Health-Related Fitness and Coronary Heart Disease Risk Factors in Youth

by

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B.Sc. (Hons.), University of Victoria, 1993

A Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of

MASTER OF ARTS

in the Department of Physical Education

We accept this thesis as conforming
to the required standard

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ABSTRACT

The purpose of the study was to determine the relationship between performance on a health-related fitness test battery and coronary heart disease (CHD) risk factors in youth. 37 female and 58 male volunteer subjects in Grades 4 - 7 (classified as either pre- or mid-pubescent) from two public elementary schools (mean height = 149.0 cm and weight = 40 kg) completed the Manitoba Schools Fitness criterion-referenced test battery (1600m run/walk, push ups, modified sit ups, sit and reach, and 4 skinfolds), and were assessed for resting blood pressure, body mass index (BMI), waist to hip ratio (WHR), level of physical activity, and smoking status. Mean values (SD) for the fitness test items were 9:00 (1:47) min for the 1600m run/walk, 12 (8) push ups, 35 (9) sit ups, 29.0 (9.0) cm for the sit and reach, and 38.4 (19.9) mm for the sum of 4 skinfolds. Passing rates on the fitness tests ranged from 35% for push ups to 68% for the sum of two skinfolds, and trends were seen between gender and maturation groups. More males and early-pubescent subjects passed the push ups test, females had a higher passing rate on the sit and reach test, and more early-pubescent subjects passed the modified sit ups test. Mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 98 (12) and 60 (12) mmHg, respectively, for all subjects combined. The mean physical activity score (PAS) was 35.8 (15.9) out of a possible 100 points. There were no gender differences for these variables, but the early-pubescent subjects had significantly lower SBP than mid-pubescent subjects. No subjects reported smoking.

Canonical correlation indicated that there was a moderate relationship between the items in the Manitoba Schools Fitness test battery and the CHD health risk variables. The first three canonical correlations were statistically significant, with moderate values of .66, .64, and .40. Overall, the highest correlations between the two sets of variables were for the sum of 4 skinfolds and push ups from the fitness test set and DBP and BMI in the health set.

Discriminant analyses were performed to investigate if the health variables, as a group, could predict pass or fail status on each of the fitness test items. Chi-square values indicated that the set of health variables was a significant discriminator for the sum of 2 skinfolds, the sum of 4 skinfolds, push ups and the 1600m run/walk tests. Further, it was found that BMI had the highest individual loading with the discriminant function for all tests.

MANOVA was performed to assess the effects of gender, maturation, and their interaction on the sets of fitness variables and health variables. A significant gender effect was found for fitness and health variables combined and each set separately. A significant maturation effect was found for all variables combined, and for the set of health variables only. A significant interaction effect was found for all variables combined and for the set of fitness variables separately. Individual variables that appeared to have been significantly influenced by gender were the sum of 4 skinfolds, push ups, the sit and reach, and WHR. Females had higher sum of 4 skinfolds and sit and reach scores, and males had higher WHR scores and completed more push ups. In conclusion, results indicated that there was a moderate relationship between the two sets of variables, that the set of health variables could discriminate pass or fail status on the two skinfold tests, push ups, and the 1600m run/walk, and

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Acknowledgements

There are many people to acknowledge for assistance in the preparation of this thesis. I value the guidance, friendship, and opportunities Drs. David Docherty and Howard Wenger have provided in the Physical Education Department over the several years I have been at the university. I would like to also thank Drs. Bill Zuk and Walter Muir for their support and advice. I appreciate the career recommendations and enthusiasm of Dr. Kathy Gaul, and the friendship and administrative assistance of Mrs. Gladys Whittal. Paula McFadyen, Wendy Pethick and Roisheen Doherty have been wonderful friends and co-workers in the lab, offering advice and support in a variety of ways. The work-study and graduate students who assisted at the schools were efficient testers and terrific with the children.

I also wish to acknowledge the enthusiasm and cooperation of the students, teachers and principals at Uplands Elementary and Fairburn Elementary Schools; they allowed the data collection to be a pleasant and memorable experience.

INTRODUCTION

Although outward signs of chronic disease do not usually appear until adulthood, the early stages of disease begin in childhood and adolescence. Epidemiological studies have established the following risk factors in adults which are associated with susceptibility to premature development of coronary heart disease (CHD): family history of CHD, elevated blood lipids (serum cholesterol and triglycerides), obesity, hypertension, smoking, diabetes mellitus, stress, and inadequate physical activity (Vaccaro & Mahon, 1989). Risk factors for CHD can be identified in children and youth, but it is still unknown if an adverse risk factor profile will persist over time to an age when a person is most likely to develop the clinical manifestations of CHD (Vaccaro & Mahon, 1989). CHD risk factors will not have the same effect on the morbidity and mortality of children and youth as in adults, but the presence of these risk factors, especially when "clustered" as in the obese child, could lead to the eventual development of CHD. The identification of CHD risk factors in childhood may help to prevent or delay the progression of CHD through modification of the risk factor profile (Despres, Bouchard & Malina,1990).

It is difficult to address CHD risk factors separately since they tend to be inter-related. Obesity is considered to be a major CHD risk factor during growth because it is associated with other risk factors such as high blood pressure and adverse blood lipid profiles (Spady, 1991). The age at which childhood obesity can be considered indicative of adult obesity has not been established, although later childhood and adolescence have been suggested (Vaccaro & Mahon, 1989). In adults, a high proportion of abdominal or central fat appears to be a greater risk factor than obesity alone. Body mass index (BMI) and waist to hip ratio (WHR) have been used as convenient field assessments, especially in adults, to determine levels and distribution of body fatness which may negatively influence health (Despres, 1992; Burton, Foster, Hirsch & Van Itallie, 1985; Reeder, Angel, Ledoux, Rabkin, Young & Sweet, 1992). The potential complications of central fat in childhood have not been extensively studied (Despres et al., 1990). In adults, cigarette smoking is considered to have an independent adverse effect on the development of CHD. Adults who smoke generally acquire the habit in adolescence (Nora, 1980). Longitudinal studies of adolescent smokers show unfavorable changes in other CHD risk factors (Spady, 1991), and cigarette smoking has been associated with less frequent participation in sports (Rantakallio, 1983). Physical activity and physical fitness have received attention in the area of pediatric health because they generally show significant inverse relationships to CHD in adults (Blair, 1993). It is generally believed children and youth who are physically active and leaner have a more favorable risk factor profile than sedentary children (Despres et al., 1990). Family history of CHD is considered to be an important variable since CHD risk factors in children are generally higher if their parents' risks are greater (Vaccaro & Mahon, 1989). Some risk factors, such as obesity, may be more strongly related between parents and children than others (Crawford, McCargar & Limbert, 1993). The identification of CHD risk factors in children and adolescents and the relationship between these factors requires further investigation.

Physical fitness testing has traditionally been part of physical education in schools. Originally, performance-related test items were emphasized, and the tests and associated awards became a method of rewarding superior performance status and were intended to motivate students toward improvement. As society has become more aware of the health benefits of regular physical activity, fitness testing techniques and programs have been altered in content and delivery (Pate, 1988). Current fitness test batteries attempt to measure capacities that are related to health and can be improved through adherence to regular physical activity. The components assessed in test batteries typically include aerobic fitness, body composition, muscular endurance, and flexibility. The programs also promote and reward exercise behaviour in children, with the belief that behaviours related to optimal health and well-being developed in childhood may be maintained in adulthood. Currently, the only Canadian health-related fitness battery is the "Manitoba Schools Fitness" test (1989). The test battery includes the 1600m timed run, modified sit ups, push ups, sit and reach, and a 2-site or 4-site skin-fold assessment.

Health-related physical fitness tests generally use criterion references to categorize performance as either at a level that is sufficient to be associated with good health or at a level that should be improved. Students achieving the criterion level are encouraged to maintain or improve performance; students failing to reach the criterion are encouraged to change their exercise habits in order to reach at least the criterion level. However, because it is not specifically known what level of fitness in children is associated with reduced risk of hypokinetic disease, criterion standards for fitness performance are often set arbitrarily using specific percentile cut-off points. The validity of health-related fitness test batteries is questionable since the tests do not provide any direct assessment of health status and fail to provide evidence that reaching the criterion levels on the tests provides sufficient fitness to experience the health-related benefits that are purportedly associated with the test (Seefeldt & Vogel, 1989).

The "passing rates" on the FITNESSGRAM (IAR, 1987) health-related fitness test have been reported, using data from the National Children and Youth

Fitness Survey I and II (Looney & Plowman, 1990). The most frequently passed test item was the sit and reach (90-97%), followed by percent body fat (89-91%), body mass index (85-88%), mile run (60-77%), sit ups (57-65%), and push ups (32-73%). Males demonstrated higher passing rates for body mass index, mile run, sit ups, and push ups in the FITNESSGRAM test; this discrepancy between male and female performance was not found in the Fit Youth Today health-related fitness test (Zinkgraf, Johnson & Murthy, 1988). The relationship between performance on the "Physical Best" (AAHPERD, 1989) battery and the risk factor of blood pressure has been investigated in Italian youth aged 10 - 17 years. With the possible exception of diastolic blood pressure for boys, it was concluded that performance on the test battery was not associated with resting blood pressure in this age group (Bazzano, Cunningham, Varrassi & Falconio, 1992). Tests of aerobic fitness and body fatness have been investigated in relation to the presence of risk factors in children and adolescents (Bazzano et al., 1992; Pate, Slentz & Katz, 1989; Kemper & Vershuur, 1990; Armstrong, Williams, Balding, Gentle & Kirby, 1991), although overall performance on health-related fitness test batteries has not been compared to multiple CHD risk factors in children and adolescents.

Therefore, the purpose of the study was to determine the relationship between performance on the Manitoba Schools Fitness battery and the health risk measures of smoking, blood pressure, habitual physical activity, body mass index, and waist to hip ratio in a sample of youth aged 9 - 13 years. Further, it was to determine if health variables, as a set, could predict pass or fail status on each of the fitness test items. The effect of gender and maturational level on all variables was also examined.

It was hypothesized that the sum of skinfolds and performance on the mile run would be related to all health measures, and that there would be similar passing rates for males and females on the fitness test items.

METHODS

A. SUBJECTS

The subjects for this study were 37 female and 58 male volunteer subjects in Grades 4 - 7 from Uplands Elementary and Fairburn Elementary Schools in Victoria. Physical characteristics of the subjects are displayed in Table 1. The subjects were obtained by providing information sessions during class-time at the schools, and involvement in the research study was promoted as a class activity to improve the likelihood of obtaining a sample that was representative of the population. Further written information was sent home with interested students to obtain informed consent from a parent/guardian. Approximately 75% of the students approached at Uplands Elementary School agreed to participate in the study. The participation rate was lower at Fairburn Elementary School (approximately 60%), and participation was higher in younger subjects at both schools.

B. PROCEDURES

1. Maturational self-assessment

Maturational self-assessment from drawings and written descriptions developed by Morris and Udry (1980), based on the five stages of maturity suggested by Tanner were completed by the subjects for male genitalia and male pubic hair, or female breast development and female pubic hair (See Appendix G). Pearson product-moment correlations ranging from 0.59 - 0.81 have been reported (Morris & Udry, 1980) between self-assessments by adolescents and physician observation.

The maturation forms were explained in small groups of boys or girls or to individuals. A member of the testing team (usually of the same gender) explained the necessity of assessing maturation in this age group, and reinforced the idea that there was no particular score that was desirable or correct. Following verbal instructions, subjects privately marked the drawing on each form that was closest to their stage of development, and placed the forms in an envelope. Forms were identified by subject number only. Scores from the two forms were added for a combined score out of ten; a combined score of four or less was considered to represent early-pubescence, and those with a score of 5 or more were considered mid-pubescent. The maturation scores of the subjects ranged from 2 - 8.

2. Written questionnaire

Subjects completed a written questionnaire (Appendix F) in a classroom setting. Consistent verbal instructions were initially given to the group, and additional clarification of questions was provided to individuals when requested.
Questions 1 - 12 were selected from the Northern Ireland Health and Fitness Survey 1988/89. Questions 1 - 10 were used to calculate a physical activity score for each subject, using the methods of the Northern Ireland Health and Fitness Survey 1988/89 (Appendix H). Question 11 was used as a self-rating of physical activity level. Question 12 was used as a self-rating of physical fitness.
Questions 18, 20, and 27 were selected from the Campbell's Survey on Well-Being in Canada (1988). Question 18 was used as a self-rating of health. Question 20 was used to determine experience with tobacco, although subjects were categorized only as smokers or non-smokers. Question 27 was used to determine lifestyle factors that were perceived by the subjects to be very important to health.

The questionnaire used in the Campbell's Survey on Well-being in Canada (1988) was comprised primarily of questions from the original Canada Fitness Survey in 1981. The 1988 questionnaire was administered twice in a pilot study of 200 subjects, and test-retest reliability over 3 weeks showed a percentage agreement of 73 to 83 and Kramer's phi values of 0.53 to 0.86. In addition, 59 individuals were selected and debriefed on the ease of completion and comprehension of the questionnaire, and recommendations to increase understanding were implemented into the final questionnaire (Stephens & Craig, 1990).

The remaining questions from the present survey were used for additional information regarding lifestyle of the subjects for descriptive purposes.

3. Manitoba Schools Fitness test battery (Manitoba Education and Training, 1989) All tests were performed according to the Manitoba Schools Fitness manual (1989).

a. 1600 m timed run/walk

Subjects were instructed to run/walk 1600 m at an even pace. Walking was permitted, but the subjects were encouraged to run again when they felt able. Subjects performed a standardized warm-up that included a 400 m jog, followed by hamstring, quadriceps, and calf stretches, and 2 x 50 m accelerations on the track. Approximately 10 - 15 students completed the test at the same time, usually in groups of the same gender. Split times were given for each lap completed. The elapsed time from the starting command to the passage of the runner's torso across the finish line was scored to the nearest second.

b. modified sit ups

The arms of the subjects were crossed on the chest with the hands on the opposite shoulders. The feet were held flat by a partner, in contact with the mat. Subjects repeated as many sit ups as possible in the one-minute time limit. Rest between sit ups was allowed in either the up or down position. The total number of completed sit ups was recorded as the score.

c. push ups

Subjects performed "full" push ups (using the feet as the pivot point) on a mat or the gym floor. There was no time limit to the test but push ups had to be performed rhythmically and continuously using proper technique. The total number of complete push ups was recorded as the score. Subjects who could not complete any push ups (n= 2 males, 8 females) attempted modified push ups (using the knees as the pivot point). Scores for modified push ups were reported back to the subjects for their personal information, but were not included in the grouped data for analysis.

d. sit and reach

The modified hurdler's stretch was performed twice on each leg for 20 seconds as the standardized warm up. With shoes removed, subjects sat with legs straight out in front of them with the bottoms of both feet contacting the sit and reach box. The backs of the knees remained in contact with the floor. While exhaling, subjects reached forward with both hands and pushed the wooden marker as far as possible, with a smooth, gradual motion. When subjects had reached as far as possible, the tester counted aloud "one, one thousand; two, one thousand" while subjects maintained the stretched position. The test was repeated twice and the best score, to the nearest 0.5 centimeter, was recorded.

4. Anthropometric Data

a. skinfold measurements

Skinfold measurements were taken with Harpenden calipers (British Indicator Ltd., UK) at the biceps, triceps, subscapular, iliac crest and calf sites as outlined by the Manitoba Schools Fitness manual (1989). Values were recorded to the nearest 0.1 mm. Two measurements were taken at each site and a third measurement was taken if the first two differed by more than 0.4 mm. The median score was recorded if three measurements were taken and if two measurements were taken, the mean to the nearest 0.1 mm was recorded. The sum of skinfolds using the 2-site method (triceps + calf) and the 4-site method (biceps + triceps + subscapular + iliac crest) were recorded for each subject.

b. girth measurements

Waist and hip girth measurements were collected according to the CSTF Operations Manual (1986).

c. Height and weight

Height was measured according the procedures outlined in the CSTF Operations Manual (1986). A portable weigh scale placed on a uncarpeted surface was used to measure weight to the nearest 1.0 kg. Subjects were weighed without shoes and instructed to stand in the center of the scale.

5. Blood pressure

Subjects were instructed to sit quietly for 5 minutes prior to blood pressure measurements; many subjects continued to fill in their questionnaires as they rested. Duplicate measurements were performed three minutes apart on the right upper arm with an appropriately sized cuff while the subjects were seated. The systolic point of appearance of sound (Korotkoff I) and the point of disappearance of sound (Korotkoff V) were recorded. The lower value of Korotkoff I (systolic blood pressure) and Korotkoff V (diastolic blood pressure) were used as the final values (Bazzano et al., 1992).

C. TESTING SCHEDULE

All data, except the 1600 m run, were collected during class-time at each school over two testing days. The 1600 m run was performed at the University of Victoria Warm-Up track on the third testing day.

