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Influence of school community and fitness on prevalence of overweight in Australian school children

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ABSTRACT

The study objectives were (1) to determine the variation in prevalence of overweight between school communities, (2) to evaluate the relationship between cardiorespiratory fitness and the probability of being overweight among different school communities, and (3) to test whether this relationship varies between school communities. Using a repeated cross-sectional design, data from 31,424 (15,298 girls, 16,126 boys) Australian school children who had objective assessments of body composition and physical performance were used. Ninety-one schools located across 5 states and territories were included. Independent samples were taken across 12 school years (2000–2011). Analysis used generalised linear mixed models in R with a two-level hierarchical structure—children, nested within school communities. Predictor variables considered were: level 1—gender, age, cardiorespiratory fitness and year of measurement; level 2—school community. A total of 24.6% of the children were overweight and 69% were of low fitness. Variation in the prevalence of overweight between school communities was significant, ranging from 19% to 34%. The probability of being overweight was negatively associated with increasing cardiorespiratory fitness. The relationship was steepest at low fitness and varied markedly between school communities. Children of low fitness had probabilities of being overweight ranging between 26% and 75% depending on school community, whereas those of high fitness had probabilities of <2%. Our findings suggest that most might be gained from a public health perspective by focusing intervention on the least fit children in the worst-performing communities.

Introduction

Childhood overweight is considered to be a primary public health issue in children and is associated with a variety of adverse health, social and psychological consequences (Dietz & Robinson, 2005; Daniels, 2009). The prevalence of childhood overweight in Australia has increased rapidly from a level of about 7.5% in the mid-1960s to the epidemic level today of around 25% (Norton et al., 2006). At the same time, children's physical activity and physical fitness levels have been seen to decline (Dollman et al., 2005; Healthy Kids Australia, 2014). Despite much attention in published research, government reports and international calls for action (Lobstein et al., 2004; Bull et al., 2004; World Health Organisation, 2004), there has been limited success only in stopping either the spread of overweight or the downward trend in fitness within the school age population.

Most research focuses on the individual and interventions seek change within the individual or their immediate family (Waters et al., 2011). Although there has been some success using such a focus, childhood overweight has been demonstrated to have multifactorial drivers, not all of which are under the control of the individual (or their family). Thus, it has been proposed that more may be gained by adopting an ecological systems perspective (Huang et al., 2009; Penhollow & Rhoads, 2013), examining the physical, social and psychological development of children through the opportunities provided within their social circumstances. This approach has been widely applied in developmental and educational psychology research but has so far not received as much attention in relation to childhood overweight and physical fitness (Bronfenbrenner, 1993).

The purpose of this study was to address this limitation of previous research by examining the prevalence of overweight and low physical fitness in a large sample of Australian school children from the perspective of children within school communities. By school communities here, we mean the settings and people who provide, or can provide, opportunities for children to be physically active and to eat a balanced healthy diet. The central focus is the children themselves, as individuals and as a population, and the key setting is the school as this environment has a defining influence on children's development and their future prospects. The key perspectives are the adequacy and balance of opportunities provided to children. Specific questions addressed were: (1) What is the variation in the prevalence of overweight or obesity between schools? (2) How does fitness relate to the probability of being

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overweight or obese and how does this relationship vary between schools?

Methods

Data for the present analysis were entirely cross-sectional, i.e. no individual child was included more than once in the data set analysed and were from a large sample of 31,424 Australian school children who had assessments of body composition and physical performance competences carried out as part of a service offered to Australian schools (in the Australian Capital Territory (ACT), New South Wales, South Australia, Queensland and Northern Territory) in the school years between 2000 and 2011 by SmartStart for Kids, a not-for-profit organisation specialising in healthy exercise, eating and lifestyle programmes for school children.

Ethical approval for the research carried out here was granted by ACT Health Human Research Ethics Committee's Low Risk Sub-Committee on 5th November 2014 (ETHLR14.264). All work on which the study is based was carried out with the prior approval of the appropriate local authorities who commissioned the service. Schools involved in collection of the original data gave their informed consent and all parents gave written informed consent for their children to take part. Data collection was carried out during normal school hours. School administrators and class teachers assisted with the coordination of the various class groups. Overall participation rate was 82%. Measurements were carried out by SmartStart for Kids' trained assessors, usually three in number, to accommodate small groups of children moving round a set of measurement stations. All data processed by the researchers carrying out the current analysis had been de-identified so that no individual child or participating school could be identified from any of the information available. However, each record in the data file contained both a school linkage key and an individual child key so that the original commissioners of the research would be able to consider the findings in context and respond appropriately if necessary.

Body weight status was represented by the body mass index (BMI = weight (kg)/height (m); (Daniels, 2009)). Height was measured using a standard stadiometer (Surgical and Medical Products, Seven Hills, New South Wales, Australia) calibrated in 1 mm increments and weight was measured to the nearest 0.1 kg using Tanita TBF-522 electronic weight and body fat monitor scales, calibrated and spot-weight checked regularly. Cardiorespiratory fitness was measured using the 20 m multi-stage fitness test (Ramsbottom et al., 1988). Instructions were played using a calibrated CD player. Children did the test in small peer groups. One member of the SmartStart for Kids evaluation team acted as lead/runner for each group and two other members independently recorded the final stage and shuttle reached by each child. Assessments were carried out using 1220 class groups in 91 schools over 12 school years (2000–2011).

