associated with her usual physical education class participation.

We feel various tests have been explained adequately and we feel comfortable continuing with this research project.

If you have any questions contact Cara Kokenes at (217) 348-0999 or
Dr. Brian Pritschet at (217) 581-7586

Subject signature___________________________Date____________

Legal guardian signature______________________Date___________

APPENDIX C
Sport Participation, Menarche status, and Axillary Hair Assessment Questionnaire

I. General Information

Name__________________________ **Subject #**_____

Birthdate____________

Physical activity background: (circle one)

A. I participate in physical education class only.

B. I participate in after school sports: (circle which ones):

cheerleading	basketball	track
cross-country	swimming	softball
volleyball	other_____________	

C. I am involved in sports/athletics outside of school.(list activitiesbelow)

____________________ ____________________

____________________ ____________________

II. Physical Maturity Assessment

Please circle the number which most accuratelty describes your axillary (underarm hair).

1. I have not yet begun to grow any underarm hair--this means I do not have to shave yet either.

2. I have slight growth of hair--there is a small amount of thin hair that does not fully cover the underarm. I may have started to shave, but not on a regular basis.

3. I have complete growth of underarm hair--the hair is thick/coarse and covers most or all of my underarm.

Have you experienced your first menstrual period: (circle one) YES NO

If you answered yes, please give the approximate month and year___________

APPENDIX D
EAT Questionnaire

NATIONAL EATING DISORDERS SCREENING PROGRAM
EATING ATTITUDES TEST (EAT-26)

1 Age ____ 2 Sex ____ 3 Height ____ 4 Current Weight ____ 5 Highest Weight ____ (excluding pregnancy) 6. Lowest Adult Weight ____

7. Education: If currently enrolled in college/university are you a: Freshman ☐ Sophomore ☐ Junior ☐ Senior ☐ Grad Student ☐

If not enrolled in college or university, level of education completed: Grade School ☐ High School ☐ College ☐ Post College ☐

8. Ethnic/Racial Group: African American ☐ Asian American ☐ Caucasian ☐ Hispanic ☐ American Indian ☐ Other ☐

9. Do you participate in athletics at any of the following levels: Intramural ☐ Inter-Collegiate ☐ Recreational ☐ High School Teams ☐

Please check a response for each of the following statements:	Always	Usually	Often	Some times	Rarely	Never	Score
1. Am terrified about being overweight.	☐	☐	☐	☐	☐	☐	
2. Avoid eating when I am hungry.	☐	☐	☐	☐	☐	☐	
3. Find myself preoccupied with food.	☐	☐	☐	☐	☐	☐	
4. Have gone on eating binges where I feel that I may not be able to stop.	☐	☐	☐	☐	☐	☐	
5. Cut my food into small pieces.	☐	☐	☐	☐	☐	☐	
6. Aware of the calorie content of foods that I eat.	☐	☐	☐	☐	☐	☐	
7. Particularly avoid food with a high carbohydrate content (i.e. bread, rice, potatoes, etc.).	☐	☐	☐	☐	☐	☐	
8. Feel that others would prefer if I ate more.	☐	☐	☐	☐	☐	☐	
9. Vomit after I have eaten.	☐	☐	☐	☐	☐	☐	
10. Feel extremely guilty after eating.	☐	☐	☐	☐	☐	☐	
11. Am preoccupied with a desire to be thinner.	☐	☐	☐	☐	☐	☐	
12. Think about burning up calories when I exercise.	☐	☐	☐	☐	☐	☐	
13. Other people think that I am too thin.	☐	☐	☐	☐	☐	☐	
14. Am preoccupied with the thought of having fat on my body.	☐	☐	☐	☐	☐	☐	
15. Take longer than others to eat my meals.	☐	☐	☐	☐	☐	☐	
16. Avoid foods with sugar in them.	☐	☐	☐	☐	☐	☐	
17. Eat diet foods.	☐	☐	☐	☐	☐	☐	
18. Feel that food controls my life.	☐	☐	☐	☐	☐	☐	
19. Display self-control around food.	☐	☐	☐	☐	☐	☐	
20. Feel that others pressure me to eat.	☐	☐	☐	☐	☐	☐	
21. Give too much time and thought to food.	☐	☐	☐	☐	☐	☐	
22. Feel uncomfortable after eating sweets.	☐	☐	☐	☐	☐	☐	
23. Engage in dieting behavior.	☐	☐	☐	☐	☐	☐	
24. Like my stomach to be empty.	☐	☐	☐	☐	☐	☐	
25. Have the impulse to vomit after meals.	☐	☐	☐	☐	☐	☐	
26. Enjoy trying new rich foods.	☐	☐	☐	☐	☐	☐	
Total Score:							