Day 1	Day 2	Day 3
written questionnaire	modified sit ups	1600 m walk/run
blood pressure	push ups	
anthropometrics	sit and reach	

D. DATA ANALYSIS

1. Canonical correlation to analyze the relationship between two sets of variables was used to determine the relationship between performance on the health-related fitness tests items in the Manitoba Schools Fitness battery (1600 m run, modified sit ups, push ups, sit and reach, sum of 2 skinfolds and sum of 4 skinfolds) and the CHD risk factors (smoking, physical activity level, systolic blood pressure, diastolic blood pressure, WHR, and BMI).

2. Discriminant function analysis was used to determine if CHD health risk scores (smoking, physical activity level, systolic blood pressure, diastolic blood pressure, WHR, and BMI) could predict pass or fail status (group membership) of the criterion-referenced health-related fitness tests in the Manitoba Schools Fitness battery (1600 m run, modified sit ups, push ups, sit and reach, sum of 2 skinfolds and sum of 4 skinfolds).

3. A 2 x 2 multivariate analysis of variance was used to investigate the effects of gender, maturational level, and their interaction on the fitness tests in the Manitoba Schools Fitness battery (1600 m run, modified sit ups, push ups, sit and reach, and sum of 4 skinfolds), and the health variables (smoking, physical activity level, systolic blood pressure, diastolic blood pressure, WHR, and BMI).

RESULTS

Descriptive data for the subjects are summarized in Table 1. Mean age for all subjects was 11 (1) years, and mean height and weight were 149.0 (8.0) cm and 40 (9) kg, respectively. Mean body mass index (BMI) for all subjects was 18.0 (2.6), and waist to hip ratio was 0.79 (.05). Male subjects had significantly higher WHR than females, and mid-pubescent subjects were significantly taller and had a higher BMI than early-pubescent subjects.

Insert Table 1 here (see p. 31)

The sum of 2 skinfolds (triceps + calf) and the sum of 4 skinfolds (triceps + biceps + subscapular + iliac crest) are presented in Table 2. Mean values were 24.2 (11.1) mm for the sum of 2 skinfolds and 38.4 (19.9) mm for the sum of 4 skinfolds. Females had significantly higher values for both measures compared to males. There were no significant differences in skinfolds between the early- and mid-pubescent subjects. Table 3 includes mean values for the remaining fitness test variables. For all subjects combined, mean time to complete the 1600m walk/run was 9:00 (1:47) minutes. Mean number of repetitions for modified sit ups and push ups were 35 (9) and 12 (8), respectively. Mean sit and reach score was 29.0 (9.0) cm. Females did significantly fewer push ups than males, but had higher sit and reach scores. There were no differences on any fitness tests between early- and mid-pubescent subjects. The passing rates (based on gender and chronological age) for all fitness test items except the sum of skinfolds are presented in Table 4. For all subjects combined, the 1600m walk/run had the highest passing rate (66%), followed by modified sit ups (51%), sit and reach (41%) and push ups (35%).

When passing rates between the genders were compared, the 1600m run/walk and modified sit ups rates were similar, but more males (43%) than females (22%) passed the push ups, and the opposite trend was observed for the sit and reach test (females 57% vs. males 31%). Passing rates between the early- and mid-pubescent subjects were similar for the 1600m run/walk and identical for the sit and reach test, but early-pubescent subjects had higher passing rates compared to the mid-pubescent subjects for modified sit ups (55% vs. 46%) and push ups (41% vs 28%).

Insert Tables 2, 3 & 4 here (see pp. 32 - 34)

The sum of skinfolds have criterion levels for both too little fat and too much fat. Therefore, Table 5 presents the results as below, within, or above the criterion levels of fatness. In all subjects combined, for the sum of 2 skinfolds, 6.3% were below the lower criterion level, 68.4% were within the recommended level, and 25.3% were above the upper criterion level. For the sum of 4 skinfolds, 3.2% were below the lower criterion level, 63.2% were within the recommended level, and 33.7% were above the upper criterion level. Trends were seen when the data were analyzed by gender; more males were within the recommended level of fatness than females, and more females were above the upper criterion level. Early-pubescent subjects had a higher number of subjects within the recommended level of fatness than mid-pubescent subjects; mid-pubescent subjects demonstrated a higher prevalence of being above the upper criterion level of fatness. The remaining health risk variables are presented in Table 6. Mean systolic blood pressure (SBP) and diastolic blood pressure (DBP) were 98 (12) and 60 (12) mmHg, respectively, for all subjects combined. The mean physical activity score

(PAS) was 35.8 (15.9). There were no gender differences for these variables, but the early-pubescent subjects had significantly lower SBP than mid-pubescent subjects. No subjects reported smoking.

Insert Tables 5 & 6 here (see pp. 35 - 36)

The correlational matrix for all variables in all subjects combined is shown in Table 7. The strongest correlations were observed between BMI, sum of 2 skinfolds, and sum of 4 skinfolds (.80-.94). Moderate correlations were found between SBP and DBP (.60), between push ups and the skinfold measurements (-.53), and between the 1600m run/walk and the skinfold measurements (.48-.52). Lower but significant correlations were found within some other fitness test items (.22-.47), and between BMI, skinfold measurements and some fitness test items (-.24-.38). In addition, PAS score was related to the 1600m run/walk (-.33) and the sum of 4 skinfolds (.22) and WHR was correlated to BMI (.26).

Insert Table 7 here (see p. 37)

Canonical correlation was performed between the set of fitness variables and the set of health variables. The fitness set included the sum of 4 skinfolds, 1600m run/walk, modified sit ups, push ups, and the sit and reach. The health set measured systolic blood pressure, diastolic blood pressure, physical activity level, body mass index, and waist to hip ratio. For all subjects combined, the first canonical correlation was .66 (44% of variance), the second was .64 (41% of variance), and the third was .40 (16% of variance). Data for the three significant pairs of canonical variates for all subjects are presented in Table 8. Shown are the correlations between the variables and the canonical variates, standardized canonical variate coefficients, within-set variance accounted for by the canonical variates (percent of variance), and canonical correlations. Using a cutoff point of .3, as recommended by Tabachnick and Fidell (1989), the variables in the fitness set that were correlated to the first canonical variate (the linear "composite score" of the fitness set) were the sum of 4 skinfolds, push ups, and the 1600m run/walk. The variables of DBP, BMI, and WHR correlated with the first canonical variate formed by the health variable set. The first pair of canonical variates indicate that those subjects with a higher sum of 4 skinfolds (.78), fewer push ups (-.49), and longer 1600m run/walk time (.32) also tended to have higher DBP (.89), BMI (.39), and WHR (.31). The second canonical variate from the fitness set was composed of positive "influences" from push ups, the sum of 4 skinfolds, and modified sit ups; the 1600m run/walk was negatively correlated to the canonical variate. The health set was composed of SBP and DBP, and negatively influenced by BMI and WHR. As a pair, these variates suggest that a combination of lower 1600m run/walk time, more push ups, a higher sum of 4 skinfolds, and more sit ups corresponded with a combination of lower BMI, lower WHR, and higher SBP and DBP. The third canonical variate in the fitness set was composed of 1600m run/walk and push ups, and negatively correlated to sit and reach. The health set consisted of PAS and negative of DBP. As a pair, these variates suggest that subjects with lower sit and reach values, more push ups and slower 1600m run/walk times correspond with higher PAS and lower DBP.

Insert Table 8 here (see p. 38)

Direct discriminant function analyses was performed using the five health variables as predictors of membership in two groups (pass or fail) for each of the fitness tests. Skinfold scores that were below the lower criterion level (n = 6 for sum of 2 skinfolds and n = 3 for sum of 4 skinfolds) were not included in these analyses. The loading matrix of correlations between predictors and the discriminate function (Table 9) suggest that the best predictor for distinguishing between pass or fail status on the sum of 2 skinfolds and sum of 4 skinfolds tests for all subjects combined was body mass index (BMI). Subjects who were within the recommended levels of fatness for the sum of 2 skinfolds had significantly lower BMI (mean = 17.2) than subjects who were above the upper criterion level (mean = 20.8); this trend was also found between subjects who passed and failed the sum of 4 skinfolds (means = 17.0 and 20.3, respectively). No other predictors had loadings higher than .50, and were, therefore, not interpreted. Eigenvalues of .59 (sum of 2 skinfolds) and .68 (sum of 4 skinfolds) indicate that the discriminate function is a better predictor of group membership for the skinfold tests than any of the other fitness tests (see Table 14). 82.0% and 81.5% of group membership for the sum of 2 skinfolds and the sum of 4 skinfolds, respectively, were classified correctly (Table 11).

Insert Tables 9 & 11 here (see pp. 39 - 41)

Table 14 shows the direct discriminant function analyses results for the remaining fitness tests. BMI was the best predictor of group membership for modified sit ups, push ups and the 1600m run/walk, but for the sit and reach test, DBP had the highest loading with the discriminant function. With the exception of SBP for the push up test, DBP for the sit and reach test, and WHR for the 1600m run/walk, all other health variables had correlations of less than .50 on all tests. Eigenvalues ranged from .04 (sit and reach) to .24 (1600m run/walk) for these fitness tests. Rates of correctly classified cases were 59.0% for modified sit ups, 64.2% for sit and reach, 68.4% for push ups, and 69.5% for the 1600m run/walk (Table 11).

Insert Table 10 here (see p. 40)

A 2 x 2 MANOVA was performed with all fitness and health variables as dependent measures and gender and maturation level as independent measures (Table 12). With the use of Wilks' criterion, the combined dependent variables were significantly affected by both gender, $\underline{F}$ (10, 82) = 6.1, $\underline{p} < .05$, and maturation, $\underline{F}$ (10, 82) = 2.1, $\underline{p} < .05$, but not by their interaction $\underline{F}$ (10, 82) = 1.6, $\underline{p} > .05$. The results reflected a moderate association between gender and all of the combined dependent variables, $\eta^2 = .43$, and a smaller association ($\eta^2 = .20$) between maturation and all of the dependent variables.

Insert Table 12 here (see p. 42)

In a separate analysis, there was a significant gender effect, $\underline{F} = 6.63$, $p < .05$ and interaction effect, $\underline{F} = 2.63$, $p < .05$ for the fitness test variables alone (Table 13). The results reflected a small association between gender and all of the combined dependent variables, $\eta^2 = .28$, and a lower association ($\eta^2 = .13$) between the interaction of gender and maturation for all of the dependent variables.

Insert Table 13 here (see p. 43)

When the health variables were analyzed alone (Table 14), a significant gender effect, $F = 5.84$, $p<.05$ and significant maturation effect, $F = 3.67$, $p<.05$ were found. Level of maturation and gender accounted for 17% and 25%, respectively of the variance in health variables.

Insert Table 14 here (see p. 44)

DISCUSSION

Descriptive data

Subjects in this study (37 females and 58 males) ranged in age from 9 - 13 years. Mean height and weight in females was 150.0 cm and 42 kg, respectively. Males were 148.5 cm in height and weighed 39 kg. These values were similar to those reported by others for the same age group (Docherty & Gaul, 1991; Anderson, 1992).

Fitness Variables

The sum of 2 skinfolds (triceps + calf) and sum of 4 skinfolds (triceps + biceps + subscapular + iliac crest) were significantly higher in females (27.7 mm and 44.9 mm) than in males (22.4 mm and 33.5 mm) in the present study. Data for the sum of 2 skinfolds and sum of 4 skinfolds were also analyzed for the prevalence rates of subjects falling below, within, and above criterion levels of fatness suggested by the Manitoba Schools Fitness test battery. In females, 48.6% - 51.4% of subjects were within the recommended levels of fatness. 13.5% of girls were below the criterion for the sum of 2 skinfolds and no girls were below the criterion for the sum of 4 skinfolds. 35.1% - 51.4% of girls were above the criterion levels of fatness. In males, there was a higher number of subjects (72.4% - 79.3%) within the recommended guidelines for fatness. 19.0% - 22.4% of males exceeded the criterion level for fatness. Few studies have reported "pass/fail" rates for criterion-referenced fitness test batteries. Looney & Plowman (1990) re-analyzed data from the NCYFS I and II and reported that 84.6% - 95.7% of girls aged 6 - 18 years "passed" the FITNESSGRAM criteria of carrying less than 32% body fat. Rates for boys were based on the criterion of 25% body fat, and 82.4% - 95.7% of subjects passed this level. These American data indicate a much higher passing rate than those in the present study. This is likely due to differences in the criterion levels; the criterion levels used by FITNESSGRAM (25% and 32% body fat) may be considered obesity cutoff points in children and youth (Lohman, 1987), while the Manitoba Schools Fitness criterions attempt to indicate levels of fatness that may be associated with increased health risk, which are lower than the cutoffs used in FITNESSGRAM.

Mean time to complete the 1600m run/walk and scores for modified sit ups were similar between males and females, but there were significant gender differences for push ups and sit and reach scores. The sit and reach criterion score on the Manitoba Schools Fitness test is the same for both genders and all ages, so gender differences in passing rates were expected. Higher passing rates have been reported for the sit and reach test on health-related fitness tests (Looney & Plowman, 1990; Hoeger, Hopkins, Button & Palmer, 1990), but the criterion standard for Manitoba Schools Fitness (30 cm) is higher than for the FITNESSGRAM (10 cm) and Physical Best (25 cm) tests. Criterion levels differ for age and gender for the other test items; passing rates were similar for modified sit ups between males and females, but were higher for females in the 1600m run/walk and higher for males for push ups. Mean time to complete the 1600m run/walk in the present study was less than reported for boys aged 10 - 12 years (Anderson, 1992), although passing rates for the 1600m run/walk were similar to those reported for 6 - 18-year-olds with FITNESSGRAM (Looney & Plowman, 1990), and higher than those reported for 10 - 17-year-olds with Physical Best (Bazzano et al., 1992). Passing rates for modified sit ups in this study were slightly lower than for sit ups in FITNESSGRAM (Looney & Plowman, 1990);

pull ups rather than push ups are used to measure upper body endurance in FITNESSGRAM so comparison with the present study is inappropriate.

Health Variables

Mean body mass index (BMI) was 18.6 in females and 17.7 in males. These values are slightly lower than those reported for other Canadian girls (19.2) and boys (18.4) with mean age of 13 years (Suter & Hawes, 1993) and females (20.3) and males (20.8) aged 17.4 years (Bouchard, Persusse & LeBlanc, 1989). In the present study, waist to hip ratio (WHR) was significantly higher in males (0.81) than in females (0.77). These values are lower than those reported for 4th grade girls (0.94) and boys (0.96) in Southern Italy (Esposito-Del Puente et al., 1994) and for black and white American youth aged 8 - 13 years, whose WHR ranged from 0.85-0.88 (Shufford, Duey, Allen & Williford, 1995). Few pediatric studies have assessed WHR, but adult studies indicate that WHR is usually greater in males than females, and increases with age in both genders (Reeder et al., 1992; Despres, 1992; Must, Dallal & Dietz, 1991). Mean systolic and diastolic blood pressure was 98 and 60 mmHg, respectively. These values are lower than those reported by other authors for similar age groups (Esposito-Del Puente et al., 1994; Crawford et al., 1993; Bazzano et al., 1992; Sallis, Buono, Roby, Micale & Nelson, 1993), but only Bazzano et al. (1992) specified that fifth phase was used to define DBP. Other authors may have used the fourth phase, which would result in higher diastolic values. In the present study, SBP was significantly higher in mid-pubescent subjects than early-pubescent subjects, which was expected since blood pressure is related to age and increases during growth (de Swiet, 1986). DBP, however, was not significantly different between the two maturation groups.

The mean physical activity score was 35.8 out of a possible 100 points; there were no differences between gender or maturation groups. The activity score was calculated from a series of questions regarding normal physical activity during an average day, eg. travel to and from school, recess and lunch time activities, and after school and evening activities such as clubs and teams. Each activity was subjectively weighted according to its perceived energy cost and an activity score assigned using the methods of the Northern Ireland Health and Fitness Survey 1988/89. That Survey divided subjects into four activity groups, using the activity score (above or below the class mean) in conjunction with the amount of time spent in high intensity activity determined from a 7-day recall of physical activity. Since the activity score was used in different ways, it is not appropriate to compare the activity scores reported in the present study with data from the original source. Although there is no accepted criterion measure of physical activity, relatively objective measures such as heart rate monitoring, direct observation and use of electronic sensors (eg. Caltrac) have been found to be significantly related to self-reported measures from questionnaires and re-call forms in children (Baranowski, Dworkin, Cieslik, Hooks, Clearman, Ray, Dunn & Nader, 1984; Wallace, McKenzie & Nader, 1985; Sallis et al., 1993; Simons-Morton, Taylor & Huang, 1994). A questionnaire, rather than a re-call of activities was used in the present study to gain a general understanding of the amount of activity that was engaged in during a typical week.

Relationship between Manitoba Schools Fitness test items and CHD risk factors

Canonical correlation indicated that there was a moderate relationship between the items in the Manitoba Schools Fitness test battery and the CHD health risk variables. The first three canonical correlations were statistically significant, with moderate values of .66, .64, and .40. These correlations accounted for 44%, 41%, and 16% of overlapping variance, respectively. Since the canonical correlations, especially the third, are only moderate, interpretation must be conservative. Overall, the highest correlations between the two sets of variables appeared to be for the sum of 4 skinfolds and push ups from the fitness test set and DBP and BMI in the health set. Relationships between the sum of 4 skinfolds, push ups and BMI were supported by the simple correlational matrix (Table 7), with coefficients ranging from -.36-.84.