Body weight categories for each child in each gender half-year age subgroup were defined using established international thresholds (Cole et al., 2000; Cole et al., 2007). Physical fitness categories were estimated as follows. For each gender and half-year age band in the range 4.5 to 15 years, the fitness range was divided into 8 equal segments and four cut-points were set at the end of the 1st, 3rd, 5th and 7th segments, allowing us to derive a working estimate of 5 fitness categories for each child in each gender/age combination. Category labels were chosen to reflect the link between physical activity and fitness, i.e. we derive our fitness from physical activity in a combination of volume and intensity and adaptation of the muscles and organs used in that activity (specificity). Thus, the physical fitness (activity) levels are better interpreted as 'the level of fitness that might be expected in a child who is CATEGORY'.

The response variable for the multi-level analyses was the binary indicator of whether a given child was overweight or obese (1) or not (0). Analyses were carried out using SPSS21 (descriptives) and R (multi-level models) (R Core Team, 2014). The analytical approach is described in detail by Szmaragd and Leckie (ibid p. 6–8 for the null model, i.e. considering only variation by school community and p 27–33 for the two-level random slope model) (Szmaragd & Leckie, 2008), and used the lme4 package for fitting linear and generalised linear mixed models in R (Bates et al., 2014). The data were considered to have a two-level hierarchical structure with 31,434 children at level 1, nested within 91 school communities at level 2. Predictor variables considered were: level 1—gender, age, cardiorespiratory fitness (hereinafter referred to simply as fitness) and year of measurement; level 2—school community.

Results

The number of schools assessed per year ranged from 9 to 30 with a mean of 19. The number of children per school ranged from 9 to 1572 (mean 345). The number of years a given school was assessed ranged from 1 to 11 (median 2). There were 226 school assessments and the number of children per assessment ranged from 9 to 644 (mean 139).

Table 1 summarises the body weight and physical fitness categories for the children included in the sample. A total of 3.8% were classified underweight, 24.6% were overweight or obese and 71.6% were in the normal range. These figures compare favourably with those reported nationally, where the proportion of overweight children (aged 2–17) was 24.6% (Australian Bureau of Statistics (ABS), 2013). Nearly 69% of children were classified as being in the bottom two physical fitness (activity) categories for each gender/age band, whereas only 6.4% of children were in the two highest categories.

Fig. 1 summarises the null model, which is a two-level model with an intercept and school community effects only. Plotted points represent the estimated deviation of each school from the global mean (intercept) and the vertical lines represent the 95% confidence intervals of this estimate for each of the 91 schools. Schools to the left where the 95% confidence interval does not overlap the horizontal line at zero have significantly lower probabilities of children being overweight or obese whereas those on the right that do not overlap the horizontal line at zero have significantly higher probabilities of children being overweight or obese.

Adding fitness as an explanatory variable improved the model fit markedly (random intercept, random slope model). The fitted relationships between the probability, p, of being overweight or obese and fitness by school are shown in Fig. 2. To produce this plot, the linear log odds of being overweight or obese outputs from the model were converted to the probability scale using the transformation $p = 1/(1 + e^{-L})$, where L is the original log odds transformation used to perform the fit, i.e. $L = \ln(p/(1 - p))$, where ln denotes the natural logarithm.

It is clear from this figure that there was considerable variation between school communities in the relationship between being overweight or obese and fitness. Variation was greatest at low fitness levels (left of figure) but converged to a low level at the highest fitness levels, coupled with low probabilities of being overweight or obese (right of figure). Children of the lowest fitness level had probabilities of being overweight or obese ranging between about 26% (best-performing

Table 1
Body weight and physical activity (fitness) categories (Australia, 2000–2011).

Weight category[a]	Gender				Total	
	Female		Male			
	N	%	*N*	%	*N*	%
Severe thinness	11	0.1	10	0.1	21	0.1
Moderate thinness	54	0.4	46	0.3	100	0.3
Mild thinness	552	3.6	508	3.2	1060	3.4
Normal range	10,600	69.3	11,896	73.8	22,496	71.6
Overweight	3027	19.8	2637	16.4	5664	18.0
Obese	1054	6.9	1029	6.4	2083	6.6
Total	15,298	100	16,126	100	31,424	100
Physical fitness (activity) category[b]						
Sedentary	994	6.5	1816	11.3	2810	8.9
Light active	10,151	66.4	8643	53.6	18,794	59.8
Moderate active	3420	22.4	4384	27.2	7804	24.8
Heavy active	681	4.5	1214	7.5	1895	6
Vigorous active	52	0.3	69	0.4	121	0.4
Total	15,298	100	16,126	100	31,424	100

[a] Thresholds for each weight category were determined from published cutoffs for each gender half-year age group (Cole et al., 2000; Cole et al., 2007).
[b] Physical fitness (activity) levels to be interpreted as 'the level of fitness that might be expected in a child who is CATEGORY'