'Children should be encouraged to adopt more active lifestyles. Their health and well-being may well depend upon it.'

Neil Armstrong & Joanne Welsman

Today's children: Fitness, fatness, and physical activity

The Allied Dunbar National Fitness Survey (ADNFS, 1992) demonstrated that 48% of men and 40% of women are overweight, and that nearly one-third of men and two-thirds of women find it difficult to sustain walking at a reasonable pace up a 1 in 20 slope. Furthermore, the ADNFS reported that *people who exercise regularly in their youth are more likely to continue or resume exercise in later years.*

These findings emphasise the importance of promoting physical activity during childhood and adolescence. But are today's children as unfit, overfat and inactive as many of their parents?

How do we know if children are fit?

Physical fitness is a complex phenomenon that is extremely difficult to define. In this article we will focus upon arguably the most important component of physical fitness, *aerobic fitness.* Aerobic exercise is dependent upon the respiratory and cardiovascular systems delivering oxygen to the exercising muscles. As maximal aerobic fitness is limited by peak oxygen consumption (peak $\dot{V}O_2$) this parameter is widely recognized as the best single index of aerobic fitness.

On the treadmill: Determining peak $\dot{V}O_2$ in the PEA Research Centre, University of Exeter.

The assessment of peak $\dot{V}O_2$ requires children to exercise almost to exhaustion while their oxygen consumption is continually monitored.

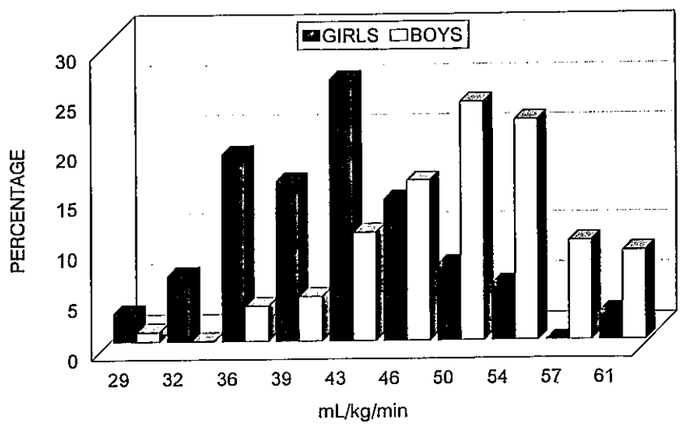

Fig. 1. Mass-related peak $\dot{V}O_2$ for 220 11–16 year old children, determined from treadmill measurements. It has been proposed that values below 30 $mL.kg^{-1}.min^{-1}$ for girls, and 35 $mL.kg^{-1}.min^{-1}$ for boys, represent a health risk.

Reliable data on children under the age of 8 years are difficult to obtain, and we will therefore limit our discussion to the more secure database of children aged 8 to 16 years. Boys' peak $\dot{V}O_2$ increases by about 150% over this age range, whereas girls demonstrate an 80% increase over the same period. At the end of Key Stage 2 boys' peak $\dot{V}O_2$ is, on average, 18% higher than that of girls. By the end of Key Stage 4 the difference between the sexes will have increased to about 37%.

As most physical activity involves moving body mass from one place to another, peak $\dot{V}O_2$ is usually expressed in relation to body mass (but see Note on page 69). With this convention a different picture emerges from that apparent when absolute values are used. Boys' *mass-related peak $\dot{V}O_2$* is remarkably stable over the age range 8 to 16 years whereas, from about the beginning of Key Stage 3, girls demonstrate a decrease in mass-related peak $\dot{V}O_2$ with age. This decline in girls' mass-related aerobic fitness is related to the accumulation of subcutaneous fat during maturity, and for some early maturers it may be apparent in Key Stage 2. Boys' mass-related peak $\dot{V}O_2$ values are significantly higher than those of girls, at least from the age of 10 years.

Are British children less fit than they should be?

