Fitness, Diet and Coronary Risk Factors in a Sample of Southeastern U.S. Children

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Abstract. The purpose of this study was to evaluate the relationship between physical fitness variables and nutrient intake to coronary risk factors (CRF) in a sample of children living in the Southeastern U.S. A total of 22 sixth-grade children of whom 10 were boys (mean age = 11.83 ± 0.3) and 12 were girls (mean age 11.7 ± 0.3) volunteered for this study. Results indicated that boys in comparison to girls weighed more (54.0 ± 10.8 kg versus 42.1 ± 8.0 kg; p<0.05), had a higher body mass index (BMI) (23.6 ± 2.7 versus 20.2 ± 3.3; p<0.05), a higher lean body mass (37.8 ± 6.0 kg versus 30.7 ± 3.8 kg; p<0.01) and a higher systolic blood pressure (115.7 ± 11.1 versus 106.4 ± 8.1; p<.0001). There were, however, no significant gender differences in serum lipoproteins or nutrient intake. Stepwise multiple regression analyses indicated that physical fitness variables which included VO₂max, one-mile run for time, grip strength, and leg strength could significantly predict resting diastolic blood pressure (DBP) (F = 3.06; p<0.05) and percent body fat (F = 4.98; p<0.01) in children. Analysis of food intake revealed that total and saturated fat, and carbohydrate intake could predict serum triglycerides (TG) (F = 5.18; p = 0.01) while total kilocalorie, fat, and carbohydrate intake could significantly predict percent body fat (F = 3.42; p<0.03). These findings may be clinically relevant since both serum triglyceride levels and percent body fat were well above the 50th percentile according to U.S. norms. In summary, the present study showed that measurements of muscular strength in addition to aerobic fitness are associated with DBP and percent body fat in children. Furthermore, it is recommended that nutrient intake be used when evaluating CRF in children due to its ability to predict TG and percent body fat.


Keywords: fitness variables, serum lipids, children

Introduction

Coronary artery disease (CAD) is a cause of a major proportion of all adult deaths among industrialized nations today (WHO, 1990). Past research has shown that risk factors for CAD such as hyperlipidemia, high blood pressure (BP), and obesity do not suddenly appear in adulthood but rather progress on a continuum of unfavorable lifelong experiences that may begin as early as childhood (Montoye, 1985). Investigators have thus examined the relationship between coronary risk factors (CRF) and physical fitness in both adults and children.

Physical fitness is a multifaceted trait or ability which includes a variety of components such as aerobic capacity/fitness, muscular strength, muscular endurance and flexibility (Safrit, 1990). In adults, a high level of aerobic fitness is associated with a favorable lipid profile, BP, and body composition (Tucker and Bagwell, 1991; Lochen and Rasmussen, 1992; Rotkis et al., 1981) while the relationship between muscular strength and favorable CRF appears to be more controversial (Stone et al., 1991; Kohl et al., 1992).

In children, studies tend to show a significant association between aerobic fitness and favorable lipid and BP levels (Anderson, 1994; Hager et al., 1995), however, this relationship has not always shown the consistency that it has in adults (Despér et al., 1990; Zaumer et al., 1989). Part of the variability may be due to the method used to evaluate aerobic fitness which may include estimating the maximal volume of oxygen (VO₂max) as an indication of aerobic fitness which is usually measured through a graded exercise test (GXT) or using a submaximal GXT (Swain and Wright, 1997) or a submaximal field test (Buono et al., 1991; Safrit, 1995) to estimate aerobic fitness. Another possible explanation may be related to the intake of total and saturated fat both of which may have an adverse affect on serum lipoproteins and obesity levels (Shea et al., 1991; Gilksman et al., 1993; Eck et al., 1992). It has recently
been shown that the yearly increases in body weight and obesity in the United States were 50% greater from 1983-1994 than between 1973-1982 (Freedman et al., 1997). Children between the ages of 10-12 constitute the largest percentage of elementary school children reported to be overweight at the 95th percentile (Center for Disease Control, 1990).

