Selected Fitness and Motor Behavior Parameters of Children and Adolescents With Insulin-Dependent Diabetes Mellitus

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Few studies have investigated the fitness levels of children and adolescents with insulin-dependent diabetes mellitus (IDDM), with no data presently available on such children's level of motor proficiency. The present investigation was prompted by this lack of information. Twenty-one girls (mean age = 11.0 years, range = 7-14) and 23 boys (mean age = 11.5 years, range = 8-15) with IDDM were tested on selected fitness and motor behavior parameters. Results indicated that children and adolescents with IDDM follow similar fitness and motor behavior profiles of their nondiabetic peers: Boys tended to be in better physical condition than girls of similar ages, particularly in the 12-15 year range. In the areas of body composition and abdominal strength/endurance, subjects displayed values below those obtained in studies of nondiabetic subjects. Subjects’ scores on the Bruininks-Oseretsky Test of Motor Proficiency for each age grouping were relatively high, indicating that children and adolescents with IDDM need not have diminished psychomotor skills.

Insulin-dependent diabetes mellitus (IDDM) is a complex hereditary or developmental disease of carbohydrate metabolism such that for every 10,000 persons in the United States there is 1 diabetic under the age of 20, 10 between ages 20 and 40, 100 between ages 50 and 60, and 1,000 over age 60 (Coram & Mangum, 1986). Insulin-dependent diabetes mellitus requires regular daily injections of insulin to regulate blood glucose concentration to within normal levels. Daily injections are required because, for some unknown reason, little to no insulin is produced by the pancreas. Common symptoms include constant thirst, frequent urination, and rapid weight loss (Dorchy & Poortmans, 1989). Chronic long-term problems associated with IDDM include eye retinopathy; blindness; kidney failure; nervous system problems affecting sensory, motor, and autonomic function; increased risk of cardiovascular disease (including hyperlipidemia, low HDL cholesterol levels, and obesity); and hypertension (Coram & Mangum, 1986; Sherman & Albright, 1990).
Value of Exercise and Fitness in IDDM

Although the preponderance of research has confirmed that the metabolic and physiological alterations observed with regular exercise and training have therapeutic value in controlling IDDM (for reviews, see Richter & Galbo, 1986; Zierath & Wallberg-Henriksson, 1992), the metabolic effects of long-term exercise on individuals with diabetes are nonetheless equivocal. For example, according to some authors (e.g., Kemmer & Berger, 1983), there is currently no convincing evidence that long-term physical exercise will improve diabetic control beyond the hypoglycemic effects observed with acute exercise. On the other hand, other researchers (e.g., Larsson, Sterky, Ekgengren, & Moller, 1962) have reported that children with diabetes who are physically active have lower blood glucose levels, lower glycosylated hemoglobin values, less glucosuria, and a more stable metabolism than do children with diabetes who are sedentary.

Notwithstanding these differences, the overwhelming consensus among health-care professionals is that nonketotic, well-controlled individuals with IDDM can benefit from regular exercise and generally do not need to restrict their activities. Fitness benefits include improved glucose tolerance; increases in endurance, strength, and maximum oxygen uptake; decreases in LDL, blood pressure, and percent body fat; and an overall reduced risk for arteriosclerosis (although not to the same extent as in healthy individuals) (Robbins, 1989; Rowland, 1990). Research additionally supports the belief that a strong and significant correlation exists between exercise and the reduction of day-to-day insulin requirements needed to maintain good glycemic control (Sato et al., 1986). This, in turn, may have an effect on reducing blood pressure and cardiovascular disease (Sherman & Albright, 1990).

Although exercise therapy has been considered an integral part of long-term diabetic control (Campaigne, Gillman, Spencer, Lampman, & Schork, 1984; Campaigne et al., 1985; Jensen & Miles, 1986), individuals with IDDM give a myriad of reasons for avoiding exercise and are often less fit than their nondiabetic peers (see Bar-Or, 1983; Rowland, 1990). In particular, it has been shown that individuals with IDDM have a higher heart rate at a given exercise workload (Sterky, 1963), a lower maximal heart rate (Rubler & Arvan, 1976), and a decreased VO\textsubscript{2}max (Larsson, Persson, Sterky, & Thoren, 1964). Two of the most commonly advanced reasons for individuals with diabetes not exercising is their fear of postexercise hypoglycemic attack and their overall reduced ability to exercise. Although the underlying mechanisms for reduced exercise performance are not fully understood, cardiovascular insufficiencies are suspected as the major determinant (Coram & Mangum, 1986; McMillan, 1979, 1981; Wahren, Hagenfeldt, & Felig, 1975).

