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Tracking of physical activity in pubertal boys with different BMI over two-year period

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(Accepted 22 January 2015)

Abstract
We examined the tracking of physical activity (PA) measured by accelerometers and subjective self- and parental reports in normal weight and overweight and obese pubertal boys over two-year period. In total, 156 boys with mean (±SD) age of 11.53 ± 0.76 at baseline and with mean age of 13.94 ± 0.74 at 2 year follow-up were studied. At baseline and approximately two years later, the boys completed self-report questionnaire and wore an accelerometer for seven consecutive days. On the basis of first year assessment’s body mass index (BMI), the children were grouped as normal weight and overweight and obese groups according to BMI cut-offs. Tracking correlations of objectively measured PA and subjectively measured PA were fairly similar across the 12–14 year-old-boys weight groups over two year period. Tracking correlations of objectively measured PA and subjectively measured PA were not significantly different over two-year period between both BMI groups. The results of the study show that pubertal boys objectively measured PA decreased over two-year period and so the boys started to be less active in their pubertal period.

Keywords: children, parents, body mass index, self-report, activity patterns

Introduction
Tracking is usually defined as the tendency of individuals to maintain their rank or position of physical activity (PA) within a group over certain time period. Increasing PA, especially in young children and adolescents, is of great importance for the advancement of public health (Kjonniksen, Torsheim, & Wold, 2008; Nyberg, Ekelund, & Marcus, 2009; Telama, 2009). However, it has been found that PA declines during the lifespan, particularly in adolescence (Corder et al., 2010; Dumith et al., 2011; Kolle, Steene-Johannessen, Andersen, & Anderssen, 2010; Kristensen et al., 2010, 2008). Different rates of decline have been found in children with different body fat proportions, with change in children with greater body fat (Corder et al., 2010). The studies are not entirely consistent as to whether the change is uniform over the whole period, or mostly concentrated to a part of it (Dumith et al., 2011; Duncan, Duncan, Strycker, & Chaumeton, 2007; Kwon, Janz, & ICAD Collaborators, 2012; Nyberg et al., 2009).

Most tracking studies have used correlation between two measurement occasions as a measure of tracking change (Dumith et al., 2011; Telama, 2009). Another common measure, PA change (expressed as percentage of change per year), is of obvious interest but is independent of tracking as defined above (rank-order stability): for example, an individual may retain his or her rank-order position when there is a mean-level change, and lack of mean-level change is by no means a guarantee of high rank-order stability.

Commonly, the follow-up duration in tracking studies is longer than a year. However, it has been
suggested that the decrease of PA can already be seen over one and two-year period and this may be a health promotion target (Baggett et al., 2008; Corder et al., 2010; Nyberg et al., 2009). It has also been suggested, to pay attention to the adjustment of tracking correlations for different error variations because this may influence tracking results (Telama, 2009).

Most PA tracking studies have used questionnaires (Dumith et al., 2011), with only a few utilising objective methods to measure PA (Corder et al., 2010; Kristensen et al., 2008; Nilsson et al., 2009). It is highly desirable that objective methods are used in tracking studies because of their better validity and reliability compared to the self-report methods (Corder et al., 2010; Telama, 2009). Because objective measurement of PA is not always feasible, comparing the stability of self-report and objective methods would also be of interest but has only been the subject of a few studies (Baggett et al., 2008; Cleland, Dwyer, & Venn, 2012; Ham & Ainsworth, 2010).

PA interventions are often designed to target overweight and obesity (Telama, 2009). If it is true, as some studies suggest (Corder et al., 2010) that the decline of PA is especially marked in overweight children, and consequently, tracking of (in)activity is in this group is higher, which is problematic for behavioural interventions as this is exactly the group where a change is the most desirable.

Consequently, there is a clear need for tracking adolescent boys’ objectively measured PA with different BMI. The purpose of the present study was twofold. The first aim was to examine the tracking of PA in normal weight and overweight/obese pubertal boys over two-year period, as well as to observe any mean-level changes. The second aim was to compare the tracking of PA between accelerometer measured PA and subjectively measured PA by children self-reports questionnaire and parental questionnaire in normal weight and overweight and obese pubertal boys over two-year period.