Use of CHD risk factor variables to predict pass or fail status on Manitoba Schools Fitness test items

Discriminant analyses was performed to investigate if the health variables, as a group, could predict pass or fail status on each of the fitness test items. Chi-square values indicated that the set of health variables was a significant discriminator for the sum of 2 skinfolds, the sum of 4 skinfolds, push ups and the 1600m run/walk tests. Further, it was found that BMI had the highest individual loading with the discriminant function for all tests. For the skinfold tests, it was the only individual variable with a significant loading. In the push ups test, BMI and SBP had significant loadings, and for the 1600m run/walk, BMI, WHR, and PAS loaded significantly with the discriminant function. Overall, these analyses suggest that BMI is a very important discriminator between subjects who pass or fail over half of the fitness test items in the Manitoba Schools Fitness battery. As expected, it was found that subjects who failed the skinfold tests, push ups and the 1600m run/walk had a higher mean BMI than those who passed.

Much of the fitness literature discusses skinfolds rather than BMI, but since the two measures are highly correlated, BMI can be interpreted in a similar way to skinfolds. Skinfold thickness has often been reported to be inversely related to performance of distance run fitness tests (Cureton, Boileau, Lohman & Misner, 1977; Pateetal., 1989; Cureton, Baumgartner & McManis, 1991; Bazzano et al., 1992; Murray, Walker, Jackson, Morrow, Eldridge & Rainey, 1993). The effect of skinfolds on other fitness test items has been examined less frequently. Pate et al. (1989) reported that, for two previously existing data sets of children aged 6 - 16 years, the sum of two skin folds (triceps and abdominal or triceps and subscapular) was also significantly inversely related to sit up performance in both data sets and sit and reach performance in one data set. Similar results have been found (Bazzano et al., 1992) using the sum of triceps and calf skin folds. Cardiovascular fitness in 10-15 year old Canadian youth, determined by a PWC_{170} test, was significantly correlated to a lower sum of ten skin folds in both genders (Suter & Hawes, 1993).

Subjects in the present study who failed the 1600m run/walk also had a higher WHR, but lower SBP than those who passed. Since WHR can indicate body fat patterning, it might be expected that it would be associated with running performance. Lower SBP in subjects who failed the 1600m run/walk is unexpected compared to previous pediatric literature, but blood pressure was not related to skinfolds in this study which may have influenced this finding. Many authors have found that the relationship between aerobic fitness and blood pressure in children and youth is influenced by body fatness, with higher body fat being associated with higher blood pressure and poorer aerobic fitness (Wynder, Williams, Laakso &

Levenstein, 1981; Armstrong et al., 1991; Kwee & Wilmore, 1990; Fripp, Hodgson, Kwiterovich, Werner, Schuler & Whitman, 1985). In the present study, simple correlations showed no significant relationships between blood pressure and either skinfold test, BMI, or WHR, although the canonical correlation indicated some relationship between the variables of skinfolds, 1600m run/walk time, BMI, and WHR. Bazzano et al. (1992) also found that SBP was not associated with 1-mile run performance, skinfold measures, or muscular fitness in the Physical Best test battery in a sample of Italian youth aged 10 - 17 years. The authors suggested that the lack of association between blood pressure and the 1-mile run may have been partially due to the skinfold test which only included two peripheral body sites and therefore may have missed central fatness. However, the present study found no relationship between fatness and blood pressure even with the sum of 4 skinfolds which included both peripheral and central sites. Discriminant analysis suggested that physical activity also appeared to have some influence on the pass or fail status of the 1600m run/walk. The relationship between physical activity and fitness in children has primarily focused on aerobic fitness, and some authors have reported higher peak $\dot{V}O_2$ in more active children (Atomi, Iwaoka, Hatta, Miyashita & Yamamoto, 1986; Kemper & Verschuur, 1990). However, comparison between studies is difficult due to methodology used to measure physical activity.

Effect of gender and maturation on the relationship between the Manitoba Schools Fitness test items and CHD risk factors

Since the present study included both males and females with a range of physical maturation levels, a MANOVA was performed to assess the effects of gender, maturation, and their interaction on the sets of fitness variables and health variables. Initially, all variables from both sets were included in the analysis, which resulted in significant effects for gender and maturation, separately, but no significant interaction effect. More specifically, when the fitness variable set was analyzed alone, there was a significant gender effect and interaction effect, and for the health set, a significant gender effect and maturation effect were found. Individual variables that appeared to have been significantly influenced by gender were the sum of 4 skinfolds, push ups, the sit and reach, and WHR. Analyses suggested that BMI and SBP were influenced by maturation level, and the sit and reach and modified sit ups were influenced by the interaction of gender by maturation. These results indicate that it is appropriate to utilize separate criterion standards for males and females and different age groups when assessing fitness test scores. They also further demonstrate the influence of body composition (BMI and sum of skinfolds) on both fitness tests and other CHD risk factor variables.

Many fitness test batteries used in schools have shifted to criterion-referenced scoring systems; subjects either meet or fail to meet a criterion score that is believed to be related to health. However, it is not currently known if the test items or the criterion standards are actually related to health. In addition, although CHD risk factors can be identified in children, it is not clear if their presence will track over time to adulthood when CHD manifests itself. Longitudinal data are required to know which CHD risk factors should be regarded as important even in childhood. This study has attempted to determine if performance on the items in a health-related fitness test battery were actually related to some known CHD risk factors, and further, if the set of CHD health risk factor variables could discriminate pass or fail status on the fitness tests. The effects of gender and level of physical maturation on the variables was also investigated. Interpretation of the results of this study must be made with caution due to the relatively small sample size of volunteer subjects. Although the study was promoted as a class project in the schools, and students were encouraged to participate regardless of their abilities, it was possible that students who were more fit and active self-selected into the study. The physical activity score was difficult to compare to other data, since no criterion measurement of physical activity exists, and there is little consistency in the measurement of physical activity across studies. Blood pressure values were also difficult to compare across studies since DBP may be taken as the 4th or 5th Korotkoff sound; some studies do not indicate which sound was used to define DBP. However, results indicated that there was a moderate relationship between the Manitoba Schools Fitness test items (1600m run/walk, push ups, modified sit ups, sit and reach, and sum of 4 skinfolds) and the CHD risk factors (systolic blood pressure, diastolic blood pressure, body mass index, wasit to hip ratio and smoking status), that the set of health variables could discriminate pass or fail status on the two skinfold tests, push ups, and the 1600m run/walk, and that both sets of variables were influenced by gender and level of physical maturation.

Conclusions for the research questions

1. What is the relationship between performance on the health-related fitness test items in the Manitoba Schools Fitness battery (1600 m run, modified sit ups, push ups, sit and reach, and 2 or 4 skin fold sites) and the CHD risk factors of physical activity level, blood pressure, body mass index, waist to hip ratio, and smoking?

There was a moderate relationship between the items in the Manitoba Schools Fitness test battery and the CHD health risk variables. The first three canonical correlations were statistically significant, with moderate values of .66, .64, and .40. These correlations accounted for 44%, 41%, and 16% of overlapping variance, respectively. Since the canonical correlations, especially the third, are only moderate, interpretation must be conservative. Overall, the highest correlations between the two sets of variables appeared to be for the sum of 4 skinfolds and push ups from the fitness test set and DBP and BMI in the health set. Relationships between the sum of 4 skinfolds, push ups and BMI were supported by the simple correlational matrix (Table 7), with coefficients ranging from -.36-.84.

2. Can the scores of CHD risk factor variables (physical activity level, blood pressure, body mass index, waist to hip ratio, and smoking status) predict pass or fail status of any of the criterion-referenced health-related fitness tests in the Manitoba Schools Fitness battery?

The set of health risk factor variables was a significant discriminator between pass and fail groups for the sum of 2 skinfolds, sum of 4 skinfolds, push ups, and the 1600m run/walk tests. However, the results suggested that BMI was the individual variable with greatest influence for each test. SBP also loaded significantly with the discriminant function for the push ups test, while WHR and PAS also loaded significantly for the 1600m run/walk test. Correct classification of subjects into pass or fail groups, based on the discriminant function from the health variables ranged from 59% for modified sit ups to 82% for the sum of 2 skinfolds.

3. What are the effects of gender, maturational level, and their interaction on the Manitoba Schools Fitness test items and the CHD health risk variables together as a group, on the fitness test items alone, and on the CHD health risk variables alone?

When all variables from both sets were combined as the dependent variables, analyses resulted in significant effects for gender and maturation, separately, but no significant interaction effect. More specifically, when the fitness variable set was analyzed alone, there was a significant gender effect and interaction effect, and for the health set, a significant gender effect and maturation effect were found. Individual variables that appeared to have been significantly influenced by gender were the sum of 4 skinfolds, push ups, the sit and reach, and WHR. Analyses suggested that BMI and SBP were influenced by maturation level, and the sit and reach and modified sit ups were influenced by the interaction of gender by maturation.

Table 1
Mean Values and Standard Deviations of Age, Height, Weight, Body Mass Index (BMI), and Waist to Hip Ratio (WHR)

	Variables				
Group	Age (yrs)	Ht. (cm)	Wt. (kg)	BMI	WHR
All Combined n = 95	11 (1)	149.0 (8.0)	40 (9)	18.0 (2.6)	0.79 (.05)
All Girls n = 37	11 (1)	150.0 (9.0)	42 (10)	18.6 (2.7)	0.77 (.05)[a]
All Boys n = 58	11 (1)	148.5 (8.0)	39 (8)	17.7 (2.5)	0.81 (.04)[a]
All Early-pubescent n = 49	11 (1)	144.5 (7.0) [b]	36 (6) [c]	17.4 (2.2) [d]	0.80 (.05)
All Mid-Pubescent n = 46	12 (1)	154.0 (7.0)[b]	45 (9)[c]	18.7 (2.9)[d]	0.78 (.05)

* paired letters indicate significant differences at the p<0.05 level, between rows ie. aa, bb, etc.

Table 2
Mean Values and Standard Deviations for Sum of 2 Skinfolds (Triceps + Calf) and Sum of 4 Skinfolds (Triceps + Biceps + Subscapular + Iliac Crest)

	Variables	
Group	Sum of 2 (mm)	Sum of 4 (mm)
All Combined n = 95	24.2 (11.1)	38.4 (19.9)
All Girls n = 37	27.7 (10.7) [a]	44.9 (18.7)[b]
All Boys n = 58	22.4 (9.8)[a]	33.5 (18.3)[b]
All Early-pubescent n = 49	22.3 (10.1)	35.6 (19.2)
All Mid-Pubescent n = 46	25.5 (10.8)	40.4 (19.1)

* paired letters indicate significant differences at the $p<0.05$ level, between rows ie. aa, bb

Table 3
Mean Values and Standard Deviations for the 1600m Run/Walk, Modified Sit Ups, Push Ups, and Sit and Reach

	Variables			
Group	1600m Run/Walk (min:sec)	Modified Sit Ups (reps)	Push Ups (reps)	Sit & Reach (cm)
All Combined n = 95	9:00 (1:47)	35 (9)	12 (8)	29.0 (9.0)
All Girls n = 37	9:21 (1:55)	33 (8)	8 (8) [a]	32.0 (9.0) [b]
All Boys n = 58	8:47 (1:41)	36 (10)	14 (8) [a]	27 (8.0) [b]
All Early-pubescent n = 49	9:02 (1:52)	34 (7)	12 (9)	29.0 (8.0)
All Mid-Pubescent n = 46	8:59 (1:44)	36 (11)	11 (9)	29.5 (9.0)

* paired letters indicate significant differences at the p<0.05 level, between rows
ie. aa, bb

Table 4
Passing Rates* for Manitoba Schools Fitness Test Items of 1600m Walk/Run, Modified Sit Ups, Push Ups and Sit and Reach

	Variables			
	1600 m Walk/Run	Modified Sit Ups	Push Ups	Sit & Reach
Group	Percentage of total group reaching at least the criterion level			
All n = 95	66	51	35	41
All Girls n = 37	70	51	22	57
All Boys n = 58	64	50	43	31
All Pre-pubescent n = 49	65	55	41	41
All Pubescent n = 46	67	46	28	41

* Pass/fail status for the Manitoba Schools Fitness manual (1989) is based on gender and chronological age.

Table 5

Prevalence Rates for Subjects Falling Below, Within, and Above the Criterion Levels For Sum of 2 Skinfolds (Sum 2) and Sum of 4 Skinfolds (Sum 4) for the Manitoba Schools Fitness Test

	Variables					
	Sum 2			Sum 4		
	Below	Within	Above	Below	Within	Above
Group	Percentage of total group					
All Combined n = 95	6.3	68.4	25.3	3.2	63.2	33.7
All Girls n = 37	13.5	51.4	35.1	0	48.6	51.4
All Boys n = 58	1.7	79.3	19.0	5.2	72.4	22.4
All Early-Pubescent n = 49	8.2	73.5	18.4	6.1	69.4	24.5
All Mid-Pubescent n = 46	4.3	63	32.6	0	56.5	43.5

Table 6
Mean Values and Standard Deviations for Systolic Blood Pressure, Diastolic Blood Pressure, and Physical Activity Score

	Variables		
Group	Systolic Blood Pressure (mmHg)	Diastolic Blood Pressure (mmHg)	Physical Activity Score (/ 100)
All n = 95	98 (12)	60 (12)	35.8 (15.9)
All Girls n = 37	100 (12)	60 (12)	33.4 (14.7)
All Boys n = 58	98 (12)	60 (12)	37.4 (16.6)
All Early-pubescent n = 49	96 (12)[a]	60 (11)	35.4 (16.1)
All Mid-Pubescent n = 46	102 (12)[a]	60 (13)	36.3 (16.3)

*paired letters indicate significant differences at the $p<0.05$ level, between rows
ie. aa

Table 7
Correlational Matrix For All Variables: Push Ups (PU), Sit Ups (SU), Sit and Reach (S&R), 1600m Run/Walk (1600m), Systolic Blood Pressure (SBP), Diastolic Blood Pressure (DBP), Physical Activity Score (PAS), Waist to Hip Ratio (WHR), Body Mass Index (BMI), Sum of 2 Skinfolds (S2) and Sum of 4 Skinfolds (S4)

All subjects (n = 95)

Variables

	PU	SU	S&R	1600m	SBP	DBP	PAS	WHR	BMI	S2	S4
PU	1.00	.47*	.22*	-.45*	-.10	.04	.20	.13	-.36*	-.53*	-.53*
SU		1.00	.09	-.35*	.04	-.02	-.02	-.07	-.24*	-.32*	-.35*
S&R			1.00	-.13	-.08	.15	.17	-.15	.01	-.11	-.08
1600m				1.00	.01	.01	-.33*	.18	.38*	.48*	.52*
SBP					1.00	.60*	.09	-.04	.19	.03	.05
DBP						1.00	.15	-.01	.03	-.04	.02
PAS							1.00	-.13	-.12	-.17	-.22*
WHR								1.00	.26*	.09	.20
BMI									1.00	.80*	.84*
S2										1.00	.94*
S4											1.00

* indicates significance at the $p<0.05$ level

Table 8

Results From Canonical Correlation For All Subjects (n = 95): Correlations, Standardized Coefficients, Percent of Variance For Fitness and Health Variables

	First Canonical Variate		Second Canonical Variate		Third Canonical Variate		
	Corr.	Std. Coeff.	Corr.	Std. Coeff.	Corr.	Std. Coeff.	
Fitness Variables							
Push Ups	-.49	-.51	.73	-.51	.39	.88	
Modified Sit Ups	-.12	.20	.41	.20	.03	-.09	
Sit & Reach	-.27	-.28	.16	-.28	-.58	-.68	
1600m	.32	.11	-.76	.11	.40	.68	
SOS4	.78	.85	.49	.85	-.02	.03	
Proportion of Variance Explained by Fitness Variables	.21		.31		.13		Total = .64
Health Variables							
Systolic BP	-.09	-.11	.53	.37	-.04	.13	
Diastolic BP	.89	.96	.39	.39	-.39	-.32	
PAS	-.04	.04	-.05	.09	.87	.97	
WHR	.31	-.44	-.58	-.01	-.11	-.57	
BMI	.39	.69	-.83	-.79	-.11	.20	
Proportion of Variance Explained by Health Variables	.21		.29		.19		Total = .69
Canonical Correlation	.66		.64		.40		

Table 9

Results of Discriminant Function Analysis of Health Variables for Sum of 2 Skinfolds and Sum of 4 Skinfolds for All Subjects

