Physical Activity and Health-Related Physical Fitness in Taiwanese Adolescents

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Abstract The relationship between physical activity and health-related physical fitness was evaluated in 282 Taiwanese adolescents 12–14 years of age. The subjects were randomly selected from the 7th, 8th, and 9th grades in two junior high schools in Taiwan. Physical activity was estimated as total daily energy expenditure and energy expenditure in moderate-to-vigorous physical activity from 24-hour activity records for three days, two weekends and one weekend day. Health-related fitness was assessed as the one-mile run (cardiorespiratory endurance), timed sit-ups (abdominal strength and endurance), sit-and-reach (lower back flexibility), and subcutaneous fatness (sum of the triceps, subscapular, suprailliac, and medial calf skinfolds). Physical activity is significantly and positively correlated with one-mile run performance and the sit-and-reach, but not with sit-ups and subcutaneous fatness. Overall, the strength of the relationships between estimated energy expenditure and specific fitness items in the total sample vary from low to moderate, with only 1% to 12% of the variance in fitness variables being explained by estimated energy expenditure. Comparisons of active versus inactive, and fit versus unfit adolescents provide additional insights. The more active (highest quartile) are also more fit in cardiorespiratory endurance and in the sit-and-reach than the less active (lowest quartile), and the more fit in the one-mile run (better time, lowest quartile) and the sit-and-reach (highest quartile) are more active than the less fit in each item, respectively. J Physiol Anthropol 21 (1): 11–19, 2002 http://www.jstage.jst.go.jp/en/

Keywords: energy expenditure, moderate to vigorous physical activity, cardiorespiratory endurance, fatness, strength, flexibility

Introduction

Current discussions of physical fitness are commonly set in a health-related context. Health-related physical fitness was initially defined to include cardiovascular endurance, abdominal muscular strength and endurance, lower back flexibility, and body composition, specifically subcutaneous fatness (American Alliance for Health, Physical Education, Recreation and Dance, 1980). The concept has evolved to include morphological, muscular, motor, cardiovascular and metabolic components (Bouchard and Shephard, 1994). Cardiorespiratory fitness tracks moderately from childhood and adolescence into adulthood (Malina, 1996, 2001a), whereas fitness and especially overweight tracks better from childhood and adolescence into adulthood (Guo et al., 1994). Low cardiorespiratory fitness and overweight/obesity are independent risk factors for cardiovascular morbidity and mortality in adults (Wei et al., 1999; Farrell et al., 1998). Abdominal strength and endurance and low back flexibility also track at moderate levels from adolescence into adulthood, but the association between these two components of health-related fitness with morbidity in adulthood has not been established (Malina, 1996, 2001a).

It is commonly assumed that a high level of habitual physical activity is associated with higher levels of physical fitness in children, adolescents and adults. However, the relationship between activity and fitness is better in adults than in children and adolescents (Malina, 1995b, 2001a). Data from the Second National Children and Youth Fitness Survey in the United States in 1986, for example, indicated low relationships between activity and cardiorespiratory endurance of 6–9 year old children, with correlations ranging from -0.22 to +0.24 for 28 indicators of physical activity. Physical activity, age and sex accounted for only 21% of the variation in the run-walk (Pate et al., 1990). A similar analysis relating
habitual physical activity to components of health-related fitness of fourth grade children also showed low correlations, -0.16 to +0.24, and the estimated percentage of variance in the physical fitness items accounted for by physical activity, after controlling for sex, was low, 3% to 11% (Sallis et al., 1993).

Correlations between indicators of physical activity and measures of fitness are low to moderate in adolescents (Aaron et al., 1993; Ressen et al., 1990; Katzmarzyk et al., 1998a). Among Canadian boys and girls 9-18 years, only 11% to 21% of the variance in health-related fitness items (sit-ups, static leg strength, PWC150, skinfolds) was explained by energy expenditure in moderate-to-vigorous activity (Katzmarzyk et al., 1998a).