Methods

This study is a part of the project that started in 2009: Risk factors for metabolic syndrome in boys during pubertal development: A longitudinal study with special attention to PA and fitness (Lätt et al., 2013; Utsal et al., 2012). First year (T1) data collection took place from November 2010 until April 2011, second year (T2) data collection took place from November 2011 until April 2012 and the third year (T3) data collection from November 2012 until April 2013. The participants were 156 pubertal boys from schools in city and the surroundings of Tartu, Estonia, and the data collection for all participants took place at approximately same time of the year. The boys were 11.53 ± 0.76 years old in the T1 collection and 13.94 ± 0.4 years old at T3 data collection. At T1, T2 and T3 data collection, the boys completed the self-report questionnaire and wore an accelerometer for seven consecutive days. Also, the parents of the participants (n = 156) were involved in the study and had to complete a parental questionnaire (identical to the children’s questionnaire) about their children’s PA.

All children and parents were thoroughly informed of the purposes and contents of the study and the written informed consent was obtained from the parents before participation. Children gave the verbal assent. This study was approved by the Medical Ethics Committee of the University of Tartu.

Measurement of body parameters

At T1, T2 and T3 data collection, the boys’ body height and body mass were measured in standing position to the nearest 0.1 cm using Martin metal anthropometer. Body mass was measured with minimal clothing with medical scale (A&D Instruments, Abingdon, UK) to the nearest 0.05 kg. Body mass index (BMI) was calculated as the body mass divided by the square of body height (kg · m⁻²). On the basis of BMI during the T1 assessment, the participants were grouped as normal weight and overweight and obese according to BMI cut-offs by Cole (Cole, Bellizzi, Flegal, & Dietz, 2000) that has been used in previous studies (Gwynn et al., 2010; Slootmaker, Schuit, Chinapaw, Seidell, & Mechelen, 2009). Body fat percent (%) was measured using the DPX-IQ densitometer (Lunar Corp., Madison, WI, USA), with the participant in light clothing and arms at both sides. The devise was calibrated accordingly to the suggestions of the manufacturer and was run in medium scan mode. The biological age of the participants was assessed according to the self-assessment using illustrated questionnaire of the pubertal stage according Tanner classification method (Marshall & Tanner, 1970). The evaluation of pubic hair was used.

Objective measurement of PA

At T1, T2 and T3 data collection, objectively measured PA was assessed by accelerometer (GT1M ActiGraph, Monrovia, CA, USA). The accelerometer has been previously validated in laboratory and free-living conditions in young people (Freedson, Pober, & Janz, 2005; Martinez-Gomez et al., 2012, 2010). The accelerometer is compact, small (3.8 × 3.7 × 1.8 cm) and light-weight (27 g) uniaxial monitor designed to detect vertical accelerations ranging in magnitude from 0.05 to 2.00G’s with a frequency of 0.25–2.50 Hz and converts the signal to numeric values known as activity counts (Boon, Hamlin, Steel, & Ross, 2010; Freedson et al., 2005; Trost, 2010; T. Rääsk et al. 2005 T. Rääsk et al.
We used the same activity categories as previously used in other similar studies (Ekelund et al., 2007; Lätt et al., 2013; Martinez-Gomez et al., 2012, 2010; Nilsson et al., 2009) as sedentary (<100 counts per min), light (>100 counts per min), moderate (>2000 counts per min) and vigorous PA (>4000 counts per min). Additionally, moderate to vigorous physical activity (MVPA) was calculated by summing the highest two intensity categories. The participants were asked to wear accelerometer always on the right hip with adjustable elastic belt for 7 consecutive days during the waking hours, except during water and bathing activities. The participants received the accelerometer together with the written and verbal instructions and practical demonstration on how to wear accelerometer. The accelerometer was programmed to record the activity counts in 15-s epochs and non-wearing time was defined as ≥20 consecutive minutes of zero counts and this time was not included in the analysis. The recorded PA data were included for further analyses if the participant had accumulated the minimum of 8-h of activity data per day for at least 3 valid days (Corder et al., 2010; Martinez-Gomez et al., 2010). Raw 7 day accelerometer data were downloaded into the ActiLife (light version 5.3.0) computer software for determination of activity counts and then imported to R (version 2.15.1) for analysis.