Predictor Variable	Correlations of predictor variables with discriminant function	Univariate F	p	Pooled within-group correaltions among predictors: BMI	WHR	PAS	SBP	DBP
Sum of 2 Skinfolds (Chi-square = 39.3, p = .00)		F (1, 87)	p					
BMI	.97	48.1	.00		.24	-.15	.23	.06
WHR	.24	2.9	.09			-.11	-.04	.01
PAS	-.05	.15	.70				.06	.14
SBP	-.01	.00	.97					.60
DBP	-.05	.14	.71					
Eigenvalue	.59							
Sum of 4 Skinfolds (Chi-square = 45.4, p = .00)		F (1, 90)	p					
BMI	.95	55.2	.00		.28	-.06	.23	.10
WHR	.13	.96	.33			-.09	-.04	.01
PAS	-.14	1.3	.26				.08	.12
SBP	-.01	.01	.92					.60
DBP	-.10	.63	.43					
Eigenvalue	.68							

Table 10

Correlations, Standardized Coefficients, Percent of variance, and Canonical Correlations Between Fitness and Health Variables For All Male Subjects (n = 58)

	First Canonical Variate		Correlation with opposite variate	Second Canonical Variate			Correlation with opposite variate
	Correlation	Coeff.		Correlation		Coeff.	
Fitness Variables							
Push Ups	-.32	-.30	-.24	.67		.36	.42
Modified Sit Ups	.28	.49	.21	.28		.04	.18
Sit & Reach	-.39	-.26	-.29	.25		.03	.16
1600m	.34	.25	.25	-.82		-.67	-.52
SOS4	.76	.77	.56	.43		.45	.27
Proportion of Variance Explained by Opposite Set of Variables	.11			.12			Total: .23
Health Variables							
Systolic BP	-.18	-.23	-.14	.58	.40	.37	
Diastolic BP	.90	.96	.67	.31	.29	.20	
PAS	-.15	-.28	-.11	-.36	-.05	-.23	
WHR	.32	-.22	.24	-.55	.10	-.35	
BMI	.27	.45	.20	-.85	-.85	-.54	
Proportion of Variance Explained by Opposite Set of Variables	.11			.13			Total: .24
Canonical Correlation	.74			.63			

Table 11
Classification Results From Discriminant Function Analysis of Health Variables For All Subjects

Test	Percent Correct Classification (Pass or Fail Group)
Sum of 2 Skinfolds	82.0
Sum of 4 Skinfolds	81.5
1600m Run/Walk	69.5
Push Ups	68.4
Sit and Reach	64.2
Modified Sit Ups	59.0

Table 12
Tests of Gender, Maturation, and Their Interaction For All Variables

Independent Variables	Dependent Variables	Univariate F	df
Gender	**Multivariate F = 6.1, p<.05**		
	SOS4	7.5[a]	1, 91
	Modified SU	11.7[a]	1, 91
	Push Ups	3.8	1, 91
	Sit and Reach	8.2[a]	1, 91
	1600m R/W	2.2	1, 91
	BMI	1.9	1, 91
	WHR	16.0[a]	1, 91
	PAS	1.5	1, 91
	SBP	.00	1, 91
	DBP	.01	1, 91
Maturation	**Multivariate F = 2.1, p<.05**		
	SOS4	.95	1, 91
	Modified SU	.01	1, 91
	Push Ups	.58	1, 91
	Sit and Reach	.21	1, 91
	1600m R/W	.08	1, 91
	BMI	6.3[a]	1, 91
	WHR	1.4	1, 91
	PAS	.12	1, 91
	SBP	6.1[a]	1, 91
	DBP	.01	1, 91
Gender by Maturation	**Multivariate F = 1.6, p>.05**		
	SOS4	.28	1, 91
	Modified SU	5.3[a]	1, 91
	Push Ups	1.2	1, 91
	Sit and Reach	4.1[a]	1, 91
	1600m R/W	.00	1, 91
	BMI	.65	1, 91
	WHR	.02	1, 91
	PAS	.21	1, 91
	SBP	.02	1, 91
	DBP	1.3	1, 91

[a] Significance level cannot be evaluated but would reach p<.05 in univariate context

Table 13
Tests of Gender, Maturation, and Their Interaction For Fitness Variables

Independent Variables	Dependent Variables	Univariate F	df
Gender	**Multivariate F = 6.6, p<.05**		
	SOS4	7.5[a]	1, 91
	Push Ups	11.7[a]	1, 91
	1600m W/R	2.2	1, 91
	Sit and Reach	8.2[a]	1, 91
	Modified SU	3.8	1, 91
Maturation	**Multivariate F = .56, p>.05**		
	SOS4	.95	1, 91
	Push Ups	.01	1, 91
	1600m W/R	.08	1, 91
	Sit and Reach	.21	1, 91
	Modified SU	.58	1, 91
Gender by Maturation	**Multivariate F = 2.6, p<.05**		
	SOS4	.28	1, 91
	Push Ups	1.2	1, 91
	1600m W/R	.00	1, 91
	Sit and Reach	4.1[a]	1, 91
	Modified SU	5.3[a]	1, 91

[a] Significance level cannot be evaluated but would reach p<.05 in univariate context

Table 14
Tests of Gender, Maturation, and Their Interaction For Health Variables

Independent Variables	Dependent Variables	Univariate F	df
Gender	**Multivariate F = 5.8, p<.05**		
	BMI	1.9	1, 91
	WHR	16.0[a]	1, 91
	SBP	.00	1, 91
	PAS	1.5	1, 91
	DBP	.01	1, 91
Maturation	**Multivariate F = 3.7, p<.05**		
	BMI	6.3[a]	1, 91
	WHR	1.4	1, 91
	SBP	6.1[a]	1, 91
	PAS	.12	1, 91
	DBP	.01	1, 91
Gender by Maturation	**Multivariate F = .64, p>.05**		
	BMI	.65	1, 91
	WHR	.02	1, 91
	SBP	.02	1, 91
	PAS	.21	1, 91
	DBP	1.3	1, 91

[a] Significance level cannotbe evaluated but would reach p<.05 in univariate context

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(Please complete and return this page to your child's teacher)

HEALTH-RELATED PHYSICAL FITNESS AND HEALTH RISK FACTORS IN YOUTH

PARENTAL CONSENT FORM

I, ________________________________ state that I am the parent/legal guardian of
(Please print)

________________________________ and do give my permission for my child to participate in the research study "Health-related physical fitness and health risk factors in youth" proposed by Dr. David Docherty and Adele Thompson.

I am aware of the nature of the research and realize that there are no personal risks to my child greater than those encountered in play and sports activities. I am aware that the results of the study will be considered as a group and no individual data will be published or used in isolation; participants will be given a subject number and no names will be recorded. I am aware that the choice to participate or not participate in this study will have no effect on my child's academic status in the school. I am also aware that the researchers have explained the need for the study and that my child is free to withdraw at any time during the study.

________________________________ ________________________

Signature of parent/guardian Date

Telephone Number: (day) ________________ (eve) ________________

Family health history (Has a doctor said that any of these conditions are present in the family history? Please tick appropriate lines.):

	Student's mother	Student's father	Student's Grandparent
High blood pressure	______	______	______
Smoking	______	______	______
Diabetes	______	______	______
Over weight	______	______	______
Heart attack / stroke	______	______	______
			(age of attack or stroke)

APPENDIX B

STATEMENT OF THE PROBLEM

Research Questions

1. What is the relationship between performance on the health-related fitness test items in the Manitoba Schools Fitness battery (1600 m run, modified sit ups, push ups, sit and reach, and 2 or 4 skin fold sites) and the CHD risk factors of physical activity level, blood pressure, body mass index, waist to hip ratio, and smoking?

2. Can the scores of CHD risk factor variables (physical activity level, blood pressure, body mass index, waist to hip ratio, and smoking status) predict pass or fail status of any of the criterion-referenced health-related fitness tests in the Manitoba Schools Fitness battery?

3. What are the effects of gender, maturational level, and their interaction on the Manitoba Schools Fitness test items and the CHD health risk variables together as a group, on the fitness test items alone, and on the CHD health risk variables alone?

Fitness Variables	CHD Risk Factor Variables
1. 1600 m run/walk time	1. physical activity score
2. modified sit ups repetitions	2. systolic blood pressure
3. push ups repetitions	3. diastolic blood pressure
4. sit and reach score	4. smoking score
5. sum of 2 skin folds (triceps and medial calf)	5. body mass index
6. sum of 4 skin folds (biceps, triceps, subscapular, iliac crest)	6. waist to hip ratio

Categorical Variables

1. maturational status
2. gender

The health-related fitness test scores can be classified as either "passing" or "failing" the criterion level.

APPENDIX C

OPERATIONAL DEFINITIONS

1. health-related physical fitness test batteries

   - a group of test items that endeavor to measure capacities that are related to health and can be improved through adherence to regular physical activity (AAHPERD, 1989)

2. criterion-referenced standards

   - fitness scores that are believed to be related to a reduced risk of hypokinetic disease

   - levels of fitness that are considered to be attainable by the majority of students with adherence to regular physical activity

3. risk factor

   - something which is associated with an elevated frequency of occurrence of a disease, and the association cannot be explained on the basis of confounding methodological biases (Webber, Srinivasan, Voors et al., 1980)

   - coronary heart disease (CHD) risk factors are those which are associated with an elevated frequency of CHD in adulthood, and include family history of CHD, elevated blood lipids (serum cholesterol and triglycerides), obesity, hypertension, smoking, diabetes mellitus, stress, and inadequate physical activity (Vaccaro & Mahon, 1989)

4. tracking

- the tendency for a variable to maintain its relative position within a population over serial measurements over time (Spady, 1991)

5. habitual physical activity

- typical pattern of involvement in daily activities, physical education classes, and sports organizations

APPENDIX D

BASIC ASSUMPTIONS, DELIMITATIONS AND LIMITATIONS

Assumptions

1. Maximal effort was exerted by the subjects in the physical performance tests (1600 m run/walk, modified sit ups, push ups, and sit and reach).

2. Subjects answered the questionnaire and maturational status forms truthfully and accurately .

3. The activity score from questions 1 - 10 on the questionnaire provided an accurate representation of habitual activity level.

Delimitations

1. The subjects were recruited from grades 4 - 7 at two public schools in close proximity to the University of Victoria.

2. Health-related fitness was represented by the test items in the Manitoba Schools Fitness battery (1600 m run/walk, modified sit ups, push ups, sit and reach, and sum of skin folds).

3. CHD risk factors were smoking, physical activity level, blood pressure, body mass index, and waist to hip ratio.

Limitations

1. The subjects were not randomly selected.

2. There were not 10 subjects per variable measured.

APPENDIX E

REVIEW OF THE LITERATURE

I. CORONARY HEART DISEASE ORIGINATES IN CHILDHOOD AND ADOLESCENCE

Although coronary heart disease (CHD) does not manifest itself until adulthood, autopsy studies indicating fatty streaks in the aortas and coronary arteries of children and adolescents are generally considered evidence that CHD originates early in life. There is a lack of longitudinal studies showing that the presence of fatty streaks actually lead to the development of CHD in adulthood. However, fatty streaks do precede the formation of a fibrous plaque which leads to an atherosclerotic lesion and CHD (Vaccaro & Mahon, 1989). Studies finding that the casualties from the Korean and Vietnam wars (Enos, Beyer, & Holmes, 1953; McNamera, Molot, Stremple, & Cutting, 1971) displayed high incidence of atherosclerosis and evidence of CHD prompted further investigation into CHD origins in childhood. Large epidemiological studies, such as the American Muscatine and Bogalusa heart studies, were initiated to investigate the presence and progression of atherosclerosis in young subjects.

A risk factor is something which is associated with an elevated frequency of occurrence of a disease, and the association cannot be explained on the basis of confounding methodological biases (Webber, Srinivasan, Voors et al., 1980). The concept of risk factors for CHD was developed from adult epidemiological studies (Voller & Strong, 1981); risk factors include family history of CHD, elevated blood lipids, obesity, hypertension, smoking, diabetes mellitus, and inadequate physical activity (Vaccaro & Mahon, 1989). It is still unknown whether children who exhibit an adverse CHD risk factor profile will exhibit this same profile at an age when one is most likely to develop the clinical manifestations of CHD (Vaccaro & Mahon, 1989). However, the identification of risk factors in children may help to prevent or delay the progression of arteriosclerosis through modification of risk factor profiles (Despres, Bouchard & Malina, 1990), especially if the risk factors have been shown to "track". Tracking has been defined as the maintenance of the relative ranking of an individual with respect to his peers, and involves examining trends over time (Webber, Cresanta, Voors, & Berenson, 1983).

Important aspects of risk factors are their relation to other risk factors, and whether they can be modified. It is difficult to address risk factors for CHD disease separately, because they tend to be inter-related or "cluster" together. In particular, obesity tends to be associated with other risk factors such as high blood pressure, adverse blood lipid profiles and low physical activity (Spady, 1991). Smoking has an independent adverse effect on the development of CHD (Vaccaro & Mahon, 1989), as well as an unfavorable influence on other risk factors (Spady, 1991; Rantakallio, 1983). Many risk factors can be modified, and the inter-relationship between risk factors suggests that changing one factor may influence other factors.

A. OBESITY

Obesity is a clearly recognizable condition that is a major factor influencing the frequency of risk factors in children. Obesity should be considered an important risk factor for CHD in children since it is related to other risk factors and is associated with adult obesity (Vaccaro & Mahon, 1989). Excessive weight is perhaps the most prevalent risk factor in our society (Spady, 1992). The degree to which obesity is determined by heredity is complicated by the interaction of heredity with the environment (Spady, 1992). There may not be a strong association between obesity, by itself, and CHD. Early atherosclerotic lesions in the aorta and coronary arteries of 35 subjects, with a mean age of 18 years, were assessed in relation to CHD risk factors (Newman, Freedman, Voors, Gard, Srinivasan, Cresanta, Williamson, Webber, & Berenson, 1986). Obesity, measured by ponderal index, Quetelet index, or triceps skin fold, was not related to fatty streaks at either site. The risk of obesity seems to be attributed to the propensity of the obese individual to have hypercholesterolemia, to be sedentary, and to have carbohydrate intolerance and hypertension. Weight reduction has been shown to beneficially affect elevated blood pressure levels and glucose tolerance (Voller & Strong, 1981; Spady, 1992). Longitudinal studies indicate that obese children have higher blood pressure, plasma glucose and insulin, and lipid levels than non-obese children (Despres et al., 1990).

A concern with the assessment of fat in children includes what level of fatness compromises health. Although densiometry may be considered the criterion method for determining percent body fat, its validity is questionable and it is often not a feasible method for the general population and for large studies, due to the necessary cost, equipment, and expertise. Common field assessment methods include skinfolds, weight for height indices, waist to hip ratio (WHR), and bioelectrical impedance. Scores for these tests, usually based on gender, have been suggested for adults that indicate levels at which health may be negatively influenced; some suggestions for children and youth have been proposed. Various percentile cutoff points are also used to classify subjects as obese; unfortunately there is currently no consensus regarding which points to use. Prevalence rates of obesity in large groups are often assessed, but it is difficult to compare across age groups and between different data sets due to different criteria. Several recommendations for assessing body fatness are discussed below, including associated estimated prevalence rates of obesity.

In adults, it has been suggested (Despres, 1992) that body mass index (BMI) and WHR should be used simultaneously by the general practitioner to assess risk of excess abdominal obesity. A BMI value greater than 27, combined with a WHR ratio greater than 0.85 in women or 0.95 in men should be considered as a level of obesity that may be associated with increased risk of metabolic complications. In addition, a waist girth greater than 100 cm may also indicate the presence of a large abdominal adipose tissue mass. The NIH Conference on Obesity in 1985 recommended that BMI and relative weight be used in clinical and public health settings, and BMI values exceeding 27.8 for men and 27.3 for women were suggested as cutoff points to classify people as obese. These values were based on the 85th percentile for subjects aged 20-44 years based on National Health and Nutrition Examination Study II (NHANES II) data (Burton, Foster, Hirsch & Van Itallie, 1985). Reeder et al. (1992) used the BMI value of 25 as the cutoff point associated with increased health risk and found that, in a sample of over 17, 000 Canadian subjects aged 18 - 74 years, nearly 40% of women and over 55% of men were above that value.

Lohman (1987) stated that by young adulthood, a percent fat content between 10 and 20% is optimal for health and fitness, as this allows for differences depending on level of activity and individual preference, and is associated with little or no health risk due to disease associated with fatness. A level of fatness above 20% that is maintained into middle age is considered to increase the risk for diabetes, heart disease, and hypertension. For young males, Lohman defined 20-25% body fat as moderately high, 25-31% as high, and above 31% as very high fatness. Optimal fatness in young females was defined as 15-25%; 25-30% was considered moderately high, with 30-35% and above 35% considered high and very high fatness, respectively. Lohman also stated that it is individuals who increase fatness from one category to another, as well as those who are consistently in the high and very high categories that need to be noted. It is not known if the same cutoff values are appropriate for children. Lohman (1986) has suggested that percent body fat equations overestimate fat in children, and therefore lower criterion definitions of obesity ($\geq$20% in males and $\geq$25% in females) may be more suitable. Prevalence rates for large samples using these criteria have not been reported.

