RELATIONSHIP OF DIET AND FITNESS TO SELECTED CARDIOVASCULAR DISEASE RISK FACTORS IN CHILDREN AGES 8-11 YEARS

A Thesis

by

Tiffany Michelle Reiss

Submitted to the Graduate School

Appalachian State University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 1996

Major Department: Health, Leisure, and Exercise Science

RELATIONSHIP OF DIET AND FITNESS TO SELECTED

CARDIOVASCULAR DISEASE RISK FACTORS

IN CHILDREN AGES 8-11 YEARS

A Thesis

by

Tiffany Michelle Reiss

APPROVED BY:

Beverly J. Warren
Chairperson, Thesis Committee

Diane E. Butterworth
Member, Thesis Committee

Robert L. Johnson
Member, Thesis Committee

Vaughn K. Christian
Chairperson, Department of Health, Leisure, and Exercise Science

Joyce V. Lawrence
Dean of Graduate Studies and Research

ABSTRACT

RELATIONSHIP OF DIET AND FITNESS TO SELECTED CARDIOVASCULAR DISEASE RISK FACTORS IN CHILDREN AGES 8 TO 11 YEARS

Tiffany Michelle Reiss

B.S., Appalachian State University

M.S., Appalachian State University

Thesis Chairperson: Beverly J. Warren

The purposes of this study were to compare the relationship of dietary intake to selected cardiovascular risk factors and to compare both quantity and quality of dietary intake between highly fit and low fit children. The study focused on the relationship between dietary quality and blood lipids, body composition, and fitness levels; and differences in quality and quantity of dietary intake when children were categorized into low fit and high fit groups. The subjects were 104 children (mean age = 9.2 ± 0.1 y).

Body composition was determined by skinfold analysis. Blood lipids included triglycerides, total cholesterol, high density lipoprotein cholesterol, low density lipoprotein cholesterol, and very low density lipoprotein cholesterol. Subjects performed a maximal graded exercise treadmill test using automated cardiorespiratory monitoring techniques to determine aerobic fitness. Subjects completed dietary records averaging at least 3 days including 1 weekend day. Statistical analysis included Pearson Product Moment

Correlation for relationships between variables, and a 2 X 2 factorial Analysis of Variance to determine group differences.

Significant relationships did exist between dietary quality and various blood lipid profiles, body composition, and fitness levels of the children. Significant negative relationships were found between body fat percentage and total calories, protein(g), polyunsaturated fat(g), dietary fiber(g), kcal/kg, protein/kg, carbohydrate/kg, and fat/kg. Significant positive relationships were found between VO_{2max} and total calories, protein(g), carbohydrate(g), fat(g), saturated fat(g), monounsaturated fat(g), dietary fiber(g), kcal/kg, and protein/kg. Significant differences between the high fit and low fit groups were apparent in both dietary quantity and dietary quality. Although the high fit children had significantly less body fat but were similar in weight, the high fit children consumed more total calories, monounsaturated fat(g), kcal/kg, carbohydrate/kg, protein/kg, and fat/kg. The results of this study suggest there is a relationship between dietary intake and blood lipid values, body composition, and fitness levels in children.

ACKNOWLEDGMENTS

The author wishes to express her gratitude to the following individuals:

Dr. Beverly J. Warren for her patience, assistance, and positive encouragement throughout this tedious undertaking;

Dr. Diane E. Butterworth for her patience, guidance and assistance with the nutritional aspects of this thesis;

Dr. Robert L. Johnson for his patience, guidance, and computer expertise in the design of the research and analysis of the data:

Mr. Allen Frommelt, Greg Haff, and Ms. Jodi Herring, for their assistance in the data collection;

Richard Hatley and the students from Granite Falls Elementary who made this study possible;

My parents for their interminable love and support of their daughter;

Mrs. Ann Stephens for somehow, despite my behavior, still managing to teach me the power of words, and the importance of self expression through writing.

DEDICATION

This thesis is dedicated to my parents and family who have continually offered their love and support throughout this entire project. Their patience has been infinite as well as their understanding. Their sacrifices for me from the day I was brought into this world have allowed me to accomplish all that I have to this date, and will give me the strength to accomplish even higher goals throughout the course of my life.

TABLE OF CONTENTS

Page

List of Tables.. xi

Chapter 1 Introduction.................................. 1

Statement of Problem................................ 9

Research Hypothesis................................. 10

Significance to the Field........................... 10

Basic Assumptions................................... 10

Delimitations....................................... 11

Limitations... 11

Operational Definitions............................. 12

Chapter 2 Review of the Literature...................... 13

Quality of Dietary Intake........................... 13

Developmental Aspects............................... 18

Physical Activity Levels of Children................ 19

Fitness as Measured by Maximal O_2 Uptake............ 20

Diet and Exercise Interrelationship................. 22

Blood Lipids, Body Fat, and Fitness................. 25

Diet, Body Fat, Blood Lipids, and Fitness........... 29

Summary... 34

Chapter 3 Methods.. 36
Research Design.................................... 36
Subjects... 36
Testing Procedures................................. 37
Statistical Analysis............................... 42
Chapter 4 Results.. 43
Subjects... 43
Maximal Exercise Test.............................. 43
Blood Lipids....................................... 44
Dietary Quantity................................... 45
Dietary Quality.................................... 46
Dietary Intake and Recommended Dietary Allowances... 47
Relationship of Dietary Intake to
Blood Lipid Profiles........... 49
Relationship of Dietary Intake to VO_2,
% Body Fat, and BMI............ 53
High Fit Group versus Low Fit Group................ 55
Dietary Quantity Low Fit Group versus
High Fit Group................. 56
Dietary Quality Low Fit Group versus
High Fit Group................. 59
Chapter 5 Discussion....................................... 60
Dietary Quality and Blood Lipid Profiles............ 61
Dietary Qantity and Fitness......................... 64
Dietary Intake and Body Composition................. 66
Dietary Intake and Recommended Dietary Allowances... 69

Dietary Intake and Fitness Levels 71
Conclusions 73
Recommendations 75
References 77
Appendices 86
Appendix A 87
Vita 90

LIST OF TABLES

Page

Table 1. President's Challenge Performance Groups, #/%. 37

Table 2. Descriptive Group Data, Means and SEM. 43

Table 3. Maximal VO_2 Group Data, Means, SEM, and Range... 44

Table 4. Blood Lipid Group Data, Means, SEM, and Range... 44

Table 5. Group Dietary Quantity, Means, SEM, and Range... 45

Table 6. Group Dietary Quality, Means, SEM, and Range.... 47

Table 7. Frequency and Percentage of Children Meeting At Least 75% of the Recommended Dietary Allowances For Their Age Group. 48

Table 8. Correlational Values For Dietary Intake of Selected Nutrients and Their Relationship to TC, TG, VLDL, LDL, HDL, and TC/HDL Ratio...... 51

Table 9. Correlational Values For Dietary Intake of Selected Nutrients and Their Relationship to VO_2, Body Fat %, and BMI. 54

Table 10. High Fit and Low Fit Descriptive Group Data, Means and SEM.................. 56

Table 11. Mean Dietary Quantity of the Low Fit and High Fit Groups, Means and SEM........... 57

Table 12. Difference in Dietary Quality of High Fit and Low Fit Groups, Means and SEM....... 59

Chapter 1

Introduction

Dietary intake of children has become a major issue to health professionals largely due to the reported decline of children's health and physical fitness levels (Gazzaniga & Burns, 1993; Kuntzleman & Reiff, 1992; Witschi, Capper, & Ellison, 1990). The evidence continues to grow linking early dietary habits to an increased risk of developing various chronic diseases during adulthood (Johnson, 1992). Dietary habits have also been found to juxtapose a strong link to the development of atherosclerosis leading to cardiovascular disease (CVD) in adulthood (Albertson, Tobelmann, Engstrom, & Asp, 1992; Newman, Wattigney, & Barenson, 1991; Weidman, Kwiterovich, Jesse, & Nugent, 1983).

Cardiovascular disease continues to be the number one cause of death in the United States (McGinnis & Forge, 1993). For this reason alone, a continued interest in the development of this disease and early detection methods for the various risk factors associated with this disease is warranted. Now strong evidence exists that the atherosclerotic process begins in childhood and progresses to adulthood, being the probable cause of CVD (National Heart

Lung and Blood Institute, 1991). Since atherosclerosis has been found to begin in early childhood, the risk factors associated with CVD have also been found to develop early in life (Linder & DuRant, 1982). These CVD risk factors can be "tracked", or monitored from year to year (Berenson, 1980; Berenson, Srinivasan, & Webber, 1980; Boulton, 1981; Costello, Disney, Dodson, & Bush, 1983; Newman, Wattigney, & Barenson, 1991). Tracking relates to the idea that a trait or risk factor assessed at one time may be indicative of this same trait or risk factor at a later time. Therefore, identification of CVD risk factors during childhood is an excellent opportunity to screen individuals early in hopes of preventing CVD later in life. The environmental risk factors associated with CVD include: diet, specifically dietary lipids; obesity; blood lipid profile; and fitness, or amount of physical activity (Tell & Vellar, 1988; Williams et al., 1992; Wynder, 1989).

In view of the atherosclerotic process developing early in childhood, with diet being a primary environmental risk factor, several committees and institutions have issued statements regarding appropriate dietary intake for both children and adults. The National Research Council Committee on Diet and Health (1989) and the National Cholesterol Education Program (1991) recommended that all healthy children two years of age and older consume a diet reduced in total fat and cholesterol. Total fat should not exceed 30% of total calories, saturated fat less than 10% of total calories, dietary cholesterol less than 300 mg, and sodium less than 2400 mg. The Consensus Development Panel on Lowering Blood Cholesterol to Prevent Heart Disease (1985) recommended that all family members over two years of age follow guidelines for lowering dietary fat, saturated fat, and cholesterol. A report from a conference aimed at preventing adult atherosclerosis through intervention during childhood recommended that trends toward the lowering of saturated fats in the diets of children 2 to 18 years old should be encouraged. The report stated that a reasonable target for fat intake was 30% of total calories from fat, with no more than 10% of calories from saturated fat (LaRosa, 1988).

Stephen and Wald (1990), using 171 previous studies of individual food intake assessments and data from CVD disease mortality rates in the United States, concluded that fat intake in the United States started to decline between the years 1960-1965, a few years before a decline in CVD mortality started to occur in the United States. This apparent association with the trend in mortality rates suggested that diet, or more specifically fat intake, may play a key role in the onset of CVD.

Numerous studies have been conducted observing fat intake in adults and have yielded mixed results. One study reported there has been a decline in the consumption of total fat from 40-42% in 1960 to 35-37% in 1984 with similar trends in saturated and monounsaturated fats and an upward trend in polyunsaturated fats (Stephen & Wald, 1990). However, this reported decline does not meet the dietary guidelines of less than 30% of total caloric intake from fat. Another study on 225 adult females found an average of 40% of their dietary intake came from fat, with 15% from protein and 44% from carbohydrate (Tucker & Kano, 1992).

Unfortunately these same trends tend to carry over to children as well. In a study conducted by Frank, Welber, Ferris, and Berenson (1987), school age children were found to eat the typical US diet of 38%-41% of their total energy in the form of dietary fat. A high saturated (14%-16%) and low polyunsaturated (5%-7%) fat intake was reflected by a low polyunsaturated/saturated fat ratio in the diet as opposed to a diet reflecting 10% saturated and polyunsaturated fat intake as suggested. Mean cholesterol intake per 1000 kcal was approximately 140-150 mg as opposed to the suggested 100 mg per 1000 kcal. Numerous other studies have reflected the same bleak picture with fat intakes of children reported as ranging from 34-35% of total caloric intake with ranges of 12%-14% saturated fat, and mean cholesterol intake ranging from 143-156 mg/1000kcal (Devaney, Gordon, & Burghardt, 1995; Johnson, 1992; Witschi, Capper, & Ellison, 1990).

With children's daily fat intake comprising such a large percentage of total calories, the literature has responded with a burgeoning of studies on the effects of high fat diets in relation to childhood obesity. An extensive amount of literature has been published identifying the problems associated with childhood obesity and the multifactorial causes of obesity in children, one of which is a high fat intake (Dreon et al., 1988; Gazzaniga & Burns, 1993; Miller, Linderman, Wallace, & Neiderpruem, 1990; Muecke, Morton, Huang, & Parcel, 1992; Romieu et al., 1988; Tucker & Kano, 1992). Miller et al. (1990) found adiposity was positively related to dietary fat content and negatively related to dietary carbohydrate consumption in adult males and females alike. They also found obese subjects derived a greater percentage of their energy from fat and less from carbohydrate than did lean subjects. Gazzaniga and Burns (1993) found adiposity was significantly and positively related to total dietary fat consumption and to saturated, monounsaturated, and polyunsaturated fatty acid consumption; adiposity was also significantly and inversely related to dietary carbohydrate consumption. A high fat diet, therefore, can be the catalyst for one of the prominent environmental cardiovascular disease risk factors, obesity. In addition, diets high in saturated fat have also been linked to unfavorable blood lipid profiles, another CVD risk factor.

Wynder et al. (1989) found dietary saturated fat and cholesterol to be major environmental causes of hypercholesterolemia. They also suggested that diets high in saturated fats and cholesterol adversely affect the lipoprotein profiles and consequently predispose individuals to atherosclerosis. They reported elevated blood cholesterol in children to be a potential early marker for adult onset CVD. This juxtaposes a study by Newman, Wattigney, and Barenson (1991) in which a relationship was found between elevated lipid and lipoprotein values and coronary artery plaques in autopsy studies of children and adolescents.

