Published in final edited form as:

Int Nurs Rev. 2008 March ; 55(1): 81–88. doi:10.1111/j.1466-7657.2007.00588.x.

Correlates of physical fitness and activity in Taiwanese children

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Abstract

Aim—This cross-sectional study examined factors related to children’s physical fitness and activity levels in Taiwan.

Methods—A total of 331 Taiwanese children, aged 7 and 8, and their mothers participated in the study. Children performed physical fitness tests, recorded their physical activities during two weekdays and completed self-esteem questionnaires. Research assistants measured the children’s body mass and stature. Mothers completed demographic, parenting style and physical activity questionnaires.

Results—Attending urban school, lower body mass index (BMI), older age and better muscular endurance contributed to the variance in better aerobic capacity, and attending rural school and better aerobic capacity contributed to the variance in better muscular endurance in boys. Attending urban school, lower BMI and better athletic competence contributed to the variance in better aerobic capacity, and younger age, rural school and higher household income contributed to the variance in better flexibility in girls.

Conclusion—Despite the limitations of the study, with many countries and regions, including Taiwan, now emphasizing the importance of improving physical fitness and activity in children, an intervention that is gender-, geographically, and developmentally appropriate can improve the likelihood of successful physical fitness and activity programmes.

Keywords

Body Mass Index; Children; Chinese; Physical Activity; Physical Fitness; Taiwan

Introduction

Engaging in adequate levels of physical activity on a regular basis has been found to decrease the prevalence of obesity, risk of cardiovascular disease-related death, diabetes and high cholesterol (Goran et al. 2003; Steinberger & Daniels 2003). It is recommended that children should accumulate at least 60 min of age-appropriate physical activity on all, or most days of the week. However, 75% of elementary school-age children in Taiwan do not engage in the recommended amount of physical activity (Lai 1996). Despite the growing emphasis on the

importance of physical fitness and activity in Taiwanese children, factors related to Taiwanese children's physical fitness and activity remain unclear.

Physical fitness is defined as a set of elements that people have and achieve related to the ability to perform physical activity (Sirard & Pate 2001). Physical activity is defined as body movement produced by the contraction of muscle and increased energy expenditure (Sirard & Pate 2001). Studies of a Chinese population have suggested that boys across all age groups (age 6–18) demonstrate higher levels of physical fitness and activity than do girls and that fitness and activity levels decrease as age increases (Lu et al. 1998). Other studies also support the findings that older age is related to lower activity levels and that boys in Taiwan report higher levels of physical activity than do girls in Taiwan (Tsai et al. 1998; Wu et al. 2003).

Several studies have suggested that low levels of physical activity are related to increased obesity (Tsai et al. 1998; Goran et al. 2003). However, other studies dispute this finding by suggesting no correlation or even a positive correlation between physical activity and obesity in children (Wolf et al. 1993; Bandini et al. 2002). These inconsistent findings could be owing to different sample characteristics (such as age), different measures used in physical fitness and activity, and different definitions of obesity (Li & Fang 1998; Lu 1998).

Other factors related to children's physical fitness and activity levels are residential area, parenting styles, parents' activity levels and children's self-esteem. Shen & Huang (2001) found that larger living space and living in a rural area were related to higher levels of physical fitness and activity among elementary school-age children in Taiwan. Equivocal findings exist with respect to the importance of residential area as a determinant of physical fitness and physical activity in children (Chen & Leong 1995; Tsai et al. 1998). However, other studies have found no relationship between residential area and children's activity levels (Huang et al. 2000). Contradictory results could be a result of different measures of physical activity and the geographical locations reported.

A positive relationship between parents' and children's levels of physical activity has been reported (Biddle & Armstrong 1992; Vilhjalmsson & Thorlindsson 1998), with the relationship between mothers' and daughters' physical activity being stronger (Fogelholm et al. 1999; Davison et al. 2003). This relationship may be owing to both genetic and role modelling to their children's activity levels. Understanding the role of parental activity level in children's fitness and activity level can help develop effective intervention programme to improve family health.