Relatively few studies have examined the relationship between muscular strength/endurance and CRF. Some investigators (Fripp and Hodgson, 1987; Weltman et al., 1987), have shown significant decreases in the atherogenic lipoproteins and increases in the cardioprotective high density lipoprotein cholesterol (HDL-C) with increased strength. On the other hand, Anderson (1994) showed no significant relationship between muscular endurance and BP. Unfortunately, serum lipids/lipoproteins were not measured in that study and none of the studies examined nutrient intake. Therefore, it may be necessary to evaluate in one study the role of aerobic fitness, musculoskeletal strength and nutrient intake in relation to CRF, including serum lipid/lipoproteins, BP, and obesity. The purpose of this study was to examine physical fitness variables and diet in relationship to CRF in a sample of sixth grade children living in the Southeastern U.S.

Methods

A total of 22 out of 87 sixth grade children at a single elementary school (10 males, 12 females) volunteered to participate in the study. Of the total volunteers, 59% of the children were Caucasian, 23% were African American, 5% were Hispanic, and 14% were mixed racial. Written informed consent was obtained from the students and their parents in accordance with the guidelines set forth by the Medical Sciences Subcommittee for the protection of Human Subjects at the University of Miami. All parents were required to fill out a medical history form. Any children displaying medical problems and/or taking medications that would affect serum lipoproteins, BP and physical fitness measurements as determined by the supervising physician, were excluded from the study. Only one child was excluded from the study for medical reasons. Data were collected at two different locations, an elementary school and the Human Performance Laboratory, University of Miami.

All students received two instructional lectures on how to accurately record nutrient intake which occurred prior to any testing. A sample of food items, liquid and solid measurement utensils and cups and plates were used during the lecture. Students were told to select two weekdays and one weekend day that were representative of typical eating habits to record all dietary intake. Parents were sent written instructions on the recording of nutrient intake to guide them in assisting their child in filling out their food log. The Dine System Software (Dine Systems, Inc., Version 3.3) was used to analyze total kilocalories (kcal), protein, carbohydrates, fat, fiber, cholesterol, calcium, iron, vitamins A and C over a three-day period. Although there is no reliability data of a three-day food log in children, it was found to be a reliable indicator of nutrient intake in adults (Basiotis et al., 1987). Furthermore, studies have used this method to assess nutrient intake in children when assisted by their parents (Oliveria et al., 1992; Hongo et al., 1992).

The initial physical and anthropometric measurements were performed at the elementary school following a 12-hour overnight fast (Phase I). These measurements included height, weight, resting BP, waist and hip circumferences, skinfold thickness, grip and leg strength, and blood serum lipoproteins. All measurements were performed at specific stations and each child was rotated through each station to complete Phase I of their testing.

One to two days later, subjects performed their one-mile run as part of their cardiovascular evaluation and Phase II testing. One week later, subjects reported to the Human Performance Laboratory at which time they completed their GXT to determine V02max and returned their completed food logs.

Physical and Anthropometric Measurements - Phase I

Height and weight were recorded using a balance scale and stadiometer supplied by the elementary school. Body mass index (BMI) was calculated for each participant using their weight in kilograms (kg) divided by their height in meters squared (m²). Using a mercury sphygmomanometer, systolic and diastolic blood pressure (SBP and DBP, respectively), were recorded for each child after they were seated for approximately five minutes. The SBP was measured as the first detectable sound (Phase I) and DBP was measured as the disappearance of Korotkoff sounds (Phase 5). Two measurements of BP were taken five minutes apart and the mean of the two measurements was the value recorded. If duplicate measurements resulted in a difference of 5 mmHg or more, a third measurement was taken following a second 5-minute rest period and the mean of the two closest values was then recorded. All measurements were recorded to the nearest 1.0 mmHg.

Using skinfold calipers (Lange 68902, Cambridge, Maryland) triceps and subscapular skinfold thicknesses were recorded and percent body fat was derived from the appropriate sex and age-adjusted formula (Boileau et al., 1985). These measurements were taken by a trained investigator demonstrating good reliability using this technique in children (r = .94 and r = .96 for triceps and subscapular, respectively). Duplicate measurements were taken and if the difference between the two measurements was more than two millimeters (mm), a
third measurement was taken. The mean of the two closest values was recorded. All measurements were recorded to the nearest whole mm.

