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Age-related patterns of vigorous-intensity physical activity in youth: The International Children's Accelerometry Database

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ABSTRACT

Physical activity declines during youth but most evidence reports on combined moderate and vigorous-intensity physical activity. We investigated how vigorous-intensity activity varies with age.

Cross-sectional data from 24,025 participants (5.0–18.0 y; from 20 studies in 10 countries obtained 2008–2010) providing ≥1 day accelerometer data (International Children's Accelerometry Database (ICAD)). Linear regression was used to investigate age-related patterns in vigorous-intensity activity; models included age (exposure), adjustments for monitor wear-time and study. Moderate-intensity activity was examined for comparison. Interactions were used to investigate whether the age/vigorous-activity association differed by sex, weight status, ethnicity, maternal education and region.

A 6.9% (95% CI 6.2, 7.5) relative reduction in mean vigorous-intensity activity with every year of age was observed; for moderate activity the relative reduction was 6.0% (5.6%, 6.4%). The age-related decrease in vigorous-intensity activity remained after adjustment for moderate activity. A larger age-related decrease in vigorous activity was observed for girls (−10.7%) versus boys (−2.9%), non-white (−12.9% to −9.4%) versus white individuals (−6.1%), lowest maternal education (high school (−2.0%)) versus college/university (ns) and for overweight/obese (−6.1%) versus healthy-weight participants (−8.1%). In addition to larger annual decreases in vigorous-intensity activity, overweight/obese individuals, girls and North Americans had comparatively lower average vigorous-intensity activity at 5.0–5.9 y.

Age-related declines in vigorous-intensity activity during youth appear relatively greater than those of moderate activity. However, due to a higher baseline, absolute moderate-intensity activity decreases more than vigorous. Overweight/obese individuals, girls, and North Americans appear especially in need of vigorous-intensity activity promotion due to low levels at 5.0–5.9 y and larger negative annual differences.

1. Background

Physical activity declines throughout childhood and adolescence (Dumith et al., 2011). Results from the International Children's

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Accelerometry Database, which includes data from studies in Europe, North America, Australia and Brazil, show a cross-sectional decrease of 4.2% in total physical activity with each additional year of age (Cooper et al., 2015). Longitudinal data indicates that over 10 min/day of physical activity every year is replaced by sedentary time between 9/10 y and 13/14 y among British children (Corder et al., 2013a). Investigations of physical activity for obesity prevention are somewhat inconclusive in young people (Steinbeck, 2008; Wareham et al., 2005) whereas evidence supporting physical activity for the reduction of cardiovascular disease risk in youth is more hopeful (Ekelund et al., 2012a; Janssen and Leblanc, 2010). Some evidence indicates that a 10-minute increase in moderate to vigorous-intensity physical activity (MVPA) is associated favorably with metabolic outcomes including a smaller waist circumference and lower fasting insulin among young people (Ekelund et al., 2012b).

The majority of available evidence describing physical activity change during childhood and adolescence focuses on combined MVPA, which may mask intensity-specific changes in activity over time (Corder et al., 2013b). It has been suggested that vigorous-intensity physical activity may be more important than lower intensity activity for weight control (Janssen and Ross, 2012; Steele et al., 2009) and has more predictive value for obesity among boys (Latt et al., 2015). Furthermore, a higher baseline BMI z-score has been associated with a greater decline in vigorous activity during weekends between the ages of 10 y and 11 y (Corder et al., 2013b). Vigorous-intensity physical activity accounts for the lowest proportion of overall physical activity among young people, and may decline more rapidly than any other activity intensity during adolescence (Corder et al., 2013b). Maintaining or increasing vigorous-intensity activity may require different health promotion strategies than interventions targeting lower intensity activity, such as promotion of organized sport versus lifestyle activities. Evidence regarding the pattern of vigorous-intensity physical activity throughout childhood and adolescence is inconclusive and more evidence is needed to reflect a wide age range and large population samples.

We investigated how vigorous-intensity physical activity varies with age among young people aged 5–18 years; we additionally compared this with the decline in moderate-intensity physical activity over the same period. We hypothesized that the decline in vigorous-intensity physical activity would be greater than that in moderate-intensity physical activity. We additionally investigated whether age-related differences in vigorous-intensity physical activity varied by sex, weight status, maternal education, ethnicity and geographic region to better understand how to target physical activity promotion among population subgroups.