Because of the methods involved in many of the studies investigating the physical fitness of individuals with diabetes (e.g., subject selection) and the limited number of studies performed on individuals with diabetes compared to nonimpaired peers, Ludvigsson (1980) has indicated that it is difficult to conclude whether children with diabetes are truly impaired in exercise capacity due to influences of the diabetes condition on physiological functioning or due to these children assuming a more sedentary lifestyle. Furthermore, studies have tended to investigate only a particular aspect of physical fitness (e.g., work capacity or exercise tolerance) rather than determine an overall physical fitness and motor proficiency profile. This lack of information prompted the present investigation. Accordingly, it was the purpose of this study to ascertain the physical fitness, motor proficiency, and physical activity levels of boys and girls with IDDM and to compare data to that of nondiabetic peers. Data on boys and girls were also compared to determine gender differences.
Method

Subjects

Twenty-one girls (mean age = 11.0 years, range = 7–14) and 23 boys (mean age = 11.5 years, range = 8–15) with IDDM attending a 2-week summer camp in New Hampshire for children with diabetes participated in the study (see Table 1). Children attended camp because it was recommended by the family pediatrician, endocrinologist, or parents. No child was denied permission to attend the camp due to financial reasons as the local Lion’s Club sponsored those who could not afford to pay. Consequently, camp participants represented all levels of socioeconomic strata in northern New England.

Of the total number of children with diabetes at camp, only 3 were denied permission by their parents to participate in the study. No subject evidenced any retinopathy, neuropathy, or nephropathy. This was probably because children with severe, documented diabetic complications normally do not attend this camp.

Procedures

Subjects were tested for peak aerobic power (treadmill), percent body fat (skinfold technique), waist-to-hip ratio (WHR), handgrip strength of the dominant hand, lower back and hamstring flexibility (sit-and-reach test), abdominal strength (sit-ups in 1 min), motor proficiency (short form of the Bruininks-Oseretsky Test of Motor Proficiency [BOTMP], Bruininks, 1978), and physical activity level (modified Bar-Or Activity Questionnaire; Bar-Or, 1983). Degree of metabolic control was ascertained by glycosylated hemoglobin (HbA1) in the blood.

Each child was tested upon arrival at the laboratory in the morning. Height, weight, percent body fat, and WHR were determined first. This was followed by strength and flexibility tests. The treadmill test was administered as the last item in the morning. Following a lunch break and a rest period, subjects completed the several test items of the BOTMP. All testing was completed between the end of the first week of camp and the first days of the second week. The Bar-Or Activity Questionnaire was completed by parents on the second day the child arrived at camp.

Subjects performed a graded exercise test on a motor-driven treadmill (Quinton Instruments) to assess maximum (or peak) VO₂. It has been contended that treadmill exercise puts a greater physiological stress on the cardiovascular system (Boileau, Bonen, Heyward, & Massey, 1977) and that maximal oxygen uptake values are approximately 10% higher on the treadmill than on a cycle ergometer. This difference most likely results from cycle exercise using less muscle mass than treadmill exercise. Also, local muscle fatigue may significantly limit cycle exercise. Bar-Or (1983) suggested that the

<table>
<thead>
<tr>
<th></th>
<th>Boys (n = 23)</th>
<th>Girls (n = 21)</th>
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<tbody>
<tr>
<td></td>
<td>M  SD</td>
<td>Min Max</td>
</tr>
<tr>
<td>Age (years)</td>
<td>11.5 2.5</td>
<td>8.0 15.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>149.2 15.4</td>
<td>125.7 181.6</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>45.4 15.7</td>
<td>25.7 84.3</td>
</tr>
</tbody>
</table>

Table 1 Physical Characteristics of Subjects
limiting influence of muscle fatigue might be even greater in children because of their relatively undeveloped quadriceps muscle mass. For these reasons, a treadmill test was used to ascertain oxygen uptake in subjects.