Circumferential measurements were obtained using a plastic spring measuring tape (Gullick II 67022, Plymouth, Michigan) to determine central adiposity. The waist circumference was the smallest circumference taken between the inferior angle of the rib and the hip. The hip circumference was taken at the maximal protrusion of the gluteal muscles. The waist to hip ratio (WHR) was the ratio calculated between the two circumferences recorded to the nearest 0.1 cm. All physical and anthropometric variables were taken prior to the fitness tests.

**Strength Measurements**

A standard hand grip dynamometer (Smedley 78010, Takei, Japan) was used to measure grip strength in the dominant arm. Students were asked to squeeze as hard as possible and three trials were allowed with a one-minute rest interval between trials. The highest value obtained in kg was recorded.

Assessment of lower body strength was made using a standard dynamometer (Dillon 2000, Van Nuys, California). By attaching a grip bar to a chain that is connected in series with the dynamometer, isometric strength was measured in kg. The children stood with their feet apart holding the grip bar of the dynamometer firmly against their thighs and were told to pull as hard as possible. The length of the chain was adjusted to accommodate the height of each subject and ensure that the bar rested against the mid thigh. All participants were positioned with their back erect against a wall to reduce the degree of backward lean and stress placed on the lower back. The highest maximum voluntary isometric contraction recorded in three trials was used to indicate lower body strength. It should be noted that because subjects were instructed to pull as hard as possible, the upper body muscles were not isolated from this isometric exercise. Mathews (1978) has indicated that with appropriate adjustment of the height of the bar and knee angle of the subject, it is primarily a lower body exercise.

**Serum Lipoproteins**

Blood serum lipoprotein measures were performed during Phase I testing. Blood specimens were obtained by venipuncture following an overnight fast. All children had to remain seated for at least five minutes prior to blood withdrawal. All blood was placed in 10 ml silica coated self-separating tubes (Fisher Scientific 6430, Orlando, Florida), centrifuged immediately, and analyzed 48 hours later. The concentration of total cholesterol (TC), HDL-C, and triglyceride (TG) levels were measured via light absorbency in serum samples using a Premiere filter photometer which measures absorbency at a wavelength of 500 nanometers (Stanbio Laboratory, Inc. 1905, San Antonio, Texas).

A blank tube was used to zero the machine and a three-point calibration curve was set up for TC, HDL-C, and TG levels using the respective standards of known concentrations. The TC and HDL-C were measured according to standard procedures (Allain et al., 1974). The HDL-C was measured enzymatically in the serum supernatant following precipitation of other lipoproteins using magnesium chloride (Warnick et al., 1982). The TG levels were measured according to standard procedures following treatment with a lipase (Dryer, 1970). The very low density lipoprotein cholesterol (VLDL-C) was calculated by dividing TG by five and low density lipoprotein cholesterol (LDL-C) was calculated by subtracting the HDL-C and VLDL-C from TC (Friedewald et al., 1972). These measurements have been validated against a large range of low, normal, and high TG levels and have been used elsewhere to estimate serum lipoproteins in children (Knip and Nuutilen, 1993; Raitakari et al., 1994a). Accuracy and precision of biochemical tests were ensured by sending a subset of blood samples to a reference laboratory for duplicate analysis. The reliability coefficient performed on samples in both laboratories was $r = .96$, .94, and .93 for TC, HDL-C, and TG's, respectively.

**Cardiovascular Fitness - Phase II**

One to two days after the initial measurements, students completed a one-mile run for time as part of Phase II testing. A half mile course was measured on an outdoor field using an odometer. Subjects were given an explanation of how to pace themselves and asked to run two laps around the measured course as quickly as possible. Verbal encouragement was provided to each group of participants throughout the run and three groups of six to eight children ran at one time. Investigators recorded each participants' time using a stop watch. All subjects were given a practice session approximately one month earlier.

