8 cardiorespiratory fitness

A sub-optimal level of cardiorespiratory fitness is a risk factor for coronary heart disease (Berlin & Colditz, 1990) and other chronic diseases among adults, such as colorectal cancer (Lee, 1995), type 2 diabetes (Helmrich, Ragland, Leung & Paffenbarger, 1991), and depression (Stephens, 1988) and is associated with all-cause mortality (Blair et al., 1989).

Although most of these health consequences do not manifest themselves until mid-adulthood, there is still a need to promote health-enhancing levels of cardiorespiratory fitness among children and adolescents for three reasons. First, many of the risk factors associated with coronary heart disease such as atherosclerosis have their genesis in childhood (Berenson et al., 1998). Unfortunately, once these risk factors are present they track quite robustly to adulthood, with the severity of symptoms increasing with the length of time they have been present (Mahoney et al., 1996). In particular, longitudinal studies show that cardiorespiratory fitness tracks from adolescence to adulthood (Twisk, Kemper & Snel, 1995). This means that if healthy exercise habits can be commenced during adolescence, there is a good chance they will carry over into adulthood. Third, improving cardiorespiratory fitness during childhood and adolescence has been shown to result in smaller age-related increases in risk factors such as blood pressure (Janz & Mahoney, 1995) and LDL cholesterol (Tolfrey, Jones & Campbell, 2000).

Due to the importance of cardiorespiratory fitness, criterion-referenced health standards were developed for older children and adolescents to identify the aerobic capacity threshold required to minimise the chance of developing associated cardiovascular risk factors (Cureton & Warren, 1990). However, only a few representative studies have measured the prevalence of adequate fitness and these have used thresholds based on a specific percentile score (usually 25th percentile for the specific test) (Boreham et al., 1993). Most population-based studies have reported means or medians. For example, reported variables include relative or absolute VO^2max for laboratory tests (Janz & Mahoney, 1997), power output at a given sub-maximal workload (Katzmarzyk, Malina & Bouchard, 1999), number of laps for the 20-metre shuttle run test (Boreham et al., 2001), or time taken for distance run tests (Ross, Dotson, Gilbert & Katz, 1985b). While these values do provide normative data for individual comparisons on a specific test, it would also be helpful to know what proportion of young people meet the health-related criterion-referenced standard with respect to cardiorespiratory fitness.

These standards have been recently updated for older children and adolescents (Cooper Institute for Aerobics Research, 1999). Based on the level of cardiorespiratory fitness needed to substantially decrease the risk of all-cause mortality (above the 20th and 40th percentiles for men and women, respectively) (Cureton & Plowman, 2001), these standards provide a benchmark to assess the proportion of boys and girls who have adequate levels of cardiorespiratory fitness. Although these standards have limitations (ie, they are based

on non-representative adult data), they do provide the best means currently possible of determining the percentages of children and adolescents who display adequate levels of cardiorespiratory fitness. The authors are unaware of any other published studies that have reported adolescent fitness levels in relation to the most recent standards.

In addition, it is frequently suggested that fitness is declining among young Australians. A recent review by Tomkinson et al., 2003, of secular trends in performance on the 20-metre shuttle run test from 1980-2000 does provide some support for this view. However, they do caution against concluding that cardiorespiratory fitness has decreased, due to the differences in sampling techniques, protocols and procedures of the various studies and the non-representative nature of some of the samples. Tomkinson et al., recommend that to better determine secular trends in cardiorespiratory fitness, identical test protocols and procedures should be used among representative samples of children and adolescents from the same region of a country. Furthermore, to maximise the validity of field-based methods such as the 20-metre shuttle run test, the studies that are being compared should have been conducted under identical environmental conditions (same time of year, time of day, and running surface) (Eisenmann, 2003).

The authors are unaware of comparisons that have been made between representative samples from the same region of a country. Hence, the purpose of this study was twofold. First, to determine the percentages of children and adolescents in NSW, Australia, who met the updated criterion-reference standard for cardiorespiratory fitness; and second, to determine if these percentages have changed from 1997 to 2004. Since it is also important to know which groups have adequate aerobic capacity, a further purpose of this study was to examine the distribution of the prevalence of adequate fitness across population groups.