After determining a comfortable running speed, subjects exercised at increasing levels of intensity (2% grade increase every 2 min) until volitional exhaustion. Minute inspired ventilation and expired concentrations of CO₂ and O₂ were continuously monitored using a Parkinson-Cowan dry gas meter, and Beckman LB-2 and OM-11 gas analyzers, respectively. The analog output of these devices was measured with an online metabolic measurement system. All variables were corrected to standard conditions (standard temperature and pressure dry [STPD]) with ambient temperature and barometric pressure measurements. The system was calibrated before each test with standard gases of known oxygen and carbon dioxide concentration. Heart rate was monitored continuously by a CM5 lead placement on a Cambridge Instruments electrocardiograph.

Skinfold measurements were made with calibrated Lange skinfold calipers (Cambridge Scientific Industries, Cambridge, MD) using the right side at three sites: calf, triceps, and subscapular. Triceps and subscapular skinfolds were used to determine percentile rankings of skinfold measures on the American Alliance for Health, Physical Education, Recreation, and Dance (AAHPERD) Health-Related Physical Fitness Test (AAHPERD, 1980). Triceps and calf skinfolds were used to determine percent body fat based on general equations developed by Slaughter et al. (1988, p. 719). According to the authors, these equations provide more accurate estimates of percent body fat than those currently available since they take into consideration the chemical immaturity of children. In general, equations that predict body density from skinfolds at or above \( r = .80 \) represent a reliable, valid, and cost-effective method for determining body composition (Pollock, Schmidt, & Jackson, 1980).

The manner in which body fat is distributed is important. Individuals with more fat centrally (i.e., on the trunk) are at increased coronary risk when compared to persons who are just as fat but have a preponderance of the fat peripherally (i.e., on the extremities). The WHR (circumference of the waist divided by the circumference of the hips) is a simple measure that reflects elevated risk (Bray & Gray, 1988).

Handgrip measurements were taken with a Lafayette pediatric hand dynamometer (Model 78011, Lafayette Instruments, Lafayette, IN). Static handgrip force has long been considered a good predictor \( (r = .80) \) of more general measures of muscle function in able-bodied individuals (Clarke, 1966). More recently, Lord, Aitkens, McCrory, and Bernauer (1992) found correlations of between .88 and .93 for isometric and isokinetic strength measurements. Therefore, static handgrip force represented a reliable, valid, and feasible method for obtaining an overall indicator of body strength in children.

Before the handgrip test was administered, the handle of the dynamometer was adjusted for each child’s hand size. The child’s arm was then raised to shoulder level, keeping it away from the body with the elbow slightly bent (approximately 15–20 degrees). The child was instructed to describe a sweeping arc downward as the dynamometer was squeezed. Emphasis was placed on squeezing the dynamometer as hard as possible. The average of three trials was used in the data analysis. Subjects rested 1 min between trials.

Sit-and-reach and sit-up tests were performed according to AAHPERD criteria (AAHPERD, 1984). Rationale for administering these tests are based on substantial clinical experience that abdominal muscle strength/endurance and lower back/hamstring flexibility reduces the risk of developing low back pain (Plowman, 1992) and developing postural problems such as excessive anterior or posterior pelvic tilt (Norkin & Levangie, 1992). Subjects warmed up by static stretching of the lower back and posterior thigh
prior to performing the sit and reach test. Data analysis was based on the average of three trials for the sit-and-reach test, and a single trial for the sit-up test.

The BOTMP has been reported to be both a reliable and valid age-related measure of motor proficiency (Moore, Reeve, & Boan, 1986). The complete battery is composed of eight subtests comprising 46 separate test items and furnishes both a comprehensive index of motor proficiency and a detailed analysis of gross and fine motor skills. The short form comprises 14 items from the complete test battery and provides a general survey of motor proficiency. Both test forms are designed for children and adolescents ages 4-1/2 to 14 years. Normative data are available based on the performance of a national sample of 765 subjects. Bruininks (1978) found test–retest reliability for second and sixth graders to be .87 and .84, respectively; however, Moore et al. (1986) found a slightly lower reliability value ($r = .76$) for 5-year old children.