Thus, there are significant associations between indicators of physical activity and health-related physical fitness, but a large fraction of the variability, about 80% to 90%, is not accounted for by physical activity, age and sex. This suggests that other factors are involved and need to be considered. Among children and adolescents, for example, components of physical fitness change with normal growth and maturation independently of physical activity (Malina and Bouchard, 1991), and with other components of lifestyle such as television viewing (Katzmarzyk et al., 1998b).

The association between habitual physical activity and health-related physical fitness in children and adolescents needs further study, especially in different cultural contexts. Presently available data are limited largely to samples of European ancestry, either in North America or Europe. This study, therefore, considers the relationship between physical activity and health-related physical fitness in Taiwanese adolescents. Physical activity is estimated as total daily energy expenditure and energy expenditure in moderate to vigorous activity, and health-related fitness is viewed as the one-mile run—a measure of cardiovascular endurance, timed sit-ups—an indicator of abdominal strength and endurance, the sit-and-reach—an indicator of lower back flexibility, and sum of skinfolds—a measure of subcutaneous fatness. This study also considers the health-related physical fitness of adolescents at the extremes of activity and inactivity, and the activity of youth at the extremes of fitness and unfitness.

The study of Taiwanese adolescents is relevant because low levels of physical activity and fitness during adolescence may underlie the potential for several health problems in adults, although the link between activity and fitness during youth and adult health is not clearly established (Malina, 2001a). An earlier survey in Taiwan (Chang, 1982) suggested that most of Taiwan’s young people do not experience sufficient physical activity. About 57% of junior high school students in Taiwan watched television after school and during weekends, and only 21% participated in regular physical activity (Chang, 1982). Two factors related to physical inactivity may be population density and time for study. The population density of Taiwan is high, 571/km², but the density is considerably higher in Taipei, 10,001/km² (Ministry of the Interior, Republic of China, 1992). Thus, space available for physical activity is limited, especially in urban centers. The majority of junior high school students participate in highly competitive high school entrance examinations, which require a good deal of time devoted to studying and thus less time available for physical activity. These features of adolescent life may have implications for other countries of the Pacific Rim.

For example, among Japanese elementary and junior high school students, “study for entrance examination” was the second more frequently listed reason for dropping out of sports participation, whereas it was the first listed reason for senior high school students (Mutoh, 1990).

**Methods**

**Sample**

A sample of 282 Taiwanese adolescents, 138 boys and 144 girls, was randomly selected from the 7th through 9th grades in two junior high schools. The study was approved by the Human Subjects Review Panel of the University of Texas at Austin and the local school authorities in Taiwan. Informed consent was obtained from all students; all students were likewise assured of their anonymity before completing any phase of the study. The subjects, 12–14 years, came from a mixed socio-economic background, and none had physical abnormalities or known medical or orthopaedic diseases (Huang and Malina, 1996).

**Anthropometry**

Heights and weights of all youth were measured. Weight was measured to the nearest 100 grams with the subject wearing light shorts, a shirt and socks. Height was measured to the nearest millimeter with the subject standing with heels together and gently stretched upward (the chin was not lifted). Intra- and inter-observer technical errors of measurement were, respectively, 0.21 and 0.15 kg, and 0.22 and 0.31 cm, which are well within the range of measurement variability in national and local surveys (Malina, 1995a).

**Health-related physical fitness**

Health-related physical fitness is operationalized in four components. The protocol of the American Alliance for Health, Physical Education, Recreation and Dance (1980) was used with one exception. Four skinfolds, rather than two, were summed to estimate subcutaneous fatness (see below).

Cardiovascular endurance—One-mile run: The one-mile
run (1.6 km) was measured in minutes. The subjects were instructed to try to keep a steady speed and finish the run as fast as possible. Walking was permitted only when the subject could not continue running.

Abdominal muscular strength and endurance—Sit-ups: The sit-up test was scored as the number of sit-ups performed within a one-minute period, thus the term timed sit-ups. The subject laid down on a mat with knees bent at right angles and hands behind the head. The ankles were firmly held by a partner for support and maintaining the count. The subject's elbows alternately touched the opposite knee during the execution of the test.

