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Original research

Anthropometric standards for Australian primary school children: Towards a system for monitoring and supporting children's development

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ABSTRACT

Objectives: To provide two foundation elements of a proposed new system to support children's physical and body status development throughout primary school: (a) age and gender appropriate achievement (anthropometric) standards and (b) a system of monitoring, feedback and support.
Design: Repeated cross-sectional sampling involving 91 schools across 5 Australian States and Territories between 2000 and 2011.
Methods: Anthropometric data from 29,928 (14,643 girls, 15,285 boys) Australian children aged between 5 and 12.5 years were used to develop progression standards (norm centiles) covering the primary school years. Measures used were: height, weight, body mass index, per cent body fat, grip strength, standing long jump, cardiorespiratory fitness, sit-ups and sit-and-reach. These norms were then used to develop a Physical Activity and Lifestyle Management (PALM) system that could form the basis for progression, monitoring and reporting of anthropometric achievement standards for children.
Results: Tables and representative centile curves (3rd, 15th, 50th, 85th and 97th) for each gender and half-year age group were produced. An illustrative example of the PALM system in operation was also provided.
Conclusions: Our research provides gender and half-year age specific anthropometric standards for Australian primary school children. Furthermore, we have developed a monitoring and progression system that could be embedded in school communities to help address the prevalence of underweight, overweight and obesity and decline in physical fitness standards. The proposed system is designed on behalf of children and families and would be administered through school settings. Change, where needed, would be delivered by the supporting school community.

1. Introduction

Developing and maintaining good levels of physical fitness, good diet and good body composition are considered important to children's future health, well-being and contribution to society.[1,2] Yet there is compelling evidence that there has been a decline in fitness and physical activity levels[3–5] and an increase in undesirable body composition in children over recent decades.[6,7] From a public health perspective, it is important to reverse these societal trends in order to forestall the adverse consequences of overweight or obesity and poor physical fitness. From an epidemiological perspective, it would be useful to have a system of monitoring and surveillance that would enable early detection of, and an earlier corrective response to, adverse changes than has been the case with the current so-called obesity pandemic and general population declines in physical conditioning.

The primary school years are important formative years in which children develop the knowledge, attitudes and behaviours that are carried through adolescence and into adult life.[8] It is important, therefore, that we support children in these early years and provide them with adequate opportunities to develop the physical abilities and social and psychological skills that will enable them to participate fully in and contribute constructively to society throughout life. Two important foundation elements of a well-designed system to provide such opportunities are: a set of age and gender appropriate achievement (anthropometric) standards and a system of monitoring, feedback and support such that as many children as possible are able to make good progress in all these

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measures throughout their primary school years. The objectives of this research were to provide these two foundation elements from a large sample of Australian primary school children.

2. Methods

The data were gathered using a repeated cross-sectional design as part of a wider evaluation of a service offered to Australian primary schools in the school years between 2000 and 2011.

The study included anthropometric data from 29,928 primary school children (14,643 girls, 15,285 boys) aged between 5 and 12.5 years from 91 different school settings. More detail on the sample and sampling process is provided in a previous publication.[9]

Anthropometric measures used were: height (cm), weight (kg), body mass index (BMI) (kg m^{-2}), per cent body fat (%), grip strength (kg), standing long jump (cm), cardiorespiratory fitness (20 m shuttle run score), sit-ups in 60 s (n) and sit-and-reach (cm). All measures have been shown to have adequate validity and good reliability for use in school settings.[10,11] The measures were chosen because they give good coverage of the main body systems: body composition, lower limb function, upper limb function, cardiorespiratory fitness and core strength, flexibility and endurance.