Growing evidence that high fat diets contribute to atherogenesis as well as the health implications of obesity have brought children's dietary habits under particular scrutiny. However, low levels of physical activity or inactivity seem to coincide with the high fat diets of children (Tell & Vellar, 1988). Since a sedentary lifestyle is another environmental CVD risk factor, this apparent lack of physical activity is important to monitor, especially in children. Unfortunately, physical activity levels in children are extremely difficult to measure accurately. Therefore, the amount of physical activity or inactivity is usually measured using fitness parameters. Bar-Or (1983) found regular physical activity can improve cardiovascular and other components of health-related fitness in children. Yet, Morrow (1992) reported that many children seldom experience the volume of physical activity that is believed to promote health-related outcomes. The fact that children are not as physically active as they should be is evidenced by lower scores on children's physical fitness tests. Updyke (1992) reported endurance-run performance for adolescents has decreased in recent years. Other physical fitness test scores have also decreased, and this apparent decline in fitness among children is considered a nationwide problem. Blair (1992) also cited low levels of physical activity and fitness in adults as a major public health problem in the United States, with estimates of up to 250,000 deaths a year associated with a sedentary lifestyle. The association between children's inactivity leading to adult inactivity however, has not been easily documented. One problem may be due to the inaccurate methods utilized to measure physical activity in children (Washburn & Montoye, 1986). However, the utilization of children's physical fitness test scores has proven to be a reliable method in the prediction of adult physical activity levels (Dennison, Strauss, Mellits, & Charney, 1988).

Fitness levels have also been associated with other environmental CVD risk factors in children such as body fat percentages and blood lipid profiles. Suter and Hawes (1992) found cardiovascular fitness was inversely related to sum of skinfolds in children. Another study reported fitness levels were inversely related to weight, and tricep skinfold, and positively related to high density lipoprotein-total cholesterol ratio (HDL/TC). The study also reported a positive relationship between fitness level and HDL in adult females (Tell & Vellar, 1988). Many additional studies have confirmed these relationships between fitness level, body fat percentages, and blood lipid profiles (DuRant et al., 1993; Kuntzleman & Reiff, 1992; Kwee & Wilmore, 1990). One study concerning diet and levels of physical activity found when both high fat foods and low levels of physical activity were assessed concurrently in the same child, there was a 38% increase in the risk of obesity (Muecke et al., 1992).

Apparently, all of these environmental CVD risk factors are interrelated and have been extensively studied and documented in adult populations. Butterworth, Nieman, Underwood, & Lindsted (1994) did find intake of energy (Kcal/kg body weight) to be higher for more physically active and fit women leading to significant increases in most nutrients consumed per kilogram of body weight. However, the literature has failed to conclusively associate dietary intake with fitness levels or regular physical activity in adults (Butterworth, Nieman, Perkins, Warren, & Dotson, 1993; Kiem, Barbieri, & Belko, 1989; Nieman, Onash, & Lee, 1990). Yet, Blair, Jacobs, and Powell (1985) hypothesized that the adoption of regular physical activity resulted in an improvement in the quality of an individual's dietary intake even though the literature has proven otherwise (Kiem, Barbieri, & Belko, 1989; Nieman, Onash, & Lee, 1990).

Strong associations have been documented between diets high in fat and CVD as well as obesity and hypercholesterolemia in adults. However, in children, the relationship appears to be less definitive. The literature is also vague on the relationship of diet to fitness levels of adults, and almost non-existent in the relationship of diet to fitness levels of children.

Statement of Problem

The purposes of this study were to compare the relationship of dietary intake to selected cardiovascular disease risk factors and to compare both quantity and quality of dietary intake between highly fit and low fit children. This study focused on the following questions:

1) Is there a significant relationship between dietary intake and blood lipid profiles in children?

2) Is there a significant relationship between dietary intake and body composition in children?

3) Is there a significant relationship between dietary intake and fitness levels in children?

4) Is there a significant difference in quantity and quality of dietary intake when children are categorized into low fit and high fit groups?

Research Hypotheses

It was hypothesized that a relationship would exist between quality of dietary intake and blood lipid profile, body fat percentage, and fitness; and that no difference would exist in quantity or quality of dietary intake between highly fit and low fit children.

Significance to the Field

There is an abundance of research relating diet to various environmental cardiovascular disease risk factors in both adults and children. The results of this study will contribute to the present literature regarding the relationship of dietary intake to blood lipid profile and body fat percentage of children. Previous studies have indicated significant relationships between all of these risk factors (Durant et al., 1993; Gazzaniga & Burns, 1993; Muecke et al., 1992; Nicklas et al., 1993; Suter & Hawes, 1992). However, the literature is inconclusive in associating dietary intake, both quantity and quality, with fitness levels or regular physical activity in adults; and is even more obscure when associated with children. The results may indicate a need for nutritional education for children for the prevention of cardiovascular disease or other chronic diseases in the future.

Basic Assumptions

It was assumed that the subjects of this study reported for the blood draw in a fasted state, that they put forth a maximal effort on the treadmill test, that they or their parents accurately recorded their 3-5 day diet records, and that the diet records they recorded were representative of their regular dietary intake.

Delimitations

This study was delimited to 104 children from 8 to 12 years of age who volunteered to participate in the study with no incentives other than the feedback provided for them. The independent variable was the grouping factor, highly fit or low fit children. The dependent variables were: blood lipid profile (total cholesterol, high-density lipoprotein, low-density lipoprotein), body fat percentage (skinfold analysis), maximal oxygen consumption, total kcal intake, nutrient quantity (nutrient/kg body weight), and quality of nutritional intake (nutrient density, percent of energy from fat, carbohydrate and protein, and various other nutrient values).

Limitations

Possible limitations that may have affected this study included the following: compliance of the subjects with all testing procedures; compliance of the subjects or their parents to accurately record their food intakes during the dietary records; accurate analysis of the diet based on the computer program used; accuracy of equations used to estimate body fat; accuracy of assessing maximal oxygen uptake in children, and the accuracy of fitness testing with tests performed at different times during the day and on varying days.

Operational Definitions

1) Nutrient Quantity - absolute nutrient intake

2) Nutrient Quality - % of kcal from fat, carbohydrate, and protein; nutrient/kg body mass

3) Low-Aerobically Fit - all subjects that were 0.25 standard deviations below the mean VO_{2max} scores

4) High-Aerobically Fit - all subjects that were 0.25 standard deviations above the mean VO_{2max} scores

5) Obesity - fat content greater than 25% for males and 32% for females (Lohman, 1987)

6) Hypercholesterolemia - 240 mg/dl or higher of cholesterol in the blood (The Surgeon General's report on nutrition and health: summary and recommendations, 1988).

7) Atherosclerosis - the most common form of coronary artery disease characterized by plaques along the inner walls of the arteries (The Surgeon General's report on nutrition and health: summary and recommendations, (1988).

8) CVD Risk Factors - Gender (being male); glucose intolerance (diabetes); heredity (history of CVD prior to age 55 in family members); high blood cholesterol, high LDL, and/or low HDL; hypertension; lack of exercise; obesity; smoking; and stress (American Heart Association, 1988).

CHAPTER 2

Review of Literature

Dietary intake is a necessary parameter to measure when investigating blood lipids, body fat percentage and fitness levels. Both quality and quantity of dietary intake can positively or negatively effect all of these CVD risk factors. Dietary intake can be recorded using 24 h diet recalls, 3-5-7 d food diaries, or food frequency questionnaires (Whitney, Cataldo, & Rolfes, 1991). Dietary intake can then be measured by downloading the recorded information into a computer program which calculates various nutrient values. Dietary intake is not the only factor which effects blood lipid levels, body fat percentage and fitness. There are various genetic factors which may effect and/or inhibit all of these variables. However, this literature review will be confined to the relationship of dietary intake to blood lipids, body fat percentage, and fitness levels of children.

Quality of Dietary Intake

Dietary quality is a difficult parameter to measure specifically. Most often measurements of macronutrient intake are used to assess quality with fat intake being the macronutrient of most concern (Nicklas, Webber, Srinivasan, & Berenson, 1993; Stephen & Wald, 1990). High fat intakes have been linked repeatedly with CVD risk factors in both children land adults (Gazzaniga & Burns, 1993; Kemper et al., 1990; Kwee & Wilmore, 1990; Miller et al., 1990; Romieu et al., 1988), and are therefore of much concern. A study by Tucker and Kimo (1992) on 205 adult females found the average fat intake was 40% of total calories with 15.5% protein and 44% carbohydrate. A similar study by Dreon et al. (1988) on 155 sedentary obese middle aged men 30-59 years found they derived 40.7% of their total calories from fat, 15.6% from protein, and 37.5% from carbohydrate. However, a review conducted by Stephen and Wald (1990) using 171 previous studies ranging from 8 to 20,000 subjects and covering all ages, all ethnic groups, and both sexes, found trends indicating decreases in fat intake since the mid 1960's. Results indicated fat intakes rising from 34% of total energy in the 1930's to 40-42% in the late 1950's to mid 1960's then falling steadily to 36% in 1984. Nevertheless, even with this slight decline in total fat, intake is still high according to the National Research Council Committee on Diet and Health which suggests total fat intake should not exceed 30% of total calories (Committee on Diet and Health, Food and Nutrition Board, 1989).

These same dietary trends appear to carry over to children as well. With the use of 24-hour dietary recalls, Frank, Webber, Farris, and Berenson (1987) reported children, preschool and school-age, ate the typical American adult diet of 38% to 41% of the total energy in the form of dietary fat. In a similar study conducted by Devaney, Gordon, and Burghardt (1995) with the use of 24 hour dietary recall on 3350 children ages 6-18 years, 33 to 35% of total energy was consumed in the form of fat and 51 to 54% in the form of carbohydrate. Of the fat consumed, 14 to 15% was saturated fat. All of the subjects consumed greater than 100% of the RDA of food energy for their age and gender group. However, on the positive side, all the subjects met the RDA for the average daily intake of vitamins and minerals. Nicklas, Webber, Koschak, and Berenson (1992) used data from the Bogalusa Heart Study taking a sample of 871 ten year olds and stratifying them according to four percent fat intakes: <30% of total kilocalories, 30% to 35% kcal, 35% to 40% kcal, and > 40% kcal. Fourteen percent of the sample had fat intakes less than 30%, 49% had a fat intake between 30% and 40% of total calories, and 37% had a fat intake greater then 40% of total calories. The high fat intake group was eating 2400 kcal/d as opposed to 1800kcal/d in the low fat intake group. The percentage of calories from carbohydrate was greater in the low fat intake group. Percentage of calories from protein was approximately 13% for all groups. Percentage of calories from saturated fat was higher in the high fat intake group (18%) than in the low fat intake group (11%). Based on the differences in total caloric intakes, the following comparison of the percentage of the high fat intake group vs the percentage of the low fat intake group not meeting the Recommended Dietary Allowances (RDA's) for the following nutrients was: vitamins B_6 (69% vs 77%), B_{12} (36% vs 70%), and E (23% vs 55%); thiamin (40% vs 58%), riboflavin (25% vs 45%), and niacin (41% vs 64%). A higher percentage of the high fat intake group met the RDA's for certain nutrients versus the low fat intake group indicating the high fat intake group consumed a higher quality diet. A corresponding study by Nicklas, Webber, Srinivasan, and Berenson (1993), also using the Bogalusa Heart Study, reported that over a 15 year period there have been changes in dietary intakes of children. Total energy intakes remained virtually the same from 1973 to 1988. Mean total protein intakes ranged from 67.4g (1981-1982) to 79.8g (1976-1977). No significant trends were reported in mean carbohydrate intakes from 1973-1974 (261.5g) to 1987-1988 (284.9g). However, significant decreases were reported in mean daily fat intake (93.1g to 88.6g), as well as in saturated and unsaturated fatty acid intakes(38.2g to 32.2g, 49.1g to 45.7g respectively). In another study conducted by Albertson, Tobleman, Engstrom, and Asp (1992) nutrient intakes of American children aged 2 to 10 years were compared for a 10 year period from 1978 to 1988.

A unique nutrient assessment system was designed and developed by the Nutrition Department at General Mills. The system integrated data from three sources: 14-day food consumption diaries collected from 4,000 households in the Market Research Corporation of America Menu Census panel surveys; serving-size data from the spring 1977 nationwide Food Consumption Survey; and nutrient data from the Michigan State University Nutrient Data Bank. The results indicated that energy (kcal) and macronutrient intakes remained fairly constant over the 10-year period. However, trends did indicate a decrease in mean protein intake and an increase in mean fat intake over the 10-year period. The mean intake of 11 of the 16 vitamins and minerals decreased from 1978 to 1988. The decreasing intake ranged from a 3% decline in zinc intake to a 17% decrease in average calcium. Mean intakes of vitamin A, riboflavin, vitamin B_{12}, phosphorus, magnesium, and copper also declined more than 10% over the 10-year period. Fifty-percent of the children studied were below 100% of the RDA for calcium and vitamin B_6. Twenty-five percent of the children were below 100% of the RDA for vitamin A and iron intakes. The findings indicated the need for continued monitoring of the impact of changing food consumption patterns on the diets of American children.

Nutrient density (nutrient/1000kcal) has been another area of concern for researchers. In a study by Butterworth et al. (1994), the nutrient density was assessed on 34 women ages 20-40 years. The mean protein intake was 69.8g/1000kcal, carbohydrate was 246g, fat was 91.0g, and cholesterol 272mg. However, nutrient density was not significantly correlated with either physical activity or cardiorespiratory fitness in these subjects. In a similar study by Butterworth et al. (1993), the nutrient density was assessed on 30 women ages 67 to 85 years. The study examined the relationship between moderate exercise training and changes in nutrient intake in the group of 30 women. No significant differences were found in nutrient density between the conditioned versus the sedentary women.

Developmental Aspects

Epidemiological studies have established a list of CVD risk factors in adults which identify individuals who are possibly susceptible to premature development of CVD. These include: family history of heart disease, elevated blood lipids (serum cholesterol and triglycerides), obesity, hypertension, smoking, diabetes mellitus, stress, and inadequate physical activity (American Heart Association, 1988). Since strong evidence now exists that the atherosclerotic process begins in childhood and progresses to adulthood, it can be assumed that these risk factors should be adopted for children as well (Johnson, 1992; Newman et al., 1991). Of all the risk factors, inadequate physical activity or poor fitness level has been found to be the most difficult to measure. The apparent assumption that adequate physical activity leads to higher levels of fitness plays an important role in the measurement of fitness levels.