Within one week of the initial testing, subjects completed a GXT on a Quinton treadmill to determine $\dot{V}O_2$max. Initially, the children were given a chance to familiarize themselves with the treadmill and comfortable running speeds were determined for each subject. Using a modified protocol from Gutin et al. (1990), each child walked at 3 mph and 0% grade for 3 minutes during a warm-up after which the speed was increased to a comfortable run (4 to 5 mph) at 0% grade. Thereafter, the speed remained constant and the grade was increased 2.5% every two minutes until subjects were unable to jog on the treadmill and were actually falling backward on
<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys (n=10)</th>
<th>Girls (n=12)</th>
<th>Total (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>11.83 ± 0.3</td>
<td>11.70 ± 0.34</td>
<td>11.76 ± 0.4</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.50 ± 0.1</td>
<td>1.44 ± 0.1</td>
<td>1.47 ± 0.1</td>
</tr>
<tr>
<td>Weight (Kg)</td>
<td>54.00 ± 10.8*</td>
<td>42.08 ± 8.0</td>
<td>47.50 ± 11.0</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>23.60 ± 2.7*</td>
<td>20.2 ± 3.3</td>
<td>21.70 ± 3.4</td>
</tr>
<tr>
<td>Waist to Hip Ratio (WHR)</td>
<td>0.84 ± 0.04</td>
<td>0.78 ± 0.12</td>
<td>0.81 ± 0.10</td>
</tr>
<tr>
<td>Skinfolds (mm)</td>
<td>43.3 ± 16.6</td>
<td>30.6 ± 11.9</td>
<td>36.3 ± 15.3</td>
</tr>
<tr>
<td>Body Fat (%)</td>
<td>29.28 ± 7.0</td>
<td>26.09 ± 7.0</td>
<td>27.54 ± 7.0</td>
</tr>
<tr>
<td>LBM (Kg)</td>
<td>37.77 ± 6.0**</td>
<td>30.69 ± 3.8</td>
<td>33.91 ± 6.0</td>
</tr>
</tbody>
</table>

Mean ± SD.

Body fat percent was derived from sex and age-adjusted equations using triceps and subscapular skinfold measurements (Boileau et al., 1985).

*Significantly greater by gender p<0.05, 2 tailed t test.

**Significantly greater by gender p<0.01, 2 tailed t test.

the apparatus. Constant verbal encouragement was provided by investigators throughout the test. Heart rate and rhythm were continuously monitored during the test and recorded every 15 seconds with a 12-lead electrocardiogram. Metabolic responses during exercise were continuously collected by analyzing the volume and concentration of expired air every 15 seconds using a Metabolic Cart (SensorMedics 2900, Anaheim, California). Gas calibration was performed prior to each test using a two-point calibration procedure for dried gases in a pressure equalization mode (SensorMedics, Inc., 1992). In all cases, subjects achieved a \( \dot{V}O_2 \)max as indicated by a difference of less than 150 mls in oxygen consumption between the next to last and last minute of exercise, a respiratory exchange ratio above unity and an inability to maintain pace while on the treadmill (Fox et al., 1988). All children achieved maximum heart rates above 200 bps · min\(^{-1}\) and most children exceeded their age-predicted maximum heart rate. During recovery, each child walked at 2.5 mph at 0% grade until heart rate returned to pre-exercise levels.

**Analysis of Data**

All statistical analyses were performed using the SAS Statistical Package (SAS Institute, Cary, North Carolina). Results are presented as means ± standard deviation. A students' t test for unpaired data was used to compare differences in measured variables by gender. Significance was accepted at the 0.05 level. A correlation matrix was performed on nutrient intake, physical characteristics, fitness measurements, and CRF to identify variables that could be used in a multiple regression analysis. A stepwise multiple regression analysis to predict CRF was performed using physical fitness variables as predictor variables. A separate multiple regression analysis was performed to determine the relative contribution of various dietary components to CRF. Dietary variables included total kcals, complex and simple carbohydrates (expressed as absolute and relative values), fat (total, polyunsaturated, and monounsaturated fat expressed as absolute and relative values), protein (expressed as absolute and relative values), total cholesterol, fiber, sodium, and vitamins A and C.

**Results**

Descriptive characteristics of subjects are presented in Table 1. Although boys and girls were similar in age and height, the boys were significantly heavier (p<0.05) had a greater BMI (p<0.05) and greater lean body mass than girls (p<0.01). There were no other significant differences by gender in any other physical variables.