Height was measured using a stadiometer (Surgical and Medical Products, Seven Hills, New South Wales, Australia) calibrated in 1 mm increments. Weight and per cent body fat were measured using Tanita TBF-522 electronic weight and body fat monitor scales. All weight and per cent body fat measures were concealed from the participants. Hand grip strength was measured bilaterally using a Jamar Digital Plus hand dynamometer and the mean of the two measures was used. Standing long jump was measured on a flat surface with a fixed strip of wood as a 'toe' starting line for the jump. Cardio-respiratory fitness was measured using the 20 m multi-stage fitness test.[12] In order to provide a quasi-continuous measure, the shuttle run score s:n was converted to the decimalised version s + n/l, where s represents the stage, n is the number of shuttles achieved and l is the number of shuttles in that stage. Sit-ups were measured with legs bent at ~90°, feet flat on the floor, hands on thighs, fingers pointing along the thigh. Finally, sit-and-reach was measured with legs straight using a folding trunk flexibility tester box. Full details of the measurement protocols are provided in Supplement S2.

Inter-observer reliability was assessed using two-way mixed, consistency, average-measures intra-class correlation (ICC) to assess the degree that observers were consistent in measurements across subjects. Blinded independent observations were made by two members from our small team of trained observers on a group made up of 51 children in total from 7 separate schools, visited on different days. Five measures were included: height, weight, BMI, per cent body fat and grip strength. Standing long jump, sit-ups in 60 s, shuttle run and sit-and-reach were not included in this inter-observer reliability check because it was not possible to isolate observer variability from within child variability for these measures. The resulting ICCs ranged from 0.992 to 0.996, indicating that negligible measurement error was introduced by the independent observers and that the statistical power to detect change across time would not be substantially reduced from this source of error.

Profiles for each measure were produced for girls and boys in the age range 5 to 12.5 years using the LMS method developed by Cole and Green[13,14] using the LMS Chartmaker Light software available from Harlow Healthcare, UK.[15] Measures that included negative or zero values were offset such that the smallest value was set at 0.1. The offset was removed in tables and plots to retain the original scaling.

The availability of an extensive database of objective measurements performed by a small team of trained independent observers provided the opportunity to develop a set of body status and physical performance ranges for gender and age groups that could form the basis of a monitoring and progression system for school age children. The system developed, which we have called here Physical Activity and Lifestyle Management (PALM) system, was similar in concept to the National Assessment Program—Literacy and Numeracy (NAPLAN), which is an annual national assessment for all students in years 3, 5, 7, and 9 in Australia (http://www.nap.edu.au/information/faqs/naplan-general.html). Each child's achievement standard on each measure was characterised on the basis of their comparator reference group, in this instance the child's gender and half-year age group in the study database. For comparison, the school average and the population average were also provided.

Ethical approval for the research was granted by the regional Health Human Research Ethics Committee's Low Risk Sub-Committee on 5th November, 2014 (ETHLR14.264). 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. School administrators and class teachers assisted with the coordination of the various class groups. All assessors had appropriate 'working with children' checks, were qualified in fitness or had related tertiary qualifications and in-house training on the assessment protocols and appropriate behaviours when testing children. 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.

3. Results

The number of children in each gender and half-year age group and ranges for body status measures are shown in Table 1.

Ranges for the physical performance measures are shown in Table 2. These ranges formed the basis for the system for monitoring of anthropometric standards discussed further below.

Representative percentiles for body status and physical performance measures for boys and girls are summarised and discussed in Supplement S1.

The complete database was used to develop a prototype monitoring and progression system for use with children of primary school age. The data for each gender half-year age group were used to construct a set of scales for each measure against which individual child scores could be referenced in terms of both actual score and percentile ranking. The system is best illustrated by means of an example which is shown in Fig. 1.

In this example for a 12 year old boy, scores on five scales are reported: BMI, grip strength, cardiorespiratory fitness, sit-ups and standing long jump, representing a broad range of anthropometric characteristics. This boy is in the obese category and his general physical condition is poor—grip strength, fitness and long jump are much lower than his peers. Thus, some supportive action to improve scores would be recommended. An example of this is shown at bottom left of Fig. 1a. For further reference, the scales for each measure also include the school and population averages (for this boy's age and gender matched peers). For ease of use and clarity of understanding, the overall profile of Fig. 1a would be accompanied by a summary table outlining the child's status in more detail as illustrated in Fig. 1b. The focus of this information is on getting nutritional intake about right and participating in a broad range of physical activities to improve or maintain general musculoskeletal and cardiovascular conditioning. The information provided includes ranges for each measure, the national

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