**Results**

Data analysis consisted of descriptive statistics and a $2 \times 2$ (Gender x Age Group, 7–11 and 12–15) multivariate analysis of variance (MANOVA) (Kachigan, 1986) on the following dependent measures: peak VO$_2$, dominant handgrip strength, percent body fat, WHR, sit-and-reach, number of sit-ups in 60 s, and percentile ranking on the BOTMP. Pearson product-moment correlation coefficients between subjects’ HbA1 levels and peak VO$_2$ levels and between subjects’ peak VO$_2$ levels and percent body fat were also calculated. Data were analyzed using StatSoft statistical software package for the Macintosh (StatSoft, Tulsa, OK). Descriptive statistics on the fitness and motor behavior characteristics of subjects are shown in Table 2.

**Table 2  Descriptive Statistics on Fitness and Motor Behavior Parameters by Gender and Age**

<table>
<thead>
<tr>
<th></th>
<th>Boys Ages 7–11 ($n = 13$)</th>
<th>Girls Ages 7–11 ($n = 12$)</th>
<th>Boys Ages 12–15 ($n = 10$)</th>
<th>Girls Ages 12–15 ($n = 9$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$M$</td>
<td>$SD$</td>
<td>$M$</td>
<td>$SD$</td>
</tr>
<tr>
<td>Peak VO$_2$ (ml/kg/min)</td>
<td>44.0</td>
<td>4.0</td>
<td>47.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Peak heart rate (b/min)</td>
<td>187.5</td>
<td>8.4</td>
<td>196.8</td>
<td>13.2</td>
</tr>
<tr>
<td>Dominant handgrip (Kg)</td>
<td>14.5</td>
<td>3.5</td>
<td>29.1</td>
<td>10.3</td>
</tr>
<tr>
<td>% body fat</td>
<td>23.0</td>
<td>6.8</td>
<td>22.3</td>
<td>8.6</td>
</tr>
<tr>
<td>AAHPERD body fat (%) rank</td>
<td>16.5</td>
<td>15.6</td>
<td>22.5</td>
<td>15.5</td>
</tr>
<tr>
<td>Waist–hip ratio</td>
<td>0.85</td>
<td>0.04</td>
<td>0.83</td>
<td>0.04</td>
</tr>
<tr>
<td>Sit-and-reach (cm)</td>
<td>21.3</td>
<td>4.9</td>
<td>22.2</td>
<td>8.3</td>
</tr>
<tr>
<td>AAHPERD sit-and-reach (%) rank</td>
<td>29.1</td>
<td>25.2</td>
<td>31.0</td>
<td>31.2</td>
</tr>
<tr>
<td>Sit-ups (1-min)</td>
<td>28.9</td>
<td>7.8</td>
<td>39.2</td>
<td>8.8</td>
</tr>
<tr>
<td>AAHPERD sit-ups (%) rank</td>
<td>39.9</td>
<td>21.4</td>
<td>43.1</td>
<td>29.2</td>
</tr>
<tr>
<td>Bruininks-Oseretsky (%) rank</td>
<td>58.7</td>
<td>33.2</td>
<td>59.0</td>
<td>17.4</td>
</tr>
</tbody>
</table>
Based on the Wilks's lambda criteria, the MANOVA indicated significant gender, $F(7, 23) = 8.39, p < .0001$, and age group, $F(7, 23) = p < .05$, main effects. Follow-up univariate analysis of variance (ANOVA) and Scheffé post hoc tests (significance at $p < .05$) indicated the following:

1. A significant gender main effect, $F(1, 36) = 3.34, p < .0001$, for peak $\dot{V}O_2$. For ages 7–11 years, peak $\dot{V}O_2$ for boys (44.0 ml/kg/min) was significantly higher ($p < .05$) than for girls (37.5 ml/kg/min); for ages 12–15, peak $\dot{V}O_2$ for boys (47.4 ml/kg/min) was also significantly higher ($p < .01$) than for girls (37.0 ml/kg/min).