The seasonal effects on PA were minimised in the current study because the follow-up assessments were carried out during the same time of the year as in T1; the effect of measurement time was not significant in any of the statistical models presented below.

**Subjective measurement of PA**

At T1, T2 and T3 data collection, the subjective reports of PA were obtained using a questionnaire that has been previously used in Estonian Children Personality Behaviour and Health Study (ECPBHS) (Harro et al., 2009) and in the European Youth Heart Study (EYHS) (Nilsson et al., 2009; Wedderkopp, Froberg, Hansen, Riddoch, & Andersen, 2003). The used PA Questionnaire is a short self-report questionnaire that consisted of 26 questions about the last week PA. Nineteen of the questions were not directly about PA level (e.g. costs of attending the sports club, reasons for missing the physical education classes, does the respondent’s best friend attend to a sports club, etc.). In our study, we used those questions that were directly related to PA; in some cases, information from two or more questions was combined to make up a single variable: (1) Going to school on foot (minutes per week were computed by multiplying two answers: how many days in a typical week did the child go to school by foot, and how many minutes did it take; after this, weekly minutes of going to school and going home from school were added); (2) Sport club minutes per week (computed analogously to item 2); (3) Frequency of PA (how many days in the previous week was the child at least moderately active for at least 30 min); the score ranged from 0 to 7; (4) Frequency of PA yes vs. no (at least 30 min 5 times a week was the child moderately active); (5) Screen time (how many hours a day watching TV or using computer), coded as no time = “1”; less than 1 h = “2”; 2–3 h = “3”; 4–5 h = “4”; more than 6 h = “5”. The questionnaires for children and their parents contained identical questions: the only difference was that the parents’ version was rephrased so that the ratings would still be about the child’s behaviour. At T1, T2 and T3 data collection, the participants filled the self-report questionnaire during a research day but the parents filled the report questionnaire at home and then sent the questionnaire back to the investigators.

**Statistical analysis**

All analyses were made using R version 2.15.1 (R Core Team, 2012). Descriptive statistics of the participants are presented as means ± SD. Differences in mean values were assessed by ANOVA. Statistical significance was set as $P<0.05$. Pearson correlations were used to index tracking: T1–T2, T1–T3 (correlations between T1 and T3), and analogously, T1–T2, and T2–T3. Differences between dependent correlations were assessed using a method developed by Steiger (1980) and implemented by Revelle (2013).

Questionnaire-based MVPA indexes were calculated based on children’s and parental reports as follows. Based on the T2 assessment, objective MVPA scores (logit-transformed proportions) were regressed on the questionnaire variables. Regression weights from two separate analyses (children and parents) were averaged, and these averaged weights were used to compute MVPA indexes in T1, T2 and T3 data collection. The rationale behind using such indices is twofold. First, for comparing objective and subjective assessments of PA, we need to express both in a comparable way, that is, items from the self-report questionnaire need to be combined into a single index. Secondly, the self-report variables had different units (minutes per week, yes/no scale, number of days per week) which could not be combined by just adding all items. Using regression weights, we combined the information from all items, and at the same time made the unit of the resulting index comparable with the objective assessment of MVPA.

**Results**

Descriptive statistics of the participants at T1 (first year), T2 (second year) and T3 (third year) data collection in total sample, normal weight and overweight and obese are shown in Table I. Mean body...
### Table I. Descriptive statistics of the participants.

