The effect of an emerging school playground strategy to encourage children's physical activity: the Accelerometer Intensities from Movable Playground and Lunchtime Activities in Youth (AİM-PLAY) study

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Abstract  
An emerging strategy to enhance school children’s opportunities for unstructured physical activity opportunities is to implement diverse materials within school playgrounds during school break periods. The aim of this study was to evaluate the effects of a movable/recycled materials playground intervention on elementary school children’s individually measured physical activity intensities and sedentary behavior. The Accelerometer Intensities from Movable Playground and Lunchtime Activities in Youth (AIM-PLAY) study consisted of a movable/recycled materials intervention that included baseline, a 7-week post-test and an 8-month follow-up data collection phase. Children within an intervention school (n = 54) and a matched control school (n = 79) aged 5-to-12-years-old participated in the AIM-PLAY study. Children’s proportion of lunch breaks spent in each physical activity intensity, counts per minute (CPM) and sedentary behavior were measured using accelerometers. A multilevel mixed effect linear regression model was applied using STATA (version 12.0) using the xtmixed command to fit linear mixed models for each of the variables. It was revealed that children in the intervention elementary school spent a significantly greater proportion of lunch breaks in moderate and moderate-vigorous physical activity (MVPA) and less proportion in sedentary behavior at post-test (7-weeks) and follow-up (8-months) than children in the control elementary school. The AIM-PLAY study findings suggest that the introduction of movable/recycled materials can have a significant, positive long-term intervention effect on children’s engagement in higher intensity physical activity during school lunch breaks.

Keywords: physical activity, elementary school, intervention, lunchtime, children, recess, school playground
**Introduction**

A widespread public health priority to enhance health worldwide and to alleviate chronic diseases such as obesity, type two diabetes, osteoporosis and cardiovascular disease is to promote physical activity (WHO 2015). In Australia, 81% of children are not meeting national guidelines for physical activity (Active Healthy Kids Australia, 2014). Despite childhood being a vital period to develop regular physical activity habits, strategies to increase and maintain the physical activity participation of school children requires further attention (Hyndman, 2015).

The implementation of strategies within school break periods (e.g. morning recess, lunchtime recess) is an area of school-based physical activity research which continues to grow (Hyndman and Lester 2015). Children can have restricted opportunities to engage in physical activity beyond the ‘critical window’ of school breaks (Ridgers et al. 2010, Ridgers et al. 2012, Stanley et al. 2012, Stanley et al. 2014), therefore providing physical activity opportunities in the school playground during break periods that can be reproduced within community settings is important (Bundy et al. 2011). Developmental opportunities such as physical activity within the school playground during break periods have been suggested to be part of a ‘hidden curriculum’ (Hyndman, Telford, Finch and Benson 2012), resulting in international objectives to improve children’s opportunities for play development in schools. The United Nations High Commission for Human Rights outlines that active play is a fundamental entitlement for every child (Office of the United Nations 1989). Children’s physical activity opportunities within the school playground during breaks periods via active play require little adult intervention or burden from supervision, instruction or organisation demands. Children in many schools can have access to physical activity within the school playground during break periods on hundreds of occasions each year (Stratton 2000). Furthermore, physical activity within school playgrounds during break periods has been recognized as the primary source of children’s physical activity (Ridgers et al. 2010, Ridgers et al. 2012, Stanley et al. 2012, Stanley et al. 2014).

Whilst effective school playground strategies during break periods have the potential to significantly enhance children’s physical activity, many Australian schools have experienced the destruction or replacement of playground facilities, possess over-crowded play areas and administer restrictive play policies that can have a negative impact on children’s school physical activity opportunities (Chancellor 2013). Nonetheless, a number of structured school playground physical activity strategies have been implemented (e.g. set time, location and purpose) during break periods to optimize children’s physical activity opportunities such as playground surface markings, fixed playground structures, fitness breaks, weekly physical activity themes, sporting and games equipment and active supervision (Hyndman 2015). Unstructured playground physical activity (e.g. spontaneous physical activity, without a set regime or
purposely) strategies have also been implemented via natural environmental features, play pods and movable/recycled materials that have facilitated physical activity via improvements in choice and diversity to children’s playground physical activity during break periods (Hyndman 2015).