2. A significant gender main effect, $F(1, 40) = 9.05, p < .005$, for percent body fat. For ages 7–11 years, percent body fat for boys (23.0%) was significantly lower ($p < .05$) than for girls (27.0%); similarly, for ages 12–15 years, percent body fat for boys (22.3%) was significantly lower ($p < .05$) than for girls (34.4%). Using the sum of subscapular and triceps skinfolds and the AAHPERD (1980) health-related physical fitness percentile norms, data indicated a percentile ranking of 16.5% for boys and 19.1% for girls in the 7–11 age range; for the 12–15 age range data indicated a 22.5% for boys and 20.5% for girls. Furthermore, only 3 of the 44 subjects tested were at or above the 50th percentile when using the AAHPERD sum of triceps and subscapular skinfolds percentile rankings.

3. A significant gender main effect, $F(1, 40) = 15.30, p < .0005$, for WHR. For ages 7–11 years, WHR for boys (.85) was significantly higher ($p < .05$) than for girls (.79); similarly, for ages 12–15 years, WHR for boys (.83) was significantly higher ($p < .01$) than for girls (.76).

4. A significant interaction effect, $F(1, 40) = 4.24, p < .05$, for handgrip strength. For ages 7–11 years, there was no significant difference ($p > .05$) in handgrip strength between boys (14.5 kg) and girls (12.1 kg); however, for ages 12–15 years, boys’ handgrip strength (29.1 kg) was significantly higher ($p < .05$) than girls’ (19.0 kg).

5. Significant gender, $F(1, 39) = 10.84, p < .005$, and age group, $F(1, 39) = 4.40, p < .05$, main effects for sit-and-reach scores. For ages 7–11 years, boys’ sit-and-reach scores (21.3 cm) were significantly lower ($p < .05$) than girls’ scores (24.5 cm). Using AAHPERD (1980) health-related physical fitness norms, data indicated a percentile ranking of 29.1% for boys and 30.3% for girls. Similarly, for ages 12–15 years, boys’ sit-and-reach scores (22.2 cm) were significantly lower than girls’ scores (31.5 cm). Using AAHPERD health-related physical fitness norms, data indicated a percentile ranking of 31.0% for boys and 54.8% for girls.

6. A significant age group main effect, $F(1, 40) = 13.79, p < .001$, for sit-ups. Boys ages 12–15 performed significantly more sit-ups (39.2) than boys ages 7–11 (28.9), and girls ages 12-15 (35.8) performed significantly more sit-ups than girls ages 7–11 (27.8). Using AAHPERD (1980) health-related physical fitness norms, data indicated the following percentile rankings: for ages 7–11, boys 39.9% and girls 37.3%; for ages 12–15, boys 43.1% and girls 50.4%. Interestingly, there were no significant differences between boys and girls of the same age grouping ($p > .05$).

7. There was no significant difference ($p > .05$) in percentile ranking on the BOTMP between boys (58.7%) and girls (51.2%) ages 7–11 years and between boys (59.0%) and girls (47.9%) ages 12–15 years. The BOTMP scores were quite variable for subjects as noted by the standard deviations in Table 2.

8. A nonsignificant ($r = .016, p > .05$) correlation between HbA1 levels in subjects and corresponding peak $\dot{V}O_2$ values was found.
9. A highly significant negative correlation \( r = -0.70, p < 0.01 \) between peak \( \dot{V}O_2 \) and percent body fat was found.

10. Based on data obtained from parents on the modified Bar-Or Physical Activity Questionnaire, subjects were as physically active as their nondiabetic siblings.

**Discussion**

**Peak Heart Rate and Peak Aerobic Power**

Comparing the peak \( \dot{V}O_2 \) data obtained from the individuals with IDDM in our investigation to those of nondiabetic peers is difficult because methods of measuring oxygen uptake (e.g., maximal versus submaximal tests and treadmill versus cycle ergometry) and subjects’ age differ. Ludvigsson (1980) noted that fitness comparisons depend in large part on the selection of both experimental and control subjects. Thus, it is difficult to conclude whether children with diabetes in general, or those in our investigation in particular, are actually impaired in aerobic power.