Physical Activity Levels of Children

There has been some question regarding whether the positive effects of physical activity seen in adults will also occur in children. Several studies have reported that regular physical activity in children does not result in increases in the dimensional and functional components of the cardiovascular system (Mocellin & Wasmund, 1973; Stewart & Gutin, 1976; Yoshida et al., 1980). However, others have reported that regular physical activity in children will produce increases in VO_{2max} (Astrand et al., 1963; Brown, Harrower, & Deeter, 1972; Ekblom, 1969; Kellet et al, 1978; Lussier & Buskirk, 1977; Vaccaro et al., 1980). In a study by Brown et al. (1972), 12 females ages 8 to 13 years were studied before and after 6 and 12 weeks of cross-country running. Eight untrained females served as controls. Oxygen consumption, ventilation, and heart rate were measured during continuous increment treadmill runs to exhaustion prior to training, at 6 weeks, and at 12 weeks. Mean VO_{2max} increased by 18% at 6 weeks and 26% at 12 weeks above pre-training values. In a similar study looking at the effects of cross-country running on males ages 8 to 11 years, 8 elite cross-country runners were found to exhibit a significantly higher VO_{2max} (56.6 ml/kg/min) than that of the non-runners (46.0 ml/kg/min) (Mayers & Gutin, 1979). Swimming has also been found to have positive effects on VO_{2max} in children. A study conducted by Vaccaro and Clarke (1978), found a significant difference in VO_{2max} in 15 children ages 9 to 11 years after beginning a swimming program for 7 months.

<u>Fitness as Measured by Maximal O_2 Uptake</u>

Currently the debate appears to be whether $V0_{2max}$ is an appropriate mechanism by which to measure children's fitness levels. Massicote and Macnab (1974) found an increase in VO_{2max} with training in boys ages 11 to 13 years. Thirty-six boys were tested on a cycle ergometer prior to and following a six week training program. The subjects were ranked according to their VO_{2max}, blocked into three fitness levels and then randomly assigned to one of four treatment groups. Group 1 trained at a heart rate of 170-180 beats/min; Group 2 at 150-160 beats/min; Group 3 at 130-140 beats/min; and Group 4 acted as a control participating in no training. The training sessions were conducted on a cycle ergometer three times per week, 12 min per session. The VO_{2max} of Group 1 increased significantly by the end of the six week program. Boileau, Bonen, Heyward, and Massey (1977) compared the relative merits of the cycle ergometer and the treadmill in assessing the aerobic capacity of children in response to graded exercise. Twenty-one males, age 11 to 14 years participated in the study. Two continuous, progressive load maximal exercise tests (cycle ergometer and treadmill) respectively, were employed to obtain selected measurements of maximal aerobic capacity. Both tests utilizing each form of ergometry were administered to each subject within a four week period with one week between each test. Results indicated the tests on each instrument were reproducible as reflected in the lack of statistically significant differences, and the treadmill test resulted in a higher and/or equivalent correlation coefficient between the two test trials. The study concluded that both forms of ergometry were suitable for the assessment of maximal aerobic capacity, but the treadmill appeared to offer slightly better measurement precision and ease for testing children. Similar results were found in a study by Cunningham, Waterschoot, Patterson, Lefcoe, and Sangal (1977) when assessing the VO_{2max} of 66, 10 year old hockey players. Maximal oxygen uptake was measured twice on a treadmill over a 4 month period during hockey season. The mean VO_{2max} values did not differ between test 1 and test 2 indicating the treadmill to be a reliable method of measuring maximal oxygen uptake in children. The evidence exists that increasing physical activity levels can heighten childrens' fitness levels; and that VO_{2max} is an appropriate measurement tool in assessing children's fitness levels thus indirectly assessing children's physical activity.

Diet and Exercise Interrelationship

Blair et al. (1985) theorized that the adoption of regular exercise resulted in an improvement in the quality of an individual's dietary intake. The literature, however, has failed to associate high fitness levels with improvement in quality of dietary intake. Nieman, Onash and Lee (1990) compared exercise and nonexercise groups of mildly obese sedentary women. Fifteen weeks of moderate exercise consisting of 45 min of brisk walking at 62% VO_{2max} resulted in a significant decrease in the caloric intake of the exercise group (as measured by 3-day diet records), but no significant change in nutritional quality. Kiem, Barbieri, & Belko (1989) reported the effects of exercise on the dietary intake of 12 moderately obese women, aged 21-36 years. Subjects were randomly rotated through three 18 day exercise treatment periods which consisted of no exercise, moderate duration exercise, and long duration exercise. Results indicated that daily aerobic exercise did not affect quantity of energy intake. Energy and carbohydrate intake increased in the last five days of the moderate duration exercise and long duration exercise periods, but were not significant. Butterworth et al. (1993), found no difference in the quantity or quality of nutritional intake of elderly women 67-85 years after 12 weeks of walking 30-40 minutes, 5 days a week at 60% of heart rate reserve. These previously sedentary women increased their VO_{2max}, but did not significantly alter nutritional intake.

While there is no evidence of increased dietary quality with the initiation of exercise, there is evidence of increased nutritional intake and quality at athletic levels of fitness and exercise. Cross sectional studies of athletes compared to sedentary controls revealed that athletes have increased nutritional intakes (Butterworth et al. 1993; Deuster, et al., 1986; Nieman, Butler, Pollet, Dietrich & Lutz, 1989; Pate, Sargent, Baldwin, & Burgess, 1990) and enhanced nutritional quality (Butterworth et al., 1993; Deuster et al., 1986; Nieman et al., 1989; Pate et al., 1990).

Deuster et al. (1986) found highly trained female runners' nutritional intakes were closer to the RDA than the average American female. Three day food records of 291 male and 56 female marathon runners indicated a higher nutritional intake and better nutritional quality than the general population (Nieman et al., 1989). Pate et al. (1990), using 3-day food records on a group of 103 females, reported female recreational runners more closely followed dietary practices recommended by current health authorities in comparison to inactive females of the same age. A comparison between sedentary and highly conditioned elderly women revealed higher quality of nutritional intake in the group of highly conditioned women. The highly conditioned elderly women had higher energy and nutrient intakes, especially when expressed on a weight adjusted basis (Butterworth, Nieman, Perkins, Warren, & Dotson, 1993).

In contrast, Blair et al. (1981) compared 34 male and 27 female long distance runners with 38 male and 42 female sedentary controls and found that although the runners had increased caloric intake, there was no difference in the quality of their nutritional intake. Butterworth et al. (1993) investigated the relationship between cardiorespiratory fitness, activity levels and quality of diet in a group of 34 females, 20-40 years. Activity levels were measured using a Caltrac Personal Activity Computer which estimates 24-hour energy expenditure as a function of basal metabolic rate calculated by age, height, weight, and gender of the subject. Nutrient intakes were measured using 10 repeated 24-hour diet records. The study found no significant correlations. The literature remains inconclusive in regards to higher fitness levels in adults causing a corresponding raise in quality of dietary intake.

Cross sectional studies comparing physically active children to sedentary controls also indicate active individuals eat more calories, but found no difference in quality of nutritional intake (Thorland & Gilliam, 1981; Tremblay, Despres, & Bouchard, 1985).

In summary, the literature suggests that exercise or high levels of physical activity alone will not improve the quality of nutritional intake. Cross sectional studies of highly competitive athletes compared to sedentary controls have revealed increased nutritional intake by the athletes even though results vary on improved nutritional quality. The literature is inconclusive in showing that athletes or active individuals improve their nutritional intake as a result of increased levels of physical activity or fitness levels in adults.

Blood Lipids, Body Fat, and Fitness

Cross-sectional studies have found significant relationships between levels of physical activity and serum lipid and lipoprotein levels among adolescents (Linder & DuRant, 1982). Population based studies of children and adolescents have found significant relationships between body fat percentage and serum lipids and lipoprotein levels (Aristimuno, Foster, Voors, Srinivasan, & Berenson, 1984; Durant et al. 1993; Suter & Hawes, 1992). Obviously all of these CVD risk factors are interrelated and therefore may be additive.

Williams et al. (1992) examined the relationship between percent body fat, serum total cholesterol, and serum lipoprotein ratios in a biracial sample of 3320 children and adolescents ages 5 to 18 years. To determine the critical level of body fat associated with elevated CVD risk factor variables, the males and females were divided into five groups by level of percent fat. Males were divided into the following five fatness groups: <10%, 10% to 14.9%, 15% to 19.9%, 20% to 24.9%, and >25%. Females were grouped by body fat as follows: <20%, 20% to 24.9%, 25% to 29.9%, 30% to 34.9%, and >35%. The percentage of subjects in the uppermost quintile for all CVD risk factor variables was significantly greater in males with >25% fat and females with >30% fat. The >35% fat group of females exhibited an even greater chance of significant CVD risk factors than did the 30% to 34.9% fat group of females. DuRant et al., (1993) examined the relationship among indicators of physical fitness, body composition, and serum lipid and lipoprotein levels in 123 children ages four to five years. The study was based on a one year cohort design, with serum lipid and lipoprotein levels measured at the end of a 1-year period. The children were initially seen at age three to four years. Children were observed for up to four days, with an approximate three month interval between observation days. Cardiovascular fitness was assessed on a treadmill with the children walking at a speed of four kph starting at no grade from two minutes, after which the treadmill grade increased by 5% every two minutes. Heart rate was monitored during the last 15 seconds of each stage. The test was terminated after the fourth exercise stage of two minutes at four kilometers per hour (kph) on a 15% grade unless otherwise necessary. Heart rate was plotted against work stage and extrapolated to the percentage grade of 150 and 170 beats/min. For each child, work load was regressed on heart rate and the slope of the regression line computed. The assumption was that aerobic fitness would be inversely associated with the slope of the line. Using multiple regression analysis, the sum of seven skin-fold measurements was inversely correlated with the high-density lipoprotein (HDL) level. Higher levels of cardiovascular fitness and lower levels of fatness were associated with more favorable serum lipid and lipoprotein levels. Taylor and Baranowski (1991) used a physical working capacity index on a cycle ergometer as a measure of cardiovascular fitness. A physical activity score was computed for each child from a 2-day observation period. The study used 93 high adiposity and 93 low adiposity children ages 8 to 13 years. Low and high adiposity samples were classified by a median split in the sum of three skinfold measures. For the high adiposity sample, the physical activity score was significant in accounting for 38% of the variance in physical working capacity on a cycle ergometer. The study indicated that high adiposity can negatively impact physical working capacity as measured by a cycle ergometer.

In a study conducted by Tell and Vellar (1988) on 431 boys and 397 girls ages 10-15 years, fitness level was found to be inversely related to weight, and tricep skinfold, and positively related to HDL/TC. In females, there was a positive relationship between fitness level and HDL; and a negative relationship to triglycerides (TG). Females with higher levels of VO_{2max} were also associated with favorable blood lipid profiles. In males, there was a negative relationship between fitness level and TC. Adolescents in the lowest quartile of VO_{2max} had higher tricep skinfold measurements. Measurement for this study included self-reported health behaviors, indirect assessment of maximal oxygen uptake by counting students' pulses while they performed on bicycle ergometers, blood pressure, resting pulse rate, height, weight, tricep skinfold thickness, serum total cholesterol, high-density lipoprotein cholesterol, fasting triglycerides, and hematological parameters. The maximal oxygen uptake test was based on the principle that from registration of the workload and heartbeat frequency measured in steady state, VO_{2max} could be estimated by extrapolating to the assumed maximum heart rate. Similar results were found in a study by Kwee and Wilmore (1990) on 399 boys ages 8 to 15 years. The subjects were divided into four groups on the basis of their directly measured VO_{2max}, which was assessed via a treadmill test to exhaustion. Significant differences were found between fitness (VO_{2max}) groups for relative body fat, and plasma triglycerides, with the higher fitness groups exhibiting lower values. No significant differences between groups were found for TC, HDL-C, or LDL-C. However, there was a significant inverse relationship with triglycerides and fitness levels (r=-.20), with lower values in the above average and high fitness categories in comparison to the below average fitness category. In another study, Kemper, Verschuur, Snel, and Essen (1990) reported significant differences between fitness (VO_{2max}) and TC levels. This study, known as the Amsterdam Growth and Health Study, used a population of 93 males and 107 females measured annually from 1977 to 1980 with a fifth measurement made in 1985. Ages ranged from 13 to 21 years of age. Four skinfolds (biceps, triceps, subscapular, and suprailliac) were used to assess body composition. VO_{2max} was measured directly during a standard running test on a treadmill with a constant speed (8kph) and increasing slope until exhaustion. Blood sampling and serum preparations were done with subjects in a fasting state. Males and females with a high percentage body of fat and a low VO_{2max} showed significantly higher TC, LDL-C, and high TC/HDL-C levels.

Diet, Body Fat, Blood Lipids, and Fitness

High-fat, high-cholesterol diets have long been associated with increased obesity and unfavorable blood lipid profiles in adults (Dreon et al. 1988; Tucker & Kano, 1992). These same effects appear to carry over to children as well. However, very few studies have examined the effects of the interrelationships between diet, body fat, blood lipid profiles, and fitness levels in children. Accordingly, an increasing interest in the effects of all of these variables has been observed noting the evidence that CVD risk factors can originate in childhood and can be additive in nature.