The variety and choice from introducing movable/recycled materials into a school playground is an important consideration for school decision makers (Hyndman 2015). Cost-effective interventions such as movable/recycled materials with no fixed purpose have been recognized as encouraging sustainable school health outcomes that can be translatable to other school settings (Hyndman, Benson and Telford 2014). The introduction of movable/recycled materials has been associated with improvements in urban early childhood participants (5-7 year olds) by increasing levels of playability (Bundy et al. 2008), activity intensities (Bundy et al. 2009, Engelen et al. 2013) and teacher-reported cognitive and social skills (Bundy et al. 2009). Significant long-term physical activity effects have also been reported from introducing such materials on children’s steps and distance accumulated (via pedometers) and direct observation across all elementary school year levels (5-13 years; Hyndman et al. 2014). Additionally, short-term effects from introducing movable/recycled materials on children’s physical health-related quality of life and enjoyment of active play activities in 8-13 year olds have been reported (Hyndman et al. 2014). Such findings suggest that the use of movable/recycled materials could revolutionize children’s school playground opportunities for creative and diverse play (Hyndman, Benson, and Telford 2014).

Despite the positive findings and previous measurement of early childhood participants’ physical activity intensities (Bundy et al. 2009, Engelen et al 2013), there is an absence of literature reporting on the effects of movable/recycled school playground materials on the proportion of lunch break time 5-12 year old elementary school children spend in each physical activity intensity (light, moderate, hard, very hard) and sedentary behavior within a regional setting. There is also an important need to increase our understanding of longer-term effects of school physical activity interventions (Kriemler et al. 2011). The Accelerometer Intensities from Movable Playground and Lunchtime Activities in Youth (AIM-PLAY) study builds upon previous studies (Bundy et al. 2009, Bundy et al. 2011, Hyndman et al. 2014) to examine the effects of introducing movable/recycled materials on the proportion of lunch breaks elementary school children spent in each physical activity intensity, counts per minute (CPM) and sedentary behavior within a regional Australian setting. It was hypothesized that children within the AIM-PLAY study intervention school would spend a greater proportion of school lunch breaks in higher intensity physical activity and a lower proportion of school lunch breaks in sedentary behavior compared to children in a matched control school throughout a school year.
Methods

Recruitment
A newly built catholic co-educational elementary school with an absence of fixed playground facilities was approached to participate in the AIM-PLAY study. A control school matched by enrolment, size (m²), socio-economic status, geographical area (Regional Western Victoria, Australia) and school type (5-12 years old; co-education, prep to year 6), was approached to participate, via phone, email and on-site correspondence with the Principal. All children in the AIM-PLAY study continued to participate in their normal school routines. Baseline data collection was conducted between March and April 2010 (Autumn in the southern hemisphere), post-test data were collected 7-weeks after baseline between April and June 2010 (Autumn/Winter in southern hemisphere) and follow-up data were collected 8-months after baseline in November 2010 (Spring in the southern hemisphere).

All children aged 5-12 years old received a plain language statement outlining the research, along with a participant and parental consent form. A total of 123 children from the intervention school (response rate: 90%; males: 54%; mean age: 7.0) and 152 children from the control school (response rate: 86%; males: 46.7%; mean age: 8.2) returned signed informed parental consent forms to participate in the AIM-PLAY study. The schools recruited within Hyndman and colleagues’ (2014) study that measured pedometer steps/distance, direct observation, enjoyment and quality of life outcomes were used within the AIM-PLAY study. The present study builds upon this previous investigation by examining the effects of movable/recycled materials on further variables; including the proportion of lunch breaks children spend in each physical activity intensity, counts per minute (CPM) and sedentary behavior, individually and objectively measured by accelerometers. From the total pool of participants, children were randomly selected to wear an accelerometer motion sensor at the intervention elementary school (n=54; males: 59.3%; mean age: 6.4) and at the control elementary school (n=79; males: 51.3%; mean age: 7.5). Due to the expenses and accessibility of obtaining accelerometer motion sensors (Dollman et al. 2009), not all originally consenting participants were able to participate in the AIM-PLAY study. Ethical approval for the study was obtained from the University Human Research Ethics Committee, the Catholic Education Office of the Archdiocese of Ballarat and permission was obtained from the school principal.