In Western research, positive self-competency in children has been found to be associated with higher levels of physical fitness and activity (Hagger et al. 1998; Crocker et al. 2000). However, the conflicting findings suggest that no relationship exists between children's self-competency and their levels of physical fitness and activity (Biddle & Armstrong 1992). Comparisons may be questionable because of the different age groups that were studied and various measures of physical activity and self-competency used in these studies. Understanding the nature of self-competency in relation to fitness and activity level can help develop appropriate and efficient programmes that improve Taiwanese children's self-competency and their health.

Theoretical framework

The social cognitive theory (SCT), developed by Bandura, has been used to examine children's health behaviour (Bandura 1986). Bandura indicated that SCT subscribes to a model of interactive agency, meaning human beings are interdependent with environment, their actions and motivation. It combines intrapersonal (age, gender and ethnicity), social (parental support) and environmental (access to safe environment) factors. The theory proposes that intrapersonal, social and environmental influences interact as determinants of each other.

Several studies in Western society have suggested that children's health-related physical fitness and activity levels are influenced by intrapersonal, social and environmental factors. However, to our knowledge, these characteristics have not been thoroughly examined in a Chinese paediatric population in Taiwan, and their relationships with children's levels of fitness and activity are unclear. The purposes of this study were to examine factors related to Taiwanese children's physical fitness and activity levels.

Methods

Participants and procedures

A cross-sectional study design was used to examine factors related to Taiwanese children's physical fitness and activity levels. The University of California, San Francisco Committee on Human Research and local school authorities in Taiwan approved this study. Children (aged 7 and 8 years old) and their mothers who self-identified as Chinese were invited to participate in this study. Participants were recruited through two elementary schools (one rural and one urban school) located in northern Taiwan. A total of 331 children participated in the study, yielding a 43% response rate.

Children performed physical fitness tests, recorded their activities during two weekdays and completed a standardized instrument assessing self-esteem. In a private classroom, research assistants measured each child's body mass and stature; the children wore lightweight clothes and no shoes. Stature was measured three times using a portable stadiometer (Seca 214 Road Rod, Vogel & Halke GmbH & Co., Hamburg, Germany). Body mass was measured three times using an electronic body mass scale (840 Bella Digina; Scale, Vogel & Halke GmbH & Co., Hamburg, Germany). The mean values of the three measurements of stature and body mass were used to calculate children's body mass index (BMI). Mothers completed standardized questionnaires regarding demographic information, parenting style and physical activity.

Instruments

Family demographic information—This 12-item questionnaire includes parent(s)' and children's ages, children's birth weight, parents' weight and height, parents' occupation(s), parents' level of education, family income and maternal perception of children's weight status. The questionnaire is written at a third-grade reading level. Maternal BMI was computed as weight/height^2 (kg/m^2).

Child-Rearing Practice Report (CRPR)—This 91-item questionnaire is used to assess Chinese authoritative and authoritarian parenting styles (Chen et al. 1997). A 5-point Likert scale, ranging from 1 to 5 (1 = strongly disagree to 5 = strongly agree), was used. The scores were calculated by summing the items on each factor, with higher scores indicating the specific patterns. The CRPR was in English and has been translated in Chinese and indicates adequate reliability and validity (Chen et al. 1997). Internal consistencies ranged from 0.75 to 0.85 in a previous study with a Chinese sample (Chen et al. 1997). Cronbach's alphas in the current study were 0.82 for the authoritative sub-scale and 0.72 for the authoritarian sub-scale.