The well-publicised belief that British children's aerobic fitness is low and has deteriorated over time stems from a misunderstanding of the concept of aerobic fitness and its assessment and interpretation. The facts are these:

- The peak $\dot{V}O_2$ values of British children compare favourably with those of young people from elsewhere.
- Comparisons of recent data with earlier studies of similar groups of youngsters suggest that the aerobic fitness of children has not deteriorated over the last five decades (Armstrong & Welsman, 1994).

The European Pediatric Work Physiology Group has expressed the view that a low mass-related peak $\dot{V}O_2$ in the absence of other health-related problems, may contribute to health risk. Risk levels of 35 $mL.kg^{-1}.min^{-1}$ for boys and 30 $mL.kg^{-1}.min^{-1}$ for girls were proposed. Fewer than 2% of the young people who have been tested in our laboratory during the last 10 years could be classified as 'at risk' (see Fig. 1). This is not to say that efforts should not be made to enhance further the aerobic fitness of children, but there is little evidence to suggest that they are unfit.

Can aerobic fitness be improved?

Young people's habitual physical activity has little or no relationship with their aerobic fitness, and the reason for this will become readily apparent later in this article. Relatively few studies have reported the responses of children to carefully-controlled and well-defined exercise training programmes.

Payne and Morrow (1993) conducted a meta-analysis of training studies involving children aged 13 years or less and suggested that the typical change in peak $\dot{V}O_2$ (pre- to post-training) in 'prepubertal' children is about 5%. Pate and Ward (1990), in a rigorous review of the literature, could identify only three controlled training studies with adolescents, but the results were consistent with an average increase in peak $\dot{V}O_2$ of about 14%. It appears, therefore, that children's peak $\dot{V}O_2$ may be enhanced through an appropriate exercise training programme, but the magnitude of the response may be dependent upon the age and maturity of the child. The literature suggests that an exercise programme to improve aerobic fitness would need to be of at least 8 weeks' duration and would require three 20-minute sessions per week with the heart rate sustained above 80-90% of maximum.

Are children fat?

The assessment of adults' body composition

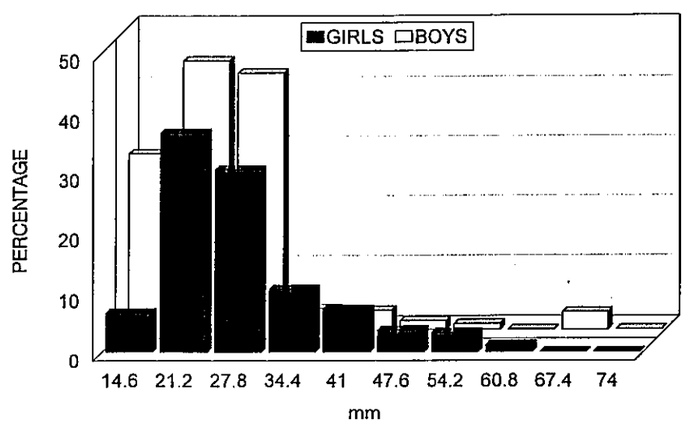

Fig. 2. Sum of subscapular and triceps skinfold thicknesses for 685 11–16 year old children.

is problematic enough, but with children the issue is further confounded by the fact that growth and development evoke changes in body composition that affect the basis for estimating fatness and leanness. Available data need to be interpreted in this context. Furthermore, there is a difference between being *overfat* and *overweight*. Although excessive body mass usually denotes excessive fatness among adults, this is not always the case with young people. Height-weight (mass) ratios of children and adolescents must be interpreted with caution, and 'overweightness' must not be confused with 'overfatness' (obesity). Obesity is, of course, one extreme on the continuum of body fatness, and although this paper will focus on fitness, activity and overfatness, the problems associated with severe dietary restraint should not be underestimated.

Boys appear to have a greater body density and a lower percentage of body fat than girls of the same age. Sex differences are small at birth and relatively slight during pre-pubescence, but during the circumpubertal period girls experience an annual *increase* in relative fatness of 0.9%. In contrast, boys experience an annual *reduction* in relative fatness of 0.5%.