Further, if they are impaired, we do not know whether this is the result of the disease process or the proclivity of children with diabetes to be inactive. However, in a recent study by Rowland, Martha, Reiter, and Cunningham (1992), 11 IDDM boys, ages 10–16 years, were compared to control subjects matched for age and body size. The authors observed no differences in \( \dot{V}O_2 \text{max} \), submaximal stroke volume, cardiac output, heart rate, and rate-pressure product between groups. The authors concluded that habitual physical activity is a better predictor of aerobic fitness in boys with diabetes than the influence of the disease is.

In general, when compared to nondiabetics, children with IDDM often demonstrate higher heart rates for a given exercise work load, lower maximal heart rates, and decreased aerobic power (Larsson et al., 1964; Larsson et al., 1962; Rubler & Arvan, 1976). Our data are consistent with this viewpoint. Results of our investigation indicated that the peak \( \dot{V}O_2 \) values of our subjects were below those obtained by other investigators with nonimpaired subjects (e.g., Armstrong, Balding, Gentle, Williams, & Kirby, 1990; Shephard, 1986). Similar to healthy individuals, boys’ peak \( \dot{V}O_2 \) values in our investigation were higher than those obtained by girls (Armstrong et al., 1990).

In our investigation, subjects’ peak heart rates and peak \( \dot{V}O_2 \) values (Table 2) were consistent with values reported by other authors for children and adolescents with IDDM (Fremion, Marrero, & Golden, 1987; Poortmans, Sarens, Edelman, Vertongen, & Dorchy, 1986; Rowland, Swadba, Biggs, Burke, & Reiter, 1985). For example, Fremion et al. (1987), in a small study of 12- to 14-year-old individuals with IDDM, reported \( \dot{V}O_2 \text{max} \) values of 44 and 34 ml/kg/min for boys and girls, respectively. Our data for peak aerobic power are comparable to, albeit slightly higher than, data from Fremion et al. (1987). In our investigation, boys \((n = 5)\) in this age range showed a peak \( \dot{V}O_2 \) of 48.0, and girls \((n = 9)\) revealed a peak \( \dot{V}O_2 \) of 37.0.

Based on results from the activity questionnaire completed by the subjects’ parents, the individuals with IDDM in our investigation were as active as siblings and peers. This could account for the slightly higher values obtained in our investigation compared to those from Fremion et al. (1987). It is important to note that in our investigation only 3 of the total number of subjects failed to meet at least one of the following criteria for achievement of peak aerobic power: (a) plateau in \( \dot{V}O_2 \), (b) respiratory exchange ratio > 1.0, and (c) maximal heart rate of 200 beats per min.
Metabolic Control

Recently, a number of researchers have attempted to address the issue of oxygen uptake, exercise, and metabolic control in individuals with IDDM. Poortmans et al. (1986) investigated the degree of metabolic control on physical fitness in adolescents with IDDM. Glycosylated hemoglobin (HbA1) in the blood reflects the blood glucose level over the life of the red blood cell. HbA1, when expressed as a percentage of total Hb, is a useful measure of glycemic control. Poortmans et al. demonstrated a significant inverse relationship between HbA1 concentration and maximal workload. Ludvigsson (1980) also observed a significant relationship between degree of physical activity (weekly diary) and index of metabolic control in a large sample of children with IDDM.

Campaigne and co-workers (Campaigne et al., 1984; Campaigne et al., 1985), in two studies, found conflicting results regarding exercise and metabolic control. In the first study, Campaigne et al. (1984) found significant improvements in both VO₂max and metabolic control in 9 children with IDDM, ages 5–11 years, following a 12-week exercise program. However, in a second training study of 14 adolescents with IDDM, Campaigne et al. (1985) found no improvements in metabolic control. Mean HbA1 levels remained unchanged after a 3-month, three-times-per-week aerobic training program.

Similar findings were reported by Rowland et al. (1985) in 14 children with IDDM, ages 9–14 years. These authors were unable to demonstrate an improvement in metabolic control as a result of participation in a 12-week aerobic exercise program. However, VO₂ max improved 9% over pretraining values.

Clearly, results of these types of studies are mixed, and the relationship between physical exercise, oxygen uptake, and metabolic control is a tenuous one. Our investigation tends to support the work of Campaigne et al. (1985) and Rowland et al. (1985). HbA1 levels were obtained for 20 of our subjects (12 males and 8 females). We calculated a nonsignificant \( r = -.016, p > .05 \) correlation between HbA1 and peak VO₂.