Suter and Hawes (1993) hypothesized that a higher physical activity pattern would be related to a more favorable CVD risk factor profile in youths. They studied 97 children aged between 10 and 15 years. Physical activity of each subject was obtained using a 7-day recall that contained a list of 23 popular activities with provision for adding more unusual activities. Duration and nature of activities was recorded so metabolic equivalents could be used to appropriately classify activity. A submaximal test using a bicycle ergometer was conducted to predict the level of cardiovascular fitness. Food intake characteristics were determined from analysis of 3-day food records. Venous blood samples were drawn the morning after an overnight (12-14 h) fast. The sum of 10 skinfolds was calculated as an indicator of subcutaneous adipose deposition. The results indicated a higher sum of skinfolds was associated with a higher TC/HDL-C ratio in boys and with lower concentrations of HDL-C. A higher physical activity index was significantly related to a higher HDL-C level in both boys and girls. A higher physical activity index was also associated with a lower ratio of TC/HDL-C and lower levels of TG and VLDL-C in boys. No significant relationship was found between cardiovascular fitness as measured by a submaximal cycle ergometer test, and any of the lipid concentrations. Intake of both saturated fats and dietary cholesterol exhibited a positive correlation to the level of total cholesterol in boys. Sum of skinfolds was inversely related to physical activity in girls and to cardiovascular fitness in boys and girls. Physical activity was directly related to cardiovascular fitness (VO_{2max}) in boys but not in girls.

In adults, dietary fat intake has been associated with obesity without excessive energy consumption. However, in adults the relationship may be a function of age, cigarette smoking, past and/or present involvement in physical activity, intake of other macronutrients, or similar factors (Tucker & Kano, 1992). Tucker and Kano (1992) examined the association between diet composition, particularly dietary fat intake, and body fat percentage in 205 adult females. Diet questionnaires were completed by each subject and were analyzed via Dietanal software program. Adiposity was assessed using two-site skinfold-thickness measurements (triceps, suprailliam). The results indicated a direct relationship between body fat percentage and total energy intake, grams of fat, carbohydrate, and protein consumed, and percent of total energy intake from fat. Fat intake was a significant predictor of body fat percentage, accounting for 6.3% of the variance in the measure of adiposity. Percent of total energy from fat (%fat) was also significantly related to percent body fat. It was concluded, with no variables controlled, that obese females consumed significantly more total energy and more grams of fat and protein than did those in the moderate or lean groups. Obese subjects also reported a significantly greater intake of grams of carbohydrate than did the moderately fat group. Percent of total energy from fat was significantly less among the lean females than in obese females, and percent of total energy intake from carbohydrate was significantly greater among the lean subjects than in the other two groups.

A similar study by Miller, Linderman, Wallace, and Neiderpruem (1990) examined the relationships among body fat, diet composition, energy intake, and exercise in adults. Subjects included 107 males and 109 females ages 18-71 years. Percent body fat was calculated using hydrotensiometry techniques. Dietary recall was performed for the 24 h period prior to testing and then a 2-d food diary was used to record all food and beverage intake over one additional weekday and one weekend day. The results revealed that adiposity was positively related to dietary fat content and inversely related to dietary carbohydrate consumption for both genders. Nevertheless, the most significant finding was that diet content rather than energy consumption was characteristic of increased adiposity for both male and female adults. These results support other studies indicating that dietary fat rather than total energy consumption leads to obesity. Dreon et al. (1988) studied the nutrient intakes from 7-d diet records and compared those with hydrostatically determined body composition in 155 sedentary obese men aged 30-59 years. Seven-day food records were completed by each participant. Fitness level was determined by all subjects performing a graded exercise test to exhaustion. Body density was determined by hydrostatic weighing. The study found that percent body fat correlated significantly and positively with total fat, saturated fatty acids, and monounsaturated fatty acids when expressed as g/1000 kcal. Plant protein, total carbohydrate, and fiber as g/d and other carbohydrate consumption as g/1000 kcal were negatively correlated with percent body fat. These results support the findings of the previously mentioned studies. Romieu et al. (1988) conducted a study encompassing 194 female participants aged 34-59 years. Seven-day food records were completed by all participants. Nutrient intake from the diet records was computed using the University of Massachusetts data-base system. Quetelet index (wt/ht^2) was calculated from self reported weights and heights. The study found obese women reported higher intakes of total fat, and relative weight was significantly correlated with intakes of total fat ($r=0.20$) and saturated fatty acids ($r=0.16$).

The impending question remains whether or not these same findings hold true in children and preadolescents. Gazzaniga and Burns (1993) found body fat percentage correlated positively with intakes of total fat, saturated, monounsaturated, and polyunsaturated fatty acids; and correlated negatively with carbohydrate intake and total energy intake adjusted for body weight in 48 children ages 9-11 years. Each subject had height, weight, tricep and subscapular skinfold thickness, and resting energy expenditure measured, and was educated about the dietary and physical-activity recalls. Dietary and physical-activity recalls were taken by telephone on three consecutive evenings after the initial education. The researchers concluded the most significant finding from this study was that diet composition and not excess energy consumption was characteristic of increased adiposity in the children studied. These results juxtapose previous results and conclusions in similar studies on adult populations.

Summary

Research clearly solidifies the relationships between diet, blood lipids, body fat, and fitness levels. All of these variables appear to be interrelated. Diet plays a key role in the control of blood lipid levels and body fat deposition. As dietary quality improves, especially a decrease in the intake of fat and cholesterol, both blood lipid levels and body fat decrease. The literature also suggested that dietary quality may improve as an individual becomes more physically active and their fitness levels improve. However, the literature failed to consistently report such effects in adults. There is no known literature on increasing fitness levels and increasing dietary quality on children and adolescents.

The literature clearly defines the relationship between blood lipid profiles, body fat, and fitness levels. As physical activity increases and fitness levels improve, in both adults and children, measurable improvements can be found in both blood lipid profiles and body composition.

CHAPTER 3

Methods

Research Design

The purposes of this study were to determine the relationship of dietary intake to selected cardiovascular disease risk factors and to compare both quantity and quality of dietary intake between highly fit and low fit children. It was hypothesized that a relationship would exist between quality of dietary intake to blood lipid profile, body fat percentage, and fitness; and that no difference would exist in quantity and quality of dietary intake between highly fit and low fit children.

Subjects

One hundred four children ages 8 to 11 years (mean age = 9.2 ± 0.1 yr) from Granite Falls Elementary School, Granite Falls, NC volunteered to participate in the study . Since a true randomized design was impossible, there were concerns regarding the distribution of subjects across all fitness levels in the volunteer group. The President's Fitness Challenge test, a battery of physical fitness parameters, had previously been administered to 84% of the subjects in the volunteer group. Results from the mile run, a cardiovascular fitness parameter, indicated a fairly even distribution across low to high aerobically fit groups. Low, moderate and high aerobically fit groups were catagorized by: < 33%, 33-67%, and > 67% of national norms respectively. Table 1 represents the President's Challenge performance results.

Table 1.

President's Challenge Performance Groups

Variable	Low group #/%	Moderate group #/%	High group #/%
Pull-Up	53/60.9	15/17.2	19/21.8
Sit-Up	11/12.6	31/35.6	45/51.7
Shuttle Run	27/31.0	41/47.1	19/21.9
Mile Run	35/40.2	30/34.5	22/25.3
Sit/Reach	30/34.5	29/33.3	28/32.2

Subjects voluntarily signed an informed consent statement approved by the University Institutional Review Board for Human Studies and received parental permission prior to testing (Appendix A). Subjects completed a medical/health questionnaire and were screened by a physician before participating in the study. Subjects were tested on site at Granite Falls Elementary School.

Testing Procedures

Measurement of Body Composition. Weight was measured to the nearest .25 lb on a physician's balance beam scale.

Height was measured to the nearest .25 in with a calibrated stadiometer. Measurements were made wearing recreational clothing and without shoes.

All skinfold measurements were taken on the right side of the body with Lange skinfold calipers. Skinfolds were taken using the technique of Pollock, Schmidt and Jackson (1980) at the following sites: subscapular, chest, suprailliac, midaxillary, abdomen, thigh, calf, and triceps. The subscapular skinfold was an angular fold taken at a 45-degree angle 1-2 cm below the inferior angle of the scapula. The chest skinfold was a diagonal fold taken one third of the distance between the anterior axillary line and the nipple. The suprailliac skinfold was on oblique fold taken in line with the natural angle of the iliac crest taken in the anterior axillary line immediately superior to the iliac crest. The midaxillary skinfold was a horizontal fold taken on the midaxillary line at the level of the xiphoid process of the sternum. The abdominal skinfold was a horizontal fold taken at a distance of 2 cm to the right side of the umbilicus. The thigh skinfold was a vertical fold taken on the anterior midline of the thigh, midway between the proximal border of the patella and the inguinal crease. The calf skinfold was a vertical fold taken at the level of the maximum circumference of the calf on the midline of its medial border. The triceps skinfold was a vertical fold taken on the posterior midline of the upper arm, halfway between the acromion and the olecranon processes, with the arm held freely to the side of the body. All measurements were taken by the same experienced technician. Three measurements were taken at each site and the average used to determine body density. A 2-site (triceps and calf) formula developed by Slaughter et al. (1988) was used to calculate body composition:

% Fat = $0.735 * \Sigma SF + 1.0$ Males, all ages

% Fat = $0.610 * \Sigma SF + 5.0$ Females, all ages

Blood Lipids. Blood was drawn in a fasted state via an antecubital vein by phlebotomists experienced in venipuncture on children. Collection and handling of blood samples were performed following the CDC lipid standardization guidelines (Cooper, et al., 1988). Blood was collected into serum separator vacutainers, allowed to clot at room temperature for 30 min and then centrifuged for 15 min at 5,000 rpm. The serum was then transferred to cryogenic vials and frozen at -80°C for later analysis. All serum samples were analyzed at Watauga Medical Center Chemistry Laboratory (WMC).

Watauga Medical Center Analysis

Serum samples were transported to WMC where immediate processing occurred. Samples were thawed under refrigeration, vortexed for 5 to 10 s at 900 rpm and analyzed for Triglycerides (TG), Total Cholesterol (TC), High Density Lipoprotein Cholesterol (HDL-C), Low Density Lipoprotein

Cholesterol (LDL-C), and Very Low Density Cholesterol (VLDL-C) within 7 hours using Abbott Spectrum (Irving, TX) processing procedures. This involved enzymatic procedures for all lipid measurements including TC, TG, and cholesterol content of HDL-C after precipitation procedures were used for lipoprotein separation. Quality control was run upon completion of the lipid processing. Values for LDL-C were calculated as follows: LDL-C = TC - [HDL-C +(0.16 x TG)] (DeLong, DeLong, & Wood, 1986).

Maximal Exercise Test. Subjects performed a maximal graded exercise treadmill test using automated cardiorespiratory monitoring techniques (MMC Horizon System Exercise Evaluation Cart, SensorMedics, Yorba Linda, CA). Resting heart rate (RHR) was taken with the subject seated following a 10 min rest. Following the protocol developed by Kwee & Wilmore (1990), subjects performed a graded exercise test with velocity and grade increasing every minute until the subject reached volitional exhaustion. Heart rate was measured by a Polar Pacer electronic heart rate monitor (Polar USA, Inc, Stamford, CT) and recorded every min. Continuous measurements of VO_2, expired ventilation (VE) and respiratory exchange ratio (RER) were made and recorded at the end of each stage and at the point of test termination. The test was terminated when the subject was unable to continue despite verbal encouragement from the testing staff. Subjects were given an additional incentive (candy) for reaching a maximal exercise HR above 200 bpm. Maximal exercise performance was defined as an RER above 1.1, a maximal HR within one standard deviation (±12bpm) of age predicted values (220-age), and an inability of the subject to continue (McMiken and Daniels, 1976). Subjects walked at stage 1 velocity for recovery until their HR returned to 110 bpm.

Dietary Records. Subjects were instructed to complete a 5-day dietary record including 1 weekend day and 4 weekdays. Subjects were carefully instructed in a 25-30 min overview on how to measure serving size and to accurately record each food item on the dietary record sheet. Each morning before school, records of the previous day were collected by an investigator who also verbally repeated directions on how to appropriately record food intake, and a new sheet was distributed to all subjects participating in the study. The investigator then reviewed the collected dietary records and returned inappropriate or incomplete records to the subjects before the end of that school day. Subjects receiving returned dietary records were informed of recording inaccuracies and were individually shown how to record adequate food intakes. After completion of the dietary records, analysis of nutrient composition was conducted using the Food Processor II software program (version 5.03, 1993) (ESHA Research, Salem, Oregon) which contains nutrient composition data on 2,400 foods and analyzes for 30 food components. Food intakes were analyzed for nutrient density [nutrient/(total energy intake/1000)], percent energy from carbohydrate, fat, and protein; dietary fiber(g), dietary cholesterol(mg), and dietary sodium(mg); and percentage of the Recommended Dietary Allowances (RDA) of vitamins and minerals.

Statistical Analysis

Statistical analyses were performed using the Statistical Analysis System (SAS), Cary, NC. Significance was set at 0.05. Relationships were determined between diet and fitness, blood lipid values, and body composition utilizing the Pearson Product Moment Correlation procedures. Correlations included VO_{2max}, percent body fat, triglycerides, TC, HDL-C, LDL-C, VLDL-C, nutrient density [nutrient/(total energy intake/1000)], and percent energy from fat, carbohydrate, and protein. Subjects were then divided into high aerobically fit and low aerobically fit, by taking the subjects who fell 0.25 standard deviations above and below the mean VO_{2max} results of all subjects tested. A 2 X 2 factoral analysis of variance was then utilized to find any differences among dietary measures between the high and low fit groups. Results were expressed as mean ± SEM.

Chapter 4

Results

Subjects

All 104 subjects were measured for body composition, body mass index (BMI), blood lipid profile and completed a maximal exercise test. Sixty-five of those subjects completed at least a 3-day dietary record which included two weekdays and one weekend day. Not all children completed the requested 5-day records and some records were eliminated due to inaccuracies and insufficient descriptions of food intake. Age ranged from 8 to 11 years, height from 115.6 cm to 152.37 cm, weight from 18.2 kg to 65.5 kg, body fat from 6.2% to 29.1%, and BMI from 15.0 kg/m^2 to 39.0 kg/m^2. Descriptive data (mean ± SEM) of subjects are presented in Table 2.

Table 2.

