Physical Activity and 3-Year BMI Change in Overweight and Obese Children

**WHAT’S KNOWN ON THIS SUBJECT:** Effective interventions are still elusive for the large numbers of children affected by overweight/obesity. The value of targeting physical activity (PA) remains unclear because its predictive relationship with improved BMI is still surprisingly poorly quantified.

**WHAT THIS STUDY ADDS:** In overweight and mildly obese children presenting to primary care, 3-year changes in PA (especially the moderate-vigorous component) predicted BMI outcomes. However, the effect was small, possibly explaining the disappointing BMI outcomes of brief primary care interventions targeting PA.

**abstract**

**OBJECTIVES:** Targeting physical activity (PA) is a mainstay in obesity treatment, but its BMI benefits are poorly quantified. We studied long-term predictive PA-BMI relationships in overweight/obese children presenting to primary care.

**METHODS:** Three-year follow-up of 182 overweight/obese 5- to 10-year-olds recruited from 45 Melbourne general practices. Predictor: 7-day accelerometry (counts per minute, cpm). Outcomes: change in BMI z score, BMI category, and clinically significant BMI improvement (z score change ≥0.5). Analysis: Linear and logistic regression.

**RESULTS:** Mean (SD) baseline and 3-year BMI z scores were 1.8 (0.6) and 1.8 (0.7), and mean (SD) activity scores 334 (111) and 284 (104) cpm, respectively. Baseline activity did not predict BMI change. However, for every 100 cpm increase in change in activity over 3 years, BMI z score fell by 0.11 (95% confidence interval [CI] 0.03–0.20; P = .006). There were also trends toward greater odds of staying in the same, versus moving to a higher, BMI category (odds ratio 1.85, 95% CI 0.99–3.46) and clinically significant BMI improvement (odds ratio 1.96, 95% CI 0.90–4.27; P = .09). Change in percentage time spent in moderate-vigorous (P = .01), but not sedentary (P = .39) or light (P = .59), activity predicted reduced BMI z score.

**CONCLUSIONS:** Sustained increase in moderate-vigorous PA predicts reducing BMI z score over 3 years in overweight/obese children presenting to primary care. However, the small BMI change associated with even the largest activity changes may explain disappointing BMI outcomes of brief primary care interventions targeting PA.

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**KEY WORDS**
BMI, obesity, child, PA, primary health care, longitudinal studies

**ABBREVIATIONS**
CI—confidence interval
cpm—counts per minute
LEAP2—Live Eat and Play trial
MVPA—moderate-vigorous PA
OR—odds ratio
PA—physical activity

The project was initiated and supervised by Dr Wake with Dr Campbell. Dr Wake and Dr Trinh cowrote the paper, with all authors providing critical contributions to reviewing and editing, as well asapproval of its final version. Ms Gerner was the project manager for the original 12-month LEAP2 trial, which was planned and implemented by Dr Wake with the LEAP2 trial coinvestigators including Dr Ukoumunne. Dr Trinh, Ms Gerner, and Dr Emily Incledon managed the 3-year follow-up and collected the outcomes data. Dr Ukoumunne supervised and finalized Dr Trinh’s analyses. Dr Wake is the guarantor and accepts full responsibility for the conduct of the study, had access to the data, and controlled the decision to publish.

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(Continued on last page)
Childhood obesity is endemic in many countries,1–3 and its long-term health and social consequences urgently demand reduction strategies.4,5 However, slow progress in learning how to effectively prevent6 and treat7 it may reflect fundamental lack of knowledge as to what predicts successful long-term weight loss in children.

Physical activity (PA) has long been integral to a multifaceted approach to childhood obesity, but the extent to which it contributes to changing BMI in obese children remains surprisingly poorly quantified. This may reflect the challenges of PA interventions (the most robust way to quantify a causal association)9 to modify obesity. In the most recent Cochrane review10 of childhood obesity trials, only 5 of 12 PA intervention studies satisfied the quality criteria, that is, randomized controlled trials for children aged <18 years followed for at least 6 months; of these, results were extremely variable, most had null findings, and no conclusive associations could be made.