<table>
<thead>
<tr>
<th></th>
<th>T1</th>
<th>T2</th>
<th>T3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total sample (n = 156)</td>
<td>Normal weight (n = 117)</td>
<td>Overweight and obese (n = 39)</td>
</tr>
<tr>
<td><strong>Age (y)</strong></td>
<td>11.53 ± 0.76</td>
<td>11.56 ± 0.74</td>
<td>11.46 ± 0.85</td>
</tr>
<tr>
<td><strong>Body height (cm)</strong></td>
<td>154.03 ± 8.30</td>
<td>152.88 ± 7.39</td>
<td>157.49 ± 8.50</td>
</tr>
<tr>
<td><strong>Body mass (kg)</strong></td>
<td>47.52 ± 14.59</td>
<td>41.30 ± 6.96</td>
<td>66.18 ± 15.63</td>
</tr>
<tr>
<td><strong>BMI (kg · m⁻²)</strong></td>
<td>19.73 ± 4.57</td>
<td>17.53 ± 1.76</td>
<td>26.34 ± 4.02</td>
</tr>
<tr>
<td><strong>Body fat (%)</strong></td>
<td>23.34 ± 11.39</td>
<td>18.20 ± 6.13</td>
<td>38.65 ± 9.55</td>
</tr>
<tr>
<td><strong>Tanner stage</strong></td>
<td>1/2/3/4/5/6 (%)</td>
<td>3/35/55/8/0/0</td>
<td></td>
</tr>
<tr>
<td><strong>Sedentary time</strong></td>
<td>533 ± 74/65 ± 6</td>
<td>530 ± 73/56 ± 7</td>
<td>541 ± 76/66 ± 6</td>
</tr>
<tr>
<td><strong>Light PA (min/d)</strong></td>
<td>221 ± 46/27 ± 5</td>
<td>222 ± 48/27 ± 5</td>
<td>219 ± 41/27 ± 5</td>
</tr>
<tr>
<td><strong>Moderate PA</strong></td>
<td>47 ± 16/6 ± 2</td>
<td>48 ± 16/6 ± 2</td>
<td>45 ± 14/6 ± 2</td>
</tr>
<tr>
<td><strong>Vigorous PA</strong></td>
<td>18 ± 14/2 ± 2</td>
<td>20 ± 15/2 ± 2</td>
<td>12 ± 8/1 ± 1</td>
</tr>
<tr>
<td><strong>MVPA (min/d)</strong></td>
<td>65 ± 28/8 ± 3</td>
<td>68 ± 26/8 ± 3</td>
<td>57 ± 18/7 ± 2</td>
</tr>
<tr>
<td><strong>Total PA</strong></td>
<td>460 ± 145</td>
<td>476 ± 155</td>
<td>412 ± 97</td>
</tr>
<tr>
<td><strong>Valid time (min/d)</strong></td>
<td>819 ± 76</td>
<td>820 ± 75</td>
<td>817 ± 81</td>
</tr>
<tr>
<td><strong>MVPA index</strong></td>
<td>7.6 ± 1</td>
<td>7.6 ± 1</td>
<td>7.5 ± 0.9</td>
</tr>
<tr>
<td><strong>Sport club</strong></td>
<td>223 ± 149</td>
<td>234 ± 148</td>
<td>187 ± 147</td>
</tr>
<tr>
<td><strong>Going to school on</strong></td>
<td>324 ± 324</td>
<td>297 ± 318</td>
<td>407 ± 331</td>
</tr>
<tr>
<td><strong>Frequency of PA (0–7)</strong></td>
<td>3.83 ± 1.37</td>
<td>3.97 ± 1.37</td>
<td>3.38 ± 1.27</td>
</tr>
<tr>
<td><strong>Frequency of PA (yes %)</strong></td>
<td>69 ± 69</td>
<td>69 ± 69</td>
<td>74 ± 74</td>
</tr>
<tr>
<td><strong>Screen time (1–5)</strong></td>
<td>3.14 ± 0.85</td>
<td>3.15 ± 0.84</td>
<td>3.13 ± 0.89</td>
</tr>
<tr>
<td><strong>MVPA index (min/week)</strong></td>
<td>200 ± 153</td>
<td>213 ± 153</td>
<td>162 ± 148</td>
</tr>
<tr>
<td><strong>Going to school on</strong></td>
<td>374 ± 324</td>
<td>349 ± 319</td>
<td>455 ± 330</td>
</tr>
<tr>
<td><strong>Frequency of PA (0–7)</strong></td>
<td>3.95 ± 1.37</td>
<td>4.03 ± 1.39</td>
<td>3.69 ± 1.28</td>
</tr>
<tr>
<td><strong>Frequency of PA (yes %)</strong></td>
<td>62 ± 68</td>
<td>45 ± 45</td>
<td>57 ± 45</td>
</tr>
<tr>
<td><strong>Screen time (1–5)</strong></td>
<td>3.01 ± 0.69</td>
<td>2.95 ± 0.66</td>
<td>3.21 ± 0.73</td>
</tr>
</tbody>
</table>