Physical fitness variables have been presented in Table 2. Although the absolute measure of \( \dot{V}O_2 \)max, grip strength, and leg strength were all significantly greater in boys, these gender differences were not seen when expressed relative to body weight. In addition, there were no significant differences between boys and girls in time taken to complete a one-mile run.

The serum lipoprotein and BP values by gender and for the entire sample are presented in Table 3. There were no significant differences by gender in any serum lipid values. Only SBP was significantly higher in boys (p<.001). Of interest was the fact that the mean HDL-C was below the 5th percentile for boys and below the 50th percentile for girls, while the mean TG levels were above the 75th percentile for boys and above the 50th percentile for girls (Wynder et al., 1989).

Dietary intake and U.S. recommended levels of nutrient intake are presented in Table 4. Although total carbohydrates fell exactly at the recommended level of 55% of total kcals, (55 ± 7.0%), simple sugars (15.0 ± 6.7% of total kcal) exceeded the 10% recommended level (Wynder et al., 1989). Total fat intake (29.0 ± 6.0% of total kcals) was below the 30% level recommended by
Table 2  Physical fitness variables in elementary children

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys (n=10)</th>
<th>Girls (n=12)</th>
<th>Total Group (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative VO_{max} (mls / Kg / min / 1)</td>
<td>45.2 ± 9.0</td>
<td>45.4 ± 6.9</td>
<td>45.3 ± 6.9</td>
</tr>
<tr>
<td>Abs. VO_{max} (L / min / 1)</td>
<td>2.33 ± 0.2*</td>
<td>1.89 ± 0.3</td>
<td>2.1 ± 0.4</td>
</tr>
<tr>
<td>Grip Strength (Kg)</td>
<td>30.2 ± 5.0**</td>
<td>23.3 ± 4.2</td>
<td>26.50 ± 5.5</td>
</tr>
<tr>
<td>Grip (Strength / Kg / 1)</td>
<td>0.57 ± 0.1</td>
<td>0.57 ± 0.1</td>
<td>0.57 ± 0.1</td>
</tr>
<tr>
<td>Leg Strength (Kg)</td>
<td>95.9 ± 18.6*</td>
<td>69.70 ± 14.7</td>
<td>81.6 ± 21.0</td>
</tr>
<tr>
<td>Leg (Strength / Kg / 1)</td>
<td>1.81 ± 0.3</td>
<td>1.67 ± 0.3</td>
<td>1.73 ± 0.3</td>
</tr>
<tr>
<td>1 Mile run time (Min / Sec)</td>
<td>10:40 ± 1.4</td>
<td>10:19 ± 2.1</td>
<td>10:26 ± 1.6</td>
</tr>
</tbody>
</table>

Mean ± SD.
*Significantly greater by gender p<0.01.
**Significantly greater by gender p<0.001.

Table 3  Serum lipoproteins and blood pressure values in elementary children

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys (n=10)</th>
<th>Girls (n=12)</th>
<th>Total (n=22)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC (mg / dl / 1)</td>
<td>139.33 ± 18.0</td>
<td>124.08 ± 25.8</td>
<td>130.61 ± 23.6</td>
</tr>
<tr>
<td>LDL-C (mg / dl / 1)</td>
<td>83.33 ± 22.6</td>
<td>66.68 ± 16.1</td>
<td>73.80 ± 20.5</td>
</tr>
<tr>
<td>HDL-C (mg / dl / 1)</td>
<td>36.22 ± 7.9</td>
<td>40.25 ± 16.9</td>
<td>38.52 ± 13.6</td>
</tr>
<tr>
<td>VLDL-C (mg / dl / 1)</td>
<td>20.00 ± 4.5</td>
<td>17.25 ± 7.2</td>
<td>18.42 ± 6.2</td>
</tr>
<tr>
<td>TG (mg / dl / 1)</td>
<td>99.88 ± 21.1</td>
<td>87.00 ± 36.3</td>
<td>92.52 ± 30.8</td>
</tr>
<tr>
<td>TC / HDL-C (Ratio)</td>
<td>4.04 ± 1.1</td>
<td>3.35 ± 1.1</td>
<td>3.65 ± 1.1</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>115.70 ± 11.1*</td>
<td>106.41 ± 8.1</td>
<td>110.63 ± 10.5</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>74.40 ± 5.8</td>
<td>70.58 ± 7.8</td>
<td>72.31 ± 7.0</td>
</tr>
</tbody>
</table>

Mean ± SD.
*Significantly greater by gender p<0.001.