Descriptive Group Data, Means ± SEM (n=104)

Variable	Mean ± SEM
Age (yr)	9.0 ± 0.1
Height (cm)	133.1 ± 19.0
Weight (kg)	35.7 ± 0.80
Body Fat (%)	20.6 ± 8.0
BMI (kg/m^2)	18.7 ± 0.3

Maximal Exercise Test

Descriptive maximal exercise test data (mean ± SEM) for all subjects are presented in Table 3. Maximal oxygen uptake (VO_{2max}) ranged from 30.5 ml·kg^{-1}·min^{-1} to

69.4 $ml \cdot kg^{-1} \cdot min^{-1}$.

Table 3.

Maximal VO_2 Group Data, Means ± SEM, Range(n=104)

Variable	Mean ± SEM	Range
VO_2 ($ml \cdot kg^{-1} \cdot min^{-1}$)	49.8 ± 0.9	30.5 - 69.4
RER	1.1 ± 0.01	0.96 - 1.28
VE (l/min)	66.2 ± 1.2	36.7 - 96.0
MHR (bpm)	204.3 ± 1.0	165.0 - 218.0
Time on Treadmill (min)	6.1 ± 0.2	3.9 - 10.6

Blood Lipids

Descriptive blood lipid data (mean ± SEM) are presented in Table 4. Total cholesterol levels ranged from 99 mg/dl to 272 mg/dl, triglycerides from 37 mg/dl to 319 mg/dl, VLDL from 7 mg/dl to 64 mg/dl, LDL from 55 mg/dl to 172 mg/dl, HDL from 26 mg/dl to 73 mg/dl, and TC/HDL ratio from 1.9 to 7.8.

Table 4.

Blood Lipid Group Data, Means ± SEM, Range(n=104)

Lipid Variable (mg/dl)	Mean ± SEM	Range
Total Cholesterol	164.5 ± 2.7	99 - 272
Triglycerides	95.0 ± 5.0	37 - 319
Very Low Density Lipoprotein	19.1 ± 1.0	7 - 64
Low Density Lipoprotein	100.0 ± 2.4	55 - 172
High Density Lipoprotein	45.7 ± 1.0	26 - 73
TC/HDL Ratio	3.8 ± 0.1	1.9 - 7.8

Dietary Quantity

Sixty-five children completed at least a 3-day diet record. Total kilocalories ranged from 844 to 4206, protein(g): 29.5 - 139, carbohydrate(g): 116 - 591, fat(g): 29.7 - 150, dietary fiber(g): 5.0 - 34.4, dietary cholesterol(mg): 41.6 - 676.0, saturated fat(g): 11.7 - 60.3, monounsaturated fat(g): 10.3 - 65.8, and polyunsaturated fat(g): 3.8 - 30.0. Descriptive dietary quantity data (mean ± SEM) are presented in Table 5.

Table 5.

Group Dietary Quantity, Means ± SEM, Range(n=65)

Nutrient	Mean ± SEM	Range
Kilocalories ($kcal \cdot d^{-1}$)	1931 ± 54	844 - 4206
Protein (g)	70.0 ± 2.1	29.5 - 139
Carbohydrate (g)	251.4 ± 8.0	116 - 591
Fat (g)	75.2 ± 2.5	29.7 - 150
Dietary Fiber (g)	12.1 ± 0.5	5.0 - 34.4
Dietary Cholesterol (mg)	239.1 ± 11.9	41.6 - 676
Saturated Fat (g)	28.7 ± 0.9	11.7 - 64.3
Polyunsaturated Fat (g)	12.4 ± 0.6	3.8 - 30
Monounsaturated Fat (g)	28.2 ± 1.0	10.3 - 65.8

Table 5 (continued)

Vitamin A (RE)	957.1 ± 67.4	196 - 3843
Vitamin C (mg)	84.9 ± 5.0	14.1 - 267
Vitamin D (ug)	4.7 ± 0.3	0.83 - 13.5
Vitamin E (mg)	5.1 ± 0.2	1.1 - 12.1
Vitamin K (ug)	16.4 ± 1.4	2.4 - 77.2
Thiamin (mg)	1.6 ± 0.6	0.8 - 5.3
Riboflavin (mg)	2.0 ± 0.1	1.0 - 6.7
Niacin (mg)	21.3 ± 0.9	11.8 - 76.1
Vitamin B-6 (mg)	1.6 ± 0.1	0.7 - 6.5
Vitamin B-12 (ug)	4.7 ± 0.3	1.7 - 17.4
Folate (ug)	260.9 ± 14.3	100 - 1261
Calcium (mg)	853.1 ± 33.7	453 - 2038
Phosphorus (mg)	1240.2 ± 44.9	663 - 2755
Magnesium (mg)	221.8 ± 13.3	129 - 504
Iron (mg)	13.5 ± 1.1	6.6 - 62
Zinc (mg)	9.7 ± 0.7	4.7 - 12.6
Sodium (mg)	3000.6 ± 75.0	1782 - 5211
Potassium (mg)	2192.6 ± 56.9	1086 - 4000
Copper (mg)	1.1 ± 0.03	0.6 - 2.5

Dietary Quality

Descriptive dietary quality as expressed as nutrient/kg body weight and as a percentage of caloric intake from carbohydrate, protein, and fat data (mean ± SEM) are presented in Table 6.

Table 6.

Group Dietary Quality, Means ± SEM, Range(n=65)

Nutrient	Mean ± SEM	Range
Kilocalories/kg	57.3 ± 1.6	39.7 - 74.1
Protein(g)/kg	2.1 ± 0.7	0.8 - 4.1
Carbohydrate(g)/kg	7.1 ± 0.4	1.4 - 18.7
Fat(g)/kg	2.2 ± 0.1	0.7 - 4.6
% Protein	14.6 ± 0.7	9.1 - 18.4
% Carbohydrate	50.7 ± 1.3	39.6 - 60.2
% Fat	34.6 ± 1.0	18.3 - 41.8

Dietary Intake and the Recommended Dietary Allowances

Table 7 includes the frequency and percentage of children who were above at least 66% of the Recommended Dietary Allowances.

Table 7.

Frequency and Percentage of Children Meeting At Least 66% of the Recommended Dietary Allowances For Their Age Group.

Nutrient	Frequency/%
Protein(g)	58/64.4
Vitamin A(RE)	47/52.2
Vitamin C(mg)	48/53.3
Vitamin D(ug)	10/11.1
Vitamin E(mg)	31/34.4
Vitamin K(ug)	13/14.4
Thiamin(mg)	58/64.4
Riboflavin(mg)	58/64.4
Niacin(mg)	58/64.4
Vitamin B6(mg)	49/54.4
Vitamin B12(ug)	58/64.4
Folate(ug)	58/64.4
Calcium(mg)	48/53.3
Phosphorus(mg)	58/64.4
Magnesium(mg)	56/62.2
Iron(mg)	55/61.1
Zinc(mg)	50/55.6

* Percentages based on Recommended Dietary Allowances (RDA) 1989.

Relationship of Dietary Intake to Blood Lipid Profiles

There was a significant positive relationship between protein intake(g) and HDL-C levels ($r=.38$, $p<0.05$). A significant negative relationship was also found between protein (g) and TC/HDL ratio ($r=-.26$, $p<0.05$). There was no significant relationship between dietary fat (g), polyunsaturated fat (g), monounsaturated fat (g), dietary fiber (g), and dietary cholesterol (mg) to any of the blood lipid profiles measured. A significant positive relationship was found between kcal/kg and HDL-C ($r=.30$, $p<0.05$) and a negative relationship between kcal/kg and TC/HDL ratio ($r=-.29$, $p<0.05$). There was a significant negative relationship between protein/kg and triglyceride level ($r=-.24$, $p<0.05$), LDL-C ($r=-.24$, $p<0.05$), and TC/HDL ratio ($r=-.38$, $p<0.05$), and a significant positive relationship with HDL-C ($r=.46$, ($p<0.05$). Fat/kg, and percent of total caloric intake from protein were found to have a significant positive relationship with HDL-C levels ($r=.30$ and $r=.26$, respectively) and percent of total caloric intake from carbohydrate was found to have a negative relationship with HDL-C ($r=-.27$, $p<0.05$). A negative relationship was also found between carbohydrate/kg and fat/kg with TC/HDL ratio ($r=-.24$, $r=-.27$ respectively ($p<0.05$). No significant relationship was found between percent of total caloric intake from fat and any of the blood lipid profiles. Tables

8 represents the r values for dietary intake of selected nutrients and their relationship to blood lipid profiles.

Table 8.

Correlational Values for Dietary Intake of Selected Nutrients and Their Relationship to Total Cholesterol, Triglycerides, VLDL, LDL, HDL, and TC/HDL Ratio (n=65)

Nutrient	TC	Triglycerides	VLDL	LDL	HDL	Ratio
Kilocalories	-0.05	-0.04	-0.05	-0.12	0.12	-0.15
Carbohydrate (g)	-0.07	0.02	0.02	-0.12	0.08	-0.07
Protein (g)	-0.02	-0.14	-0.14	-0.12	0.38*	-0.26*
Fat (g)	-0.04	-0.08	-0.08	-0.09	0.21	-0.16
Saturated Fat (g)	-0.06	-0.08	-0.08	-0.14	0.24	-0.19
Polyunsaturated Fat (g)	-0.04	-0.002	-0.003	-0.09	0.14	-0.09
Monounsaturated Fat (g)	-0.02	-0.09	-0.08	-0.06	0.19	-0.14
Dietary Fiber (g)	-0.15	-0.08	-0.08	-0.21	0.21	-0.18
Dietary Cholesterol (mg)	-0.01	-0.07	-0.08	-0.05	0.16	-0.13
Kcal/kg	-0.18	-0.14	-0.14	-0.26	0.30*	-0.29*
Protein/kg	-0.14	-0.24*	-0.24	-0.24*	0.46*	-0.38*
Carbohydrate/kg	-0.11	-0.15	-0.15	-0.15	0.25	-0.24*
Fat/kg	-0.14	-0.15	-0.15	-0.21	0.30*	-0.27*

Table 8 (continued)

% Protein	0.05	-0.09	-0.08	-0.02	0.26*	-0.15
% Carbohydrate	-0.03	-0.13	-0.13	0.02	-0.27*	0.21
% Fat	-0.02	-0.14	-0.14	-0.05	0.20	-0.21

* denotes significance at $\underline{p} \leq 0.05$

Relationship of Dietary Intakes to VO_2, % Body Fat, and BMI

There were no significant relationships found between VO_{2max} and polyunsaturated fat, dietary cholesterol, percentage of total calories from protein, carbohydrate, and fat. However, there were significant positive relationships found between VO_{2max} and total kilocalories, protein(g), carbohydrate(g), fat(g), saturated fat(g), monounsaturated fat(g), dietary fiber, kilocalories/kg, protein/kg, carbohydrate/kg, and fat/kg. No significant relationships were found between % body fat and carbohydrate (g), fat (g), saturated fat (g), monounsaturated fat (g), dietary cholesterol (mg), percentage of total calories from protein, fat, or carbohydrate. Significant negative relationships were found between % body fat and total kilocalories, protein(g), polyunsaturated fat(g), dietary fiber, kilocalories/kg, protein/kg, carbohydrate/kg, and fat/kg. A significant negative relationship was found between BMI and kcal/kg, protein/kg, carbohydrate/kg and fat/kg ($p<0.05$). Correlational values for dietary intake and VO_2, % body fat, and BMI are presented in Table 9.

Table 9.

Correlational Values for Dietary Intake of Selected Nutrients and Their Relationship to VO_2, Body Fat %, and BMI (n=65)

Nutrient	VO_2	Body Fat %	BMI
Kilocalories	0.37*	-0.19*	-0.05
Protein (g)	0.31*	-0.23*	-0.01
Carbohydrate (g)	0.31*	-0.17	-0.06
Fat (g)	0.31*	-0.14	-0.02
Saturated Fat (g)	0.35*	0.14	0.03
Polyunsaturated Fat (g)	0.21	-0.21*	-0.15
Monounsaturated Fat (g)	0.27*	0.11	-0.02
Dietary Fiber (g)	0.35*	-0.27*	-0.02
Dietary Cholesterol (mg)	0.18	-0.07	0.10
Kcal/kg	0.48*	-0.36*	-0.53*
Protein/kg	0.39*	-0.40*	-0.51*
Carbohydrate/kg	0.29*	-0.23*	-0.26*
Fat/kg	0.48*	-0.28*	-0.46*
% Protein	-0.05	-0.09	0.01
% Carbohydrate	0.04	-0.09	-0.06
% Fat	-0.01	0.05	-0.08

* denotes significance at $p \leq 0.05$

High Fit Group versus Low Fit Group

The high fit group was defined as all subjects that were 0.25 standard deviations above the mean for all subjects participating in the VO_{2max} test. The low fit group was defined as all subjects that were 0.25 standard deviations below the mean of all subjects participating in the VO_{2max} test. Of the 104 total subjects, 36 fell within the specified criteria for the low fit group and 37 fell within the specified criteria for the high fit group.

Subjects

Subjects were divided into low fit and high fit groups to determine if fitness was related to dietary quantity and dietary quality. VO_{2max} ($ml \cdot kg^{-1} \cdot min$-1) for the low fit and high fit groups ranged from 30.5 to 52.5, and 49.4 to 69.4 respectively. There was a significant difference ($p<0.0001$) between VO_{2max} values, age, height (cm), weight (kg), % body fat, and BMI of the low fit and high fit groups. Descriptive low fit and high fit group data (mean ± SEM) are presented in Table 10.

Table 10.