Gender-, age- and race-specific 85th and 95th percentiles for triceps skinfold and BMI in charts based on anthropometric data from the NHANES I conducted in the early 1970's (n = 20 839, aged 6 - 74 years) have been published, which can assist in the evaluation of secular trends of obesity (Must et al., 1981). Crawford et al. (1993) assessed the prevalence of obesity and demographic, familial, and lifestyle factors associated with obesity among Canadian children aged 6 - 12 years, using the previous data sets of the 1981 Canada Fitness Survey (n = 2601), the 1988 Campbell's Survey on Well-Being in Canada (n = 337), the 1978 Coquitlam Growth study (n = 369), and the 1991 Vancouver Inner City Growth study (n = 648). No skinfold data were available from the 1991 Vancouver Inner City Growth Study, and the sum of five skinfolds was not available from the Coquitlam Growth Study. Prevalence of obesity for the sample was estimated using several different criteria. The United States Triceps Skinfold (USTR) method classified children as obese if their triceps skinfold was equal to or greater than the 85th percentile for their age and gender using normative standards from the Nutrition, Health and Examination Survey I (NHANES I). The Canadian Triceps Skinfold (CTR) method classified children as obese if their triceps skinfold was equal to or greater than the 85th percentile for their age and gender using the

1981 Canada Fitness Survey for normative standards. The Canada Fitness Survey SUM5 (SUM5) method classified children as obese if their sum of five skinfolds (biceps, triceps, subscapular, iliac crest, and calf) was equal to or greater than the 85th percentile for their age and gender. The weight-for-height percentiles method (WHP) classified children as obese if their weight-for-height was equal to or greater than the 85th percentile for their gender as established by the U.S. National Centre for Health Statistics (NCHS) reference curves for physical growth. Prevalence of obesity using the U.S. triceps skinfold criteria ranged from 8.7 - 13.3% for all subjects, 8.8 - 13.0% for females, and 8.7 - 15.1% for males across the data sets. Using this criteria, obesity increased 52.9% for all subjects, 47.7% in females, and 56.3% in males between 1981 and 1988. Prevalance rates using the Canadian Triceps Skinfold method were higher than the U.S. method. 15.3 - 23.5% of all subjects, 15.3 - 26.9% of females, and 15.2 - 20.3% of males were classified as obese. The prevalence of obesity increased 53.6% in all subjects, 75.8% in females, and 33.6% in male subjects between 1981 - 1988. Using the CSTF Sum of Five Skinfolds method, 15.4 - 23.9% of subjects, 15.3 - 25.9% of females, and 15.5 - 22% of males were classified as obese. Prevalence of obesity increased 55.2% in all subjects, 69.3% in females and 41.9% in males between 1981 - 1988. All three skinfold indicators used to define obesity in children demonstrated significant increases in obesity between 1981 and 1988. The Campbell's 1988 Survey on Well Being in Canada estimated the prevalence of obesity in adolescent Canadians with one of three indicators: body mass index greater than or equal to 25, waist to hip ratio greater than 0.9 in males and 0.8 in females, and sum of 5 skin folds greater than the 85th percentile. In the 15-19-year-old age group, 16% of males and 20% of females were classified as obese (Stephens & Craig, 1991). Triceps and subscapular skinfold data from three large, nationally representative samples in the United States (National Center for Health Statistics, National Health Examination Survey II, and the National Children and Youth Fitness Study II) indicated that between the 1960's to the 1980's, skinfold thickness has increased in boys and girls aged 6-9 years (Ross, Pate, Lohman & Christenson, 1987). Some factors that may be contributing to the trend of increased fatness in children and youth are physical inactivity, poor nutrition, and genetic influences (Lohman, 1989). In contrast, Reeder et al. (1992) has suggested that, in adults, there has been little change in the prevalence of obesity, as assessed by BMI and WHR, during the past two decades. Changes over time in BMI and WHR in children have not been analyzed.

Six adiposity measures (relative weight, relative BMI, ponderal index, triceps skinfold, the Canadian Standardized Test of Fitness (CSTF) sum of five skinfolds, and the O-scale geometrically scaled sum of skinfolds were compared in 533 subjects aged 11 - 15 years (Marshall, Hazlett, Spady & Quinney, 1990). The following cutoff points were used to classify subjects as obese: a value of $\geq$120% for relative weight and relative BMI, a value $\geq$85th percentile for age and gender for the CSTF sum of five skinfolds, or a rating of 8 or 9 for the O-scale system was used to define obesity. A four point visual rating scale method of classifying obesity was developed for this study and used as the criterion method of determining obesity. As expected, the proportion of the sample classified as obese varied (from 8.4% with the O-scale rating to 18.8% with the CSTF sum of five skinfolds). It was found that there were significant differences in obese classifications among all measures, except for the comparison between relative weight and O-scale rating. A principal components analysis of the adiposity measures resulted in a unifactoral solution that accounted for 85.6% of the total variance. It was found that the visual inspection method was significantly correlated to all of the other measures, providing logical support that the factor scores were measures of obesity ($r = 0.66 - 0.81$). This was the first study to use a visual inspection as the criterion method for classifying subjects as obese, and validation of this method with the accepted "gold standard" of densiometry is desirable. However, it has been reported that some observers can visually estimate percent fat almost as accurately as it can be calculated from skinfold measurements, with densiometry used as the criterion method (Sterner & Burke, 1986).

The prevalence of obesity in nursery school pupils, aged 3 - 6 years, was assessed using a value of greater than 120% of ideal body weight (actual weight divided by expected weight for height percentile, based on data from the Centre of Disease Control growth charts) to define obesity (Ginsberg-Fellner, Jagendorf, Carmel & Harris, 1981). The overall prevalence rate for obesity in 2606 children was 12.2%, and 4.7% were above 130% ideal weight and considered "truly obese". It was also reported that over 90% of the obese subjects were at or above the 75th percentile for weight, and therefore it was suggested that this is a valid cutoff point. The authors do not say whether any subjects who were not classified as obese were also above the 75th percentile; it would seem likely that there would be such cases. It is also suggested by these authors that children above 120% ideal weight may not appear obese by current-day standards, and state that a child who is above 150% ideal weight is actually "noticeably obese" for his age.

Examining prevalence of obesity using percentile cutoff points is questionable because the percent fat changes markedly with age and the fat content for determining obesity is changing with age (Lohman, 1989). Lohman (1987) developed continuums that indicate skinfold sums (triceps plus calf or triceps plus subscapular) that correspond to percent body fat for girls and boys, and provide six ratings that range from very low to very high body fatness. This allows fatness to be categorized with only two skinfold measurements, and would likely be meaningful information for individual assessments. The author stated that the relationship between skinfolds and percent fat changes only slightly with age so that the charts can be used for children between the ages of 6 and 17 years.

Many fitness test batteries used in schools have shifted to criterion-referenced scoring systems; subjects either meet or fail to meet a criterion score that is believed to be related to health. Often, the sum of two skinfolds is used to assess body composition (Physical Best, 1989; FITNESSGRAM, 1987; Fit Youth Today, 1986). The EUROFIT (1988) battery uses the sum of four skinfolds, and the Manitoba Schools Fitness (1989) battery has the option of sum of two or four skinfolds. FITNESSGRAM also suggests BMI as an alternative to the sum of two skinfolds. Criterion-referenced standards are another way to assess obesity, but there has been little work done to describe prevalence rates using this method. Secondary analysis of the data collected from the National Children and Youth Fitness Study I and II (Looney & Plowman, 1990) showed that 84.6-95.2% of girls aged 6 to 18 years passed the FITNESSGRAM criterion level for body fatness (less than 32% body fat), and 82.4-95.7% of males passed (less than 25% body fat). The criterion scores for body fat do not differ for age in FITNESSGRAM, and are based on triceps and calf skinfolds.

It seems desirable to have an obesity identification system because it could be used as a general screening tool that would identify children who require further assessment. It is likely that some subjects identified as obese or at an undesirable level of fatness may be in fact nonobese, as in the case of a high BMI due to a large musculoskeletal system. Further examination of subjects could determine if they are actually obese. The continuums proposed by Lohman (1987) is a convenient way of assessing skinfold measurements. This method has two options of skinfold sites to use and body fatness can be interpreted as sum of skinfolds or percent body fat.

Although obesity can be identified in children as young as 3 years of age (Ginsberg-Fellner et al., 1981; Gutin, Basch, Shea, Contento, DeLozier, Rips, Irigoyen, & Zybert, 1990), the age at which obesity in childhood is indicative of adult obesity has not been established (Vaccaro & Mahon, 1989). A longitudinal study of CHD risk factors during adolescence and young adulthood (Kemper & Verschuur, 1990) used the "cut off points" indicating CHD risk for obesity suggested by Bell, Macek, Rutenfranz, and Saris (1986). It was found that percent fat was relatively stable, with 20-30% of subjects remaining in the same group (above or below the cut off) over the course of the study. In Bogalusa Heart Study subjects (aged 5-17 years) initially above the 90th percentile for triceps skin fold, 57% and 49% remained there after 4 years and 6 years, respectively (Webber et al., 1983). Childhood fatness at 6-11 years was found to be predictive of adolescent fatness, and between 68% and 77% of subjects were above the fifth quintile on both exams 3 to 4 years apart (Zack, Harlan, Leaverton & Cormoni-Huntley, 1979). A longitudinal study of British children found that the prevalence of obesity increased from infancy to childhood, to adolescence to young adulthood. Overweight 7-year-olds had a 40% risk of becoming an overweight adult. It was concluded that treatment of overweight in adolescence would have a greater effect on the reduction of adult obesity than treatment of overweight in childhood (Griffith, Rivers & Hoinville, 1985). Forty three percent of 222 initially obese children aged 2-14 years remained obese after 8 years (Freedman, Shear, Burke, Srinivasan, Weber, Harsha & Berenson, 1987).

Results obtained in adults suggest that central obesity is involved in the clustering of CHD risk factors (Despres et al., 1990). Patterns of fat distribution develop during childhood and adolescence; after puberty, males carry a greater relative accumulation of fat on the trunk than females (Lohman, 1989). Significant differences in the pattern of fat distribution were found in children as young as 5 and 6 years old (Gutin et al., 1990), with the boys displaying more central fat. Subscapular, suprailiac, and abdominal skin folds have been used as indices of central body fat and have been associated with risk factors such as high blood pressure, higher serum lipid levels, and a decreased glucose tolerance in children (Lohman, 1989).

Skin fold thickness has often been reported to be inversely related to performance of distance run fitness tests (Cureton, Boileau, Lohman & Misner, 1977; Pate, Slentz & Katz, 1989; Cureton, Baumgartner & McManis, 1991; Bazzano, Cunningham, Varrassi & Falconio, 1992; Murray, Walker, Jackson, Morrow, Eldridge & Rainey, 1993). The effect of skin folds on other fitness test items has been examined less frequently. Pate et al. (1989) reported that, for two previously existing data sets of children aged 6 - 16 years, the sum of two skin folds (triceps and abdominal or triceps and subscapular) was also significantly inversely related to sit up performance in both data sets and sit and reach performance in one data set. Similar results have been found (Bazzano et al., 1992) using the sum of triceps and calf skin folds. Cardiovascular fitness in 10-15 year old Canadian youth, determined by a PWC_{170} test, was significantly correlated to a lower sum of ten skin folds in both genders (Suter & Hawes, 1993).

Obesity is probably the most prevalent risk factor for coronary heart disease in Western society. The etiology is unclear, although it is generally believed that a combination of heredity and environmental factors are responsible for obesity. Obesity is an intriguing risk factor, because it does not seem to be necessary or sufficient for the development of CHD. It is the propensity of the obese individual to have other risk factors that is of concern. Obesity in children should be considered an important risk factor because it is clearly linked to an increased risk of CHD in adulthood, it can be identified in childhood, and it seems to track over time.

B. BLOOD PRESSURE

Adult epidemiological studies have demonstrated that hypertension is a significant CHD risk factor (Voller & Strong, 1981). The relationship of blood pressure and the extent of fatty streaks and fibrous plaques was investigated in 35 young adults (mean age at death, 18 years) in whom autopsies were performed. Correlation coefficients of 0.56 and 0.57 for were reported between coronary artery fatty streaks and systolic and diastolic blood pressure, respectively (Newman, Freedman, Voors, Gard, Srinivasan, Cresanta, Williamson, Webber, Berenson, 1986). In adults, it has been suggested that the cut-off point that distinguishes hypertension should be related to the level at which a significant improvement in mortality and/or morbidity is found with antihypertensive therapy (de Swiet, 1986). Criterion levels in children and youth suggested by Bell et al. (1986) are based on the World Health Organization definition of high blood pressure as a level that is equal to or exceeds the mean value for the age group plus two standard deviations. A value of 140/90 mmHg in children over 12 years represents the 95th percentile; it is proposed that levels above this are excessive (Berenson, Voors, Webber & Frerichs, 1978). The Campbell's 1988 Survey on Well Being in Canada defined high blood pressure as a diastolic value greater than 90 mmHg. Two percent of the males and 1% of females in the 10-14 year old age group had high blood pressure; 3% of the males and 2% of the females in the 15-19 year old age group were classified as hypertensive (Stephens & Craig, 1990).

The tracking coefficient of blood pressure rises with age, and has been reported to reach 0.7 by the age of 18 years (Rosner, Hennekens, Kass & Miall, 1977). Tracking of blood pressure in Bogalusa Heart Study subjects aged 5-17 years was examined over a 5-year period; correlation coefficients of 0.38-0.66 and 0.22-0.49 were found for systolic and diastolic values, respectively. Children with high systolic blood pressure tended to remain in that category during childhood and adolescence (Webber et al.,1983). In the Muscatine Study of 5-18 year olds followed over 6 years, changes in percentile rank order were large and the distribution of diastolic blood pressure quintiles after 6 years of follow-up could not be predicted by the initial level (Clarke, Schrott, Leaverton & Lauer, 1978). Coronary risk factors in Dutch youth was investigated through annual testing for four years and then once five years later (age 13.5-21.5 years). Using risk levels of >140 mmHg for systolic and >90 mmHg for diastolic blood pressure (Bell et al., 1986), 40% of males and 15% of females surpassed the systolic criterion by age 21.5 years, and the percentage of subjects surpassing the diastolic criterion increased from 8-12% in adolescence to 16-19% in young adults. Blood pressure data were also examined for stability over time, by investigating the percentage of individuals who were constantly above or below the median value. For all 5 measurements, only 10-20% of subjects remained in the same group over the 8 years (Kemper & Verschuur, 1990).

The relationship between fitness and blood pressure is influenced by body fatness. Peak $\dot{V}O_2$ from a treadmill running protocol and blood pressure using cut off points for coronary risk of 130 mmHg for systolic and 85 mmHg for diastolic

(Wynder et al., 1981) was investigated in 11-16 year old males and females. When the common effects of skin fold thickness were removed, peak $\dot{V}O_2$ was not significantly related to blood pressure (Armstrong et al., 1991). Similar findings were reported in 8-15 year old boys classified into four fitness groups based on $\dot{V}O_2max$ scores from a treadmill running test. Differences in blood pressure between the fitness groups were no longer significant when age and relative body fat were controlled (Kwee & Wilmore, 1990). In tenth grade males with low-to-moderate fitness (based on the Cooper run-walk test), higher $\dot{V}O_2max$ values measured by a treadmill test were associated with lower systolic and diastolic blood pressure. However, body mass index provided the largest explanation of inter-individual variation in blood pressure (Fripp, Hodgson, Kwiterovich, Werner, Schuler & Whitman, 1985). To examine the relationship between blood pressure and performance on the health-related fitness test "Physical Best", 10-17 year old Italian youth were divided into two groups based on either passing or failing the criterion standard for the 1-mile run test of aerobic fitness. Systolic blood pressure did not differ significantly between groups for either gender, but boys who failed to meet the criterion standard for the run had higher diastolic blood pressure than boys who passed (Bazzano et al., 1992). Skin folds used in the "Physical Best" battery include peripheral sites only and it was suggested that this may have influenced the lack of association between the sum of skin folds and blood pressure. Fatness also influences modification of blood pressure. Diet and exercise intervention in obese adolescents indicated decreased blood pressure, which was attributed to alterations in excess fat and an independent exercise training effect (Becque, Victor, Katch, Rocchini, Marks, Moorehead, 1988).

C. SMOKING

In adults, cigarette smoking is considered one of the three major risk factors for CHD . It is well accepted that the risk of CHD increases with the number of cigarettes smoked. The independent adverse effect of smoking on the development of CHD is probably the result of several mechanisms. Cigarette smoking is associated with decreased levels of HDL-C and increased levels of VLDL-C, LDL-C, and triglycerides. Excess risk drops rapidly with cessation of smoking (Spady, 1991). Adults who smoke generally acquire the habit in adolescence (Nora, 1980).

Smoking decreased in Canadian adolescents aged 15 - 19 years from 47% of males and 46% of females in 1979 to 20% of males and 23% of females in 1988 (Stephens & Craig, 1990). Adult values also demonstrated large decreases from 38% to 29% in women and from 61% and 33% in men between the years of 1965 and 1989 (Walker, 1993). More recently, the Youth Smoking Survey 1994 (Health Canada, 1996), reported that 7% of 10 - 14-year-olds reported smoking, as well as 23% of males and 24% of females in the 15 - 19-year-olds. In addition, Over 50% of males and females aged 15 - 19 felt it was easy to buy cigarettes. The average age of smoking initiation in Canadian youth has dropped from 16 to 12 years over the past two decades (Walker, 1993).