Intervention elementary school playground environment
The intervention consisted of introducing movable/recycled materials with no fixed purpose on a grass field within an independent elementary school on a newly developed campus. The intervention elementary school had an absence of fixed playground equipment and the children were provided
with school break periods for 30 minutes (morning recess) and 30 minutes (lunchtime recess). The movable/recycled materials were introduced during 2010 from the end of term one to the middle of term two, post-testing was conducted seven weeks after the intervention commenced and additional items were introduced up until 13-weeks after the intervention commenced (Autumn/Winter). The movable/recycled materials were made available to the children beyond the initial 13-week introduction. The grass field where the movable/recycled materials were implemented was 6,094m$^2$ and there was also a hard surfaced play area external to the grass field measuring 530m$^2$.

Introduced movable/recycled materials were generally not considered traditional school playground materials for students (Figure 1). Examples of the movable/recycled materials included buckets, cardboard boxes, hay bales (Figure 2), swimming noodles, milk crates and tyre tubes. In addition to these materials, an assortment of play balls, hula hoops and skipping ropes were also added during the intervention. Five materials were implemented week one and each week thereafter at least two types of materials were introduced throughout the intervention period. Movable/recycled materials were implemented for children to play with in the school playground and normal playground supervision duties were undertaken by the teachers by two teachers at all times (one located on the grass field and another on the hard surfaced play area). The average (SD) maximum temperatures at the intervention school were 23.25 (±4.68°C, baseline), 14.88 (±2.06°C, post-test) and 21.36 (±4.83°C, follow-up) respectively.

![Figure 1. A snapshot of the school playground after the movable/recycled materials were introduced.](image)
Control elementary school playground environment
The control elementary school had no access to movable/recycled materials being used within the intervention school and were provided with school break periods for 15 minutes (morning recess) and 45 minutes (lunchtime recess). Sports equipment access was provided by the school (usual practice in many Australian elementary schools) for use on the grass field and hard-surfaced playground areas during break periods. The control elementary school’s playground area included a 700m$^2$ hard-surfaced area that was positioned next to the school buildings at the front of the school and consisted of sets of playground markings (for down-ball and hopscotch style activities). Also at the front of the school next to the hard-surfaced area was a 100m$^2$ area of rock gardens and a 349m$^2$ area of built playgrounds with wooden walkways, climbing structures, monkey bar frames, climbing ladders and slides. Connecting the front of the control elementary school to the grass field (5250m$^2$) at the bottom of the school was a 23m walkway.

The control elementary school’s grass field consisted of a set of soccer and Australian football goals which were bordered by a line of tall trees, a rope climbing playground structure and large sandpit. Beyond the control school’s grass field was a 1224m$^2$ basketball court area. Playground supervision during lunch breaks consisted of two teachers at all times (one teacher supervising the bottom area of the control elementary school; the other teacher supervising the front area of the control elementary school). Children in the control elementary school continued to play with their usual sports equipment (e.g. cricket bats, basketballs, soccer balls), fixed playground facilities and teacher supervision remained the same. The average (SD) maximum temperatures at the control school were 22.86 (±5.96°C, baseline), 12.76 (±2.37°C, post-test) and 16.54 (±3.92°C, follow-up) respectively.
**Accelerometers**

The Actigraph™ GT1M uni-aixal accelerometers (Actigraph, Pensacola, Florida) were used with a sub-sample of 5-12 year old children to assess the intensity of children’s physical activity during school lunch breaks. The accelerations were filtered, converted to a numerical value and movement counts were summed over the lunchtime break interval (Pulsford et al. 2011). The epoch for accelerometer measurement was set to five seconds within this study to capture the sporadic nature of children’s physical activity movement (Nilsson, Ekelund, and Sjostrum 2002) during the lunchtime break periods. The Actigraph™ accelerometer has been shown to be a valid and reliable method of assessing children’s physical activity in comparison to heart rate monitoring, calorimetry, and doubly labelled water techniques (Loprinzi and Cardinal 2011).