Seven-day physical activity recall (PAR)—This tool was developed to assess adult physical activity and energy expenditure based on reported time spent in sleeping and engaging in moderate, hard and very hard physical activities during the past 7 days. The PAR was conducted using a standardized interview format (Leenders et al. 2000). Standardized values of energy expenditure are assigned to the various activities (Leenders et al. 2000). Sleep and light, moderate, hard and very hard physical activities are categorized as 1.0, 1.5, 4, 6 and 10 metabolic equivalents (METs) respectively. Physical activities were counted if the duration

was at least 10 min. Moderate to good reliability ($r = 0.61$ to 0.99) and validity ($r = 0.39$ to 0.75) have been reported (Leenders et al. 2000).

Health-related physical fitness—This four-part activity assesses a child's physical fitness and includes aerobic capacity, muscular endurance, flexibility and body composition. A common method to measure aerobic capacity is the Progressive Aerobic Cardiovascular Endurance Run (PACER), which is a multistage fitness test adapted from the 20-metre shuttle run test. In the PACER test, children were instructed to run as long as possible back and forth across a 20-metre distance at a specified pace that gets faster each minute. The PACER has shown strong reliability (0.89 and test–retest reliability was 0.81) and validity (0.70) against physiological measure such as VO₂max (Chun et al. 2000).

Muscular endurance is measured by the sit-up test, with the number of sit-ups performed within a period of 1 min being recorded. All subjects had 5 min of standardized explanation and practice time. The child lay down on a mat with his/her knees bent at right angles and hands behind the head. The ankles were firmly held by a partner for support and to maintain the count. The reliability for this test was 0.99 and 0.88 for children and adolescents respectively (Chun et al. 2000).

Flexibility is measured by the sit-and-reach test, which is scored as the most distant point (in cm) reached on the ruler with the fingertips. A specially constructed sit-and-reach box was used with a measuring scale where 23 cm is marked at the level of the feet. Each subject was given three trials and the best result was used. Validity of this test was between 0.96 and 0.99 and reliability was 0.98 (Chun et al. 2000).

Body composition was measured using BMI and skin fold thickness. BMI is determined by dividing body mass in kilograms by stature in metres squared (kg/m^2). BMI has a well-established association with stature and age in children and adolescents and has acceptable ranges of sensitivities and specificity (Goran 1998). Overweight was defined as a BMI greater than the 85th percentile for age and gender in Taiwan (Goran 1998).

The skin fold index assesses the amount of subcutaneous fat at a particular site and has been used as a direct measure of body fat (Lean et al. 1996). Skin fold thickness measurements have a moderate to good validity and reliability with low error rate of 5% to 10% (Lean et al. 1996). The mean measurements of triceps and subscapular skin folds were used as the subcutaneous fatness measure in this study (Lange Skinfold Caliper, Cambridge Scientific Industries, Cambridge, MD, USA).

Children's self-administered physical activity checklist (SAPAC)—Children were asked to recall and record activities that occurred the previous day before school (before 8 a.m.), during school (between 8 a.m. and 3 p.m.) and after school (after 3 p.m.). Children estimated the minutes they spent engaging in each activity during the three time periods. They also reported whether the activity caused them to 'breathe hard or feel tired none, some, or most of the time.' METs that were used to estimate energy expenditure were computed based on the reported frequency and intensity. The SAPAC provides a moderate criterion validity ($r = 0.57$ – 0.75) and a moderate 1-week test–retest reliability ($r = 0.60$) (Sallis et al. 1996).

Perceived competence scale (PCS)—This 36-item questionnaire measures the child's sense of competence and includes six sub-scales: scholastic, social, athletic, and physical, behavioural conduct and global self-growth (Harter & Pike 1984). Items are scored on a Likert scale, with 1 representing low competence and 4 representing high competence. The PCS has been translated to Chinese and used in a Taiwanese population (Wu & Smith 1997).

Convergent, discriminant and predictive validity have all been reported to be in acceptable ranges (Wu & Smith 1997). In this study, the internal consistency of PCS was 0.73.