Note: All values are mean and standard deviation (±SD); BMI – body mass index; MVPA – moderate-to-vigorous physical activity; Normal and overweight and obese was defined by using the BMI cut-off points from Cole et al. (2000); PA – physical activity; T1 – first year; T2 – second year; T3 – third year; 'a' significantly different between T1 and T2 assessed by ANOVA (P < 0.05); 'b' significantly different between T1 and T3 assessed by ANOVA (P < 0.05).
height, body mass and BMI increased and body fat (\%) decreased significantly (\(P < 0.001\)) over two-year period in total sample. Only in overweight/obese boys, there was no change in BMI in 2 years.

Over the 2 years, the sedentary time (\%) increased and light PA, moderate PA and MVPA decreased significantly (\(P < 0.05\)) in total sample as well as in both weight groups. There was an increase in vigorous activity in overweight/obese group when comparing T1 and T2 (on the average, 12 and 16 min, respectively, \(P = 0.04\)), but it appears to have levelled off by T2 (mean = 15). In the overweight/obese group, there was an increase in vigorous activity when comparing T1 with either T2, or T3. (The respective means were 12, 16, and 15 min per day; both \(P < 0.05\) using paired \(t\)-test.) The changes in objectively measured PA are shown in Figure 1.

MVPA indexes based on parental questionnaires decreased significantly (\(P < 0.01\)) over 2 year period; the corresponding indexes based on children’s self-report were not significantly different.

Tracking correlations (T1–T3, T1–T2, and T2–T3) in total sample, normal weight and overweight/obese boys of objectively measured PA, questionnaire-based MVPA indexes and body parameters are given in Table II. All tracking correlations were significant (\(P < 0.05\)) in both BMI boys groups, except for the following three correlations in the overweight/obese group: the T1–T2 correlations for untransformed sedentary time, and MVPA index, and the T2–T3 correlation for untransformed minutes of sedentary time. The correlations between proportions of sedentary time tracked better than untransformed minute correlations of sedentary time in both BMI groups (paralleled by a decrease in wearing time in 2 years). On the other hand, untransformed minutes of MVPA tracked better than the proportion of MVPA in both BMI groups.

T1–T3 tracking correlations of BMI and MVPA (logit-transformed proportions) in both BMI boys groups are shown in Figure 2.

The correlations between questionnaire-derived MVPA indexes based on parent reports were higher than those based on boys’ self-reports, in both BMI groups, and for all three intervals (T1–T3, T1–T2, and T2–T3). The 2-year tracking correlation (T1–T3) was also higher for parent-report MVPA index as compared to accelerometer-derived MVPA. (The respective \(r\)’s were 0.58 and 0.47.) The correlations were not different across the BMI groups.

The tracking correlations were, in general, not significantly different across BMI groups. The only cases where differences were found were sedentary time (untransformed minutes) in T1–T2 and T2–T3, and vigorous PA and BMI in T2–T3 (Table II).

**Discussion**

In this study, we found moderate tracking for PA (assessed by accelerometers, or derived from parental or self-report questionnaires) in 12–14-year-old normal weight and overweight or obese pubertal boys. The tracking of PA was not dependent on BMI group, with a few exceptions that may be due to chance. MVPA indexes derived from parental questionnaire tended to track better than both the objectively measured MVPA, and the corresponding index
derived from self-report questionnaire. We also found a decrease in both light and moderate PA and an increase in sedentary time (relative to total wearing time) over the period of 2 years, but a slight increase in vigorous PA in the obese/overweight group.

The finding of moderate tracking is consistent with a number of other studies using either questionnaires (Corder et al., 2010; Telama, 2009) or objective measures (Corder et al., 2010; Kristensen et al., 2008; Nilsson et al., 2009) in this age group.

Some previous studies have shown better tracking for inactivity than for activity (Janz, Dawson, & Mahoney, 2000). In general, this was not confirmed by our study: tracking correlations of sedentary time were similar to those of light, moderate and vigorous PA.