We estimated body fatness from skinfold thicknesses in 685 11–16 year old children, and found the following:

- Girls' subscapular and triceps skinfold thicknesses (sum of skinfolds, Fig. 2) were significantly higher than those of boys over the whole age range (Armstrong et al., 1991).
- We also observed positive relationships between skinfold thicknesses and both blood pressure and blood cholesterol.
- A negative correlation was observed between skinfold thicknesses and aerobic fitness.
- No relationship was detected between skinfold thicknesses and habitual physical activity.

Because of the limitations in converting children's skinfold thicknesses into percentage body fat we chose to use the height, mass and age criteria recommended by the Royal College of Physicians to classify our children. According to these criteria:

- 13.4% of the boys and 9.7% of the girls could be classified as 'overweight'.
- With the girls there was a gradual decline from 11% overweight in year 7 to 8% overweight in year 10.
- The boys reached a peak of 19% overweight in year 9 with a marked decrease to 7% overweight in year 10.

We concluded that too many children are overweight.

Can exercise reduce fatness?

Energy expenditure can be sub-divided into basal metabolism (resting energy expenditure), energy expended due to food digestion and temperature regulation, and physical activity. *The greatest potential for increasing an individual's energy expenditure lies with the person's level of physical activity.* This increase in energy expenditure comes about not just from the direct effect of physical activity on metabolic rate but also from the persistent elevation of metabolism following physical activity. A 30 kg child with an energy expenditure of 7,500 $kJ.day^{-1}$ can increase his or her daily energy expenditure by 20 to 25% through 40–50 minutes of jogging or swimming. As an increase in physical activity appears to have only a minimal influence on energy intake, the child could expect a 1 kg fat loss within 23 days.

Bar-Or and Baranowski (1994) analysed the evidence relating physical activity to body fatness in the obese and non-obese adolescent population. They concluded that although obese children appear to be less physically active than their non-obese peers, due to their larger body mass, there is no consistent difference in total

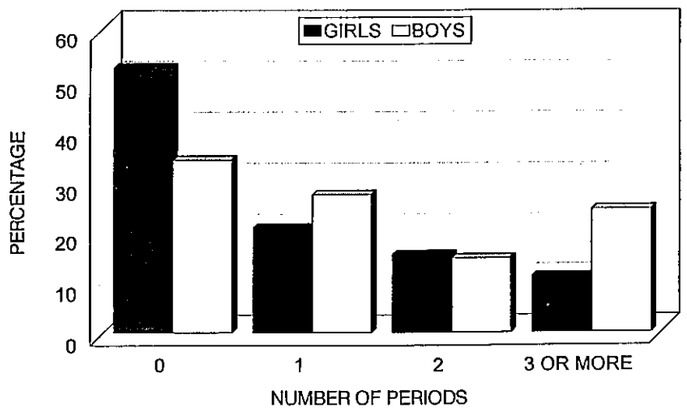

Fig. 3. The number of 10-minute periods in one schoolday (9 am to 9 pm) during which energy expenditure was equivalent to brisk walking. (Heart-rate monitoring of 266 11–16 year olds.)

energy expenditure. Numerous studies have demonstrated that aerobic exercise can induce a reduction in body fat (about 1–3%) and, to a lesser extent, an increase in fat-free mass. It appears that an increase in physical activity could be particularly advantageous to the obese child.

Bar-Or and Baranowski (1994) felt unable to make firm physical-activity recommendations, but in the context of reducing body fatness they suggested that aerobic exercise programmes lasting longer than one year are more efficacious than shorter programmes, and enhanced lifestyle activities appear to have a more lasting effect than regimented exercise.

Are children physically active?

Despite the problems involved in monitoring habitual physical activity, the physical activity patterns of young people in both Europe (Armstrong, 1995a) and North America (Pate et al., 1994) have been well documented. The data are remarkably consistent, but until recently they were difficult to interpret because widely-recognized physical activity guidelines for young people were not readily available.