Statistical analysis

Two-way analysis of variance, controlling for age and residential area, was used to detect any difference in variables. Partial correlation coefficients were used to examine correlations among variables after controlling for age and residential area. Stepwise multiple linear regressions were performed on variables regarding children's physical fitness and physical activity. Regression models were computed based on children's gender. Children's age, residential area and maternal education level were entered as the first step, followed by significant variables found in partial correlation coefficients matrix. All statistical analyses were performed using SPSS 11.5 for Windows.

Results

Demographic characteristics

A total of 331 children (160 seven-year-old children and 171 eight-year-old children) participated in this study. Approximately 48% of the children were boys ($n = 159$). One hundred and twelve children (33.8%) were recruited from one rural school and 219 children (66.2%) were recruited from one urban school. Thirty-two per cent of boys and 29% of girls were determined to be overweight (BMIs greater than the 85th percentile for age and gender). No difference was found in children's ages and BMI between the two geographical locations. Mothers whose children attended the urban school were older (39.1 years old, $SD = 4.01$) and more educated (41% received a college or post-college education) than rural mothers (36.77 years old, $SD = 5.58$; 15.3% received a college or post-college education; $t = -0.384$, $P = 0.0001$, $\chi^2 = 70.60$, $P = 0.0001$ respectively).

Gender differences

T-test with Bonferroni correction was used to examine any gender differences between variables. All variables had comparable data between genders except for BMI; boys had higher BMIs than did girls.

Age and site effects on each measure by gender

Older children of both genders had better flexibility than did younger children (Boy $F = 4.33$, $P = 0.04$; Girl $F = 7.95$, $P = 0.01$). Boys who attended the urban school had better aerobic capacity ($F = 19.38$, $P = 0.0001$) and muscular endurance ($F = 13.04$, $P = 0.0001$), but had poorer flexibility ($F = 10.09$, $P = 0.002$) than boys at the rural school. Urban girls had better aerobic capacity ($F = 18.10$, $P = 0.0001$) and flexibility ($F = 7.72$, $P = 0.006$) and had higher METs ($F = 5.24$, $P = 0.02$) than rural girls.

Correlations among variables by gender

The findings indicated two factors contributing to boys' and girls' physical fitness and activity levels were the same (lower BMI and lower skin fold thickness) and other factors were different based on gender. In both sexes, better aerobic capacity was related to lower BMI and lower skin fold thickness. In boys, better aerobic capacity was also related to better muscular endurance and a more authoritative parenting style; for girls, better aerobic capacity was related to better flexibility, athletic competence, higher maternal activity levels and a more authoritarian parenting style (see Table 1).

Increased flexibility was related to better muscular endurance in girls ($r = -0.42$, $P = 0.0001$) but not in boys. Higher muscular endurance was related to improved aerobic capacity, lower

BMI and higher athletic competence in boys, whereas better muscular endurance was associated with better flexibility in girls. More moderate and vigorous activity METs (MVPAMETs) were related to a less authoritarian parenting in boys and higher skin fold thickness in girls (see Table 1).

Factors contributing to children's physical fitness and activity by gender

For boys, four factors contributed to the variance in better aerobic capacity: urban school, lower BMI, older age and better muscular endurance. Two factors contributed to the variance in better muscular endurance: rural school and better aerobic capacity (see Table 2).

For girls, urban school, lower BMI and better athletic competence contributed to the variance in better aerobic capacity. Younger age, rural school and higher household income contributed to the variance in better flexibility. Lower flexibility was related to better muscular endurance. Attending urban school was found to contribute to the variance in more MVPAMETs (see Table 3).

Discussion

The results indicated that similarities and differences were found in relation to factors contributing to boys' and girls' physical fitness and activity levels based on gender. For example, results suggested that lower BMI and skin fold thickness in both boys and girls were related to better aerobic capacity. Aerobic capacity in children has been used as an alternative measure of cardiorespiratory fitness (Sirard & Pate 2001). Our findings suggest that Taiwanese children with higher skin fold thickness were at risk for poor cardiovascular function and this is consistent with the findings of other studies indicating that higher body weight in children increases the risk of poor cardiovascular function and cardiovascular diseases (Goran et al. 2003; Steinberger & Daniels 2003). The negative effects of overweight on children's cardiovascular function illuminate the critical need for developing a weight maintenance programme. Healthy weight management and physical activity programmes that promote aerobic capacity may improve children's cardiovascular function and decrease the likelihood of childhood obesity.