2. Methods

2.1. Study

The International Children's Accelerometry Database (ICAD, http://www.mrc-epid.cam.ac.uk/Research/Studies/) was established to pool data on objectively measured physical activity from studies in youth worldwide. The aims, design, study selection, inclusion criteria, and methods of the ICAD project have been described in detail previously (Sherar et al., 2011). Briefly, in 2008 a PubMed search for potential contributors was undertaken. From this search, 19 studies using the same type of accelerometer (Actigraph) and including at least 400 participants aged 3 to 18 years were identified. Additional studies were identified by personal communication. In total, 25 studies were identified and approached, of which 21 contributed data to ICAD (Boyd et al., 2013; Sherar et al., 2011).

2.2. Participants

Previous analyses in ICAD indicated a linear association of MVPA with age from 5 to 18 years of age (Cooper et al., 2015); therefore only participants aged ≥5.0 years were included in these analyses. Due to the age criteria, the present analysis included data on children and adolescents (aged 5–18 years) from 20 of the 21 studies included in ICAD from Australia, Brazil, Europe, and North America, in which data on objectively measured physical activity were available (N = 24,025 participants). These studies were performed between 1998 and 2009. All contributing studies obtained relevant ethical approval.

2.3. Assessment of Physical Activity

A detailed description of the assessment of physical activity is available elsewhere (Sherar et al., 2011). Briefly, all physical activity measurements were made with uniaxial, waist-worn Actigraph accelerometers (models 7164, 71256 and GT1M); these accelerometers have been validated for assessment of free living physical activity energy expenditure in young people (Ekelund et al., 2001). All available raw accelerometer data from contributing studies were reanalysed to provide physical activity outcome variables that could be directly compared (KineSoft, version 3.3.20). For consistency across studies, data files were reintegrated to a 60-second epoch where necessary and non-wear time was defined as 60 min of consecutive zeros, allowing for 2 min of nonzero interruptions (Troiano et al., 2008). All children with at least 1 day of at least 500 min of measured monitor wear time between 7 am and midnight were included in this analysis. Evenson cut-points (Evenson et al., 2008) were used to estimate moderate- (≥2296 cpm) and vigorous-intensity (≥4012 cpm) physical activity. For descriptive purposes, time spent sedentary was defined as all minutes registering less than 100 cpm (Treuth et al., 2004).

2.4. Non-accelerometer variables

Height and weight were measured using standardized clinical procedures across studies. Body mass index (BMI, in kg/m^2) was calculated and participants were categorized into normal weight or overweight/obese groups according to age and sex-specific cut points (Cole et al., 2000). As a proxy for socio-economic status, maternal education was used in three categories of up to completing high school, college or vocational training and university or higher. Participants were categorized into four groups to represent ethnicity: white, African ancestry, Hispanic and other (including Asian). Studies were grouped into five geographical areas (regions): the UK, the rest of Europe, North America, Australia and Brazil. Not all variables were available in all datasets; the studies in which they are available are shown in Table 1.

3. Statistics

Analyses were performed using STATA version 14.0 (Statacorp, College Station, TX).

The outcome variables were minutes per day of vigorous- or moderate-intensity physical activity which, due to non-normality, were (natural) log-transformed prior to linear regression analyses. Vigorous-intensity physical activity data over the 99th percentile were set to the 99th percentile value to remove extreme observations. Absolute vigorous- and moderate-intensity physical activity is also presented descriptively. Where multiple data were available from a participant, only the first measurement was included in the analyses.

Linear regression models were used to investigate age-related patterns in vigorous- and moderate-intensity physical activity. Models included age as the exposure, and were adjusted for monitor wear time and study. The beta coefficient for age was back transformed to represent a ratio of the geometric mean of vigorous-intensity physical activity for every year increase in age. Vigorous- and moderate-intensity physical activity were each modeled, with vigorous activity additionally adjusted for moderate-intensity activity. This adjusted model aimed to assess whether any age-related difference in vigorous-intensity physical activity was independent of moderate-intensity physical activity