High Fit and Low Fit Descriptive Group Data,

Means ± SEM (n=104)

Subject Characteristics	Low Fit n =36	High Fit n = 37	p value
Age	8.9 ± 0.2	9.3 ± 0.1	0.0001
Height (cm)	169.3 ± 31.8	157.5 ± 1.2	0.0001
Weight (kg)	37.8 ± 1.1	31.8 ± 0.6	0.0001
Body Fat %	23.0 ± 0.6	17.5 ± 0.6	0.0001
BMI (kg/m^2)	19.5 ± 0.5	16.7 ± 0.1	0.0001
VO_{2max} ml/kg/min	41.3 ± 0.8	57.6 ± 0.9	0.0001

Dietary Quantity

Low Fit Group versus High Fit Group

There was a significant difference between the low fit group and high fit group when comparing intake of total kilocalories ($p<0.05$)and monounsaturated fat(g) ($p<0.05$). No significant differences were found in other nutrient values. Table 11 summarizes the mean ± SEM for dietary quantity and the low fit versus the high fit group ($p<0.05$).

Table 11.

Mean Dietary Quantity of the Low Fit and High Fit Groups, Mean ± SEM (n=65)

Nutrient	Low-Fit	High-Fit	p-value
Kilocalories	1853 ± 63	2103 ± 127	0.05*
Protein (g)	67.5 ± 2.4	73.8 ± 4.7	0.24
Carbohydrate (g)	241.6 ± 10.0	273.1 ± 18.1	0.10
Fat (g)	71.9 ± 2.9	83.3 ± 5.7	0.08
Dietary Fiber (g)	11.5 ± 0.7	13.2 ± 1.1	0.16
Dietary Cholesterol (mg)	240.2 ± 16.3	226.2 ± 20.8	0.61
Saturated Fat (g)	28.0 ± 1.1	30.9 ± 2.1	0.21
Polyunsaturated Fat (g)	11.7 ± 0.7	14.2 ± 1.2	0.06
Monounsaturated Fat (g)	26.5 ± 1.1	32.0 ± 2.4	0.04*
Vitamin A (RE)	918.6 ± 86.8	1055.5 ± 152.1	0.40
Vitamin C (mg)	83.2 ± 6.5	90.6± 9.9	0.52
Vitamin D (ug)	4.5 ± 0.4	5.0 ± 0.7	0.51
Vitamin E (mg)	4.8 ± 0.3	5.6 ± 0.5	0.14
Vitamin K (ug)	16.3 ± 2.0	15.9 ± 2.5	0.90

Table 11 (continued)

Thiamin (mg)	1.5 ± 0.5	1.8 ± 0.2	0.09
Riboflavin (mg)	1.9 ± 0.7	2.2 ± 0.2	0.22
Niacin (mg)	19.7 ± 0.9	24.3 ± 2.3	0.08
Vitamin B-6 (mg)	1.5 ± 0.1	1.8± 0.2	0.11
Vitamin B-12 (ug)	4.6 ± 0.3	4.9 ± 0.7	0.64
Folate (ug)	239.2 ± 13.2	295.6 ± 38.9	0.17
Calcium (mg)	830.2 ± 39.5	893.6 ± 79.6	0.48
Phosphorus (mg)	1200.2 ± 45.1	1309.4 ± 91.8	0.29
Magnesium (mg)	209.1 ± 8.3	247.0 ± 16.6	0.06
Iron (mg)	12.7 ± 0.6	15.6 ± 1.9	0.15
Zinc (mg)	9.5 ± 0.4	10.4 ± 1.0	0.28
Sodium (mg)	2865.3 ± 101.9	3322.9 ± 190.3	0.08
Potassium (mg)	2102.5 ± 80.3	2363.2 ± 141.2	0.08
Copper (mg)	1.0 ± 0.04	1.2 ± 0.1	0.06

* denotes significance at $\underline{p} \leq 0.05$

Dietary Quality

A significant difference ($p<0.05$) was found between both the low and high fit groups and kcal/kg, carbohydrate/kg, protein/kg and fat/kg. Table 12 represents the mean ± SEM for dietary quality and the high fit and low fit groups.

Table 12.

Difference in Dietary Quality of High Fit and Low Fit Groups, Mean ± SEM (n=65)

Nutrient	Low Fit	High Fit	p-value
% Protein	14.8 ± 0.4	14.1 ± 0.5	0.27
% Carbohydrate	50.6 ± 0.9	51.1 ± 1.2	0.78
% Fat	34.5 ± 0.6	34.9 ± 1.1	0.75
Kcal/kg	53.4 ± 2.7	65.3 ± 3.6	0.01*
Protein/kg	1.9 ± 0.1	2.3 ± 0.1	0.03*
Carbohydrate/kg	6.9 ± 0.5	8.5 ± 0.6	0.03*
Fat/kg	2.1 ± 0.1	2.6 ±0.2	0.01*

* denotes significance at $p \leq 0.05$

CHAPTER 5

Discussion

This study examined the relationship of dietary intake to selected cardiovascular disease risk factors and compared both quantity and quality of dietary intake between highly fit and low fit children. Five major findings resulted from this investigation:

1) significant positive relationships were found between HDL-C and protein(g), kcal/kg, pro/kg, fat/kg, and percentage of total calories from protein; significant negative relationships were found between TC/HDL ratio and protein(g), kcal/kg, protein/kg, carbohydrate/kg, and fat/kg; significant negative relationships were also found between triglycerides and protein/kg, LDL-C and protein/kg, HDL-C and percentage of total calories from carbohydrate;
2) significant negative relationships were found between % body fat and total calories, protein(g), polyunsaturated fat(g), dietary fiber(g), kcal/kg, protein/kg, carbohydrate/kg, and fat/kg;
3) significant positive relationships were found between VO_{2max} and total calories, protein(g), carbohydrate(g), fat(g), saturated fat(g), monounsaturated fat(g),

dietary fiber(g), kcal/kg, and protein/kg;

4) significant differences were found when comparing total calories and monunsaturated fat(g) intake between highly fit and low fit children;

5) significant differences were found in the quality of dietary intake when comparing kcal/kg, protein/kg, carbohydrate/kg, and fat/kg between highly fit and low fit children.

Dietary Quality and Blood Lipid Profile

Several studies have examined the relationship of dietary intake to blood lipid profiles in children, especially total cholesterol (Suter & Hawes, 1992; Vaccaro and Mahon, 1989; Wynder et al., 1989). Suter and Hawes (1992) found that dietary intake of both saturated fats and dietary cholesterol exhibited a positive relationship to total cholesterol levels in boys ages 10 to 15 years. In a similar study by Wynder et al. (1989) on 305 children ages 6 to 10 years, dietary saturated fat and cholesterol were found to be a major environmental cause of hypercholesterolemia. However, the results of this study showed no significant relationship between dietary fat intake and total cholesterol levels. This may be attributed to inaccurate assessments of dietary intake especially by Wynder et al. (1989) who used only 24-hour recalls as a basis for dietary intake. This may also be contributed to the fact that all the significant relationships established in this study were weak relationships; and although no significant correlation was found between dietary intake and total cholesterol levels, a positive relationship did exist although not significant.

Some investigators have suggested that the ratio of HDL-C and TC may be a more important determinant of the risks of developing CAD than TC, LDL, or HDL-C cholesterol levels utilized as independent predictors (Adner & Castelli, 1980; Durant et al., 1983). DuRant et al. (1992) using 123 4-5 year olds found a stronger relationship between TC/HDL-C ratio to the CAD risk factor of obesity than TC levels as an independent determinant. Adner and Castelli (1980) also found TC/HDL-C ratio to exhibit a stronger relationship to obesity in men ages 36-45. The fact that carbohydrate/kg and protein/kg were found to exhibit a significant negative relationship to TC/HDL-C ratio may indicate that by increasing daily intake of carbohydrate/kg and protein/kg, fat intake will be lowered enough to have a positive effect on the TC/HDL-C ratio. However, this study found no significant relationship between fat/kg and TC/HDL-C ratio. The fitness levels of the children in this study may have had an impact on TC/HDL-C ratio. In a study by Suter and Hawes (1993) on 97 children ages 10 to 15 years, a higher physical fitness index was significantly related to higher HDL-C levels in both boys and girls. Tell and Vellar (1988) found similar results when utilizing data from the Oslo Youth Study. They found that of the 413 boys and 372 girls ages 10 to 14 years, higher VO_{2max} levels were positively associated with more favorable lipid profiles in females. In another study by Durant et al. (1993) on 123 4-to-5 year olds, results indicated higher fitness levels of children, as assessed utilizing a graded treadmill test, were positively related to more favorable blood lipid profiles. In the present study, when separated into high fit and low fit groups, the high fit group reported consuming significantly more carbohydrate/kg, protein/kg, and fat/kg explaining the negative relationship between carbohydrate/kg, protein/kg, and TC/HDL-C ratio. These results may indicate that a higher level of fitness has a positive impact on the TC/HDL-C ratio, and would suggest that fat/kg intake may not be as important of a factor in the TC/HDL-C ratio as fitness levels in children that it does in adults.

Protein/kg was found to be negatively related to LDL-C and triglycerides, and positively related to HDL-C. Percent of total caloric intake from protein was also found to be positively related to HDL-C. Frank et al. (1978) found that in general, children with high serum cholesterol values had higher fat intakes (and lower carbohydrate and protein intakes) than those with low serum cholesterol. This finding can be associated with the negative relationship of protein/kg to LDL-C and HDL-C in the current study. The children that consumed more protein/kg had lower LDL-C, lower triglycerides, and higher HDL-C values than those not eating as much protein. The results of this study indicate that blood lipid values in children may be attributed more to fitness and activity than strictly to dietary intake.

Dietary Quantity and Fitness

The results of this study suggest that more total calories were consumed by subjects with higher HDL-C levels and fitness levels. In a study by Suter and Hawes (1992) on 10-15 year olds, it was concluded that physical activity had a significant impact on fitness levels, and that boys with a higher cardiovascular fitness level consumed more kcal per day than their less fit counterparts. Deuster et al. (1986) found highly trained female runners consumed more total kcal than their sedentary counterparts. Butterworth et al. (1993) compared nutrient quantity between highly conditioned elderly women and sedentary controls. The study concluded the highly conditioned elderly women had higher energy intakes especially when expressed on a weight adjusted basis. DuRant et al. (1992) found higher levels of cardiovascular fitness to be positively associated with HDL-C levels in children ages 4 to 5 years. A similar study conducted by Tell and Vellar (1988) found a positive relationship between fitness level and HDL-C levels in girls ages 10-15 years. In this study, when separated into high fit and low fit groups, the high fit group did report a significantly higher intake of total calories and kcal/kg when compared with the low fit group. These results may suggest that higher fit children tend to consume more total kcal possibly due to a higher level of physical activity. This study indicated no relationship between percentage of total calories from fat or fat/kg and blood lipid variables as would be suspected. This result may indicate that fat intake does not effect blood lipid variables in children to the degree it does in adults. Blood lipid values in children may be more a factor of fitness and activity as opposed to strictly dietary intake. In fact, when separated into high fit and low fit groups, the high fit group did report consuming more fat/kg due to the consumption of more total calories, even though the percentage of total calories from fat did not differ between the two groups. Both groups consumed the same percentage of their total calories from fat, therefore, blood lipid values in children may be more related to fitness levels and genetics than just fat intake alone. The literature strongly supports the relationship between dietary fat intake and blood lipid profiles in adults (Dreon et al., 1988; Tucker and Kano, 1992). Unfortunately, the picture is not as clear with the relationship of dietary fat and blood lipid values in children. Williams et al., (1992) reported no significant relationship between dietary fat intake and blood lipid profiles in 3320 children ages 5 to 18 years. However, Vaccaro and Mahon (1989) found that dietary fat and cholesterol intakes were positively related to blood lipid values in children ages 4 to 12 years. The literature seems inconclusive on the relationship of diet to blood lipid values in children as opposed to adults. However, Vaccaro and Mahon (1989) suggested that the consumption of high fat, high cholesterol diets by children is highly related to parental or guardian influence and may be carried over into adulthood. The long-term effects of a high fat and cholesterol diet may not begin to impact blood lipid values until adulthood. This would indicate a behavior change in children is necessary in order to prevent this chronic effect.

In summary, the correlational values in this study between dietary intake and blood lipid values were not exceptionally high, even though significant, indicating weak relationships at best.

Dietary Intake and Body Composition

Body composition was found to demonstrate a significant negative relationship to total calories, protein (g), polyunsaturated fat (g), fiber (g), kcal/kg, carbohydrate/kg, protein/kg, and fat/kg. Many studies have shown body composition to have a direct positive correlation with energy intake. Miller et al. (1990) found adiposity was positively related to dietary fat content which in turn increased total energy intake in adults ages 18-71 years. Tucker & Kano (1992) found similar results in adult females. The results of the study indicated a direct relationship between body fat percentage and total energy intake. However, the results of this study indicate the opposite to be true. The results of this study are in agreement with a study conducted by Kromhout et al. (1988) on 525 men who found a negative relationship of total calories to body composition. Upon further investigation the study contributed the correlation to underestimation of energy intake by obese subjects. However, in a study by Hampton et al. (1967) on 104 children ages 7-11 years, the obese children were found to eat fewer calories than their lean counterparts and no underestimation of energy intake by obese subjects could be discerned. In the present study, the results may also have been impacted by the inaccuracies of the children recording their own diet records, the parents not knowing what the children had eaten away from home in order to accurately assist in recording the diet records; or body composition in children could be more directly related to genetics and activity as opposed to strictly dietary intake. This would be in agreement with the findings of Muecke et al. (1992) in which diet nor activity alone were independent risk factors for CAD in children, but they did exert a synergistic effect when both were present in the same child. Since activity levels were not measured in the present study, dietary intake alone may not have been a significant enough factor to effect body composition.

Dreon et al. (1988) found body composition to be negatively related to plant protein, total carbohydrate, complex carbohydrate, simple carbohydrate, and fiber (g).

Similar results were found in this study in which a negative relationship was found between protein (g), carbohydrate/kg, protein/kg, and fiber (g) to body composition. Dreon et al. (1988) also found a positive relationship between body composition and saturated fat and monounsaturated fat. This study established a negative relationship between body composition and polyunsaturated fat, but found no relationship between body composition and saturated fat and monounsaturated fat. The results of this study suggest that a higher protein and carbohydrate diet may have a positive impact on body composition in children.