Smoking habits vary widely from one country to another for a variety of socioeconomic reasons. The percentage of smokers in German, Norwegian, and "former" Czechoslavakian children aged 12-16 years ranged from 0%-56%. In a cross-sectional survey measuring factors related to cigarette use among 2212 U.S. senior high school students, 14.3% smoked at least occasionally, 5.3% were regular smokers, and 12.8% indicated that they were ex-smokers. Males and females smoked at almost equal rates, and the percentage of 10th grade student smokers was slightly higher than for the 11th and 12th grade smokers. Regression analysis indicated one of the most important predictors of cigarette use was ethnic group (McDermott, Sarvela, Hoalt, Bajracharya, Marty, and Emery, 1992).

Among 747, 9 -17-year-olds in the Bogalusa Heart Study, re-examined 5-6 years later, those who began smoking had more unfavorable changes in serum triglycerides and lipoprotein cholesterol levels during the follow-up than the non-smokers, independent of age, sexual maturation, and obesity. LDL-C levels in smokers were higher, VLDL-C also increased, and HDL-C levels were significantly reduced (Freedman, Srinivasan et al., 1986). There are little data investigating the relationship between smoking and physical activity in children and youth. In a study of 11000 children from Northern Finland, high correlations were found between juvenile smoking and less frequent participation in sports (Rantakallio, 1983). More than 10 cigarettes per day, especially if regular smoking starts before the age of 12 years, has been defined as a definite health risk (Bell et al., 1986). An important quality of smoking as a risk factor is that it can be modified entirely (Spady, 1991).

D. PHYSICAL ACTIVITY

Reviews of physical activity and CHD in adults suggest that the studies with better designs and methods were nearly unanimous in demonstrating a significant inverse relationship between physical activity and CHD (Blair, 1993). In general, studies on physical fitness show a stronger inverse relationship with mortality than physical activity in adults. Relationships between physical activity and blood pressure, total cholesterol, HDL-cholesterol, triglycerides have been reported in adults (Sallis, Haskell, Wood, Fortman & Vranizan, 1986; Bovens, Van Baak, Vrencken, Wijnen, Saris & Verstappen, 1993; Rohm Young, Haskell, Jatulis & Fortmann, 1993).

Fitness studies may give a more accurate estimate of the true impact of sedentary living on disease risk than studies on physical activity, because fitness is measured objectively by ergometric methods and physical activity is usually measured by less-precise self-reports (Blair, 1993). The importance of physical fitness versus physical activity for CHD risk factors was investigated in 412 male law enforcement officers (Rohm Young & Steinhardt, 1993). Percent body fat, smoking habits were inversely related to physical fitness, and high density lipoprotein cholesterol was positively related to physical fitness. Physical activity was not related to single CHD risk factors, although both physical fitness and physical activity were significantly related to a composite CHD risk score. It was suggested that physical fitness may be considered a stronger measure to characterize the relationship among physical activity and CHD risk factors in adults. There is some question regarding whether the positive effects of exercise seen in adults will occur in children. However, in studies of sufficient intensity, frequency and duration appear to suggest that the aerobic capacity of children can be significantly improved (Blair, 1993).

Activity patterns change over time in children and adolescents. Time spent in activity was reported to decrease from childhood to adolescence and further decrease with increasing age in Canadians (Spady, 1991). It has been suggested that even if children and adolescents lead an active lifestyle, it is due to involvement in scheduled, coached, competitive and directed activity. This pattern of active living does not seem to continue when the adolescent becomes a young adult (Spady, 1991).

It is generally believed that physically active children are leaner and healthier than sedentary children. However, the important role of selection of subjects into physical activity studies or physically active lifestyles must not be underestimated. Healthy and lean children may be more inclined to be involved in studies than obese children and/or children prone to disease, which might give an inaccurate picture of physical activity in children (Despres et al., 1990). The relationship between physical activity and fitness in children has primarily focused on aerobic fitness. Some authors have reported higher peak $\dot{V}O_2$ in more active children (Atomi et al., 1990). However,comparison between studies is difficult due to methodology used to measure physical activity.

Some data suggest that fit and active children tend to have lower triglyceride and higher HDL-cholesterol levels (Despres et al., 1990; Suter & Hawes, 1993). This relationship appears to be stronger in boys at puberty when a decrease in HDL-C is generally observed, and weaker in girls especially after puberty when HDL-C levels usually increase in all girls. The low lipid levels observed in young children make it difficult to evaluate and/or detect possible significant relationships in young children (Despres et al., 1990). There is conflicting information on the effects of experimental manipulation of exercise on blood lipids in children. It has been suggested that it is impossible to isolate the effects of a regular exercise program on the lipoprotein lipid levels of children until more studies that control for percentage of body fat, dietary intake, and intensity, frequency, and duration of exercise are conducted (Vaccaro & Mahon, 1989). There is little information available regarding the relationship of physical activity to blood pressure in children. Armstrong et al. (1991) reported no significant relationship between habitual physical activity and blood pressure or peak $\dot{V}O_2$ in 11-16-year-olds. Some pediatric studies have involved intervention of exercise training programs

(Vaccaro & Mahon, 1989). Aerobic exercise training programs produced little change in blood pressure of children who were normotensive at the onset of training. Although the results appear more promising in obese children placed on training programs, it has been suggested (Montoye, 1986) that once the effects of body fat are accounted for there is only a slight negative relationship between resting blood pressure and physical fitness.

Rowland (1991) concludes that the only CHD risk factor that appears to be consistently related to exercise in children is obesity. Obesity is a common problem in children and adolescents, and studies support the role of exercise in the prevention and management of obesity, and the contribution of obesity to elevated blood pressure and abnormal serum lipid profile. Findings of the National Children and Youth Fitness Study II (Ross & Pate, 1987) suggest that leaner children tended to participate in more community-based physical activities and watched less television. These leaner children were also rated as more physically active by their parents and teachers. However, no significant differences in habitual physical activity, as estimated from continuous heart rate monitoring over three days, was detected between 11- to 16-year olds who were classified as overweight (Armstrong, Balding, Gentle, Williams & Kirby, 1990). The Campbell's 1988 Survey on Well Being in Canada found that leisure time activity was negatively associated with body mass index and subcutaneous fat levels (Stephens & Craig, 1991).

It seems possible that physical activity can have a substantial effect on body fatness. A negative energy balance induced by an exercise training program preserves fat-free mass so that the composition of weight loss is includes a higher proportion of fat in contrast to low caloric diet methods of weight loss. It is important to remember that a considerable amount of exercise is essential to substantially alter energy balance an that the duration must be high. The feasibility of this type of exercise prescription in children is questionable (Despres et al., 1990). Unpublished observations of Despres and colleagues (cited in Despres et al., 1990) with moderately obese young men training below 60% of $\dot{V}O_{2max}$ for about 50 minutes over 100 days. The subjects lost about 9% of their body weight and improved their metabolic profile. However, because of the low intensity, there was no significant increase in aerobic power; this indicates that an increase in $\dot{V}O_{2max}$ may not be prerequisite for exercise training to induce some beneficial metabolic effects as long as the program is of sufficient duration and affects energy balance. This has implications for obese children and adolescents, who may not be involved in sport activities. Although experimental testing is required in children, this concept may be promising for the role that low-intensity, habitual physical activity has on obesity in children and adolescents .

Failure to indicate a consistent favorable influence of exercise in children on CHD risk factors may be due to the following: (i) physical activity is difficult to quantitate in children; accurate measurement of physical fitness is not easy in low-fit children with maximal testing; (ii) perhaps the effects of exercise on CHD risk factors may not be apparent in the short term (Rowland, 1991). The relationship of physical activity and physical fitness in adults and the difficulty of measuring physical activity in children support the investigation of health in children through fitness testing.

II. FITNESS TESTING IN SCHOOLS

A. SHIFT IN FOCUS FROM PERFORMANCE TO HEALTH-RELATED TESTS

The definition of physical fitness and, therefore, fitness tests and programs have evolved over time. The definition of physical fitness has changed with increased knowledge and the changing needs of society (Safrit, 1986). Fitness testing in schools originally served the purpose of measuring fitness performance in children and youth. The tests and associated awards became a method of rewarding superior fitness status and were intended to motivate students toward improvement. Over the past two decades, society has become more acutely aware of the health benefits of regular physical activity, and the fitness testing techniques and programs have been altered in content and delivery (Pate, 1988). Current fitness test batteries attempt to measure capacities that are related to health and can be improved through adherence to regular physical activity (AAHPERD, 1989). These programs promote and reward exercise behaviours in children, with the belief that behaviours related to optimal health and well-being learned in childhood will be maintained throughout adulthood.

Around the mid-1970's, research was establishing the need to develop fitness as well as motor performance. There was evidence to support the maintenance of an adequate state of physical fitness, with an emphasis on personal health and well-being (Safrit, 1986). In 1980, AAHPERD published the Health Related Physical Fitness Test. It re-defined physical fitness in terms of health rather than performance, and the test items professed to measure capacities that could be improved with appropriate physical activity. Since the introduction of this test, support has grown for health related fitness tests. The batteries typically contain tests of cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, and body composition; these components of physical fitness are often considered to be associated with health. Currently, there are several "health related fitness" test batteries in use in the United States including "Fitnessgram" (IAR, 1987), "Physical Best" sponsored by the AAPHERD (AAPHERD, 1989), and "Fit Youth Today" (AHFF, 1986). These test batteries also include educational programs designed to reinforce behavioural changes associated with good health and physical well-being. Fitness testing in Canadian schools has followed a similar pattern to that of the United States. Currently, the only health-related test battery is the "Manitoba Schools Fitness" test (1989. The stated focus of the program is a shift from performance-based standards to more health-related standards. It is intended to promote a healthy lifestyle, recognize individual differences, foster self esteem. and move away from using test scores for grading purposes (Manitoba Education and Training, 1989).

B. INTERPRETATION OF RESULTS

Health-related fitness tests generally use criterion referenced rather than norm referenced standards for interpretation of results. The use of norm referenced standards in fitness performance tests may be counterproductive to establishing behaviours associated with a healthy lifestyle. High scores due to advantageous genetic endowment could lead a child to have a false sense of security regarding their fitness, and may not emphasize the need for regular physical activity (Docherty & Bell, 1990). Criterion referenced standards endeavor to identify desirable levels of physical fitness that are related to a reduced risk of hypokinetic disease, and all students are expected to reach this criterion or take steps to improve to this level. This type of interpretation seems more conducive to the goals of health related fitness tests. Unfortunately, criterion standards are often set arbitrarily using specific percentile cut-off points, and they still do not address the issue of performance variance due to developmental age. Fox and Biddle (1986) state that tests of health related fitness are not immune to the effect of genetic factors. They state that certain anatomical and physiological features will give some individuals a clear advantage on tests of functional capacity or physical fitness, which has little to do with degree of physical conditioning.

C. VALIDITY

Validity of individual tests and the entire test battery must be considered (Franks, Morrow & Plowman, 1988). The validity concerns of fitness performance tests were primarily face validity and construct validity, because the purpose was to measure various components of physical fitness performance. Health related fitness tests and the associated educational programs have additional responsibilities regarding validity as they purport to identify components that are related to health status, set criterion levels for each component that are meant to be indicative of good health status, measure the physical fitness construct, and influence future behaviour and health status.

Seefeldt and Vogel (1989) summarize several paradoxes that demonstrate the concern regarding the current status of health-related fitness testing:

1. "health-related fitness" tests do not provide any direct assessment of health status such as blood pressure, blood lipids, and cardiac response
2. the batteries fail to provide the scientific evidence that links the four parameters commonly associated with health related fitness in

childhood (cardiorespiratory endurance, muscular strength and endurance, flexibility, and body composition) to the health status of adults

3. the batteries fail to provide evidence that reaching the criterion levels on the tests provides sufficient fitness to experience the health related benefits that are purportedly associated with the test

4. the batteries fail to demonstrate that improvements in the test components result in improvements in the health status of children and youth

In conclusion, the batteries claim relationships regarding performance and health without providing sufficient scientific evidence for justification.

III. HEALTH RELATED FITNESS TESTING IN SCHOOLS TO IDENTIFY CHILDREN AND YOUTH WITH CHD RISK FACTORS

The school physical education program has been suggested as the most logical place to begin effecting change in children's activity behaviour because it is the single community group that includes the most children (Simons-Morton, O'Hara, Simons-Morton & Parcel, 1987). Therefore, it is a logical place to identify children with CHD risk factors. Criterion standards in health-related fitness tests should be related to well-known risk factors for CHD. The only Canadian health-related fitness test, "Manitoba Schools Fitness", has criterion standards for a 1600 m timed run, push-ups, modified sit-ups, sit and reach, and sum of skin folds. The criterion levels established claim to "indicate the levels of achievement at which health risk factors may be reduced" (Manitoba Education and Training, 1989).

Test items in the "Physical Best" battery were investigated for their relationship to the CHD risk factor of blood pressure in 164 males and females aged 10 to 17 years (Bazzano et al., 1992). Using the blood pressure risk cut-off points suggested by Bell et al. (1986), it was concluded that, with the possible exception of diastolic blood pressure in boys, performance on the test items was not associated with resting blood pressure in Italian children and adolescents. The failure of Bazzano and colleagues (1992) to find a relationship between sum of skin folds and blood pressure may be partially explained by the lack of central skin fold measures in this study, since the "Physical Best" battery suggests the use of triceps and calf skin folds, with the option of using triceps and subscapular sites. Central skin folds tend to be associated with CHD risk factors in adults and children (Gutin et al., 1990; Freedman & Srinivasan et al., 1989; Despres et al., 1990). Therefore, the option of four skin folds (triceps, subscapular, suprailiac, and calf) in the "Manitoba Schools Fitness" test's would appear to be a superior measurement to detect central fat. Bazzano et al. (1992) found that the muscular fitness test items were not associated with blood pressure; they commented that this was not unexpected. Their conclusion of the investigation was that the "Physical Best" test may be best used as an educational concept in schools as suggested and not as a diagnostic tool. Further investigation into the question of the validity of the claims made by health-related fitness tests is required.

Fitness testing in schools is usually only one part of a fitness development plan. Ideally, the results are used to assist students to plan appropriate individual programs that will encourage regular, long-term physical activity. However, since the criterion standards of health-related fitness tests claim to be related to levels of fitness at which health risk factors may be reduced, the question of validity is apparent. Although the relationship between CHD risk factors and fitness in children and youth has been investigated, most of the literature has focused on aerobic fitness assessed in a laboratory setting (Gutin et al., 1990; Kwee & Wilmore, 1990; Fripp et al., 1985; Armstrong et al., 1990; Armstrong et al., 1991). In addition, investigations have not taken the possible influence of maturational status into account when examining CHD risk factors or fitness performance. Entire health-related fitness test batteries have only been examined in relation to blood pressure (Bazzano et al., 1992) and skin fold thickness (Pate et al., 1989). Therefore, the relationship between health-related fitness test batteries and multiple risk factors for CHD requires further investigation. If test batteries can be used as a diagnostic tool for even some health risk factors, the opportunity for guidance with the more controllable childhood risk factors (obesity, smoking, physical activity) is possible.

APPENDIX F

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APPENDIX G

QUESTIONNAIRE Subject #: _____

1. How do you *normally* travel to school?

   a) by bus, car, motorcycle, etc.
   b) by bicycle
   c) on foot

2. How do you *normally* travel home from school?

   a) by bus, car, motorcycle, etc.
   b) by bicycle
   c) on foot

3. How long does it *normally* take you to travel to school after leaving your house?

   a) less than 5 minutes
   b) 5 - 15 minutes
   c) 15 - 30 minutes
   d) 30 minutes - 1 hour
   e) more than 1 hour

4. During your P.E. classes, how often do you get out of breath?

   a) I don't take P.E. classes
   b) hardly ever
   c) occasionally
   d) quite often
   e) always

5. What do you *normally* do at recess?

   a) sit down (talking, reading, doing school work)
   b) stand or walk around
   c) run around or play games

6. What do you *normally* do at lunch hour (apart from eating lunch)?

a) sit down (talking, reading, doing school work)
b) stand or walk around
c) run around or play games

7. At the moment, on how many days per week do you stay after school for sports (practises or games)?

a) none
b) once or twice a week
c) 3 or 4 times a week
d) 5 times a week

8. At the moment, how many evenings per week do you take part in sports or other physical activities?

a) none
b) once or twice a week
c) 3 - 5 times a week
d) 6 or 7 times a week

9. At the moment,do you take part in sports or other physical activities on the weekend?

a) Saturday morning
b) Saturday afternoon
c) Saturday evening
d) Sunday morning
e) Sunday afternoon
f) Sunday evening

10. During school holidays, how active are you, compared to when school is in session?

a) less active

b) about the same
c) more active

11. Which <u>one</u> of the following statements best describes you?

a) All or most of my free time is spent doing things that involve little physical effort (eg. watching TV, doing homework, talking to friends).

b) I occasionally (once or twice a week) do things in my free time that involve some physical effort (eg. play a sport, go running/jogging, go swimming, go biking, dance, etc.).

c) I quite often (4 - 6 times a week) do things in my free time that involve some physical effort.

d) I very often (7 or more times a week) do things in my free time that involve some physical effort.