Flexibility of the lower back—Sit-and-reach: The sit-and-reach test was scored as the most distant point (in cm) reached on the ruler with the fingertips. A sit-and-reach box was a specially constructed box with a measuring scale where 23 cm is at the level of the feet. Each subject was given three trials and the best result was chosen. The subject removed his/her shoes before sitting at the test apparatus with the knees fully extended.

Subcutaneous fatness—Sum of skinfolds: Skinfold thicknesses were measured with a Lange caliper to the nearest 0.5 mm at the triceps, subscapular, suprailliac and medial calf sites (Malina, 1995a). All measurements were taken by the same individual. Each skinfold was measured twice, and the average of the two values for each site was used. Skinfolds were measured on the right side of the body with the subject in a standing position except for the medial calf skinfold, which was measured with the subject seated on a chair. Based on replicate measurements of 18 subjects, intra-observer technical errors of measurement ranged from 0.30–0.48 mm, which compared favorably to corresponding estimates in several surveys (Malina, 1995a). The sum of the four skinfolds was used as the indicator of subcutaneous fatness.

Physical activity and energy expenditure

Physical activity was estimated using the activity record developed by Bouchard et al. (1983). A three-day physical activity record, two weekdays and one weekend day, was completed by all subjects. The activity record divides the day (24 hours) into 96 periods of 15 minutes each. Each 15-minute period requires the subject to enter a categorical value ranging from 1 to 9 to represent the dominant activity engaged in during the period. Each categorical value corresponds to an energy expenditure expressed in kcal/kg/15 min. The nine categories and energy expenditures are as follows: (1) sleeping or resting in bed, 0.26 kcal/kg/15 min, (2) sitting, 0.38 kcal/kg/15 min, (3) light activity standing, 0.57 kcal/kg/15 min, (4) slow walking (<4 km/hr), 0.69 kcal/kg/15 min, (5) light manual work, 0.84 kcal/kg/1 min, (6) leisure activities and sports in a recreational environment, 1.20 kcal/kg/15 min, (7) manual work at a moderate pace, 1.40 kcal/kg/15 min, (8) leisure and sport activities of higher intensity (not competitive), 1.50 kcal/kg/15 min, and (9) intense manual work, high intensity sport activities, or sport competition, 1.95 kcal/kg/15 min (Bouchard et al., 1983; Bouchard, 1997).

The activity instrument was translated from English into Chinese, and then checked for accuracy and clarity of culturally sensitive or relevant terms. If necessary, additions and/or deletions were made (Huang and Malina, 1996). Test-retest reliability was estimated in a sample of 71 primary school children, 35 boys and 36 girls, in the 5th and 6th grades (Huang et al., 1999). After a two-week period, the reliability of the record was 0.74 (p<0.001) for estimated mean kilocalories of energy expenditure over three days.

A list of activities for each category was given to the subjects. If the subjects could not find an activity among those listed, they were asked to record the specific activity or activities in which they were engaged at the time. The activity records were completed for two weekdays and one weekend day. All procedures were completed at the schools in the classroom setting under the supervision of one of the authors (Y-CH) on the day after the weekday in question, and on one or two days after the weekend day in question (depending on whether it was a Saturday or Sunday). Each record was checked for clarity and completeness in the presence of the subject. If necessary, the subject was questioned to clarify or complete the activity record.

The records were converted to estimated energy expenditure using the categorical energy expenditure equivalents (kcal/kg/15 min) suggested by Bouchard et al. (1983; see also Bouchard, 1997). The sum of MET values for categories 1–9 reported over three days in the activity records was used as the indicator of overall energy expenditure. Activities in categories 6 to 9 (median energy costs, ≥4.8 METS) were classified as moderate-to-vigorous in intensity (Katzmarzyk et al., 1998a), which are recommended to develop and maintain health-related physical fitness in children and adolescents (Simons-Morton et al., 1988). The sum of MET values for categories 6–9 reported over three days was used as the indicator of moderate-to-vigorous physical activity (MVPA; see Katzmarzyk et al., 1998a).