Each Actigraph™ monitor was initialized before use and data uploaded with the Actilife™ software (version 4.3.0). Before initialisation the accelerometers were fully charged by a standard USB port connection. The start time was set to just before the school lunch breaks when the devices would be handed out to children and a stop time wasn’t selected. The investigators and research assistants distributed the accelerometers to the children participating in the AIM-PLAY study prior to school lunch breaks. The accelerometers were worn for a minimum of three school lunch breaks on consecutive days and children were instructed and assisted with the correct wearing procedure during the baseline phase and reminded of the procedure with an instruction sheet during post and follow-up testing (all data was able to be used from the participants). Accelerometer measurement was conducted in the control school immediately after the intervention school accelerometer data collection had concluded to ensure consistency with weather and timing within the school terms. Teachers were also informed of the wearing procedure and asked to remind children of the wearing procedure each day. The accelerometers were attached to an elastic belt worn over the outside of clothing and on children’s right hip on the iliac bone. Age appropriate Freedson/Trost cut points were applied to the accelerometer data due to a strong agreement with children’s moderate-vigorous physical activity (MVPA). The accelerometer data were scored and interpreted using the MeterPlus™ software (Version 4.3; Santech Inc, La Jolla, CA).

The Freedson/Trost cut points were used to convert raw accelerometer counts into the number of minutes children spent in sedentary (e.g. sitting/standing), light (e.g. strolling, light movements), moderate (e.g. walking), hard (e.g. jogging) and very hard (e.g. sprinting, skipping) physical activity intensities (Trost et al. 2011). Vigorous physical activity (e.g. hard, very hard physical activity intensity) and MVPA (moderate, hard and very hard physical activity intensity) were then able to be determined (Table 1). The MeterPlus™ program allowed batch scoring of data and the exclusion of non-wearing data. In the present AIM-PLAY study non-wearing data were calculated as a time-frame of more than 20
minutes of consecutive zero counts (Stevens et al. 2007). A time-filter was applied to only include data within the school lunch break period of both schools (Intervention school: 12.40PM-1.10PM; Control school: 1.30PM-2.15PM) for the analysis of children’s school lunchtime-specific physical activity.

**Data Analysis**
A multilevel mixed effect linear regression model was applied using STATA (version 12.0) using the `xtmixed` command to fit linear mixed models for accelerometer counts per minute (CPM; accumulated physical activity intensity) and proportions of time during school lunchtime in sedentary, light, moderate, hard, very hard, vigorous and MVPA intensities. The model was used to determine the overall intervention effects on the intervention school compared to the control school for all three time points: baseline (0-weeks), post-test (7-weeks) and follow-up (8-months). As the scores changed with age and sex, the model was adjusted by age and sex. The models were also adjusted by baseline measurements (as a function of the linear regression model). There were no significant moderation effects for age and gender.

**Results**

**Proportion of time children spent during school lunch breaks in each physical activity intensity and sedentary behavior**
At the intervention elementary school, the proportion of school lunch breaks children spent in MVPA increased by 5.68% from baseline to post-test (7-weeks) and increased by 2.06% from baseline to follow-up (8-months; Table 1). The proportion of school lunch breaks children spent in sedentary behavior decreased by 6.85% from baseline to post-test (7-weeks) and decreased by 3.64% from baseline to follow-up (8-months; Table 1).

At the control elementary school, the proportion of school lunch breaks children spent in MVPA increased by 2.09% from baseline to post-test (7-weeks), yet decreased by 3.18% from baseline to follow-up (8-months). The proportion of school lunch breaks control school children spent in sedentary behavior decreased by 1.78% from baseline to post-test (7-weeks) and increased by 4.37% from baseline to follow-up (8-months; Table 1).

After baseline, children in the intervention elementary school spent a significantly lower proportion of time within school playground during lunch breaks engaged in sedentary behavior during post-test (7-weeks; p=0.013) and follow-up (8-months; p=0.005), and a significantly greater proportion of time in moderate physical activity at post-test (7-weeks; p=0.001) and follow-up (8-months; p=0.001) compared to children in the control elementary school (Table 2).
Table 1. Descriptives of children’s participation in physical activity intensities during lunch breaks within the intervention and control elementary schools over the three time points.

<table>
<thead>
<tr>
<th></th>
<th>Intervention elementary school (n=54)</th>
<th>Control elementary school (n=79)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline (0-weeks)</td>
<td>Post-test (7-weeks)</td>
</tr>
<tr>
<td>Proportion of school lunch breaks in each physical activity intensity</td>
<td></td>
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</tr>
<tr>
<td>Mean % (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary</td>
<td>33.13 (14.95)</td>
<td>26.28 (11.53)</td>
</tr>
<tr>
<td>Light</td>
<td>30.11 (9.79)</td>
<td>30.47 (4.80)</td>
</tr>
<tr>
<td>Moderate</td>
<td>22.51 (7.81)</td>
<td>26.43 (6.07)</td>
</tr>
<tr>
<td>Hard</td>
<td>9.07 (5.73)</td>
<td>9.71 (4.56)</td>
</tr>
<tr>
<td>Very Hard</td>
<td>5.17 (6.16)</td>
<td>6.29 (3.95)</td>
</tr>
<tr>
<td>Moderate-vigorous physical activity</td>
<td>36.75 (16.04)</td>
<td>42.43 (12.45)</td>
</tr>
<tr>
<td>Vigorous</td>
<td>14.25 (10.76)</td>
<td>15.97 (10.17)</td>
</tr>
<tr>
<td>Mean (SD)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Counts per minute</td>
<td>1424.06 (478.79)</td>
<td>1645.37 (625.44)</td>
</tr>
</tbody>
</table>