Body Composition and Waist-to-Hip Ratio

Using equations developed by Slaughter et al. (1988), we have shown only slight differences in percent body fat between boys (23.0%) and girls (27.0%) ages 7–11 years. However, we demonstrated significantly greater body fat levels in girls (34.4%) than in boys (22.3%) 12–15 years.

When using the sum of subscapular and triceps skinfolds and AAHPERD body fat percentile norms (AAHPERD, 1980), we found a mean percentile ranking for boys and girls age 7–11 to be 16.5% and 19.1%, respectively, and for boys and girls age 12–15 to be 22.5% and 20.5%, respectively. Only 3 of 44 subjects were at or above the 50th percentile on norms of the AAHPERD Health-Related Fitness Test for sum of triceps and subscapular skinfolds. Day (1981) noted that body composition factors may account for maximal aerobic power differences in children. Thus, maximal aerobic power represents an expression of the combined influences of anthropometric and physiological determinants. We found a significant negative correlation \( r = -.70, p < .01 \) in our subjects between peak VO₂ and percent body fat, which confirms the strong relationship between body composition factors and VO₂ max in children found by other authors (Day, 1981; Mayhew & Gifford, 1975).

In a large-scale study of 712 nondiabetic boys and girls (mean age = 15.8 years), Donahue, Prineas, Gomez, and Hong (1992) observed a WHR for boys of .82 and for girls of .76. These data are comparable to the WHR data for 12- to 15-year-old children in our sample of children with IDDM. Further, Donahue et al. (1992) found a significant degree of familiar resemblance for WHR. Evidence continues to accumulate indicating
that an elevated WHR is a prognostic factor for individuals developing cardiovascular disease in later life.

For example, Freedman, Srinivasan, Harsha, Webber, and Berenson (1989), in a study of 361 children ages 6–18 years, found that a truncal fat pattern was associated with adverse concentrations of blood lipids. Gillum (1987), in a study of children ages 6–17 years, demonstrated that WHR was significantly associated with systolic blood pressure and serum uric acid levels in youths and diastolic blood pressure in children. It appears that early identification of teenagers with elevated WHR could result in specific strategies directed toward reducing cardiovascular disease risk.

Research also indicates that the distribution of fat in the abdominal region, in addition to the total amount of fat per se, is an important risk factor for diabetes. For example, Lundgren, Bengtsson, Blohme, Lapidus, and Sjostrom (1989), in a 12-year longitudinal study of women, found that the WHR was significantly associated with incidence level of diabetes. Further, the WHR was positively associated with increased serum glucose concentrations in the fasting state. Freedman and Rimm (1989), in a cross-sectional study of 43,000 women, reported that WHR was consistently related to diabetes independent of the degree the individual was overweight.

**Muscular Strength and Endurance**

Sit-ups evaluate abdominal muscular strength and endurance. Employing standards developed by AAHPERD (1980), only 15 of 43 children with diabetes scored at or above the 50th percentile. However, when compared to nondiabetic Canadian peers (Canada Fitness Survey, 1983), boys in both the 7–11 and 12–15 age groupings were substantially below norms; girls, on the other hand, were slightly above norms, most notably in the 7–11 age group. The importance of the sit-up data will be discussed shortly in conjunction with lower back-hamstring flexibility.

Although the most used strength measure in children is grip strength, absolute strength scores vary depending on type of dynamometer used and on variations and nuances of testing procedures. Consequently, comparisons made between our data and those of other investigations is tenuous at best.

In general, boys have been shown to have consistently higher average single and double hand grip strength than do girls from 3 to 18 years of age; moreover, these differences accelerate during the adolescent growth spurt (Blimkie, 1989). Our data confirm this point. Using standards published by Lafayette Instrument Company (1986), we compared our subjects’ dominant hand grip strengths to nondiabetic children by age and sex. Results indicated that 27 of 44 subjects had grip strength levels above mean values. Subjects also compared favorably to those of nondiabetic Canadian peers (Canada Fitness Survey, 1983).