Longitudinal studies analyzing PA and BMI in obese children could help inform future PA interventions. However, much of the existing longitudinal literature relates to preventing BMI gain across the whole spectrum rather than BMI loss in the overweight and obese subgroups. Furthermore, the subjective methods often used to assess PA impose methodologic heterogeneity and measurement limitations,9 with 12 of 17 longitudinal studies in a recent meta-analysis studying activity and weight change assessing children’s PA by questionnaire only.10 Results also vary according to nature of activity,11 gender,12 and analytic method.13 Thus, a 2011 meta-analysis suggested no prospective association between measured PA and changing fat mass in children, while acknowledging the likely role of substantial study heterogeneity despite stringent steps to minimize impacts of internal and external bias.14

In the face of this conflicting literature, high-quality longitudinal studies examining the size and nature of associations between PA and BMI in overweight and obese children presenting to primary care could inform future interventions focusing on long-term weight loss in this important population. However, we have not been able to locate any such studies. To address this gap, we draw here on an existing community sample of overweight/mildly obese 5- to 10-year-old children15 to determine whether (1) initial PA level and (2) change in PA over a 3-year period predict BMI outcomes broadly relevant to epidemiologic, public health, and clinical perspectives, expressed respectively as

1. reduced BMI z score;
2. increased odds of dropping to a lower BMI category; and/or
3. increased odds of a clinically significant BMI improvement (ie, loss of at least 0.5 BMI z score units).

METHODS
Design and Sample
For this longitudinal study, spanning 3 time points over 3 years, participants were drawn from the second Live Eat and Play randomized trial (LEAP2, ISRCTN52511065). The trial’s design and outcomes are reported elsewhere.15

Briefly, the LEAP2 trial was nested within a large BMI cross-sectional survey in 45 family practices in Melbourne, Australia. From May 2005 to July 2006, all children aged between 5 years and their 10th birthday attending these practices were invited into the BMI survey and became eligible for the trial if overweight/obese by International Obesity TaskForce cutpoints.16 Children receiving an ongoing weight-management program or with BMI z score >3.0 were excluded, on the basis that a brief secondary prevention approach would be inappropriate; 3958 children were surveyed, 781 were eligible, and 258 were recruited to the trial. The trial’s brief parent-focused behavioral intervention focused on sustainable changes in nutrition and/or PA but, although acceptable and fully implemented, did not improve BMI trajectories, dietary intake, or PA outcomes relative to controls over the course of a year.15

We report here on the natural history of PA and BMI over 3 years, combining intervention and control groups into a single longitudinal cohort as the 2 groups were similar throughout (nonetheless, treatment status was assessed as a potential covariate in the multivariate model; see Analysis). Objective PA, our key predictor, was measured for the first time 6 months after the trial commenced, which thus comprises the baseline time point for this article. Additional follow-up occurred 6 months and 3 years later (ie, 1 and 3.5 years after trial entry, respectively). As at the earlier follow-up, the original intervention and control groups were similar at the end of this period, with mean (SD) BMI z scores of 1.9 (0.7) and 1.8 (0.6), respectively, and adjusted mean difference of 0.04 (95% confidence interval [CI] –0.11 to 0.11, \( P = .61 \)).

Procedures
At every time point, researchers blind to group allocation saw the child at Melbourne’s Royal Children’s Hospital or at the family home, after a mailed parent questionnaire. Over 30 minutes, the researcher administered a questionnaire to the child, recorded child and parent anthropometric measurements, and fitted an accelerometer that parents returned via prepaid registered post. This study was approved by the hospital’s Ethics in Human Research Committee (EHRC 25006). Parents provided
written consent at the start of the study and at the 3-year follow-up.

**Measures**

**Outcome**

Children were measured by trained researchers at each time point (and by trained practice staff at trial entry) using standard protocols. Weight was measured once in light clothing to the nearest 100 g using digital scales (Tanita Model THD-646, Tokyo, Japan), and height was measured twice to the nearest 0.1 cm using a portable rigid stadiometer (Invicta Model IPO955, Oadby, United Kingdom). Height measurements were averaged unless they differed by \( \geq 0.5 \) cm (\( \sim 10\% \) of instances), when a third was taken and the mean of the closest 2 values used.