Many studies have established dietary intake of fat as a major contributor to a higher percentage of body fat in both children and adults. Tucker and Kano (1992) found fat intake to be a significant predictor of body fat percentage on 205 adult females. A study by Miller et al. (1990) on 107 males and 109 females ages 18-71 years found adiposity was positively related to dietary fat content. In a similar study be Dreon et al. (1988), percent body fat correlated significantly with total fat intake in 155 obese men. Romieu et al. (1988) using 194 female participants aged 34-59 years, found obese women reported higher intakes of total dietary fat than their lean counterparts. A study by Gazzaniga and Burns (1993), found percentage body fat correlated positively with intakes of total fat in 48 children ages 9-11 years. Similar results however, were not found in this study, in which a negative relationship between fat/kg and body composition was established. This may have been due to those children with higher percentages of body fat inaccurately recording their diet records especially snack foods as was hypothesized in the study by Kromhout et al. (1988). Or possibly, body composition in children may be more related to activity levels and pre-pubescent hormones than dietary fat intake. The majority of the studies cited above did utilize adults as subjects, and the one by Gazzinaga and Burns (1988) utilizing children obtained diet records over the phone. In addition, the correlational values in this study between dietary intake and body composition were not high values which may also partially explain the unsettling relationships established.

Dietary Intake and Recommended Dietary Allowances (RDA)

Over 40% of the children in this study did not meet at least 66% of the RDA for vitamins and minerals including: Vitamins A, C, B_6, calcium, and zinc. Over 65% of the children did not meet 66% of the RDA for Vitamins D, E, and K. This contradicts a study by Devaney, Gordon and Burghardt (1995) who in a study on 3350 children ages 6-18 years, found all subjects meeting the RDA for the average daily intake of vitamins and minerals. Such a high percentage of children meeting 100% of the RDA could be attributed to the results of that study only measuring dietary intake over a 24-hour period as opposed to longer periods of measurement and supposedly more accurate assessments of dietary intake. However, the findings of this study are in agreement with a study by Albertson et al. (1992) who found over a 10-year period, mean intakes of 11 of 16 vitamins and minerals decreased in children ages 2 to 10 years. The decreasing intake ranged from a 3% decline in zinc to a 17% decrease in calcium. Mean intakes of vitamin A, riboflavin, vitamin B_{12}, phosphorus, magnesium, and copper also declined more than 10% over the 10-year period. Fifty-percent of the children studied were below 100% of the RDA for calcium and vitamin B_6. Twenty-five percent of the children were below 100% of the RDA for vitamin A and iron intakes. In a similar study, Nicklas et al. (1992), using sample data from the Bogalusa Heart Study of 871 ten-year olds, found that children who consumed a higher fat diet and therefore consumed more total calories, met the RDA's for certain nutrients which the children who consumed a lower fat diet were not able to meet established RDA's.

Regardless of previous findings, the percentage of children not meeting at least 75% of the RDA for the average daily intake of vitamins and minerals in this study is alarming, especially the notable deficient intakes in calcium, vitamin C, and the fat soluble vitamins A, D, E, K. The results of this study suggest that deficiencies may exist in fresh citrus fruits and vegetables, especially leafy green and yellow vegetables, along with dairy products for calcium and vitamin D.

Dietary Intake and Fitness Levels

There was a significant positive relationship between kcal and $VO2_{max}$ values. This is in agreement with a study by Titchenal (1988) who also found that increased activity levels in humans caused a juxtaposing increase in energy intake, but that chronic exercise had either no effect or only a slight increase on energy intake. These results are also in agreement with studies by Butterworth et al. (1993) and Butterworth et al. (1994), who also found an increase in energy intake in more physically active and more highly fit women. In this study, when separated into high fit and low fit groups, the high fit group reported consuming more total calories, and monounsaturated fat (g), kcal/kg, carbohydrate/kg, protein/kg, and fat/kg than the low fit group. A significant difference did exist between the high fit and low fit groups when dietary quantity was measured. These results suggest that more highly fit children are possibly more physically active on a daily basis therefore requiring a higher quantity of dietary intake than the lower fit subjects who would be assumed to be less active. In this study, the high fit group was also leaner than the low fit group indicating the high fit group may have been more active since they consumed more total calories but still maintained less body fat. However, higher $VO2_{max}$ values are not necessarily a direct indication of increased or higher activity levels. VO_{2max} values are more directly related to genetics and physical fitness levels, which can be increased slightly via chronic exercise.

This study also found a significant positive relationship between protein (g), carbohydrate (g), fat (g), saturated fat (g), monounsaturated fat (g), kcal/kg, protein/kg, carbohydrate/kg, and fat/kg with VO_{2max} scores. When separated into high fit and low fit groups, significant differences were found between the two groups for kcal/kg, protein/kg, carbohydrate/kg, and fat/kg indicating the high fit group had better dietary quality than the low fit group. Although these results would make logical sense, that increased dietary quantity would also correspond to increased dietary quality, the literature has failed to irrevocably support this to be true. Butterworth et al. (1993) could find no difference in the quality of nutritional intake of elderly women 67-85 years after 12 weeks of walking 30-40 minutes, 5 days a week at 60% of heart rate reserve. In a similar study, Nieman et al. (1990) found 15 weeks of moderate exercise had no impact on nutritional quality in mildly obese previously sedentary women. In another study by Butterworth et al. (1994) no significant correlations could be found between cardiorespiratory fitness and quality of dietary intake in 34 females ages 20-40 years. However, in a study by Blair et al. (1981) comparing middle aged male and female runners with sedentary controls, three day food records indicated that runners of both sexes consumed about 600kcal/d more than controls mostly from increased fat and carbohydrate. Children who are more active on a daily basis and therefore performed better on a VO_{2max} fitness test, would be assumed to require a higher total energy intake which would correspond to higher energy intakes on all macronutrients. This possibly could have been discovered in this particular study due to the necessity of the active children's needs for higher energy consumption of all macronutrients. It is interesting to note however, that although the high fit group consumed more fat (g), monounsaturated fat (g), and fat/kg there was no significant difference between the groups in percentage of total calories from fat. This finding indicates that percentage of total calories from fat has little effect on fitness level. This coincides with Blair et al. (1981) where runners reported consuming more total calories, fat, and carbohydrate, but the percentage of energy intake from fat was not significantly different from sedentary controls.

Conclusions

This study determined the relationship of dietary intake to selected cardiovascular disease risk factors and compared both quantity and quality of dietary intake between highly fit and low fit children. Several significant relationships were found between quality of dietary intake and blood lipid profiles in children. Therefore, it could be concluded that dietary intake does have both positive and negative effects on blood lipid levels in children which may carry over into adulthood if no dietary intervention is employed.

There were also several significant relationships between dietary intake and body composition. Although a few of the relationships were unsettling in that the children with less body fat ate more total calories and therefore more protein, carbohydrate, and fat, it could be concluded that the children were more lean due to increased activity levels and that activity levels of children and genetic predispositions may actually be a better predictor of body composition than dietary intake at this age.

There were significant relationships between dietary intake and VO_{2max}. The higher the VO_{2max}, the higher the caloric intake and therefore higher protein, carbohydrate, and fat intakes. It might be concluded that the higher fit children ate more because they were more active on a daily basis assumedly with some various sports activities attributing to a higher VO_{2max}. Increased activity levels would naturally increase metabolic needs especially in growing children.

There were significant differences in dietary quantity and quality between the high fit and low fit groups. The high fit children ate more calories, monounsaturated fat, kcal/kg, carbohydrate/kg, protein/kg, and fat/kg. Once again, it might be concluded that the high fit group consumed more due to an increased metabolic need for total calories because of a higher activity level. Therefore, increased activity levels would not only make them more fit, as demonstrated by the higher $VO2_{max}$ scores, but also would increase their metabolic needs to meet the demands of higher activity levels.

Recommendations

Future research is needed in this area to determine the extent dietary intake plays a role in cardiovascular disease risk factors in children and if the negative implications carry over into adulthood. Due to weak correlational values, the relationship of dietary intake to blood lipid values, body composition, and fitness levels in children warrant further study. This study should be repeated utilizing some form of activity measurement. Longitudinal studies are needed to determine the effects of activity and diet on cardiovascular disease risk factors from childhood into adulthood and the impact choices made in childhood have on the adult disease state.

Further research is needed to determine the differences in dietary intake between high fit and low fit children. Since the high fit children exhibited a tendency towards ingesting both more calories and therefore more macronutrients, more research is needed to assess the reasons why and if the higher fit children carry these habits into adulthood.

The results of this study would indicate that fitness levels have a higher impact on body composition than does dietary intake at this age. However, since the higher fit children ingested more calories and macronutrients, activity levels would be assumed to be higher in the more highly fit children sighting the need for more calories and macronutrients. The question of activity levels impacting not only fitness but also body composition and blood lipid profiles in children needs to be investigated further.

References

Adner, M., & Castelli, W. (1980). Elevated high density lipoprotein levels in marathon runners. Journal of the American Medical Association, 343, 534-536.

Albertson, A.M., Tobelmann, R.C., Engstrom, A., & Asp, E.H. (1992). Nutrient intakes of 2 to 10 year old American children: 10 year trends. Journal of the American Dietetic Association, 92, 1492-1496.

American Heart Association. Heart Book: A guide to and treatment of cardiovascular disease, E.P. Dutton, New York, 1980.

American Heart Association. Dietary treatment of hypercholesterolemia: a manual for patients. Dallas Texas: American Heart Association; 1988.

Aristimuno, G.G., Foster, T.A., Voors, A.W., Srinivasan, S.R., & Berenson, G.S. (1984). Influence of persistent obesity in children on cardiovascular risk factors: the Bogalusa Heart Study. Circulation, 69, 895-904.

Bar-Or, O. (1983). Pediatric Sports Medicine for the Practitioner. New York: Springer-Verlag.

Berenson, G.S. (1980). Cardiovascular Risk Factors in Children. Oxford University Press: Oxford.

Berenson, G.S., Srinivasan, S.R., & Webber, L.S. (1980). Prognostic Significance of Lipid Profiles in Children. In Lauer & Shekella (Eds) Childhood prevention of atherosclerosis and hypertension. Raven Press: New York.

Blair, S.N. (1992). Are American children and youth fit? The need for better data. Research Quarterly for Exercise and Sport, 63(2), 120-123.

Blair, S.N., Ellsworth, N.M., Haskell, W.L., Stern, M.P., Farquqar, J.W., & Wood, P.D. (1981). Comparison of nutrient intake in middle-aged men and women runners and controls. Medicine and Science in Sports and Exercise, 13, 310-315.

Blair, S.N., Jacobs, D.R., & Powell, K.E. (1985). Relationships between exercise or physical activity and other health behaviors. Public Health Report, 100, 172-180.

Boileau, R., Bonen, A., Heyward, V., & Massey, B. (1977). Maximal aerobic capacity on the treadmill and bicycle ergometer of boys 11-14 years of age. Journal of Sports Medicine, 17, 153-162.

Boulton, J. (1981). Nutrition in childhood and its relationship to early somatic growth, body fat, blood pressure, and physical fitness. Acta Pediatrica Scandinavica, 284, 1-85.

Brown, C.H., Harrower, J.R., & Deeter, M.S. (1972). The effects of cross-country running on preadolescent girls. Medicine and Science in Sports, 4, 1-5.

Butterworth, D.E., Nieman, D.C., Perkins, R., Warren, B.J., & Dotson, R. (1993). Exercise training and nutrient intake in elderly women. Journal of the American Dietetic Association, 93(6), 653-657.

Butterworth, D.E., Nieman, D.C., Underwood, B.C., & Lindsted, K.D. (1994). The relationship between cardiorespiratory fitness, physical activity, and dietary quality. International Journal of Sport Nutrition, 4, 289-298.

Committee on Diet and Health, Food and Nutrition Board, Commission of Life Science, National Research Council: Diet and Health, Implications for Reducing Chronic Disease Risk. Washington, DC: National Academy Press, 1989.

Consensus Development Panel. (1985). Lowering blood cholesterol to prevent heart disease. Journal of the American Medical Association, 253, 2080.

Costello, C., Disney, G., Dodson, W., & Bush, M. (1983). Longitudinal study of the incidence and persistence of obesity in girls from ages 9 to 16 years. Federation Proceedings, 42, 535.

Cunningham, D., Waterschoot, B., Patterson, D., Lefcoe, M., & Sangal, S. (1977). Reliability and reproducibility of maximal oxygen uptake measurement in children. Medicine and Science in Sports, 9(2), 104-108.

Dennison, B., Strauss, J., Mellits, D., & Charney, E. (1988). Childhood physical fitness tests: predictor of adult physical activity levels? Pediatrics, 82(3), 324-330.

Deuster, P.A., Kyle, S.B., Moser, P.B., Vigersky, R.A., Singh, A., & Schoomaker, E.B. (1986). Nutritional intakes and status of highly trained amenorrheic and eumenorrheic women runners. Fertility and Sterility, 46(4), 636-643.

Devaney, B., Gordon, A., & Burghardt, J. (1995). Dietary intake of students. American Journal of Clinical Nutrition, 61, S205-S212.

Dreon, D.M., Hewitt, F.B., Ellsworth, N., Williams, P.T., Terry, R.B., & Wood, P.D. (1988). Dietary fat: carbohydrate ratio and obesity in middle-aged men. American Journal of Clinical Nutrition, 47, 995-1000.

DuRant, R.H., Baranowski, T., Rhodes, T., Gutin, B., Thompson, W.O., Carroll, R., Puhl, J., & Greaves, K.A. (1993). Association among serum lipid and lipoprotein concentrations and physical activity, physical fitness, and body composition in young children. The Journal of Pediatrics, 123(2), 185-192.

DuRant, R., Linder, C., Harkness, J., & Gray, R. (1983). The relationship between physical activity and serum lipids and lipoprotein in black children and adolescents. Journal of Adolescent Health Care, 4, 55-60.