Students in Years 4, 6, 8, and 10 participated in the 20-metre shuttle run test (20mSRT). Scores were recorded as to the level and shuttle reached in the test and converted to the number of laps completed. Based on this score, students were categorised as 'fit' or 'unfit' using age- and sex-adjusted criterion-referenced standards from the *FITNESSGRAM Test Administration Manual* (Cooper Institute for Aerobics Research, 1999).

Prevalence of adequate cardiorespiratory fitness by sex and Year group

Figure 8.1 and Table 8.1 show the proportion of boys and girls in each school year who met the criterion-referenced standard for cardiorespiratory endurance. The mean, standard deviation, number of valid cases and 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 85, 90 and 95 percentiles for number of laps on the Multistage Fitness Test for boys and girls in Years 4, 6, 8 and 10 are shown in Appendix N.

More than 50% of boys in each Year group were fit, with a small increase in this proportion in each Year from Year 4 to Year 10. Over 60% of girls were fit, with this proportion slightly increasing from Year 4 to Year 8, but then decreasing from Year 8 to Year 10. Compared with boys, the prevalence of adequate fitness was higher among girls, with the differences statistically significant in Years 4, 6 and 8. This should not be interpreted as girls having higher cardiorespiratory endurance levels than boys, but rather that the criterion used to categorise boys and girls (number of laps completed on the MFT) is different for boys and girls in each of the age groups assessed. For example, in Year 6 (11-year-olds), the criterion standard for boys and girls is 23 and 15 laps, respectively.

Figure 8.1. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8 and 10 (%)

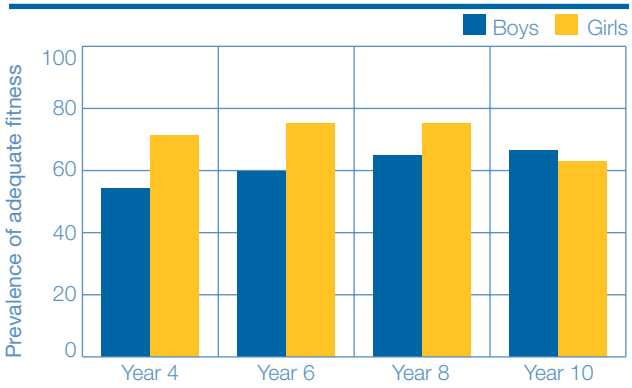


Table 8.1. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8 and 10 (%)

	Year 4	Year 6	Year 8	Year 10
Boys	54.4	59.6	65.0	66.5
Girls	71.4*	75.1*	75.2*	62.9

* Indicates a statistically significant difference at P<.05 between boys and girls within the same Year group.

Prevalence of adequate cardiorespiratory fitness by rurality, socioeconomic status, cultural background and BMI

Figure 8.2 and Table 8.2 show the proportion of students who were adequately fit by rurality, socioeconomic status, cultural background and BMI category for boys and for girls in Years 4, 6, 8 and 10.

Rurality

In every Year group, a greater proportion of boys from rural schools were fit than were boys attending urban schools. The results for girls were similar and generally indicated that more girls from rural schools were fit (except among Year 6 girls, where a greater proportion of urban girls were fit). These differences, although consistent, were not statistically significant.

Socioeconomic status

There were generally consistent relationships between socioeconomic status and cardiorespiratory endurance among boys and girls. Among boys, a higher proportion of those in the highest socioeconomic status tertile were fit, except for Year 8 boys, where more boys in the lowest tertile were fit. This relationship was statistically significant among Year 6 boys. Among girls, in every Year group, those in the highest socioeconomic status tertile clearly had a greater proportion who were categorised as fit, but there was little difference between those in the low and medium socioeconomic status tertiles. The differences between girls in the high socioeconomic status tertile and girls in the other tertiles was statistically significant for Year 6 and Year 10 and approached statistical significance for Year 8.