Change in BMI was quantified by using 3 outcomes, relevant to epidemiologic, public health and clinical perspectives, respectively. First, BMI (kg/m\(^2\)) was converted to age- and gender-standardized z scores, using the 1990 UK Growth Reference.\(^{17}\) Second, we classified participants as nonoverweight, overweight, or obese according to International Obesity TaskForce BMI cutpoints\(^{16}\) and, from this, derived a multinomial outcome of change in BMI status with 3 categories: increased by at least 1 BMI category, stayed in same category, or decreased by at least 1 category. Finally, clinically significant BMI improvement, a binary outcome, was defined as a \( \geq 0.5 \) SD unit decrease in BMI z score.\(^{18}\)

**Predictors**

PA was measured at all 3 time points by multiaxial Actical accelerometers (Mini Mitter; Bend, Oregon), with epoch length set to 60 seconds. Participants were asked to wear the accelerometer for 7 full days. The minimum data requirement for analysis was \( \geq 5 \) “valid days,” with a valid day having \( \geq 10 \) hours of nonmissing data between 6 AM and 11 PM. Missing data were defined as segments with \( \geq 20 \) minutes of consecutive “0” counts, or counts \( > 0 \) that were constant for \( \geq 10 \) minutes. Day 1 data were deleted to minimize the potential effect of children’s initial activity being influenced by awareness of the monitor. We expressed PA as mean activity in counts per minute (cpm) and, using Puyau’s thresholds,\(^{19}\) percentage time spent in each of sedentary (\( < 100 \) cpm), light (100–899 cpm), and moderate-vigorous (\( \geq 900 \) cpm) PA (MVPA). Change in PA was calculated by subtracting baseline from outcome PA in cpm.

Confounders comprised parent BMI (self-reported; measured if available), education (did not complete school, completed school, degree), and country of birth (born in Australia or not). As a proxy for neighborhood socioeconomic status, we used the 2001 census-derived Australian SocioEconomic Indexes for Areas disadvantage quintile\(^{20}\) for the child’s postal code.

**Analysis**

We used regression models to describe the relationship of (1) PA and (2) change in BMI.
in PA (both in cpm) with each of the 3 BMI change outcomes. Separate models were fitted to examine change over each of 3 periods: baseline to 3 years (main analysis), and baseline to 6 months and 6 months to 3 years (secondary analyses). In each regression model, the initial level of PA or change in PA were used to predict change in BMI in the same period. Linear, multinomial logistic, and logistic regression were used for change in BMI z score, change in BMI category (reference: increasing BMI category), and the binary outcome clinically significant reduction in BMI z score, respectively. All regression coefficients and odds ratios (ORs) presented are the changes in the BMI outcomes per 100 cpm increase in the change in activity level during the period of interest (because an increase of 1 cpm is negligible).

Crude analyses used only the activity variables as predictors. For multivariable analyses, we also adjusted for trial arm status and the potential confounders, with the exception of the change in BMI category for which age was the only included confounder, because <30 subjects were in the increasing BMI outcome category. A rule of thumb for multinomial and logistic regression is that there should be at least 10 participants per predictor in the smallest outcome category to obtain valid estimates of standard error (SE).21

Finally, in post hoc analyses, linear regression was used to examine the relationship of change in BMI z score outcomes between baseline and 3 years with percentage of time spent in each of sedentary, light PA, and MVPA. Both the initial percentage of time and change in the percentage of time spent in a particular type of activity were used as predictors. The regression coefficients presented are the changes in the BMI z score (mean increase) corresponding to an absolute increase of 10 percentage points in the specified activity intensity. Again, we rescaled the predictor in this manner because a difference of 1 percentage point is negligible.

All analyses were carried out by using Stata 11 software.22

RESULTS

Figure 1 shows the participant flow through the LEAP2 trial and follow-up study, based on the CONSORT flowchart.23 Anthropometry data were collected from 250 of the 258 trial participants (96.9%) at baseline, 242 (93.8%) at 6 months, and 182 (70.5%) at 3 years, of whom 231, 201, and 126, respectively, had both BMI and usable accelerometry data.