Moderate-vigorous physical activity= Moderate, hard and very hard intensity physical activity; Vigorous physical activity= hard and very hard intensity physical activity; SD= Standard deviation.
Table 2. Multi-level modelling of the proportion of lunch breaks in physical activity intensities in the intervention school compared to the control school over the three time points.

<table>
<thead>
<tr>
<th></th>
<th>Sedentary behavior (SE)</th>
<th>Light physical activity (SE)</th>
<th>Moderate physical activity (SE)</th>
<th>Hard physical activity (SE)</th>
<th>Very hard physical activity (SE)</th>
<th>Moderate-vigorous physical activity (SE)</th>
<th>Vigorous physical activity (SE)</th>
<th>Counts per minute (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed parameters</td>
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<td></td>
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</tr>
<tr>
<td>Intercept</td>
<td>25.88 (2.56)**</td>
<td>32.49 (1.55)**</td>
<td>29.85 (1.55)**</td>
<td>8.14 (0.92)**</td>
<td>5.75 (1.01)**</td>
<td>43.79 (2.87)**</td>
<td>12.63 (2.45)**</td>
<td>922.16 (180.05)**</td>
</tr>
<tr>
<td>School - intervention</td>
<td>7.84 (1.91)**</td>
<td>-3.47 (1.12)**</td>
<td>-5.17 (1.13)**</td>
<td>0.70 (0.62)</td>
<td>-0.73 (0.66)</td>
<td>-5.32 (1.96)</td>
<td>0.60 (1.48)</td>
<td>-3.65 (120.35)</td>
</tr>
<tr>
<td>Gender - male</td>
<td>-8.08 (1.12)*</td>
<td>-1.89 (0.68)**</td>
<td>4.78 (0.68)**</td>
<td>3.33 (0.41)**</td>
<td>1.89 (0.45)**</td>
<td>10.08 (1.27)</td>
<td>5.52 (1.10)**</td>
<td>413.02 (81.82)*</td>
</tr>
<tr>
<td>Age</td>
<td>0.72 (0.29)**</td>
<td>0.29 (0.17)</td>
<td>-0.72 (0.17)**</td>
<td>-0.29 (0.10)**</td>
<td>-0.16 (0.12)</td>
<td>-0.60 (1.48)</td>
<td>-0.31 (0.29)</td>
<td>-14.12 (20.36)</td>
</tr>
<tr>
<td>Time</td>
<td></td>
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<td></td>
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<tr>
<td>Time 2</td>
<td>-1.37 (1.44)</td>
<td>-0.65 (0.83)</td>
<td>-0.41 (0.84)</td>
<td>0.83 (0.43)</td>
<td>1.16 (0.43)**</td>
<td>1.59 (1.37)</td>
<td>2.33 (1.16)*</td>
<td>-18.57 (79.21)</td>
</tr>
<tr>
<td>Time 3</td>
<td>4.26 (1.45)**</td>
<td>-1.13 (0.84)</td>
<td>-2.68 (0.84)**</td>
<td>-1.01 (0.43)*</td>
<td>-0.25 (0.43)</td>
<td>-3.99 (1.38)**</td>
<td>-1.61 (1.16)</td>
<td>329.55 (95.04)**</td>
</tr>
<tr>
<td>Intervention school X Time 2</td>
<td>-5.57 (2.23)*</td>
<td>0.84 (1.29)</td>
<td>4.46 (1.30)**</td>
<td>-0.13 (0.67)</td>
<td>0.04 (0.67)</td>
<td>4.43 (2.13)*</td>
<td>-0.76 (1.82)</td>
<td>546.32 (133.67)**</td>
</tr>
<tr>
<td>Intervention school x Time 3</td>
<td>-6.39 (2.25)**</td>
<td>0.76 (1.30)</td>
<td>4.20 (1.31)**</td>
<td>-0.14 (0.68)</td>
<td>0.79 (0.67)</td>
<td>4.97 (2.14)*</td>
<td>1.52 (1.76)</td>
<td>287.11 (145.69)*</td>
</tr>
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<td>Random parameters</td>
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<tr>
<td>Level 3 (class variance)</td>
<td>0.00 (0.00)</td>
<td>0.04 (0.04)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
<td>0.00 (0.00)</td>
</tr>
<tr>
<td>Level 2 (between children variance)</td>
<td>5.03 (0.71)</td>
<td>3.28 (0.39)</td>
<td>3.29 (0.41)</td>
<td>2.26 (0.20)</td>
<td>2.69 (0.20)</td>
<td>6.97 (0.63)</td>
<td>5.59 (0.57)</td>
<td>470.18 (43.78)</td>
</tr>
<tr>
<td>Level 1 (within children variance)</td>
<td>9.80 (0.39)</td>
<td>5.64 (0.22)</td>
<td>5.68 (0.23)</td>
<td>2.91 (0.12)</td>
<td>2.88 (0.11)</td>
<td>9.22 (0.37)</td>
<td>6.45 (0.35)</td>
<td>685.99 (24.99)</td>
</tr>
</tbody>
</table>