12. How <u>physically fit</u> do you think you are compared to others of your age and gender?

a) very fit
b) fitter than most
c) about average
d) less fit that most
e) very unfit

13. Will you play sports or take part in physical activity when you leave school?

a) yes
b) no
c) I don't know

14. Do you think that you do enough exercise to keep you healthy?

a) yes
b) no
c) I don't know

15. In your opinion, do you think that you eat a healthy diet?

    a) yes
    b) no
    c) I don't know

16. By the time school starts in the morning, have you normally had something to eat?

    a) yes
    b) no

17. What do you normally have in your lunch at school?

18. In general, how would you describe your state of health?

    a) very good
    b) good
    c) average
    d) poor
    e) very poor

19. Do you have a regular job?
    a) yes
    b) no

    If YES, what sort of job is it?

How many hours per week do you work at your job? ____ hours

20. Which of the following best describes your experience with tobacco?

a) I have never smoked

b) I stopped smoking cigarettes recently
c) I stopped smoking cigarettes over a year ago

d) I stopped smoking a pipe, cigar or cigarillos recently
e) I stopped smoking a pipe, cigar or cigarillos over a year ago

f) I currently smoke cigarettes occasionally
g) I currently smoke less than a half pack of cigarettes daily
h) I currently smoke about 1 pack of cigarettes daily
i) I currently smoke 2 or more packs of cigarettes daily

j) I currently smoke a pipe, cigars or cigarillos

21. Does your best friend smoke?

a) yes
b) no

22. Generally speaking, do you enjoy physical activity (this means exercise that makes you get out of breath)?

a) yes
b) no

If YES, say why you like it:

If NO, say why you do not like it:

23. Does your best friend enjoy physical activity?

a) yes
b) no
c) I don't know

24. Generally speaking, do you enjoy P.E. classes?

a) yes
b) no

If YES, say why you like them:

If NO, say why you do not like them:

25. Does your best friend generally enjoy P.E. classes?

a) yes
b) no
c) I don't know

26. How much physical activity does your best friend do, compared to you?

a) much less activity
b) somewhat less activity
c) about the same amount of activity

d) somewhat more activity
e) much more activity

27. How important do you feel each of the following is to your own health?

	Very important				Not at all important
adequate rest and sleep	___	___	___	___	___
good diet	___	___	___	___	___
maintaining proper body weight	___	___	___	___	___
participation in social and cultural activities	___	___	___	___	___
control of stress	___	___	___	___	___
regular activity such as exercise, sports or games	___	___	___	___	___
a smoke-free environment	___	___	___	___	___

28. List some other things that you consider to be very important to your own health.

a)

b)

c)

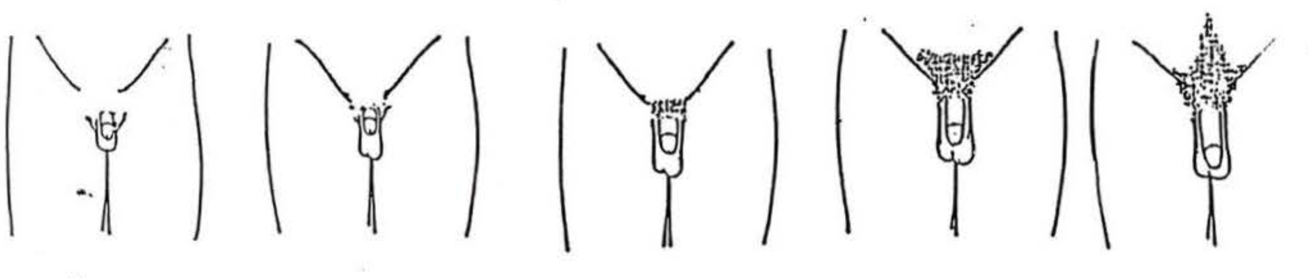
29. List any teams, clubs, and other organized groups that you spend some of your free time with (these do not have to be just sports or physical activities):

APPENDIX H

The drawings on this page show <u>different amounts of male pubic hair</u>.
Please look at each of the drawings and read the sentences under the drawings.
Then check the drawing that is **<u>closest</u>** to your stage of hair development.

<u>In choosing the appropriate drawing, look only at the pubic hair, and not at the size of the penis or scrotum!</u>

Picture 1 ___	Picture 2 ___	Picture 3 ___	Picture 4 ___	Picture 5

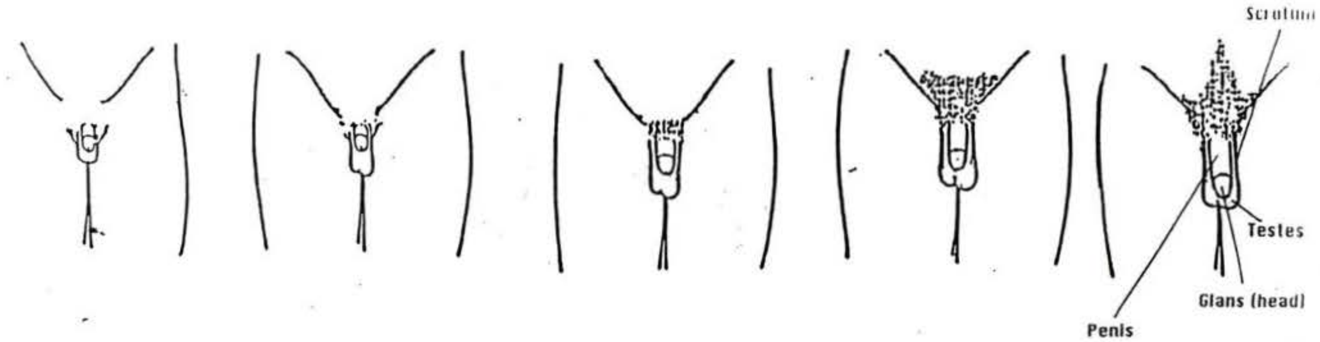


There is no pubic hair at all.	There is a small amount of long, lightly colored hair. This hair may be straight or a little curly	There is hair that is darker, curlier and thinly spread out to cover a somewhat larger area than in stage 2.	The hair is thicker and more spread out, covering a larger area than in stage 3.	The hair now is widely spread covering a large area, like that of an adult male.

The pictures on this page show <u>different stages of growth of the testes, sctrotum, and penis.</u> A boy goes through each of the 5 stages as shown. Please look at each of the pictures. Read the sentences. Put an x on the line above the picture which is <u>closest</u> to your stage of growth.

<u>Do not look at pubic hair growth!</u>

Picture 1 ___ Picture 2 ___ Picture 3 ___ Picture 4 ___ Picture 5 ___



The testes, scrotum, and penis are about the same size and shape as they were when you were a child.

The testes and scrotum are bigger. The skin of the scrotum has changed. The scrotum (the sack holding the the testes) has gotten lower. The penis has gotten only a little bigger.

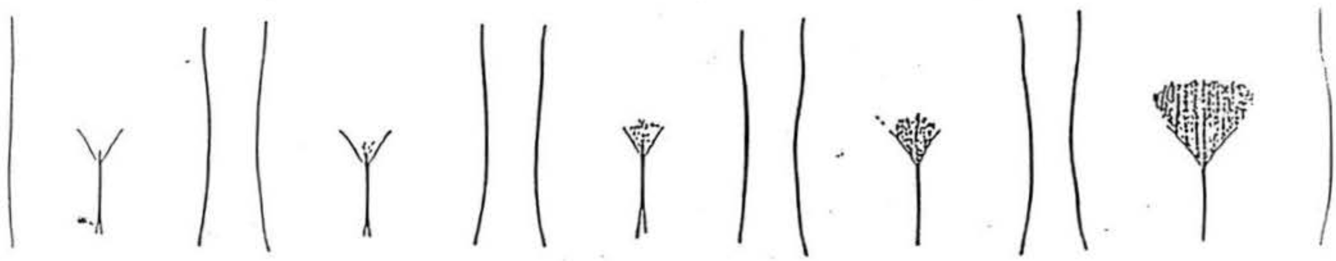
The penis has grown in length. The testes and scrotum have grown and dropped lower than in picture 2.

The penis has gotten even bigger. It is wider. The glans (the head of the penis) is bigger. The scrotum is darker than before. It is bigger because the testes are bigger.

The penis, scrotum, and testes are the size and shape of that of an adult man.

The drawings on this page show different amounts of female pubic hair.
Please look at each of the drawings and read the sentences under the drawings.
Then check the drawing that is **closest** to your stage of hair development.

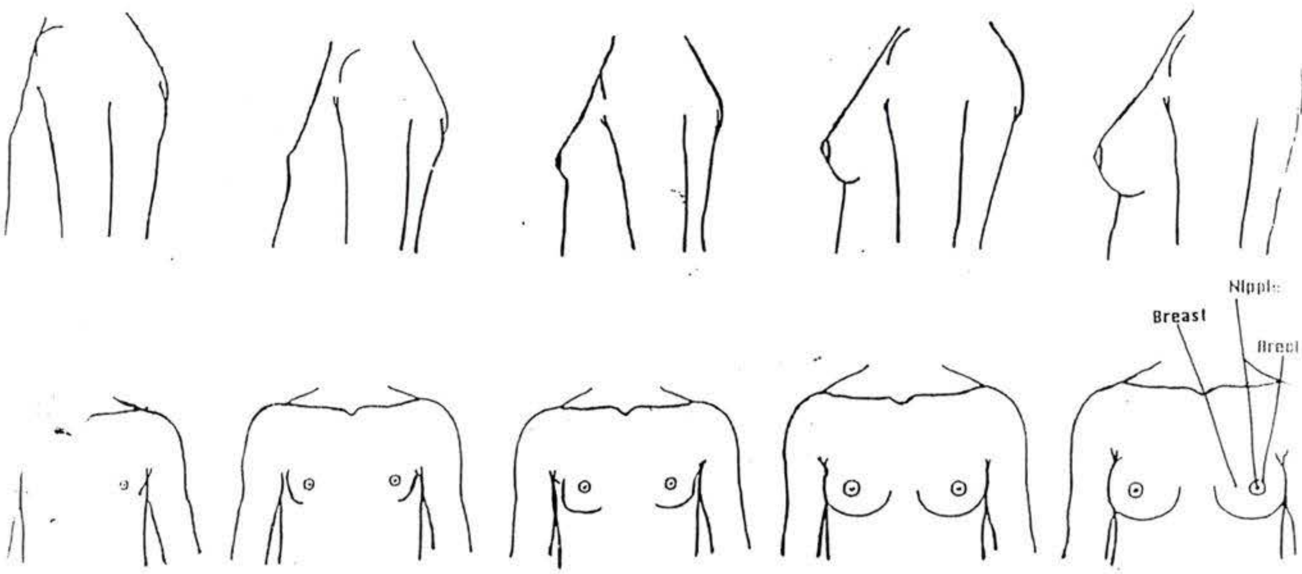
Picture 1 ___	Picture 2 ___	Picture 3 ___	Picture 4 ___	Picture 5



There is no pubic hair at all.	There is a small amount of long, lightly colored hair. This hair may be straight or a little curly	There is hair that is darker, curlier and thinly spread out to cover a somewhat larger area than in stage 2.	The hair is thicker and more spread out, covering a larger area than in stage 3.	The hair now is widely spread covering a large area, like that of an adult female.

[illegible] show different stages of how the breasts grow. A girl can go through each of the 5 stages as shown. Please [illegible] each of the pictures. Read the sentences. Put an x on the line above the picture which is <u>closest</u> to your stage of growth..

Picture 1 ___ Picture 2 ___ Picture 3 ___ Picture 4 ___ Picture 5



Picture 1: The nipple is raised a little in this stage. The rest of the breast is still flat.

Picture 2: This is the breast bud stage. In this stage the nipple is raised more than in stage 1. The breast is a small mound. The areola is larger than in stage 1.

Picture 3: The areola and the breast are both larger than in stage 2. The areola does not stick out away from the breast.

Picture 4: The areola and the nipple make up a mound that sticks up above the shape of the breast. (Note: this stage may not happen at all for some girls. Some girls go from stage 3 to stage 5, with no stage 4.)

Picture 5: This is the mature adult stage. The breasts are fully grown. Only the nipple sticks out in this stage. The areola has moved back to the general shape of the breast.

Have you had your first period? No ___

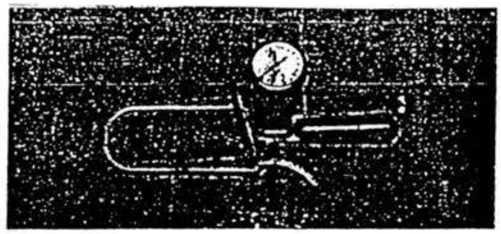
Yes ___ If yes, when did it start? ___

Calculation of activity scores

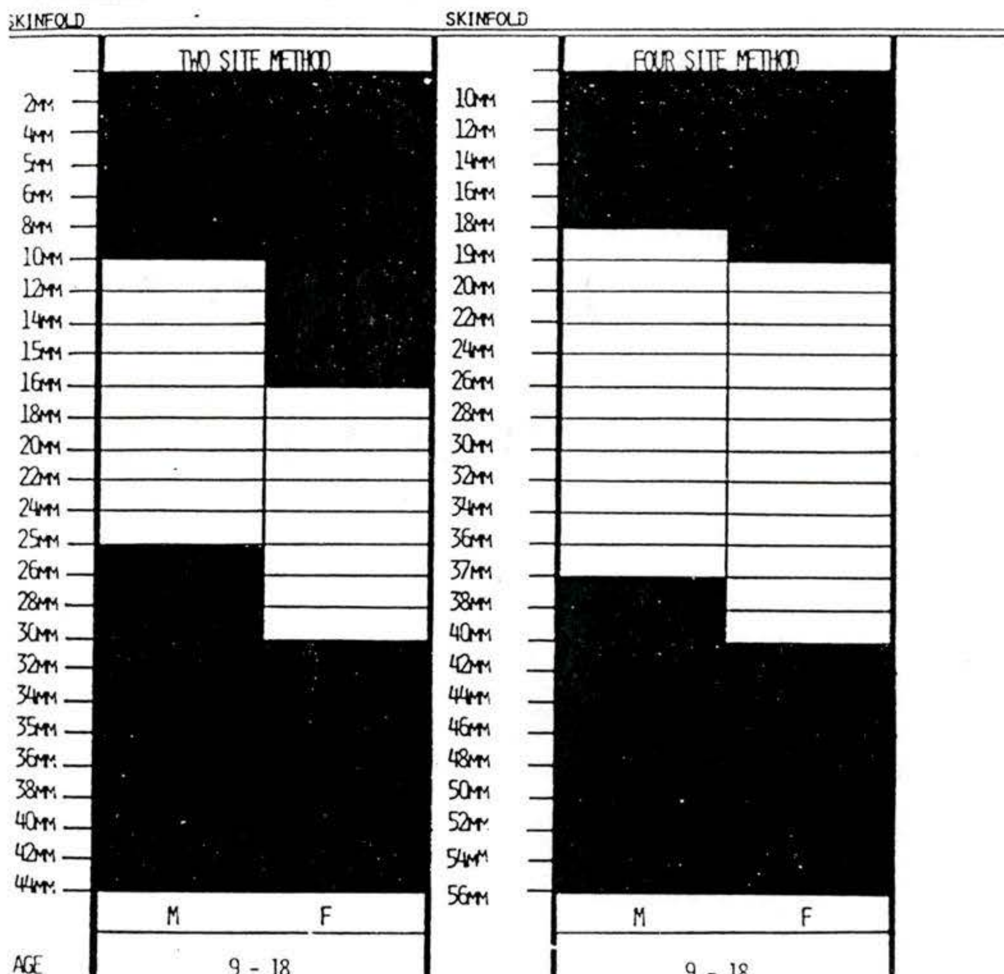
Qn. no.	Activity	Rating	Score
1/3	Cycle to and/or from school (per journey)	5-15 mins	1
		16-30 mins	2
		31 mins-1 hr	3
		more than 1 hr	4
2/3	Walk to and/or from school (per journey)	5-15 mins	0.5
		16-30 mins	1
		31 mins-1 hr	1.5
		more than 1 hr	2
4	Breathlessness during PE	occasionally	2
		quite often	3
		always	4
5	Morning break activity	running around	2
6	Lunch break activity	running around	4
7	After-school sports clubs	1-2 per week	4
		3-4 per week	8
		5 per week	9
8	Evening activity	1-2 pr week	4
		3-4 per week	8
		5 per week	10
9	Weekend activity	Sat. morning	4
		Sat. afternoon	4
		Sun. morning	4
		Sun. afternoon	4
	Score		53 (max.
10	Holidays	less active	score x 0.9
		about the same	score x 1.0
		more active	score x 1.1
	Total		58.3 (ma