Appendix E
Raw Data

	ID	Wt	Ht	Flex	St-R	St-L	RHR	HR5	HR10
1	1.0	41.6	151.25	24.50	16.0	15.5	70	130	121
2	2.0	42.2	149.75	24.50	15.0	16.0	120	153	150
3	3.0	46.8	139.75	26.25	18.0	16.5	96	145	136
4	4.0	37.3	132.25	22.50	17.0	14.0	88	157	150
5	5.0	39.9	130.25	21.75	19.0	13.0	96	169	167
6	6.0	27.2	135.25	23.50	11.0	12.0	78	122	119
7	7.0	33.1	140.50	23.50	14.0	12.5	78	135	131
8	8.0	27.5	145.50	24.00	11.0	14.0	86	138	138
9	9.0	29.5	137.75	23.50	7.5	9.0	87	132	127
10	10.0	39.2	152.50	22.25	12.0	16.0	100	166	164
11	11.0	36.7	144.75	23.00	14.0	12.5	84	144	133
12	12.0	48.3	152.40	29.00	17.0	18.5	82	158	160
13	13.0	41.2	151.25	26.75	15.0	17.0	80	131	120
14	14.0	36.2	146.00	27.00	11.0	11.0	72	142	142
15	15.0	32.5	141.00	24.00	9.0	11.0	92	155	149
16	16.0	44.7	124.50	29.00	14.0	15.0	90	145	145
17	17.0	37.5	142.25	24.25	15.0	16.0	87	133	129
18	18.0	37.9	147.25	23.25	11.0	12.0	94	136	133
19	19.0	34.3	148.00	25.25	7.0	15.0	92	152	154
20	20.0	30.1	137.25	25.75	13.0	13.5	86	138	132
21	21.0	54.1	166.50	14.50	22.0	21.0	154	205	199
22	22.0	57.0	162.50	21.00	22.0	25.0	150	188	189
23	23.0	39.9	144.75	21.00	20.0	16.0	127	201	200
24	24.0	54.7	177.50	17.50	20.0	21.0	111	191	188
25	25.0	38.4	150.00	16.50	14.0	13.0	123	134	134
26	26.0	48.1	162.50	12.00	20.0	19.0	120	95	91
27	27.0	50.2	157.00	20.50	13.0	14.0	108	178	177
28	28.0	50.3	157.00	12.00	21.0	19.0	122	219	200
29	29.0	32.8	148.00	16.50	9.0	7.0	109	158	149
30	30.0	69.1	160.75	19.00	24.0	21.0	120	181	177
31	31.0	40.4	149.75	13.50	6.0	7.5	120	201	198
32	32.0	47.9	162.00	6.75	14.0	17.0	108	162	154
33	33.0	51.8	153.75	12.50	21.0	13.0	70	126	122
34	34.0	39.3	147.50	19.00	21.0	14.0	100	161	171
35	35.0	26.9	134.00	13.00	2.0	2.0	117	142	132
36	36.0	45.5	157.50	16.00	16.0	12.0	133	202	195
37	37.0	48.3	158.75	13.00	17.0	10.0	126	164	152
38	38.0	45.2	162.50	19.50	21.5	15.0	98	140	136
39	39.0	55.0	160.75	17.00	22.0	22.0	110	192	192
40	40.0	52.1	156.25	15.00	14.0	10.0	120	201	199
41	•	•	•	•	•	•	•	•	•
42	•	•	•	•	•	•	•	•	•