Table 1 shows the baseline characteristics of those lost and retained at the

**TABLE 1** Baseline Characteristics for Those Retained and Lost to Follow-up at 3 Years for the Whole Sample and the Accelerometer Subsample

<table>
<thead>
<tr>
<th>Baseline Variable</th>
<th>Whole Sample</th>
<th>Accelerometer Samplea</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Retained</td>
<td>Not Retained</td>
</tr>
<tr>
<td></td>
<td>n = 182</td>
<td>n = 76</td>
</tr>
<tr>
<td>Child</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male gender, %</td>
<td>40.7</td>
<td>36.8</td>
</tr>
<tr>
<td>Age (y), mean (SD)</td>
<td>7.4 (1.4)</td>
<td>7.7 (1.4)</td>
</tr>
<tr>
<td>BMI status, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight</td>
<td>76.9</td>
<td>75.0</td>
</tr>
<tr>
<td>Obese</td>
<td>23.1</td>
<td>25.0</td>
</tr>
<tr>
<td>BMI z score, mean (SD)</td>
<td>1.9 (0.5)</td>
<td>1.9 (0.5)</td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (years), mean (sd)</td>
<td>39.4 (4.9)</td>
<td>39.5 (4.6)</td>
</tr>
<tr>
<td>Born in Australia, %</td>
<td>72.0</td>
<td>65.3</td>
</tr>
<tr>
<td>BMI, mean (sd)</td>
<td>27.3 (5.4)</td>
<td>26.1 (5.6)</td>
</tr>
<tr>
<td>Education, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Didn’t complete school</td>
<td>30.3</td>
<td>37.0</td>
</tr>
<tr>
<td>Completed high school</td>
<td>33.7</td>
<td>34.2</td>
</tr>
<tr>
<td>Degree</td>
<td>36.0</td>
<td>28.8</td>
</tr>
<tr>
<td>SEIFA disadvantage quintile, %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (most disadvantaged)</td>
<td>21.4</td>
<td>25.0</td>
</tr>
<tr>
<td>2</td>
<td>15.4</td>
<td>22.4</td>
</tr>
<tr>
<td>3</td>
<td>20.9</td>
<td>23.7</td>
</tr>
<tr>
<td>4</td>
<td>20.9</td>
<td>13.2</td>
</tr>
<tr>
<td>5 (least disadvantaged)</td>
<td>21.4</td>
<td>15.8</td>
</tr>
</tbody>
</table>

Sample size in retained whole sample group ranges from 170 to 182; in not retained whole sample group, from 73 to 76; in retained accelerometer sample group, from 119 to 126; and in not retained accelerometer sample group, from 125 to 132. SEIFA = SocioEconomic Indexes for Area.

a Sample size determined by those children who had valid accelerometer readings at 3-y follow-up.

b Based on cutpoints of International Obesity Taskforce.

**TABLE 2** Child PA and Anthropometry Measures at Each Time Point

<table>
<thead>
<tr>
<th>Measure, All Mean (SD)</th>
<th>Time Points</th>
<th>Baseline (0 mo)</th>
<th>6 mo</th>
<th>3 y</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Value</td>
<td>n Value</td>
<td>n Value</td>
<td>n Value</td>
</tr>
<tr>
<td>PA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counts/min</td>
<td>231</td>
<td>334 (111)</td>
<td>201</td>
<td>339 (134)</td>
</tr>
<tr>
<td>% Time in intensitiesa</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary activity</td>
<td>231</td>
<td>45.8 (7.3)</td>
<td>201</td>
<td>45.1 (8.8)</td>
</tr>
<tr>
<td>Light activity</td>
<td>231</td>
<td>38.5 (5.0)</td>
<td>201</td>
<td>39.2 (6.0)</td>
</tr>
<tr>
<td>MVPA</td>
<td>231</td>
<td>15.7 (5.0)</td>
<td>201</td>
<td>15.7 (5.7)</td>
</tr>
<tr>
<td>Anthropometry</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI z score</td>
<td>250</td>
<td>1.8 (0.6)</td>
<td>242</td>
<td>1.8 (0.6)</td>
</tr>
</tbody>
</table>

Sample size in retained whole sample group ranges from 170 to 182; in not retained whole sample group, from 73 to 76; in retained accelerometer sample group, from 119 to 126; and in not retained accelerometer sample group, from 125 to 132. SEIFA = SocioEconomic Indexes for Area.

a Intensities based on Puyau’s thresholds19: sedentary (<100 cpm), light PA (100–899 cpm), and MVPA (≥900 cpm).
3-year follow-up. Those retained were broadly similar to those lost to follow-up, although children retained in the accelerometer sample were slightly younger and had lower BMI z score.