Our findings also suggest that Taiwanese boys and girls who attended the urban school had a better aerobic capacity than those who attended the rural school. Additionally, Taiwanese girls in the urban school reported higher levels of physical activity than did girls in the rural school. Our results are inconsistent with other studies that suggest children who attend rural schools report better aerobic capacity than do children who attend urban schools (Wu & Smith 1997; Shen & Huang 2001). These inconsistent findings could be owing to different age groups and locations of the schools that were studied. As children's activity level decreases with age increases and different school locations may represent a variety of school resources and space, various school settings and school locations in these studies may explain the contradictory results.

In this study, there were more playing field spaces with play equipment in the urban school (0.58 square feet per student) than in the rural school (0.20 square feet per student). Children who have more exercise equipment and space in which to play are more likely to utilize these resources and thereby improve their aerobic capacity than are children who have limited access to such resources (Lu et al. 1998; Tsai et al. 1998). Maternal education level was also higher for children attending the urban school than for those attending the rural school. It is possible that mothers with a higher education level are more knowledgeable about adequate physical fitness than are less educated mothers. However, because this study did not collect information on the mothers' knowledge of physical fitness and activity and only one rural and one urban school were included in the study, it is difficult to interpret the results. Future studies should

address these potential factors and include more schools to examine the relationships between space and children's physical fitness and level of activity.

Better muscular endurance and older age were related to better aerobic capacity in boys, whereas better athletic competence was found to contribute to better aerobic capacity in girls. These differences could be owing to different stages of physical and psychological development and different expectations for boys and girls (Wu & Smith 1997; Lu 1998). In the Chinese culture, boys are encouraged to participate in sports-related activities (such as soccer and team games) more often than are girls (Li & Fang 1998), and thus boys may develop better muscular endurance and aerobic capacity. On the other hand, girls who engage in sports-related activities may improve their self-competence in relation to athletic performance and thus increase their aerobic capacity. Studies have found that boys have higher levels of activity and better self-competence in relation to exercise and physical activity than do girls (Lu et al. 1998; Wu et al. 2003). It is possible that encouraging girls to be physically active and participate in sports will increase their sense of self-competence and their likelihood of being active, thereby improving their aerobic capacity. Additionally, the cultural emphasis placed on different types of activities for boys and girls may help explain why certain factors contribute to their aerobic capacity.

The results suggest that Taiwanese children who attended the rural school had better muscular endurance and flexibility than did children who attended the urban school. The overall space per student in the rural school was larger (5.09 square feet) than the space per student in the urban school (1.22 square feet). Although urban schools may have more play space and exercise equipment, rural schools have more total space per student. Studies have documented that the more space per student, the more likely a student is to be physically active (Chen & Leong 1995; Lee 1996; Shen & Huang 2001). However, because our study did not collect information on type of equipment each student utilized and we had limited sites in this study, future research needs to include more schools and collect information regarding type of play equipment available.

No factor was found to contribute to Taiwanese boys' activity level measured by MVPAMETs, whereas attended urban school was contributed to increased MVPAMETs in girls. Because urban school had more play areas than the rural school, it is possible that girls utilized more play areas than boys and having more play areas encourages girls to be more active. However, a small per cent of variance (4.2%) in girls' MVPAMETs was explained by attending urban school, but the larger percentage of variance was left unexplained. Other factors, such as access to exercise and play areas, barriers to these accesses and parental knowledge regarding the importance of physical activity in children need to be examined in future studies.