Table 4  Dietary intakes in elementary children in comparison to recommended levels

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Present Study (n=22)</th>
<th>Recommended Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Means SD</td>
<td></td>
</tr>
<tr>
<td>Total Calories</td>
<td>1679 ± 527.0</td>
<td></td>
</tr>
<tr>
<td>Carbohydrates (%)</td>
<td>55% ± 7.0</td>
<td>≥55% (National Research Council, 1989)</td>
</tr>
<tr>
<td>Total Fat</td>
<td>29 ± 6.0</td>
<td>&lt;30% (National Cholesterol Education Program, 1992)</td>
</tr>
<tr>
<td>Saturated Fat (%)</td>
<td>12% ± 3.0</td>
<td>≤10% (National Cholesterol Education Program, 1992)</td>
</tr>
<tr>
<td>Unsaturated Fat (%)</td>
<td>17% ± 3.0</td>
<td>= or &lt;20% (National Cholesterol Education Program, 1992)</td>
</tr>
<tr>
<td>Protein (%)</td>
<td>15% ± 4.0</td>
<td>15% (Wynder et al., 1989)</td>
</tr>
<tr>
<td>Fiber (grams)</td>
<td>12 ± 4.0</td>
<td>20-35 grams (Kritchevsky, 1988)</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>192 ± 140.0</td>
<td>&lt;300 mg (National Cholesterol Education Program, 1992)</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>689 ± 372.0</td>
<td>≤1200 mg (National Research Council, 1989)</td>
</tr>
</tbody>
</table>

American Heart Association (National Cholesterol Education Program, 1992).

In a multiple regression analysis, physical fitness variables showed no significant contribution to the variance observed in any measured serum lipoproteins. Physical fitness variables could predict approximately 41.9% of the variance in DBP (F = 3.1; p<0.05), however, none of the individual measures of physical fitness made a significant and independent contribution to the variance observed in DBP (Table 5). Physical fitness measures were also able to predict 53.9% of the variance observed in percent body fat (F = 4.98; p<0.01). In this case, time to complete a one mile run (p<0.05) was the only fitness variable that could significantly and independently contribute to the variance observed in this measure (Table 5). Expressing grip and leg strength relative to body weight made no significant difference upon the results of the multiple regression analyses.

Examination of dietary variables revealed that the percent total and saturated fat as well as carbohydrate intake predicted 59.4% of the variance found in TG (F = 5.18; p = 0.01). Of these nutrients, carbohydrates was the only nutrient that significantly and independently contributed to the variance in serum TG (r² = 36.4%; p<0.05). Percent body fat was the only other CRF that could be predicted by nutrient intake. Not unexpected was the fact that total fat intake (expressed as percent of kcal), total carbohydrate intake (expressed as a
percent of total kcals), and total kcals consumed could
significantly predict percent body fat \( (F = 3.42; p < 0.05) \).
In this case, total fat intake was the only nutrient that
could significantly and independently contribute to the
variance observed in percent body fat \( (r^2 = 18.1; p < 0.05) \).

### Discussion

Past research has shown that the presence of CRF in
children may persist into adulthood (Nelson et al., 1992;
Porkka et al., 1994). Since coronary atherosclerosis is a
slow and progressive disease, the increased prevalence of
obesity in children coupled with other CRF such as
hyperlipidemia and high BP could have major health
implications for children as they become adults (Raitakari
et al., 1994a; Wattigney et al., 1991).