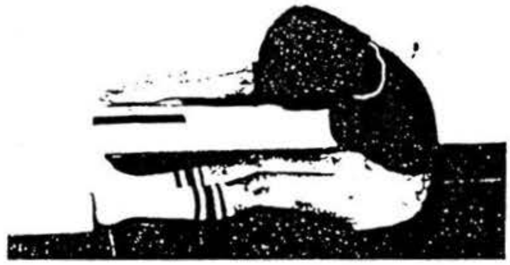
$$\text{Activity score} = \frac{\text{totalx100}}{58.3} \quad \text{(maximum score = 100)}$$

APPENDIX J



WHITE - DESIRABLE LEVEL
RED - REQUIRES IMPROVEMENT
GRAPH INTERPRETATION SEE APPENDIX

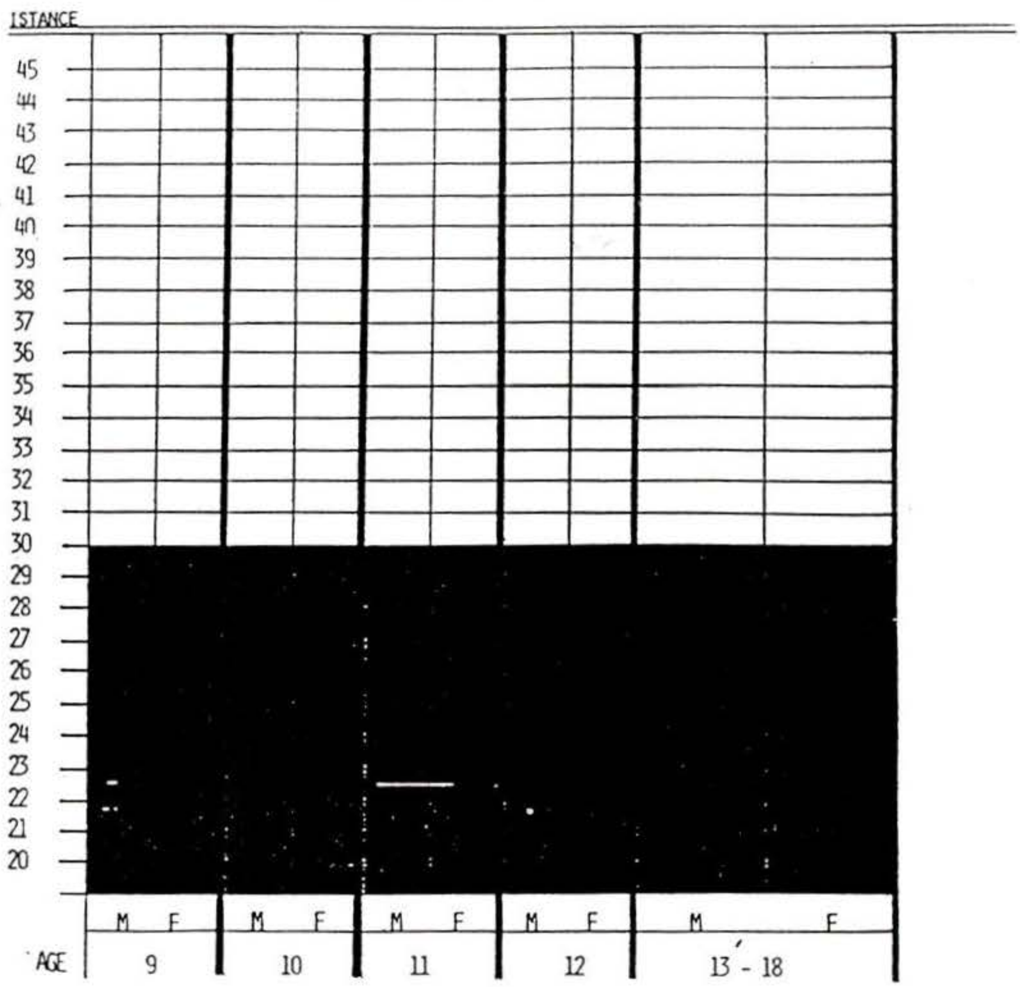




FLEXIBILITY

SIT AND REACH

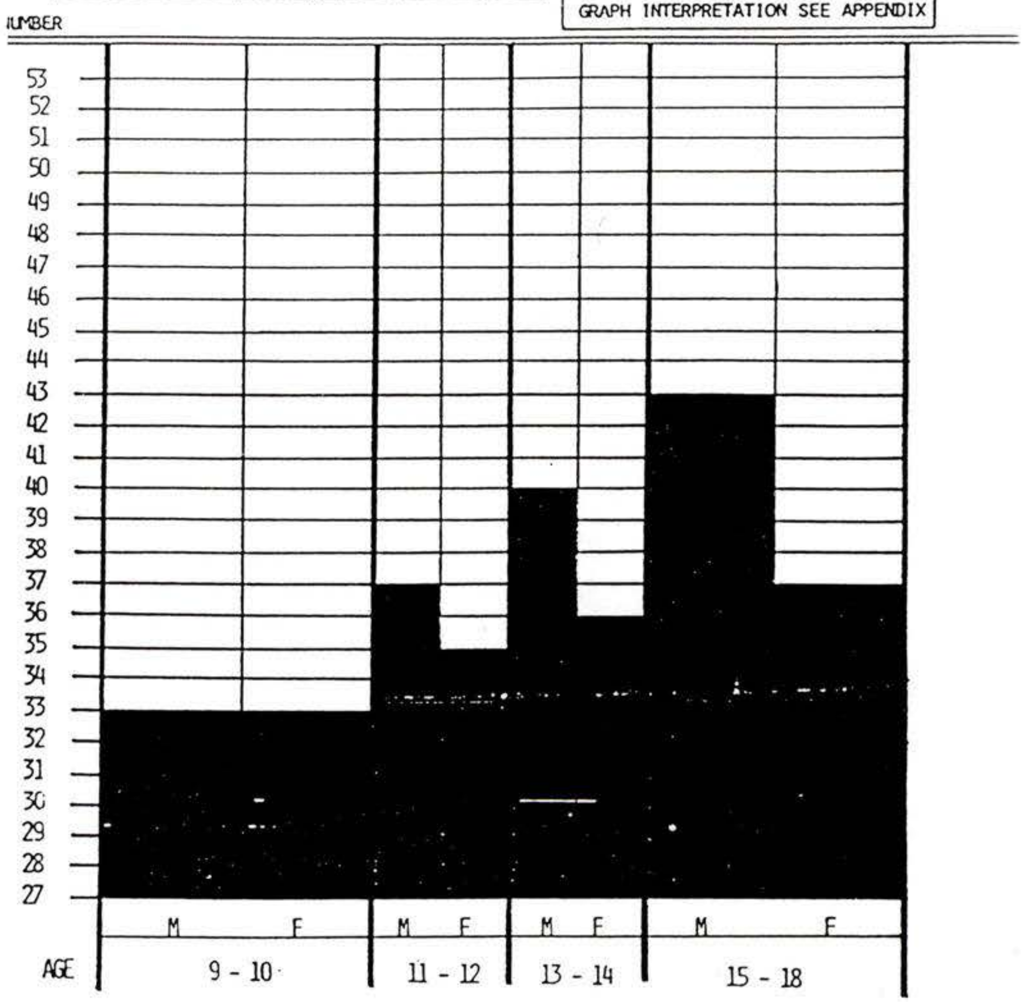
WHITE - DESIRABLE LEVEL
RED - REQUIRES IMPROVEMENT
GRAPH INTERPRETATION SEE APPENDIX



MUSCLE STRENGTH / ENDURANCE

THE SIT - UP

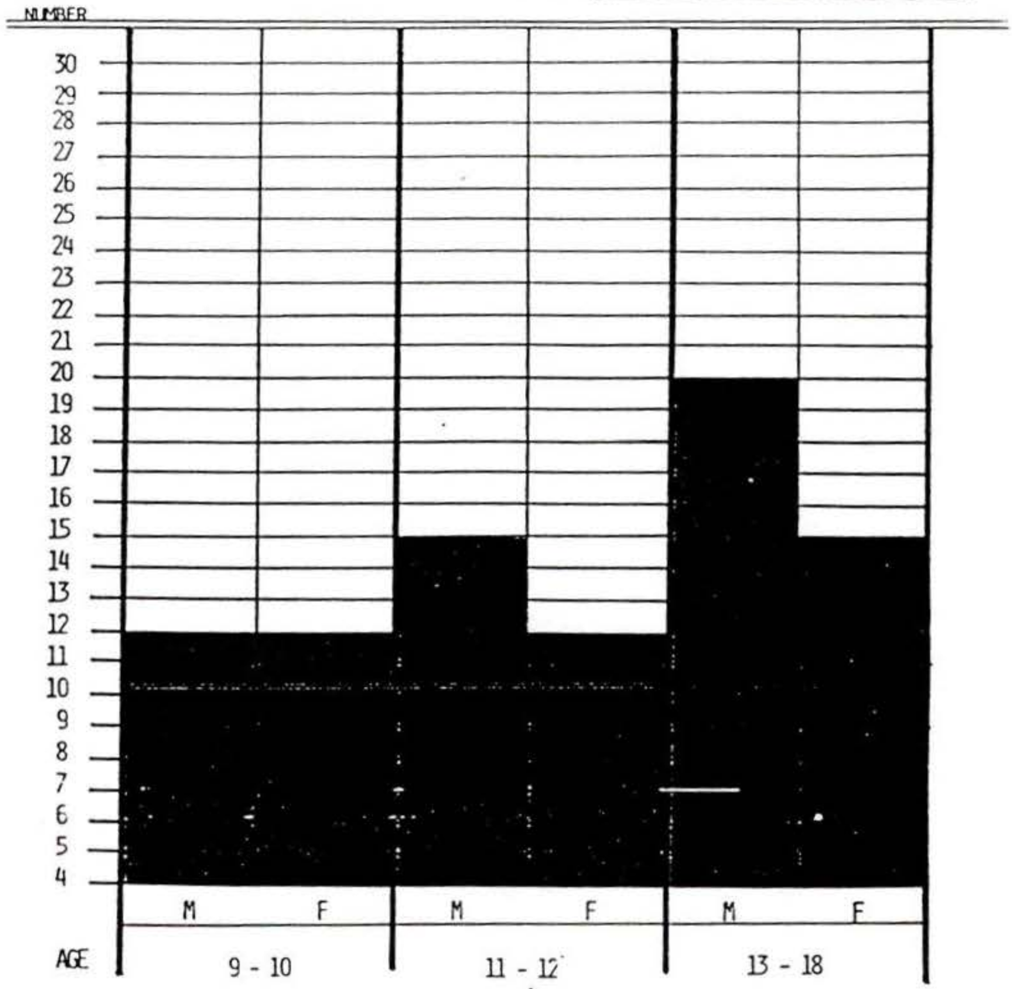
WHITE - DESIRABLE LEVEL
RED - REQUIRES IMPROVEMENT
GRAPH INTERPRETATION SEE APPENDIX



MUSCLE STRENGTH / ENDURANCE

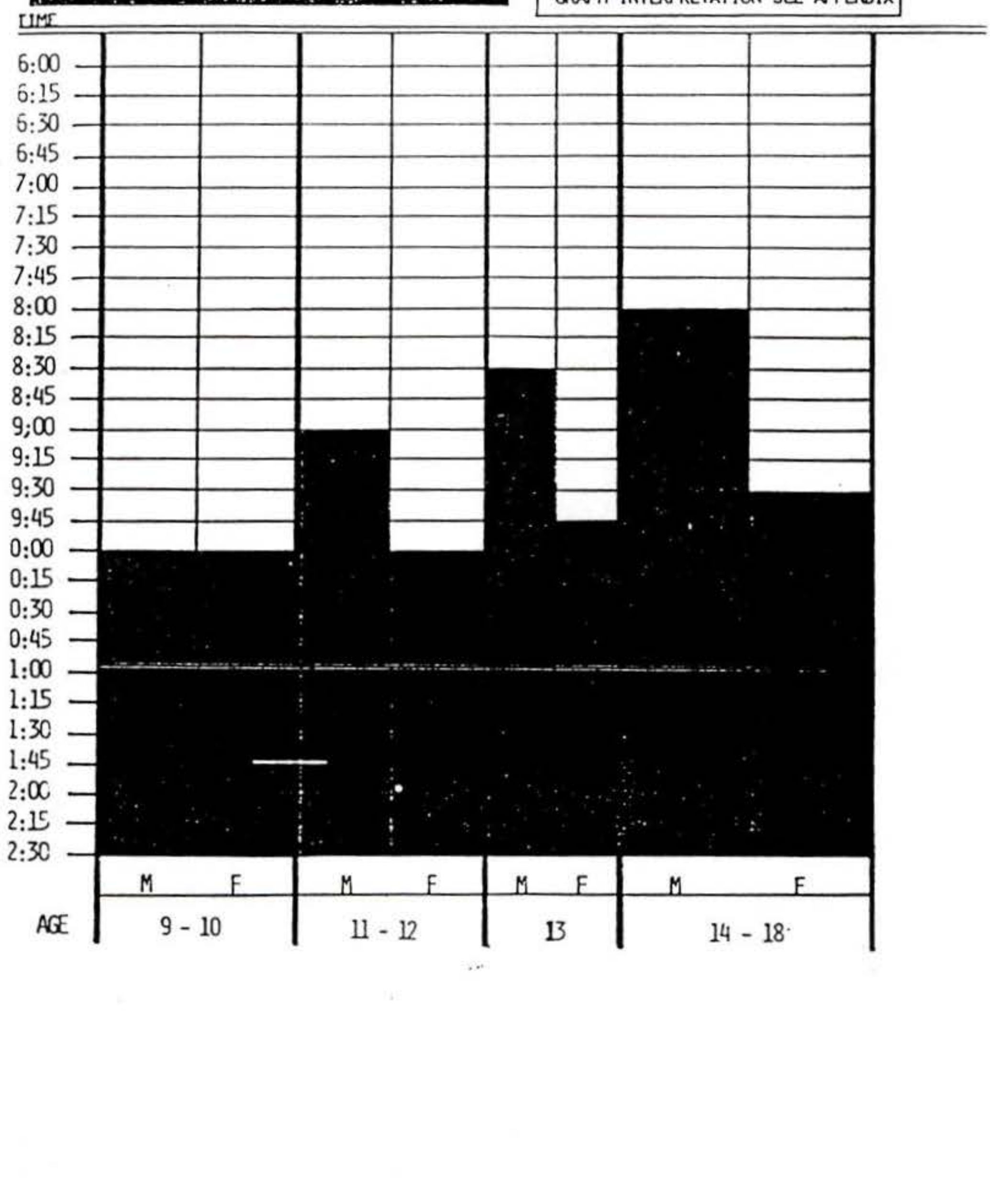
PUSH UP

WHITE - DESIRABLE LEVEL
RED - REQUIRES IMPROVEMENT
GRAPH INTERPRETATION SEE APPENDIX



CARDIOVASCULAR ENDURANCE
1600 METRE

WHITE - DESIRABLE LEVEL
RED - REQUIRES IMPROVEMENT
GRAPH INTERPRETATION SEE APPENDIX



APPENDIX K

Future Research Directions

1. A cross-sectional survey with a larger sample size is required to strengthen the findings of this study. Subjects aged 9 - 18 years of various cultures and socioeconomic levels should be included. It may be useful to include other protocols to measure the various components of fitness such as the 20 m Shuttle Run and paced sit-ups.

2. A longitudinal study is essential to track fitness and health variables over time and to determine the nature of the relationship between fitness and health variables in children at different ages and through puberty.

3. The Manitoba Schools Fitness test battery is intended as an educational tool in schools. A study that examines if the test battery is really used for its intended purpose, as well as the attitudes of teachers and students using the test battery, would be useful to evaluate the effectiveness of the Manitoba Schools Fitness test battery.

4. Other health variables such as a nutritional profile, blood lipids, family history of CHD should be investigated to assist in clarifying the relationship between health and fitness in children.

5. To improve educational programs such as the Manitoba Schools Fitness test battery, it would be useful to determine the perceptions of children and adolescents regarding the importance of fitness and health in their lives. Topics such as self-responsibility for health and fitness, and reasons for participation or non-participation in an active lifestyle could be included.

6. Various intervention programs and delivery need to be compared to determine the best method of assisting children who are "at risk" for health problems in making changes to their lifestyle.

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Docherty, D., Gaul, C. & **Thompson, A.** (1994). Within-day and between-day reliability of isokinetic peak torque in pre- and mid-pubescent males and females (Abstract). Canadian Journal of Applied Physiology , 19 (Suppl.), 12P.

Gaul, C., Docherty, D. & **Thompson, A.** (1994). Maturation and gender differences in muscular strength at various speeds of contraction (Abstract). Canadian Journal of Applied Physiology , 19 (Suppl.), 17P.

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Title of Thesis:

Health-Related Fitness and Coronary Heart Disease Risk Factors in Youth

Author [redacted]

Adele Lisa Thompson

August 31, 1995