Ekblom, B. (1969). Effects of physical training in adolescent boys. Journal of Applied Physiology, 27, 350-355.

Frank, G.C., Farris, R.P., Cresanta, J.L., & Nicklas, T.A. (1986). Dietary intake as a determinant of cardiovascular risk factor variables-Part A: Observation in a pediatric population. In: Berenson G.S. (Ed.) Causation of Cardiovascular Risk Factors in Children: Perspectives on Cardiovascular Risk in Early Life. Raven Press, New York.

Frank, G.C., Webler, L.S., Ferris, R.P., & Berenson, G.S. (1987). Dietary Data Book: Quantifying Dietary Intakes for Infants, Children and Adolescents-The Bogalusa Heart Study, 1973-1983. From the Nutrition Core and Planning and Analysis Core Components of the National Research and Demonstration Center-Arteriosclerosis (NRDC-A). New Orleans, LA: LSU Medical Center.

Gazzaniga, J.M., & Burns, T.L. (1993). Relationship between diet composition and body fatness, with adjustment for resting energy expenditure and physical activity, in preadolescent children. American Journal of Clinical Nutrition, 58, 21-28.

Hampton, M., Huenemann, R., Shapiro, L., & Mitchell, B. (1967). Calorie and nutrient intakes of teenagers. Journal of the American Dietetic Association, 50, 385-386.

Johnson, R.K. (1992). Dietary intake of young children in America compared with recommendations. Journal of Cardiopulmonary Rehabilitation, 12, 92-93.

Kellet, D., Willan, P., & Bagnall, K. (1978). A study of potential Olympic swimmers. Part 2. Changes due to three months of intensive training. British Journal of Sports Medicine, 12, 87-92.

Kemper, H.C., Snel, J., Verschuur, R., & Essen, L.S. (1990). Tracking of health and risk indicators of cardiovascular disease from teenager to adult: Amsterdam growth and health study. Preventative Medicine, 6, 642-655.

Kiem, N., Barbieri, T., & Belko, A. (1989). The effect of exercise on energy intake and body composition in overweight women. International Journal of Obesity, 14, 335-346.

Kromhout, D., Wim, M., Saris, H., & Horst, C. (1988). Energy intake , energy expenditure, and smoking in relation to body fatness: the Zutphen Study. American Journal of Clinical Nutrition, 47, 668-674.

Kwee, A., & Wilmore, J.H. (1990). Cardiorespiratory fitness and risk factors for coronary artery disease in 8-to-15 year old boys. Pediatric Exercise Science, 2, 372-383.

Kuntzleman, C.T., & Reiff, G.G. (1992). The decline in American children's fitness levels. Research Quarterly for Exercise and Sport, 63(2), 107-111.

LaRosa, J. (1988). Preliminary report from a conference entitled "Prevention of adult atherosclerosis during childhood." Journal of Pediatrics, 112, 317.

Linder, C.W., & Durant, R.H. (1982). Exercise, serum lipids, and cardiovascular disease risk factors in children. Pediatric Clinics of North America, 29, 1341-1354.

Lohman, T. (1987), The use of skinfold to estimate body fatness on children and youth. Journal of Physical Education, Recreation and Dance, 53, 98-102.

Lussier, L., & Buskirk, E. (1977). Effect of an endurance training regimen on assessment of work capacity on prepubertal children. Annals of New York Academy of Science, 301, 351-364.

Massicote, D.R., & Macnab, R.J. (1974). Cardiorespiratory adaptation to training at specified intensities in children. Medicine and Science in Sports, 6, 242-246.

Mayers, N., & Gutin, B. (1979). Physiological characteristics of elite prepubertal cross-country runners. Medicine and Science in Sports, 11(2), 172-176.

McGinnis, J.M., & Forge, W.H. (1993). Actual causes of death in the United States. Journal of the American Medical Association, 270(18), 2207-2212.

McMiken, D.F., & Daniels, J.T. (1976). Aerobic requirements and maximum aerobic power in treadmill and track running. Medicine and Science in Sports, 8, 4-17.

Miller, W.C., Linderman, A.K., Wallace, J., & Neiderpruem, M. (1990). Diet composition, energy intake, and exercise in relation to body fat in men and women. American Journal of Clinical Nutrition, 52, 426-430.

Mocellin, R., & Wasmund, U. (1973). Investigation on the influence of a running-training program on the cardiovascular and motor performance capacity in 53 boys and girls of a second and third primary class. In Bar-Or (Ed.) Proceedings of the 4th International Symposium: Pediatric work physiology. Wingate Institute, Israel.

Morrow, J.R. (1992). Are American children and youth fit? Some international perspectives. Research Quarterly for Exercise and Sport, 63(4), 449-452.

Muecke, L., Morton, B.S., Huang, I.W., & Parcel, G. (1992). Is childhood obesity associated with high-fat foods and low physical activity. Journal of School Health, 62(1), 19-23.

National Cholesterol Education Program Report of the Expert Panel of Blood Cholesterol Levels in Children and Adolescents. National Heart Lung and Blood Institute, 1991.

Neiderpruem, J. (1990). Measurement of energy expenditure. Journal of Applied Physiology, 53, 955-059.

Newman, W.P., Wattigney, W., & Barenson, G.S. (1991). Autopsy studies of United States children and adolscents, relationship of risk factors to arteriosclerotic lesions. Annual New York Acadamy of Science, 623, 16-25.

Nicklas, T.A., Webber, L.S., Koschak, M., & Berenson, G.S. (1993). Nutrient adequacy of low fat intakes for children: the Bogalusa heart study. Pediatrics, 89(2), 221-228.

Nieman, D.C. (1993). Fitness and Your Health. Bull Publishing Company, Palo Alto, CA.

Nieman, D.C., Butler, J.V., Pollet, I.M., Dietrich, S.J., & Lutz, R.D. (1989). Nutrient intake of marathon runners. Journal of the American Dietetic Association, 89, 1273-1278.

Nieman, D.C., Butterworth, D.E., & Nieman, C.N. (1992). Nutrition, Dubuque, Indiana: Wm. C. Brown.

Nieman, D.C., Onash, L.M., & Lee, J.W. (1990). The effects of moderate exercise training on nutrient intake in mildly obese women. Journal of the American Dietetic Association, 90, 1557-1562.

Pate, R., Sargent, R., Baldwin, C., & Burgess, M. (1990). Dietary intake of women runners. International Journal of Sports Medicine, 11, 461-466.

Pollock, M.L., Schmidt, T. & Jackson, A. (1980). Body composition: measurement and changes resulting from physical training. In E.J. Burke (Ed.), Toward and Understanding of Human Performance. Ithaca, N.Y., Movement Publications.

Recommended Dietary Allowances. (1989). National Academy of Sciences, National Academy Press, Washington, D.C.

Romieu, I., Willet, W.C., Stampfer, M.J., Colditz, G.A., Sampson, L., Rosner, B., Hennekens, C.H., & Speizer, F.E. (1988). Energy intake and other determinants of relative weight. American Journal of Clinical Nutrition, 47, 406-412.

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

Stephen, A.M., & Wald, N.J. (1990). Trends in individual consumption of dietary fat in the United States, 1920-1984. American Journal of Clinical Nutrition, 52, 457-469.

Stewart, K., & Gutin, B. (1976). Effects of physical training on cardiorespiratory fitness in children. Research Quarterly, 47, 110-120.

Suter, E., & Hawes, M.R. (1993). Relationship of physical activity, body fat, diet, and blood lipid profile in youths 10-15 yr. Medicine and Science in Sports and Exercise, 25(6), 748-754.

Taylor, W., & Baranowski, T. (1991). Physical activity, cardiovascular fitness, and adiposity in children. Research Quarterly for Exercise and Sport, 62(2), 157-163.

Tell, G., & Vellar, O. (1988). Physical fitness, physical activity and cardiovascular risk factors in adolescents: the Oslo Youth Study. Preventative Medicine, 17, 12-24.

The Surgeon General's Report on Nutrition and Health: Summary and Recommendations, 1988.

Thorland, W., & Gilliam, T. (1981). Comparison of serum lipids between habitually high and low active pre-adolescent males. Medicine and Science in Sports and Exercise, 13, 316-321.

Titchenal, C. (1988). Exercise and food intake: What is the relationship? Sports Medicine, 6, 135-145.

Tremblay, A., Despres, J., & Bouchard, C. (1985). The effects of exercise-training on energy balance and adipose tissue morphology and metabolism. Sports Medicine, 2, 223-233.

Tucker, L.A., & Kano, M.J. (1992). Dietary fat and body fat: a multivariate study of 205 adult females. American Journal of Clinical Nutrition, 56, 616-622.

Updyke, W.F. (1992). In search for relevant and credible physical fitness standards for children. Research Quarterly for Exercise and Sport, 63(2), 112-119.

Vaccaro, P., & Clarke, D. (1978). Cardiorespiratory alterations in 9-to-11 year old children following a season of competitive swimming. Medicine and Science in Sports, 10(3), 204-207.

Vaccaro, P., Clarke, D., & Morris, A. (1980). Physiological characteristics of young well-trained swimmers. European Journal of Applied Physiology, 44, 61-66.

Vaccaro, P., & Mahon, A.D. (1989). The effects of exercise on coronary heart disease risk factors in children. Sports Medicine, 8, 139-153.

Washburn, R., & Montoye, H. (1986). The assessment of physical activity by questionnaire. American Journal of Epidemiology, 123, 563-576.

Weidman, S., Kwiterovich, G., Jesse, I., & Nugent, T. (1983). Basal metabolic rate. Human Nutrition, 39, 94-96.

Whitney, H., Cataldo, W., & Rolfes, G. (1991). Aerobic capacity, obesity, and atherosclerotic risk factors in male adolescents. Pediatrics, 75, 813-818.

Witschi, C.O., Capper, A.L., & Ellison, R.C. (1990). Sources of fat, fatty acids, and cholesterol in the diets of adolescents. Journal of the American Dietetic Association, 99(11), 1429-1431.

Williams, D.P., Going, S.B., Lohman, T.G., Harsha, D.W., Srinivasan, S.R., Webber, L.S., & Berenson, G.S. (1992). Body fatness and risk for elevated blood pressure, total cholesterol, and serum lipoprotein ratios in children and adolescents. American Journal of Public Health, 82(3), 358-363.

Wynder, E.L. (1989). Coronary artery disease prevention: Cholesterol, a pediatric perspective. Preventative Medicine, 18, 323-409.

Yoshida, T., Ishiko, I., & Muraoka, I. (1980). Effects of endurance training on cardiorespiratory functions of 5 year old children. International Journal of Sports Medicine, 1, 91-94.

APPENDICES

APPENDIX A

INFORMED CONSENT STATEMENT

APPALACHIAN STATE UNIVERSITY
DEPARTMENT OF HEALTH, LEISURE, AND EXERCISE SCIENCE
CONSENT FORM

Relationship of Physical Fitness to Risk for CHD in Children

I have been told that this research project is designed to determine the relationship of performance on a physical fitness test battery to selected resk factors for coronary heart disease in youths 8-11 years of age.

During the study, the fitness and health status of each child will be measured using standard questionnaires, a blood sample, and various health-related assessments (body fat, blood pressure, and maximal treadmill stress test). For the blood sample, all children will fast overnight for 12 hours (no food or drink with calories after 8:00 pm). Children wil report to school at their assigned time from 7:00-8:30 am. One sample will be drawn (10 mL). The blood samples will be used to measure triglycerides, total cholesterol, VLDL-C, HDL-C, and LDL-C fractions. On an assigned date from December 14 - 22, 1993, each child will undergo a maximal exercise treadmill stress test. In addition, each shild with the assistance of parents, teachers, adn testing staff will complete a 7 day record of food and beverage intake and physical activity completed during those seven days (December 14-20).

The entire cost of all these health, fitness, and blood tests is approximately $200.00. I will not be charged for these tests, and all information will be expained to me free of charge. I understand the importance of these tests in evaluating the health status of my child and understand that this information may help others learn of the fitness of today's children and their relative risk for developing coronary heart disease. As a parent of a participant, I have had these tests explained to me and understand the relative importance of the test results for the purposes of the study.

I have been told that the risks associated with blood sampling include the possibility of pain and minor bruising in the area where the blood is to be drawn and possible temporary lightheadedness upon rising. Also, there are small risk associated with maximal treadmill testing. These include signs and symptoms of intolerance to exercise, including dizziness, nausea, fatigue, shortness of breath, and temporary pain. In the event of an emergency, however, established medical procedures will be followed and madical staff will be on hand to handle these emergencies. The test will be stopped if signs and/or symptoms of intolerance to heavy exercise occur.

I understand that I may at any time choose to discontinue my child's participation in this study and my child will not be expected to continue against his/her will. I have been told that refusal to participate in the study will involve no penalties or loss of benefits to which my child is entitled.

I have been told that I can request that my study results on maximal oxygen uptake and blood lipid profile be forwarded to my child's pediatrician.

I have been told that in the event of physical injury resulting from the research procedures, immediate first-aid is provided free of charge.

I have been told that if I wish to contact an impartial third party not associated with this study regarding any complaint I may have about the study, I may contact one of the following individuals: 1) Dr. Vaughn Christian, Chairman of the Department of Health, Leisure, and Exercise Science, Appalachian State University, Boone, NC 28608 (704) 262-3140; Dr. Paul Geyer, Institutional Review Board, Graduate Studies and Research, Appalachian State University, Boone, NC 28608 (704) 262-2130; Mr. Chris Burton, Principal, Granite Falls Elementary School (396-2222).

I have been told that my child's identity in this study will not be disclosed in any published documents.

I have read the contents of this consent form and have listened to the verbal explanation given by the investigator. My questions concerning this study have been answered to my satisfaction. I hereby give voluntary consent for my child to participate in this study. I may call Beverly Warren, Ph. D., at (704) 262-3140 if I have questions or concerns.

I have been given a copy of this consent form.

--------------------------------   --------------

Signature of Parent   Date

Signature of Witness