The mean estimated daily energy expenditure for the sample of Taiwanese adolescents was 2,167 ± 556 kcal/day in males and 1,944 ± 360 kcal/day in females (Huang and Malina, 1996). Correlations between estimated total daily energy expenditure and energy expenditure in MVPA were significant (p<0.01): 0.69 in the total sample, 0.71 in boys and 0.63 in girls. Correlations between total daily energy expenditure on a weekday and a weekend day were also significant (p<0.01) but low: 0.27 in the total sample, 0.27 in boys and 0.24 in girls. Corresponding correlations between energy expenditure...
in MVPA on a weekday and weekend day were lower: 0.16 (p<0.01) in the total sample, 0.18 (p<0.05) in boys, and -0.03 in girls.

Statistical Analysis

The relationship between energy expenditure and indicators of health-related physical fitness was evaluated with partial correlation and analysis of covariance. Partial correlations, controlling for age, were computed between estimated energy expenditure expressed in kcal/kg/day and each of the four physical fitness variables in the total sample and separately for males and females. Partial correlations for the total sample, controlling for age, sex, location of school (urban/rural), and socioeconomic status (occupation of the father), between estimated total daily energy expenditure and energy expenditure in moderate-to-vigorous physical activity (kcal/kg/day) were also calculated.

It is possible that relationships between physical activity and fitness are influenced by the relatively broad range of variability in heterogeneous samples of adolescents. The relationship may be more apparent in comparisons of groups at the extremes of the physical activity continuum. Within each sex, therefore, subjects in the lowest and highest quartiles of estimated daily energy expenditure (kcal/kg/day) were classified, respectively, as inactive and active. Estimated energy expenditure in moderate-to-vigorous physical activity (categories 6–9 in the protocol) could not be used for this aspect of the analysis because many students were rated as zero in this level of energy expenditure (32% boys, 55% girls). Analysis of covariance with age as the covariate (general linear models procedure with post hoc comparisons of least squares means), was used to compare the health-related fitness of active and inactive boys and girls.

The same logic was used to compare the estimated daily energy expenditure of adolescents classified as fit and unfit in each of the four indicators of health-related fitness. Within each sex, therefore, subjects in the extreme quartiles for each fitness variable were classified as fit and unfit as follows: one-mile run time—lowest quartile (fastest)=fit, highest quartile (slowest)=unfit; sit-ups and sit and reach—highest quartiles=fit, lowest quartiles = unfit; subcutaneous fatness—lowest quartile for the sum of four skinfolds (lean)=fit, highest quartile for the sum of four skinfolds (fat)=unfit. Analysis of covariance with age as the covariate was used to compare the estimated daily energy expenditure of fit and unfit boys and girls in each of the four health-related fitness items.

Results

Total sample

Descriptive statistics for the sample by sex are shown in Table 1. Boys are, on average, taller and heavier than girls, expend more energy per unit of body weight, and have better levels of fitness on each of the four items than females.

Partial correlations between estimated energy expenditure (kcal/kg/day) and the four indicators of health-related fitness are shown in Table 2. The one-mile run, timed sit-ups and the sit-and-reach are significantly related (p<0.01) to estimated energy expenditure in the total sample, 0.23 to 0.34, but the sum of skinfolds is not significantly related to estimated energy expenditure, -0.11. The strength of the relationships between estimated energy expenditure and specific fitness items in the total sample are generally low, and only 1%–12% of the variance in fitness variables is explained by estimated energy expenditure.

Sex-specific partial correlations show that only the one-mile run and sit-and-reach are significantly related (p<0.01) to estimated energy expenditure in both sexes (Table 2). However, the explained variance is low, only 5%–7% in both sexes.

Partial correlations between estimated energy expenditure in moderate-to-vigorous physical activities (MVPA, categories 6–9, see methods) were also calculated. Age, sex, location of school (urban/rural) and socioeconomic status (occupation of father) were controlled. The correlations for energy expenditure in MVPA are significant but low for the one-mile run (0.12, p<0.05) and sit-and-reach (0.14, p<0.05), and not significant for timed sit-ups (0.06) and the sum of skinfolds (0.02). The correlations for energy expenditure in MVPA are lower than those for total daily energy expenditure, but are in the same direction.