Table 2 summarizes the anthropometric and PA variables for the whole cohort at each follow-up, and Table 3 summarizes the changes in these variables between time points. Among those providing anthropometric data at baseline and 3 years, the mean PA dropped by 54 cpm. Although mean BMI z score changed by only 0.006 over the 3-year period, there was considerable variability across participants, ranging from a fall in BMI z score of 1.2 to an increase of 1.4; 19% moved to a lower BMI category, with 10% achieving a clinically significant BMI z score improvement of ≥0.5.

There was little evidence that the initial level of PA at the start of each period was associated with subsequent change in the BMI-related outcomes (data not presented in tables). For example, between baseline and 3 years, adjusted analyses demonstrated that baseline PA did not predict a change in BMI z score (regression coefficient = 0.02; 95% CI: −0.04 to 0.09; P = .48), a change in BMI category (OR = 0.70; 95% CI: 0.43–1.13; P = .15), or a clinically significant BMI improvement of ≥0.5 z score18 (OR = 1.04; 95% CI: 0.63–1.72; P = .87). The remainder of this section therefore focuses on the relationship between change in PA and change in BMI in the corresponding period.

Table 4 shows evidence that, unlike baseline PA, change in PA between baseline and 3 years is associated with BMI change. The adjusted regression coefficient indicates that an increase of 100 cpm in change in PA between baseline and 3 years corresponds to a fall of 0.11 (95% CI 0.03–0.20, P = .006) BMI z score units. Evidence that change in PA predicted the 2 categorical outcomes was consistent with these findings but more marginal. Thus, the OR for staying in the same, as opposed to moving to a higher, BMI category with increasing change in PA was 1.85 (95% CI 0.99–3.46). The OR for achieving a clinically significant BMI improvement18 was 1.96 (95% CI 0.90–4.27, P = .09) for every

<table>
<thead>
<tr>
<th>TABLE 3 PA and Anthropometry Outcome Change Between Time Points</th>
</tr>
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<tbody>
<tr>
<td>Outcome</td>
</tr>
<tr>
<td>PA</td>
</tr>
<tr>
<td>% time in intensities</td>
</tr>
<tr>
<td>Sedentary</td>
</tr>
<tr>
<td>Light PA</td>
</tr>
<tr>
<td>MVPA</td>
</tr>
<tr>
<td>% of time in intensities</td>
</tr>
<tr>
<td>Sedentary</td>
</tr>
<tr>
<td>Light PA</td>
</tr>
<tr>
<td>MVPA</td>
</tr>
<tr>
<td>% change in BMI</td>
</tr>
<tr>
<td>Baseline to 3 y</td>
</tr>
<tr>
<td>Baseline to 6 mo</td>
</tr>
<tr>
<td>6 mo to 3 y</td>
</tr>
</tbody>
</table>

*Regression coefficients (Coeff) and OR correspond to 100 cpm increase in activity.
additional 100 cpm increase in PA between baseline and 3 years.

Similar trends were seen in the same direction as over the baseline-to-3-year period when analyzing change over the shorter baseline-to-6-month and the 6-month-to-3-year periods for all 3 BMI change outcomes (Table 4), although these reached statistical significance at the 5% level only between 6 months and 3 years for change in BMI z score and loss of ≥0.5 BMI z score units.

Because these findings suggest that an increase in PA is associated with improved long-term BMI outcomes, we examined in post hoc analyses the components of PA intensity in relation to change between baseline and 3 years in BMI z score. Table 5 shows that in adjusted analyses, there was evidence that change in percentage of time spent in moderate-vigorous PA (P = .01), but not sedentary (P = .39) or light (P = .59) activity, predicted change in BMI z score, with BMI z score decreasing by 0.24 for every 10 percentage points increase in percentage time spent in MVPA.