In 1993 Sallis convened an International Consensus Conference on Physical Activity Guidelines for Adolescents. The consensus conference was designed to develop physical activity guidelines for 11–21 year olds based on rigorous reviews of the scientific literature. Two important recommendations emerged (Sallis & Patrick, 1994):

- All adolescents should be physically active daily or nearly every day, as part of play, games, sports, work, transportation, or recreation in the context of family, school and community activities.
- Adolescents should engage in three or more sessions per week of activities that last 20 minutes or more at a time and that require moderate to vigorous exertion.

Monitoring activity levels

Research based in our laboratory has clearly demonstrated that significant numbers of British children do not satisfy these recommendations (Armstrong et al., 1990). We estimated the volume (frequency, intensity and duration) of physical activity of 266 11–16 year olds from continuous monitoring of heart rate. Each child was monitored from about 0900 to 2100 during three normal schooldays and on a Saturday.

Brisk walking on the treadmill at 6 km/h elicited steady-state heart rates averaging 146 beats/min and jogging at 8 km/h elicited steady-state heart rates averaging 164 beats/min. Maximum heart rates with these youngsters were, on average, 200 beats/min. We therefore decided to analyse the percentage of time and the number of sustained periods with heart rate maintained above 140 beats/min (70% of maximum and equivalent to brisk walking) and 160 beats/min (80% of maximum and equivalent to jogging).

The boys spent a significantly higher percentage of their time than the girls with heart rates above 70% of maximum (6.2% v. 4.3%) and above 80% of maximum (2.6% v. 1.4%). If moderate to vigorous levels of exertion are defined as equivalent to jogging, *only 2% of the boys and none of the girls satisfied the recommendations above.* Even if moderate to vigorous levels of exertion are defined as 'brisk walking', *only 4% of the boys and fewer than 1% of the girls* demonstrated a daily 20-minute brisk walk. During weekday monitoring, *over one third of the boys and over half of the girls* failed to experience a single 10-minute period equivalent to brisk walking (see Fig. 3).

71% of the boys and 94% of the girls failed to experience a single 10-minute period equivalent to brisk walking during Saturday monitoring.

Physical activity levels decline with increasing age across adolescence, and this decrease is more marked in girls, who are less active than boys from an early age. Girls appear to be much less likely to experience the type and amount of physical activity associated with conferring health benefits.

Are today's children less active?

Although data have been collected over several decades, methodological differences between studies preclude any meaningful analysis of whether children's habitual physical activity has declined over time. However, two studies provide some insights. Durnin (1992) collated energy intake data on 14–15 year olds in the United Kingdom over a 50-year period (1930s to 1980s) and demonstrated a reduction in energy intake despite no difference in the body mass of the children. The only plausible explanation is that energy expenditure has diminished, and that this is a reflection of a radical decrease in physical activity.

In 1971, Hillman et al. (1990) surveyed children in five areas of England in order to explore their travel patterns and levels of autonomy. He repeated the survey in the same areas in 1990 and his results revealed a remarkable decline in children's freedom and choice to do things independently outside the home. Furthermore, he demonstrated that girls experience substantially less independence than boys. It is readily apparent that encouraging girls to be more active and providing appropriate support structures should be a priority, but we have addressed this problem elsewhere (Armstrong, 1995b; Armstrong & McManus, 1994).

Conclusion

Children have adequate levels of aerobic fitness, but too many are overweight. Many have already adopted a sedentary lifestyle. As a sedentary lifestyle is associated with all-cause mortality and it appears that children's physical activity patterns track into adult life, children should be encouraged to adopt more active lifestyles. Their health and well-being may well depend upon it.

Note: Although it is conventional to partition out the influence of body size by expressing peak VO_2 in ratio with body mass, this type of analysis may well cloud our understanding of growth and maturational changes in peak VO_2. We have developed these arguments further elsewhere (Armstrong & Welsman, 1994).

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