	HR15	Diet	ME Ach	Ax	Class	AGE	ME-AGE	BC	Vo2
1	112	3	No	2	Gym	12.75	•	12.75	43.460
2	147	3	No	3	Gym	12.42	•	14.98	38.110
3	132	3	Yes	2	Gym	12.33	11.75	19.68	41.430
4	135	8	No	2	Gym	12.10	•	14.60	40.880
5	162	8	No	2	Gym	12.17	•	12.18	35.890
6	103	1	No	1	Gym	12.17	•	13.40	46.790
7	119	1	No	1	Gym	12.10	•	16.20	43.830
8	138	4	No	1	Gym	12.42	•	15.23	40.320
9	127	6	No	1	Gym	12.00	•	11.99	42.350
10	160	8	No	1	Gym	12.42	•	14.25	36.260
11	129	8	Yes	3	Gym	12.83	12.10	16.90	41.980
12	145	1	No	2	Gym	12.42	•	16.26	39.030
13	112	1	No	1	Gym	12.17	•	12.42	45.120
14	114	3	No	1	Gym	12.17	•	11.99	44.750
15	142	0	No	1	Gym	12.42	•	15.23	39.580
16	135	12	No	2	Gym	12.42	•	21.10	40.880
17	129	4	No	1	Gym	12.42	•	15.83	41.980
18	133	1	No	1	Gym	12.25	•	13.03	41.240
19	138	1	No	1	Gym	12.00	•	14.86	40.320
20	128	5	No	1	Gym	12.42	•	10.95	42.170
21	195	2	Yes	2	N-Gym	12.10	11.58	20.35	29.790
22	194	19	Yes	2	N-Gym	12.33	11.50	22.97	29.270
23	201	11	No	2	N-Gym	12.42	•	23.34	28.690
24	188	2	Yes	2	N-Gym	12.66	12.10	29.30	31.090
25	145	18	Yes	2	N-Gym	12.50	12.33	20.53	39.030
26	90	3	No	2	N-Gym	12.42	•	31.45	49.120
27	174	4	Yes	3	N-Gym	12.66	12.10	27.20	33.670
28	198	5	Yes	2	N-Gym	12.10	11.00	24.80	29.240
29	147	5	No	1	N-Gym	12.25	•	17.66	38.660
30	171	15	Yes	2	N-Gym	12.17	11.25	34.90	34.230
31	185	4	Yes	3	N-Gym	12.50	11.50	25.70	31.640
32	136	14	No	1	N-Gym	12.17	•	17.01	40.690
33	108	6	No	1	N-Gym	12.50	•	16.45	45.860
34	169	4	Yes	2	N-Gym	12.58	11.75	22.12	34.600
35	130	•	No	1	N-Gym	12.17	•	10.95	41.800
36	195	3	Yes	2	N-Gym	12.00	11.42	24.01	29.780
37	150	3	No	2	N-Gym	12.58	•	22.55	38.110
38	129	4	No	2	N-Gym	12.00	•	22.36	12.160
39	191	18	Yes	2	N-Gym	12.75	11.00	19.90	30.530
40	197	5	Yes	2	N-Gym	12.12	10.42	20.10	29.420
41	•	•	•	•	•	•	•	•	•
42	•	•	•	•	•	•	•	•	•

	FFB	Kg/cm	G-rtSTR/wt	G-leftSTR/wt
1	36.300	.2750	.385	.373
2	35.880	.2818	.355	.379
3	37.590	.3349	.385	.353
4	31.850	.2820	.455	.375
5	35.040	.3063	.476	.326
6	23.560	.2011	.404	.441
7	27.740	.2356	.423	.378
8	23.310	.1890	.400	.509
9	25.960	.2142	.254	.305
10	33.610	.2570	.306	.408
11	30.500	.2535	.381	.341
12	40.450	.3167	.352	.383
13	36.080	.2724	.364	.413
14	31.860	.2479	.304	.304
15	27.550	.2305	.388	.338
16	35.270	.3590	.313	.336
17	31.560	.2636	.400	.427
18	32.960	.2574	.290	.317
19	29.200	.2318	.204	.437
20	26.800	.2193	.432	.449
21	43.090	.3249	.407	.388
22	43.910	.3508	.386	.439
23	30.590	.2756	.501	.401
24	38.670	.3285	.366	.384
25	30.520	.2560	.365	.339
26	32.970	.2960	.416	.395
27	36.550	.3197	.259	.279
28	37.830	.3204	.417	.378
29	27.010	.2216	.274	.213
30	44.980	.4299	.347	.304
31	30.020	.2698	.149	.186
32	39.750	.2957	.293	.355
33	43.280	.3369	.405	.251
34	30.610	.2664	.534	.356
35	23.950	.2007	.074	.074
36	34.580	.2889	.352	.264
37	37.410	.3043	.352	.207
38	35.090	.2782	.476	.332
39	44.060	.3421	.400	.400
40	41.630	.3334	.269	.192
41	•	•	•	•
42	•	•	•	•