Corder et al. (2010) found greater decline in MVPA in children with higher body fat over 12 month period. In our study, in contrast, we found no differences in tracking of MVPA between the BMI groups. The only interesting difference in tracking between BMI groups was lower tracking of

<table>
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<tr>
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<th>T1 T3</th>
<th>T1 T2</th>
<th>T2 T3</th>
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<tbody>
<tr>
<td></td>
<td>Total sample</td>
<td>Normal weight</td>
<td>Overweight/obese</td>
</tr>
<tr>
<td>Sedentary time</td>
<td>0.54/0.36</td>
<td>0.49/0.36</td>
<td>0.58/0.34</td>
</tr>
<tr>
<td>Light PA</td>
<td>0.57/0.51</td>
<td>0.56/0.51</td>
<td>0.54/0.44</td>
</tr>
<tr>
<td>Moderate PA</td>
<td>0.36/0.38</td>
<td>0.33/0.39</td>
<td>0.39/0.39</td>
</tr>
<tr>
<td>Vigorous PA</td>
<td>0.51/0.62</td>
<td>0.51/0.60</td>
<td>0.42/0.64</td>
</tr>
<tr>
<td>MVPA</td>
<td>0.40/0.47</td>
<td>0.39/0.47</td>
<td>0.37/0.48</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Questionnaire-based MVPA index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children self-report</td>
</tr>
<tr>
<td>0.40</td>
</tr>
<tr>
<td>0.37</td>
</tr>
<tr>
<td>0.50</td>
</tr>
<tr>
<td>0.46</td>
</tr>
<tr>
<td>0.48</td>
</tr>
<tr>
<td>0.30 (n.s)</td>
</tr>
<tr>
<td>Parent report</td>
</tr>
<tr>
<td>0.58</td>
</tr>
<tr>
<td>0.62</td>
</tr>
<tr>
<td>0.46</td>
</tr>
<tr>
<td>0.55</td>
</tr>
<tr>
<td>0.56</td>
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<tr>
<td>0.51</td>
</tr>
</tbody>
</table>

Note: All correlations except the three marked (n.s.) are significant (P < 0.05); BMI – body mass index; MVPA – moderate-to-vigorous physical activity; Normal and overweight & obese was defined by using the BMI cut-points from Cole et al. (2000); PA – physical activity; T1 – first year; T2 – second year; T3 – third year; T1 T3 – correlations between T1 and T3; T1 T2 – correlations between T1 and T2; T2 T3 – correlations between T2 and T3;* = Correlations are significantly different (P < 0.05) between normal weight and overweight and obese groups.

Figure 2. Tracking of body mass index (BMI) (left panel) and moderate to vigorous physical activity (MVPA) (right panel); T1 – first year; T3 – third year.
vigorous activity in obese/overweight group when comparing T2–T3; this result, if not chance finding, may reflect increases in vigorous activity in the overweight boys that were found in our study.

Increases in sedentary time are consistent with earlier findings (Ortega et al., 2013) and may partly reflect increases in screen time that we saw in parental reports, as well as increasing time spent at school.

It is known and discussed previously that objective measurement of PA improves validity and avoids the recall bias associated with self-reported PA data (Nyberg et al., 2009; Telama, 2009). Better validity should, other things being equal, result in better tracking, but this was not seen in our study. In some cases, we even found an opposite pattern of results: the MVPA index derived from parent reports tended to track better than either self-report MVPA index, or objectively measured MVPA. Does this really indicate better validity of parent reports? While in the absence of direct proof, indirect and conjunctival evidence does not support a “yes” answer to this question.

One could imagine questionnaire-based measures as being a summary of a series of observations of behaviour. However, this is not the whole truth: other sources, such as stereotypes and schemas are known to influence both reports about the self and acquaintances. Generalisations about oneself and others can be stored in semantic memory, and accessed directly when responding to a questionnaire, with no need to get any specific behavioural observations involved (Srull & Wyer, 1993). This means that once a parent has got the idea that their child is, say, moderately active, they may respond to even quite specific questions based on just this general idea – leading to good tracking but not necessarily good validity. The same logic applies equally to self-report. It has been shown, though, that in periods of change, people tend to base their answers to generalised questions more on specific behavioural observations (Klein, Babey, & Sherman, 1997): therefore, one might expect better validity from PA questionnaires when the person is experiencing a significant change in their PA.