*p<0.05; **p<0.01; Reference categories: Gender – female; Time – Time 1; adjusted for time, school and school X time; SE= Standard Error; Time 2= post-test (7-weeks); Time 3= follow-up (8-months); Moderate-vigorous physical activity= Moderate, hard and very hard intensity physical activity; Vigorous physical activity= hard and very hard intensity physical activity; SE= Standard error.
After baseline, children within the intervention elementary school spent significantly greater proportions of time within school playground during lunch breaks in MVPA at post-test (7-weeks; p=0.037) and follow-up (8-months; p=0.020) compared to children in the control school (Table 2).

Males spent a significantly lower proportion of time within school playgrounds during lunch breaks in sedentary behavior (p<0.001) and light physical activity (p=0.006) and a significantly greater proportion of time in moderate (p<0.001), hard (p<0.001), very hard (p<0.001) and vigorous physical activity (p<0.001) than females (Table 2). As children aged, the proportion of time spent within school playground during lunch breaks in sedentary behavior increased (p=0.013), while the proportion of school lunchtime in moderate (p<0.001) and hard physical activity significantly decreased (p=0.006; Table 2). Males spent significantly greater proportions of time within school playground during lunch breaks in moderate-vigorous physical activity than females (p<0.001; Table 2). As age increased, MVPA significantly decreased (p<0.001; Table 2).

**Accelerometer counts per minute**
Males engaged in greater counts per minute during school lunch breaks than females (Table 2; p<0.001). After baseline, children within the intervention elementary school engaged in significantly greater counts per minute at post-test (7-weeks; p<0.001) and follow-up (8-months; p=0.049) compared to children in the control elementary school compared to baseline (Table 2; Figure 3).

<Insert Figure 3 about here>

**Discussion**
The AIM-PLAY study fills a unique gap within the international literature by examining the effects of introducing movable/recycled materials on the accelerometer-determined (individual) physical activity intensities and sedentary behavior during lunch breaks of 5-12 year old elementary school children within a regional setting. The results revealed that after baseline, the intervention elementary school children spent a significantly lower proportion of school lunch breaks in sedentary behavior during post-test (7-weeks) and follow-up (8-months) and participated in significantly greater proportions of school lunch breaks in moderate intensity physical activity and MVPA at post-test (7-weeks) and follow-up (8-months) compared to the control school. Building upon previous literature (Bundy et al. 2009, Bundy et al. 2011, Engelen et al. 2013, Hyndman et al. 2014), findings over an 8-month period highlight that introducing movable/recycled materials can be a sustainable playground strategy to promote children’s engagement in a greater proportion of school lunchtime in higher physical activity intensities and reduced sedentary behavior. The AIM-PLAY study findings provide further evidence to suggest that interventions should implement movable equipment (e.g. non-fixed playground items) into school playgrounds (Bundy et al. 2009,