One striking finding in this study was the fact that
both males and females in this study exhibited
remarkably low levels of HDL-C. The mean value for boys
and girls was 38 mg/dl. The U.S. norm for children is 57
mg/dl and 54 mg/dl for boys and girls, respectively
(National Cholesterol Education Program, 1992). In
adults, a low HDL-C is the single best lipoprotein used to
predict cardiovascular disease risk (Stampfer et al., 1991)
and low levels of HDL-C levels tend to track into
adulthood (Porkka, 1994; Raitakari et al., 1994b).
Examination of diet revealed that the mean total fat
intake for participants contributed to less than 30% of the
total kcal intake although saturated fat exceeded the
recommended 10% level (National Cholesterol Education
Program, 1992). In addition, carbohydrate intake of
subjects was at the recommended 55% level (National
Research Council, 1989) and was higher than the intake
reported for children living in the U.S. (Wynder et al.,
1989) and abroad (Glicksman et al., 1993; Raitakari et al.,
1994a). The fact that nutrient intake of children in this
study was within a healthy range (NIH, 1991) would
suggest that diet was probably not the cause of their low

### Table 5

Regression findings for the influence of physical fitness variables on diastolic
blood pressure and percent body fat

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>R²</th>
<th>P</th>
<th>STB</th>
<th>Squared Partial Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DBP</td>
<td>3.06</td>
<td>0.419</td>
<td>0.045</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VO₂max</td>
<td></td>
<td></td>
<td>0.403</td>
<td>-0.225</td>
<td>0.941</td>
</tr>
<tr>
<td>one-mile run</td>
<td></td>
<td></td>
<td>0.905</td>
<td>0.032</td>
<td>0.0008</td>
</tr>
<tr>
<td>grip strength</td>
<td></td>
<td></td>
<td>0.249</td>
<td>0.365</td>
<td>0.077</td>
</tr>
<tr>
<td>leg strength</td>
<td></td>
<td></td>
<td>0.439</td>
<td>0.242</td>
<td>0.036</td>
</tr>
<tr>
<td>% Body Fat</td>
<td>4.98</td>
<td>0.539</td>
<td>0.007</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>VO₂max</td>
<td></td>
<td></td>
<td>0.793</td>
<td>-0.062</td>
<td>0.004</td>
</tr>
<tr>
<td>one-mile run</td>
<td></td>
<td></td>
<td>0.023</td>
<td>0.581</td>
<td>0.266</td>
</tr>
<tr>
<td>grip strength</td>
<td></td>
<td></td>
<td>0.595</td>
<td>-0.147</td>
<td>0.170</td>
</tr>
<tr>
<td>leg strength</td>
<td></td>
<td></td>
<td>0.141</td>
<td>0.419</td>
<td>0.123</td>
</tr>
</tbody>
</table>

STB, standardized estimate; R², correlation coefficient

HDL-C levels. One could therefore speculate that the
lower HDL-C level found in the present study was due to
poor cardiovascular fitness levels and/or physical activity
levels. This was shown by Després et al. (1990) and
Raitakari et al. (1994a).

Other contributing factors to the low HDL-C levels
could also be a high BMI and skinfold thickness. Children
who are overweight and have a greater level of adiposity
tend to have lower HDL-C levels (Glicksman et al., 1993;
Kikuchi et al., 1992; Wattigney et al., 1991; Knip and
Nuutinen, 1983). Boys and girls had a mean BMI above
the U.S. average (17.9 and 18.3 for boys and girls,
respectively) (Hammer et al., 1991). The sum of
skinfolds for boys and girls in this study also exceeded
U.S. norms (18 mm and 21 mm for boys and girls,
respectively) (Ross et al., 1985). This would indicate a
greater than average level of adiposity found in our
children and coincides with the low HDL-C levels
observed in this study.