Objective measures in our study showed a decline in PA, consistent with numerous previous results (Ortega et al., 2013). This was somewhat reflected also in parent report-based MVAP index: there was a 0.3% point decline from T1 to T3, corresponding to an average decline of 2.3 min (0.3/100 * 771). In contrast, the objective measures showed a decline from 65 to 56 min, i.e., approximately 9 min. In sum, the change appears almost 4 times larger when measured by objective methods as opposed to parental questionnaire. In addition, children’s self-reports showed no change in MVPA index over the 2 years. This has important implications for use of questionnaires for indexing PA, especially when one attempts to measure a change.

It has been suggested, that it is important to adjust the tracking correlation for possible confounders (such as wearing time and season) to have higher reliability of the results (Kristensen et al., 2008; Telama, 2009). In our study, the proportion of sedentary time correlation tracked better than the raw (untransformed) minutes of sedentary time correlation, indicating that tracking of sedentary time measured by accelerometer depends on accurate detection of the non-wear time. Studies indicate that seasonal variation affects tracking of PA in pubertal boys (Nyberg et al., 2009; Telama, 2009) with tends to decreases in PA more in winter and in the presence of adverse weather conditions (Dumith et al., 2011; McKee, Murtagh, Boreham, Nevill, & Murphy, 2012). In the current study, season effects were, if anything, minimal because the T1 assessments were during the same season as the T2 and T3 assessments and the effect of measurement time was not significant.

One of the confounding factors in studies like this might be the body mass. The tracking of body parameters (body height, body weight, BMI and body fat per cent) was high over 1 and 2 years in pubertal boys indicating that individual changes in body composition are not significant. It has been reported previously that BMI is moderately stable (r varied from 0.29 to 0.53) over 22 years in males through childhood into adulthood, while subjectively measured PA tracks less well (Herman, Craig, Gauvin, & Katzmarzyk, 2009). Our study showed the body parameters to be fairly stable in 12–14 year pubertal boys in different BMI groups.

Strength of our study is that we used objectively measured PA data, and could compare it to subjective data (children self-report questionnaire and parental questionnaire). Our study had also some limitations that need to be recognised. We used the data from an ongoing longitudinal study; the questionnaire was adopted from a previous study, and was not specially designed to test our hypotheses. A second limitation is that accelerometers cannot detect some activities, such as cycling, rowing, swimming and upper body resistance training, and may have underestimated PA in the participants in this study therefore some amount of MVPA activities could have been lost during the measurement.

Conclusions and implications

Tracking correlations of objectively measured PA and subjectively measured PA were fairly similar across the 12–14-year-old boys weight groups over 2 year period. Tracking correlations of objectively measured PA and subjectively measured PA were
not significantly different over two-year period between both BMI groups. MVPA as assessed by parent reports tended to track better than both objectively measured MVPA and boys’ self-reported MVPA; however, this does not indicate a superior validity of parent reports.

The results of the study show that pubertal boys objectively measured PA decreased over two-year period and so the boys started to be less active in their pubertal period. This change was reflected in parent report, although appearing 4 times smaller than the objective change; on the other hand, children’s self-reports indicated, on the average, no change in MVPA. This makes it problematic to use questionnaires as a measure of change in PA, whether in longitudinal or intervention studies. Even if subjective assessments are validated with reference to objective measures, it has to be demonstrated that the former are sensitive to change. In our study, a significant and relatively large change in MVPA in 2 years was not reflected in boys’ self-reports, and was considerably diminished in parent reports. Therefore, in this age, it is not advisable to use self-reports as a measure of change in PA, and parent reports can only be used as a last resort, and with caution.

Another implication of our study concerns the importance of light PA in characterising the change in PA. In 2 years, the light activity decreased from 221 to 168 min, corresponding to approximately 24% of change. Both in absolute and relative terms, this change is larger than for MVPA, and has obvious implications for energy balance. Moreover, even if an increase in MVPA is achieved with an intervention, it is important to make sure that this is not counterbalanced by a much larger decrease in light activity. This finding is in line with the pivotal role of non-exercise activity thermogenesis in energy balance that is being stressed by several researchers (e.g. Levine, 2007).

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