Cultural background

Among boys, the relationship between cultural background and cardiorespiratory endurance was mixed. There appeared to be little difference between boys from English-speaking, European, and Asian backgrounds in Years 6 and 8, and only a small difference between all four cultural backgrounds among Year 10 boys. However, smaller proportions of boys from Middle-Eastern cultural backgrounds were fit in Years 4, 6, and 8, with these differences statistically significant in Years 4 and 6. Boys from European backgrounds also had a much lower proportion in the fit category in Years 4 and 6. Among Year 4 and Year 6 girls, there was little difference between those from English-speaking, European, and Asian cultural backgrounds. However, compared with girls from English-speaking and European backgrounds, those from Asian backgrounds clearly had lower levels of fitness in Year 8 and Year 10, with these differences statistically significant in Year 10. A smaller proportion of girls from Middle-Eastern cultural backgrounds were fit, with the differences statistically significant in all Year groups.

BMI category

For boys and girls in every Year group, there was a very marked decline in the prevalence of adequate fitness across BMI categories. Among both boys and girls in every Year group, the prevalence of adequate fitness was significantly lower in the overweight group than the healthy weight group and was significantly lower in the obese group than the healthy weight group.

Figure 8.2. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8 and 10 by rurality, socioeconomic status (SES), cultural background and BMI category (%)

Table 8.2. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8, and 10 by rurality, socioeconomic status (SES), cultural background and BMI category (%)

	Boys				Girls			
	Year 4	Year 6	Year 8	Year 10	Year 4	Year 6	Year 8	Year 10
Rurality								
Urban	52.9	58.9	64.6	64.5	70.3	76.1	73.5	61.3
Rural	61.7	64.7	66.7	77.5*	78.4	68.4	83.1	70.6
SES								
Low	52.6	52.3*	68.5	63.9	69.3	64.1*	70.7	57.7*
Medium	50.9	54.2*	64.7	63.1	63.7	72.4*	65.1*	59.1
High	59.1	69.6	62.0	73.2	79.0	89.2	87.4	71.0
Cultural background								
English-speaking	56.6	61.8	66.0	69.2	73.9	75.9	75.5[n]	69.1
European	25.0	71.4	70.0	50.0	57.1	76.9	100.0	50.0
Middle-Eastern	28.6	17.7*	40.0	60.0	33.3*	35.7*	0.0	11.1*
Asian	52.9	54.2	57.6	50.0*	70.6	81.6	60.7	34.8*
BMI category								
Healthy weight	67.0	70.8	74.2	73.5	78.6	84.2	81.4	66.7
Overweight	24.0*	42.9*	43.3*	48.8*	63.0*	51.5*	59.7*	50.0*
Obese	4.3*	13.5*	10.5*	15.0*	21.4*	31.3*	28.6*	18.2*

* Indicates a statistically significant difference at P<.05. Comparisons are: between urban and rural; low and medium socioeconomic status compared with high socioeconomic status; European, Middle-Eastern and Asian cultural backgrounds compared with English-speaking cultural background; and overweight and obese compared with healthy weight. Comparisons are within each sex/Year group category.

n Indicates that statistical significance could not be calculated due to low numbers.