**Lower Back-Hamstring Flexibility**

Values in the sit-and-reach test did not compare favorably to those of nondiabetic American peers (AAHPERD, 1980) and Canadian peers (Canada Fitness Survey, 1983). Using AAHPERD (1980) health-related physical fitness norms, data indicated a percentile ranking of 29.1% for boys and 30.3% for girls for ages 7–11. Similarly, for ages 12–15 years, data indicated a percentile ranking of 31.0% for boys and 54.8% for girls. As the data indicated, there was a large variability seen in subjects’ sit-and-reach raw scores and percentile rankings by both gender and age grouping. Girls in the 12–15 age grouping demonstrated the greatest flexibility of all the groups. When compared to Canadian cohorts, both the boys and girls ages 7–11 in our investigation were substandard in the
sit-and-reach test; for ages 12–15, boys were significantly below norms, whereas girls were only slightly below norms.

When one considers the impact of inflexible lower back and hamstring musculature and weak abdominal muscles on lower back pathology and postural deviations, the substandard scores on both the sit-up and sit-and-reach test (particularly those of the boys) have clinical significance (AAHPERD, 1984; Plowman, 1992). In excessive anterior pelvic tilt, the hip joint is slightly flexed. This condition is usually due to weakened or stretched abdominal muscles. Quite often, anterior pelvic tilt exacerbates into an increased lumbar anterior convexity (lordosis).

Major disadvantages of this flexed hip posture are that compressive forces develop on the anterior portion of the lumbar disks and the hydrostatic pressure in the nucleus pulposus (central portion of the vertebral disk) increases. In combination, these two problems lead to inadequate nutrition of the lumbar disks and excessive stress on a number of structures of the lumbar spinal region (Adams & Hutton, 1985).

In posterior pelvic tilt, the opposite condition is present, and the individual develops a backward leaning position. This displaces the trunk’s center of gravity posteriorly, increasing the weight force arm and increasing the torque about the mediolateral axis. This condition can be due to excessively tight or shortened hamstrings and usually progresses into a condition known as flat back. This condition, too, can create unnatural stresses on a number of anatomical structures in the lower back (Adams & Hutton, 1985).

Consequently, the low values found in our subjects on both the sit-up and sit-and-reach tests have clinical significance and should not be regarded as trivial and unimportant. Educators and therapists should be cognizant of the potential impact of these deficiencies on the health and well-being of individuals with diabetes, and the possibilities for remediation by way of therapeutic exercises.

Physical Activity Questionnaire
The parents of our subjects completed a physical activity questionnaire modified from Bar-Or (1983). Only 7 of 42 parents characterized their child as less active than his or her friends. In addition, only 7 of 38 parents felt that their youngster was less active than other children in the family. Finally, 41 of 44 noted that their child took part in all physical education classes at school with no exceptions. These data suggest that children with diabetes are not less physically active than their nondiabetic counterparts.

Motor Proficiency
The BOTMP scores were quite variable for subjects, as noted by the standard deviations on Table 2. It is interesting to note that subjects’ scores on the BOTMP for each age grouping were relatively high, indicating that children and adolescents with IDDM need not have diminished psychomotor skills. As mentioned previously, information from the modified Bar-Or Activity Questionnaire (Bar-Or, 1983) strongly suggested that the children in our sample were not less physically active than their nondiabetic counterparts. Consequently, children and adolescents with diabetes need not display psychomotor behaviors considered below developmental levels and, in fact, can display extremely high levels of motor proficiency.

Summary
Based on the data analysis and given the limited sample size used in this investigation, it was concluded that children and adolescents with IDDM follow fitness and motor behavior profiles similar to their nondiabetic peers regarding fitness trends between
male and female subjects. In general, the boys tended to be in better physical condition than girls of similar ages, most particularly in the 12–15 year range. These differences may be due to the onset of puberty as suggested by Bar-Or (1983) and Rowland (1990). Furthermore, when compared to their nondiabetic peers, individuals with IDDM are below minimum standards (i.e., 50th percentile on AAHPERD percentile rankings) in two very important categories: body composition and abdominal strength/endurance. Future researchers should investigate the causes of these deficiencies, as well as procedures for their amelioration.

References