The mean VO₂max (mL·kg⁻¹·min⁻¹) was below the
reported average for boys (52 mL·O₂·kg⁻¹·min⁻¹) although
it fell within the average value for girls (43.5 mL·kg⁻¹·
min⁻¹) (Bar-Or, 1983). This finding is consistent with
other research reporting a range in VO₂max from 47.0–
59.4 mL·O₂·kg⁻¹·min⁻¹ for age-matched boys and 39.6–
52.4 mL·O₂·kg⁻¹·min⁻¹ for age-matched girls using the
treadmill (Krahenbuhl et al., 1985). In contrast, both
McCormack et al. (1991) and Cureton et al. (1997),
reported faster one-mile run times for both boys (7.39 ±
0.8 min and 8.23 ± 2.0 min for McCormack et al., 1991
and Cureton et al., 1997, respectively) and girls (9.72 ±
1.6 min and 8.9 ± 1.4 min for McCormack et al., 1991 and
Cureton et al., 1997, respectively) in their studies.
Therefore, the low levels of HDL-C observed in boys was
consistent with their low levels of aerobic fitness. In girls,
there was variability in aerobic fitness relative to other
studies depending upon the method used to evaluate
aerobic fitness. Since girls consistently showed greater
BMI and skinfold measures than reported national averages it is possible that their low HDL-C levels were more closely related to their greater than average adiposity levels. Indeed, Hager et al. (1995) found that the strong relationship between aerobic fitness and serum lipoproteins in their study was negated after controlling for body fat and abdominal fat. They concluded that the relationship between aerobic fitness and serum lipids/lipoproteins may be primarily mediated by adiposity levels. In our study, none of the physical fitness variables accounted for a significant percent of the variance found in serum lipoproteins. Perhaps as suggested by Hager et al. (1995), this relationship was overshadowed by the elevated BMI and adiposity levels.

The present study demonstrated that physical fitness variables significantly predicted resting DBP. This is in agreement with the work by Gutin et al. (1990) who showed that a submaximal physical work capacity test to 170 bts - min\(^{-1}\) (PWC 170) was significantly and inversely correlated with DBP in children. It is also in agreement with the work by Anderson (1994) showing that aerobic fitness as indicated by VO\(_{2}\)max was the best predictor of resting BP in adolescent children being inversely related with BP. In that study, other physical fitness measures i.e., flexibility and muscular endurance also contributed to a smaller yet significant percent of the variance found in resting BP. We know of no other studies showing that the inclusion of grip and leg strength in addition to aerobic fitness in a regression model could significantly predict DBP.

Percent body fat was the only other CRF that could be significantly predicted by physical fitness variables (Table 5). In this case, the one mile run and not VO\(_{2}\)max was the only fitness variable that independently accounted for a significant percent of the variance shown for percent body fat. This is somewhat surprising since both measures of aerobic fitness were significantly and inversely correlated with each other (r = - 0.69; p<0.001) and this inverse relationship has been demonstrated elsewhere (Cureton et al., 1997; McCormack et al., 1991; Cureton, 1994). The relationship implies that the greater the amount of time to complete a one-mile run, the lower the VO\(_{2}\)max. Indeed, Buono et al. (1991) reported that the one-mile run for time showed the strongest inverse relationship with VO\(_{2}\)max.

Nutrient intake was used to predict TG and percent body fat. It was interesting that carbohydrate rather than fat intake made the largest independent and only significant contribution toward the variance found in TG. More important is the fact that all three nutrients could predict close to 50% of the variance found in TG. Expected was the fact that total fat intake contributed significantly to the variance in percent body fat (p<0.05). This trend has been shown in some (Eck et al., 1992; Raitakari et al., 1994b) but not all studies (Shaw and Jequier, 1991) conducted in children. These findings may have clinical implications since elevated TG and body fat values have been shown to track into adulthood (Porkka et al., 1994; Garn and LaVelle, 1985).

There are limitations that should be considered when interpreting the results of this study. First, it is possible that parents of the more overweight and obese children had a greater vested interest in the study and were more likely to have their children participate in the study. Another confounding factor was the fact that boys and girls were combined in the multiple regression analysis. In girls, the growth spurt and secondary sex characteristics tend to occur approximately two years ahead of boys (Nelson, 1996). Although Tanner stages of development were not determined in this study, all girls were premenarcheal. Boys in this study were actually taller, significantly heavier (p<0.05) and had a greater BMI (p<0.05) than girls. Additionally, the low subject number limited the power of the statistical analyses. Therefore, caution is recommended in interpreting results and these findings should be considered preliminary in nature.

Within the context of these limitations, measurements of physical fitness variables which include aerobic fitness and strength are associated with DBP and percent body fat in children, however, physical fitness variables did not appear to be associated with serum lipoproteins. Furthermore, it is recommended that nutrient intake be included in the evaluation of CRF in children due to its predictive value in assessing TG and percent body fat.

References

Bar-Or O (1983) Pediatric sports medicine for the practitioner from physiologic principles to clinical applications. New York, NY: Springer
Institute for Aerobic Research, Dallas, 35-55


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