Trends in the prevalence of adequate cardiorespiratory fitness 1997-2004

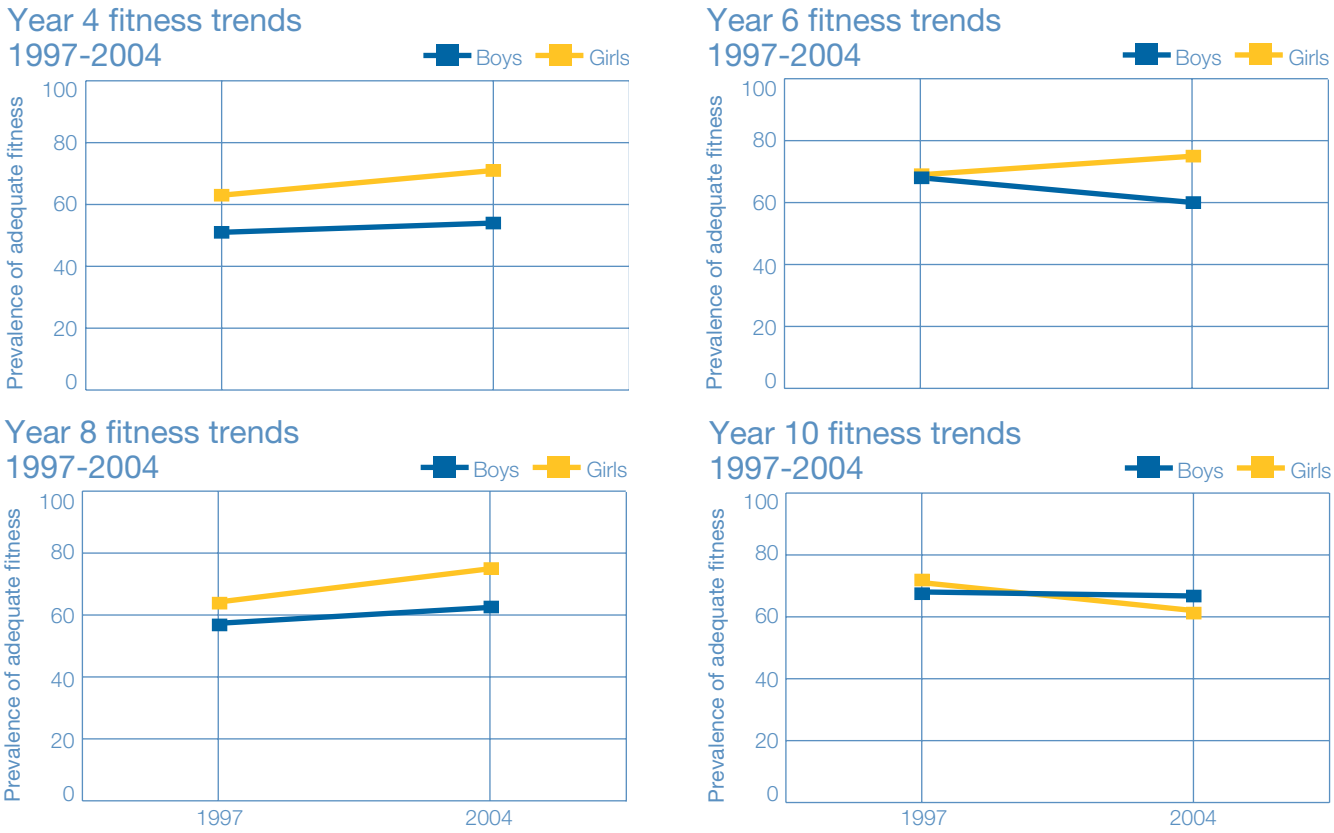
Table 8.3 and Figure 8.3 show the proportion of boys and girls in Years 4, 6, 8 and 10 who were classified as 'fit' in 1997 and in 2004. For both boys and girls, the results were fairly consistent, with the proportion who were fit slightly increasing from 1997 to 2004 among three of the four Year groups. Among boys, increases ranged from 1% to 7%, with Year 6 boys the only Year group in which the proportion who met the criterion for cardiorespiratory fitness declined (by approximately 8%). The proportion who were fit increased from 1997 to 2004 among girls in Years 4, 6 and 8, with these increases averaging 8% in each Year group. Year 10 were the only group of girls in which the proportion declined, registering a 6% decrease from 1997 to 2004. None of these differences were statistically significant.

Table 8.3. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8 and 10 in 1997 and 2004 (%)

	Year 4	Year 6	Year 8	Year 10
Boys				
1997	51.0	68.0	58.0	65.0
2004	54.0	60.0	65.0	67.0
Girls				
1997	63.0	69.0	65.0	69.0
2004	71.0	75.0	75.0	63.0

* Indicates a statistically significant difference at P<.05 between 1997 and 2004 for each sex/Year group.

Figure 8.3. Prevalence of adequate fitness among boys and girls in Years 4, 6, 8 and 10 in 1997 and 2004 (%)



Discussion

Aerobic fitness is an important indicator of overall physical health in children and young people (Krahenbuhl et al., 1985), hence it is of concern that a substantial minority of children and young people may be compromising their health through sub-optimal levels of cardiorespiratory fitness. If these levels track into mid-adulthood, as they are likely to (Twisk, Kemper & Snel, 1995), many of these individuals will have increased risk for coronary heart disease, type 2 diabetes, and other chronic diseases.