**DISCUSSION**

**Principal Findings**

We conclude that a long-term increase in MVPA may improve long-term BMI in overweight and obese primary school-age children presenting to primary care. Although this finding is novel in children, it is supported by recently reported adult simulation studies and by both school-based trials and observational clinical follow-up studies in which only prolonged intervention over 1 to 2 years were successful. However, the long-term reductions in absolute BMI were small even with the largest increases in observed PA.

**Interpretation in Light of Other Studies**

Given the current research interest in incidental, light PA, it is also intriguing that improvements in BMI were most strongly associated with changes in MVPA, rather than sedentary or light PA. This is supported by Kriemler’s recent yearlong trial of a daily school-based universal PA program that successfully reduced BMI gain in Grades 1 and 5 children via an increase in total daily MVPA, but not light, PA. It may also explain why the Scottish Childhood Overweight Treatment Trial (SCOTT) randomized trial targeting obese 5- to 11-year-olds did not reduce BMI gain, despite successfully increasing total PA via increasing the light (but not moderate or vigorous) component of PA.

There was little evidence that levels of baseline PA level alone were associated with subsequent BMI change. We are confident in this finding, given our objective measurement of PA, the similar findings for both of the shorter periods, and the study’s congruence with accelerometer-based findings in a population sample of similarly aged children. This conclusion seems more robust than the studies that do report associations because the latter have mainly measured PA by questionnaire. Although it has been suggested that lack of associations between baseline activity and subsequent BMI could be explained by reverse causation (ie, it is BMI that determines PA), these null findings seem predictable to us given the exquisite day-to-day homeostatic balance between energy input and output in all but the most rapid states of BMI change. In other words, one would not expect PA at any 1 time point to predict weight change.

Similarly, we cannot exclude the possibility that improved BMI led to the sustained increase in PA, rather than the other way round. Although it has been suggested that reverse causality could also explain the reported lack of efficacy of trials targeting PA to reduce childhood obesity, it seems more likely that this inefficacy is due to the generally short and/or low-intensity nature of most interventions. Nonetheless, weight loss itself may well enhance PA, and bidirectional influences seem likely.

Strengths of the study include its repeated, prospective, objective measures of both PA and BMI over a prolonged period in a community-based overweight sample recruited through primary care, so that our results could be relevant to policymakers, public health advocates, and clinicians in many countries. The prolonged follow-up is a particular strength in a field that systematic reviews show is dominated by short follow-up and evidence of attenuation of effect by 12 months in virtually all intervention trials. It supports, but goes well beyond, a recent study in obese Hispanic adolescents.
showing that BMI improvement is predicted by changes in, but not initial, PA levels in the short-term (6 months). Limitations include our relatively small sample size, resulting in wide confidence intervals for some ORs because of the small numbers of children who were able to decrease a BMI category or achieve clinically significant weight loss. Confirming these findings would require a larger sample size or pooling data across studies. Nonetheless, with >100 children, this study compares favorably to the sample sizes ranging from 39 to 138 in Wilks’s recent systematic review of associations between PA and adiposity. Two possible threats to internal validity (the original randomized trial design and attrition) seem unlikely to have altered our conclusions because we adjusted in analyses for the low-intensity intervention and, despite a slightly greater loss of obese children and those with less-educated mothers, those lost to follow-up generally resembled those retained. Additionally, we acknowledge that although accelerometry is vastly superior to self-reported PA, limitations remain such as interpreting a zero reading (eg, device removal vs taking a nap). Finally, examination of nutrition was beyond the scope of this study, as were measurements of total energy expenditure and body composition.

CONCLUSIONS
A sustained increase in PA, especially the moderate-vigorous component, predicts reduced BMI z score over a 3-year follow-up period in overweight/obese children presenting to primary care. However, the small BMI change associated with even the largest changes in PA may explain why so many randomized trials of brief primary care interventions targeting PA have had disappointing BMI outcomes. Multilevel and multisectoral efforts are likely to be needed to increase children’s endemically low levels of PA to the point that it can become a route to a healthier-weight population.

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REFERENCES
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<table>
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Andrew Trinh, Michele Campbell, Obioha C. Ukoumunne, Bibi Gerner and Melissa Wake

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