Table 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Boys (n=138)</th>
<th>Girls (n=144)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Age, yrs</td>
<td>13.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Height, cm</td>
<td>163.8</td>
<td>8.6</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>52.1</td>
<td>11.6</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>20.0</td>
<td>3.4</td>
</tr>
<tr>
<td>EE, kcal/kg/day</td>
<td>40.6</td>
<td>7.2</td>
</tr>
<tr>
<td>One-mile run, sec</td>
<td>534.2</td>
<td>91.9</td>
</tr>
<tr>
<td>Timed sit-ups, n/1 min</td>
<td>34.7</td>
<td>9.6</td>
</tr>
<tr>
<td>Sit-and-reach, cm</td>
<td>26.8</td>
<td>7.4</td>
</tr>
<tr>
<td>Sum of 4 skinfolds, mm</td>
<td>48.8</td>
<td>25.7</td>
</tr>
</tbody>
</table>

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Table 2 Partial correlations, controlling for age, between estimated daily energy expenditure (kcal/kg/day)* and health-related fitness variables in Taiwanese adolescents

<table>
<thead>
<tr>
<th>Fitness Item</th>
<th>Total Sample (n=282)</th>
<th>Boys (n=138)</th>
<th>Girls (n=144)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>R^2</td>
<td>r</td>
</tr>
<tr>
<td>One-mile run(a)</td>
<td>0.34*</td>
<td>0.12</td>
<td>0.25*</td>
</tr>
<tr>
<td>Timed sit-ups</td>
<td>0.33*</td>
<td>0.05</td>
<td>0.14</td>
</tr>
<tr>
<td>Sit-and-reach</td>
<td>0.24*</td>
<td>0.06</td>
<td>0.27*</td>
</tr>
<tr>
<td>Sum of skinfolds</td>
<td>-0.11</td>
<td>0.01</td>
<td>0.00</td>
</tr>
</tbody>
</table>

*Estimated energy expenditure is the average of two weekdays and one weekend day. \(a\)Since a lower time for the one-mile run indicates better performance, the signs of the correlations were inverted. \(p<0.01\)

Table 3 Results of the analysis of covariance, with age as the covariate, of health-related fitness variables between inactive and active* adolescent boys

<table>
<thead>
<tr>
<th>Fitness Variable</th>
<th>Inactive (n=94)</th>
<th>Active (n=94)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SE</td>
<td>Mean SE</td>
</tr>
<tr>
<td>One-mile run, sec</td>
<td>578.1 14.9</td>
<td>506.7 14.9</td>
</tr>
<tr>
<td>Timed sit-ups, n/1 min</td>
<td>33.7 1.4</td>
<td>35.3 1.4</td>
</tr>
<tr>
<td>Sit-and-reach, cm</td>
<td>23.9 1.2</td>
<td>29.5 1.2</td>
</tr>
<tr>
<td>Sum of skinfolds, mm</td>
<td>49.1 4.6</td>
<td>50.7 4.6</td>
</tr>
</tbody>
</table>

Means and standard errors are age-adjusted. *Subjects in the lowest and highest quartile of estimated daily energy expenditure (kcal/kg/day) were classified, respectively, as inactive and active. \(p<0.01\)

Table 4 Results of the analysis of covariance, with age as the covariate, of health-related fitness variables between inactive and active* adolescent girls

<table>
<thead>
<tr>
<th>Fitness Variable</th>
<th>Inactive (n=96)</th>
<th>Active (n=96)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SE</td>
<td>Mean SE</td>
</tr>
<tr>
<td>One-mile run, sec</td>
<td>686.2 16.0</td>
<td>621.6 16.0</td>
</tr>
<tr>
<td>Timed sit-ups, n/1 min</td>
<td>23.3 1.2</td>
<td>23.4 1.2</td>
</tr>
<tr>
<td>Sit-and-reach, cm</td>
<td>25.2 1.0</td>
<td>28.9 1.0</td>
</tr>
<tr>
<td>Sum of skinfolds, mm</td>
<td>71.8 3.5</td>
<td>71.7 3.5</td>
</tr>
</tbody>
</table>