The finding that girls had a significantly higher prevalence of fitness in Years 4, 6 and 8 does differ from a similar study (Boreham et al., 1993) and may be explained by the different criteria used to determine adequate fitness in the two studies. However, the finding that a larger proportion of Year 10 boys were adequately fit compared with girls is similar to the aforementioned study.

Similar to previous studies (Booth et al., 1997; Panterbrick, Todd, Baker & Worthman, 1996; Renson et al., 1978), the current study found a higher prevalence of cardiorespiratory fitness among rural compared with urban students. Specifically, the proportion who were fit was higher in rural than urban students in all but one Year group (Year 6 girls). Although these differences were statistically significant only among Year 10 boys, they were consistent across age and Year groups, suggesting that a greater proportion of rural students are fit. Possible explanations for these differences are that safe and open rural environments may be more conducive to sports and leisure activities that promote fitness than the more densely populated urban areas (Sallis, 1995). In addition, fitness-enhancing and sustaining activities such as organised sports play a large part in the social fabric or culture of small towns and rural areas, often being the catalyst for drawing people together. Although there may not be the range of organised sports and games available compared with urban areas, those that are available may have higher levels of participation because they are traditional.

This study found that the prevalence of adequate fitness was greater among boys and girls from higher socioeconomic backgrounds and that these differences were statistically significant for half of the Year groups. These findings are similar to those of prior studies (Lehnhard, Lehnhard, Butterfield, Parker & Young, 1995; Renson et al., 1978) and may be a result of those students who are more socially advantaged having greater access to sports and leisure activities that enhance and maintain cardiorespiratory fitness (Sallis, Zakarian, Hovell & Hofstetter, 1996; Taylor, Baranowski & Sallis, 1994) and receive more encouragement and support to participate in them (Yang, Telama & Laakso, 1996).

With respect to cultural group comparisons, the main finding was a low prevalence of adequate fitness among children and adolescents from Middle-Eastern backgrounds, compared with other cultural groups, with these differences statistically significant for three out of four Year groups when compared with students from English-speaking backgrounds. These differences may be explained by lower activity energy expenditure (Booth, Okely, Chey & Bauman, 2004), higher adiposity (Booth, Macaskill, Lazarus, & Baur, 1999), and possibly less importance placed on physical activity and fitness by this cultural group, especially among girls.

The finding of significantly lower prevalences of fitness among overweight and obese students is not surprising and is consistent with other studies (Slaughter, Lohman & Misner, 1980; Watson, 1988). What is perhaps interesting is that when the overweight and obese students are separated, statistically significant differences still exist among overweight students compared with their healthy-weight peers for boys and girls in all Year groups. That is, a young person does not have to be obese before a significant drop in the prevalence of fitness occurs, as this also occurs among overweight students. It should be mentioned that this mode of testing (running) would have been more of a disadvantage to overweight and obese young people, as they have to transport their body weight from one place to another. Still, only about one-third and just

under one-half of the overweight and obese boys and girls, respectively, are adequately fit. Reasons for this lower proportion include the movement of a greater mass of body fat (which acts as an inert load, similar to carrying excess 'baggage') (Rowland, 1996) when running; increased foot pressure when weight bearing, which may increase pain and discomfort (Dowling, Steele & Baur, 2001); and less proficient running ability or economy of movement (Okely, Booth & Chey, 2004).

In terms of secular trends, the main finding was that the prevalence of adequate fitness increased between 1997 and 2004 in six of the eight sex/Year groups, although none of the differences were statistically significant. These findings are in contrast with those of a recent review by Tomkinson et al. (2003). However, most of the studies in their review have the mid-1990s as their last time point and have compared time periods before this (up to 20 years prior). The present study has 1997 as the first time point and 2004 as the last so it is difficult to compare between studies that have used different time frames.

The results of this study are consistent with the observations of Eisenmann (2003), who reported that directly measured cardiorespiratory fitness (expressed as peak VO2) has remained relatively stable over the past 50 years among boys of all ages and among young girls, but has decreased among older adolescent girls. In this study, it was also found that levels were relatively stable for boys (except Year 6) and younger girls, but had declined among Year 10 girls. These trends may be real and may reflect a slight increase in cardiorespiratory fitness over this time. Although not statistically significant, these results are encouraging and may suggest that fitness is not declining with the concomitant population increase in the prevalence of obesity.

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