The results of this study regarding correlation of physical fitness and physical activity in Taiwanese children should be interpreted carefully. Because of the cross-sectional design of this study, no causal relationship can be established. Moreover, because the study used self-report measures in physical activity, errors in measurement may have occurred. Results can only be generalized to similar populations. Future studies should include children and families who are from different locations and educational backgrounds. Although results indicated a small to moderate percentage of variance was explained by children's physiological and psychological factors and family factors, a larger amount of variance was unexplained in this study. Future studies should incorporate other important factors, such as access to play equipment, barriers to exercise and beliefs on physical fitness and activity and health.

Conclusions

As aerobic capacity has been used as a proxy measure of cardiovascular fitness in children, understanding factors related to aerobic capacity is imperative in improving cardiovascular function in children. Despite the limitations of the study, with many countries and regions, including Taiwan, now emphasizing the importance of improving physical fitness and activity in children, an intervention that is gender-, geographically and developmentally appropriate can improve the likelihood of successful physical fitness and activity programmes.

Acknowledgments

This study was funded by the University of California Pacific Rim Research Program (03TPRRP-2-5) and NIH National Center for Research Resources (KL2RR024130).

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Table 1

Partial correlation coefficients controlling for age and school location

	Boys	Girls
Aerobic capacity	Better muscular endurance ** ($r = 0.28$)	Better flexibility * ($r = 0.17$)
	Lower BMI ** ($r = -0.37$)	Lower BMI ** ($r = -0.30$)
	Lower skin fold thickness * ($r = -0.17$)	Lower skin fold thickness * ($r = -0.20$)
	More authoritative parenting * ($r = 0.18$)	Higher athletic competence * ($r = 0.20$)
Flexibility	None	Higher maternal activity level * ($r = 0.21$)
		More authoritarian parenting * ($r = 0.16$)
		Better muscular endurance ** ($r = -0.42$)
Muscular endurance	Better aerobic capacity ** ($r = 0.28$)	Better flexibility ** ($r = -0.42$)
	Lower BMI * ($r = -0.20$)	
	High athletic competence ** ($r = 0.22$)	
MVPAMET	Less authoritarian parenting * ($r = -0.18$)	Higher skin fold thickness ** ($r = 0.53$)

* $P < 0.05$;** $P < 0.01$.

BMI, body mass index; MVPAMET, moderate and vigorous activity metabolic equivalent.

Table 2

Stepwise multiple regression summary table for boys (*n* = 159)

Measure	Adjusted R ²	Beta	F	P	s ²
Better aerobic capacity					
Overall	0.279		14.03	0.0001	
Urban school		0.372	23.57	0.0001	0.152
Lower BMI		-0.338	20.76	0.0001	0.137
Older age		0.182	6.01	0.016	0.044
Better muscular endurance		0.172	4.93	0.028	0.030
Better flexibility	None				
Better muscular endurance					
Overall	0.123		10.75	0.0001	
Rural school		-0.358	18.11	0.0001	0.117
Better aerobic capacity		0.265	9.89	0.002	0.007
Increased MVPAMET	None				

BMI, body mass index; MVPAMET, moderate and vigorous activity metabolic equivalent.

Table 3Stepwise multiple regression summary table for girls ($n = 172$)

Measure	Adjusted R ²	Beta	F	P	s ²
Better aerobic capacity					
Overall	0.223		13.32	0.0001	
Urban school		0.367	22.17	0.0001	0.15
Lower BMI		-0.286	13.43	0.0001	0.10
Better athletic competence		0.226	8.46	0.004	0.06
Better flexibility					
Overall	0.095		6.11	0.001	
Younger		-0.181	5.13	0.025	0.035
Rural school		-0.219	7.50	0.007	0.05
Higher household income		0.166	4.26	0.041	0.03
Better muscular endurance					
Overall	0.157		28.16	0.000	
Poorer flexibility		-0.403	28.15	0.000	0.163
Increased MVPAMET					
Overall	0.04		6.32	0.013	
Urban school		0.204	2.514	0.013	0.042

BMI, body mass index; MVPAMET, moderate and vigorous activity metabolic equivalent.