Means and standard errors are age-adjusted. *Subjects in the lowest and highest quartile of estimated daily energy expenditure (kcal/kg/day) were classified, respectively, as inactive and active. \(p<0.01\)

Active and inactive youth
Adolescents of both sexes in the highest quartile of the estimated energy expenditure (active) have significantly higher performances in the one-mile run and the sit-and-reach than those in the lowest quartile (inactive) after controlling for age (Tables 3 and 4). Thus, more physically active boys and girls have greater cardiovascular endurance and low back flexibility. In contrast, there is no significant difference between the active and inactive groups for timed sit-ups and sum of skinfolds.

Fit and unfit youth
Adolescents of both sexes in the highest quartile of the one-mile run time (poorest time, unfit) have significantly lower estimated energy expenditure per unit of body weight than those in the lowest quartile (best time, fit) after controlling for age (Tables 5 and 6). Students of both sexes in the highest quartile of the sit-and-reach (fit) also have a significantly higher estimated energy expenditure per unit of body weight than those in the lowest quartile (unfit) after controlling for age. In contrast, the estimated energy expenditure of fit and unfit groups in timed sit-ups and the sum of skinfolds do
not differ significantly.

Discussion

Physical activity estimated as daily energy expenditure and energy expenditure in moderate-to-vigorous activities, and indicators of health-related physical fitness are weakly related in this sample of Taiwanese adolescents. The results, however, are consistent with other studies of adolescents. Aaron et al. (1993), for example, reported a correlation of 0.37 between an estimate of leisure activity and one-mile run performance in a sample of American adolescents. Age and sex were not controlled in the analysis, but the corresponding correlation in the present study of Taiwanese adolescents, not controlling for sex, was similar (0.34).

The results of the sex-specific partial correlation analysis indicated that when the effect of age was controlled, estimated energy expenditure and intensity of physical activity showed a low, significant positive association with the one-mile run (r=0.23-0.25) and sit-and-reach (r=0.22-0.27) in Taiwanese adolescents (Table 2). The results are similar to those of Sallis et al. (1993). A physical activity index based on six activity variables in fourth-grade children (boys 10.5 ± 0.6 years, girls 10.4 ± 0.5 years) was positively and significantly related, though at low levels, to the one-mile run (r=0.16), sit-ups (r=0.11), and sit-and-reach (r=0.10) when the effect of sex was controlled. The estimated percentages of variance in the health-related fitness components accounted for by physical activity after controlling for sex were low, 3–11% (Sallis et al., 1993). Correlations of similar magnitude were also reported among Canadian youth 9–18 years of age and only a small portion of the variability, 11–21%, in indicators of health-related fitness was accounted for by habitual physical activity in youth (Katzmarzyk et al., 1998a). In the present study, only 1–12% of the variance in fitness variables was explained by physical activity as estimated from the three day records.

The results from several studies using similar analytical strategies thus indicate that a large part of the variability in indicators of health-related physical fitness is not
accounted for by habitual physical activity. This suggests that factors other than activity influence the fitness of adolescents. These factors are probably both biological and behavioral, and are associated with growth, maturation and behavioral development during adolescence (Malina, 1995b, 2001b). The factors likely include, among others, individual differences in the timing and tempo of the growth spurt and sexual maturation, and interactions with social competence and perceptions of competence in physical activities.

The relatively broad range of variability in activity and fitness in heterogeneous samples of adolescents may influence the relationship between these variables. Moreover, the relationships may be more apparent in comparisons of groups at the extremes of physical activity and health-related physical fitness. Hence, the present study examined differences in health-related physical fitness between active and inactive youth, and differences in health-related fitness of fit and unfit youth.

Active Taiwanese adolescents of both sexes had significantly better performances in the one-mile run and sit-and-reach. The results are consistent to some extent with longitudinal studies of adolescents. In the Leuven Longitudinal Growth Study of Belgian adolescents (Beunen et al., 1992), active boys had better cardiovascular fitness than inactive boys based on heart rate recovery after a step test. On the other hand, active and inactive boys did not differ in the sit-and-reach, leg lifts (a measure of abdominal strength analogous to sit-ups), and skinfold thicknesses from 13 through 18 years of age. Among Dutch adolescents followed from 13 to 16 years in the Amsterdam Growth Study (Verschuur, 1987), active boys performed better than inactive boys in the 12-minute run (cardiorespiratory endurance), flexed-arm hang, and shuttle run, whereas active girls performed better than inactive girls only in peak VO2 and the 12-minute run. In contrast, active and inactive boy and girls, respectively, did not differ in static arm strength, the sit-and-reach, vertical jump, and speed of upper limb movement.

Results from cross-sectional and longitudinal studies (see also Blair et al., 1989; Mirwald and Bailey, 1986) are generally consistent with the present study of Taiwanese adolescents. Although methods of classifying youth as active and less active vary among studies, there is a consistent observation—more active youth are generally more fit in measures of cardiorespiratory endurance. On the other hand, results for other components of health-related physical fitness are somewhat inconsistent among studies, suggesting that habitual physical activity is only one of several factors that influences fitness.

Comparisons of the estimated habitual physical activity of fit and unfit youth provide additional insights. The Taiwanese sample was classified as fit (highest quartile) or unfit (lowest quartile) for each component of health-related physical fitness. The position of the quartiles was inverted for the one-mile run and sum of skinfolds because a lower score was indicative of better fitness. Boys and girls classified as fit in the one-mile run and the sit-and-reach had a significantly greater estimated daily energy expenditure (kcal/kg/day) than those classified as unfit (Tables 5 and 6). In contrast, boys and girls classified as fit and unfit in timed sit-ups and the sum of skinfolds did not differ in estimated energy expenditure.

The activity status of fit and unfit youth as classified by each health-related fitness item is heterogeneous. Among 34 boys classified as physically fit based on performance in the one-mile run, 15 were in the highest quartile for estimated energy expenditure (active) and 7 were in the lowest quartile for estimated energy expenditure (inactive). In contrast, among the 34 boys classified as unfit in the one-mile run, 3 were active and 16 were inactive. Results were similar for girls. Among the 36 girls classified as fit in the one-mile run, 16 were active and 8 were inactive, whereas among the 36 girls classified as unfit in the one-mile run, 5 were active and 13 were inactive. The activity status of youth classified as fit and unfit in the other health-related fitness tests showed similar overlap.

Although youth classified as fit in some health-related fitness items are, on the average, more active, there is much variability. The results echo earlier observations relating habitual physical activity to maximal aerobic power in 14–18 year old boys and girls: "...among those with the poorest fitness, there are sedentary, moderately active and very active children. Similarly, there are sedentary, moderately active and very active children among those who are in excellent physical condition" (Lange Anderson et al., 1984, p. 436).

Summary

Physical activity is significantly and positively correlated with one-mile run performance and the sit-and-reach, but not with sit-ups and subcutaneous fatness. The strength of the relationships between estimated energy expenditure and specific fitness items, however, vary from low to moderate, with only 1% to 12% of the variance in fitness variables being explained by estimated energy expenditure. Comparisons of active versus inactive, and fit versus unfit adolescents provide additional insights. Although more active adolescents are also more fit in cardiorespiratory endurance and in the sit-and-reach than less active adolescents, the extreme activity groups are in fact quite heterogeneous and include both fit and unfit youngsters. The same is true in the comparison of adolescents at the extremes of health-related fitness. The more fit in the one-mile run and the sit-and-reach are more active than the less fit in each item, respectively, but the extreme fitness groups include...
both active and inactive adolescents. The observations highlight the complexity of assessing relationships between physical activity and fitness of adolescents. They also highlight the need to consider the biological and behavioral determinants of activity and fitness, i.e., the need for a biocultural approach.

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