Consistent with previous studies (Ridgers et al. 2010, Ridgers et al. 2012, Stanley et al. 2012, Stanley et al. 2014), children within the AIM-PLAY study were recorded as spending up to 50% of school lunch breaks engaged in MVPA. In addition, the intervention school children’s overall average percentage in MVPA within the school playground during lunch breaks was approximately 40% after the movable/recycled materials were introduced. These results are highly encouraging, as children’s engagement in MVPA is important to meet recommended physical activity guidelines (Department of Health and Ageing, 2014). As these measurements were undertaken during only school lunch breaks, there is strong potential for children to reach the recommended physical activity guidelines of one hour of MVPA per day by using the movable/recycled materials to participate in physical activity during multiple school break periods (e.g. including both morning and afternoon recess). The proportion of school lunch breaks children spent in MVPA also increased by 5.68% from baseline to post-test (7-weeks) and increased by 2.06% from baseline to follow-up (8-months) to demonstrate the positive long-term effects from introducing movable/recycled materials. A similar finding was revealed for the proportion of school lunch breaks intervention school children spent in sedentary behavior by decreasing by 6.85% from baseline to post-test (7-weeks) and by 3.64% from baseline to follow-up (8-months).

Although the physical activity intensity gains seemed to decrease slightly at 8-months, previous area-level direct observation research has reported that positive physical activity benefits from the introduction of movable/recycled materials can be sustained over a 2 ½ year period (Hyndman, Benson, and Telford, 2014). Within early childhood participants, there has also been encouraging results of sustained physical activity over after two years (Englen et al. 2013). As slight declines in lunchtime physical activity intensity can occur over the long-term from school playground interventions (Ridgers et al. 2010), the introduction of movable/recycled materials beyond the initial intervention period could be considered by schools to continue to improve physical activity intensity levels. Children are suggested to enjoy having choice and variety in their school playground activities (Hyndman et al. 2012) and implementing an intervention with a diverse range of equipment may have assisted in such positive physical activity intensity outcomes during lunch breaks.

Similar to previous studies in early childhood participants (Bundy et al. 2008, Bundy et al. 2009, Engelen et al. 2013) and studies across all elementary year levels examining other physical activity outcomes (e.g. pedometers and area-level direct observation; Hyndman et al. 2014), having a diversity of items introduced that could be moved, used and placed where the children desired improved the proportion of school
lunchtime in higher physical activity intensity and reduced sedentary behavior within the intervention elementary school children. The AIM-PLAY study was also able to show that the effects of the movable/recycled materials intervention on physical activity intensities and sedentary behavior could be sustained over 8-months above baseline levels and be significantly higher in comparison to a matched control school. Although children can convert many school areas into physical activity spaces (Hyndman et al. 2012), the quality of physical activity opportunities determines how successful the environment will be to improve school children’s health behaviors (Hyndman et al. 2013). There are many benefits of offering children with varying interests and abilities a diverse range of opportunities to engage in physical activity with movable/recycled materials. Movable/recycled materials are a cost-effective option for schools and are readily available for physical skills and activity to be replicated within the home and community settings (Bundy et al. 2009), an important outcome for educators (Pangrazi and Beighle 2010).

As the movable/recycled materials within the AIM-PLAY study could be moved to different spaces within the school playground, the mobility of the items may also have ensured children used the spaces to be more active. A ‘good’ school playground has been described as an environment that children can invent physical activities and use more playground places (Hyndman et al. 2012). A previous study examining the effects of movable/recycled materials via direct observation revealed that activities with such materials can be the predominant activity across over half of school playground areas as children can engage in activities such as obstacle courses, building structures, sleigh running and balancing beams (Hyndman, Benson, and Telford 2014). Many playgrounds are designed and installed without input from children (Hyndman et al. 2012), therefore providing children with materials to direct their own physical activities reflects modern educational trends to provide student-directed physical activity opportunities (Hyndman, Benson, and Telford 2014).

Unstructured physical activity opportunities allow children to develop skills to understand their world and, therefore school playground environments should provide ample opportunities for children to enhance their development and physical functioning (Ridgers et al. 2010, Ridgers et al. 2012, Stanley et al. 2012, Stanley et al. 2014). With the modern demands on schools to equip children with skills to be physically active (Hyndman and Telford 2015), movable/recycled materials could be implemented without burdening busy teaching staff. Movable/recycled materials provide a cost-effective, sustainable educational strategy that could be used to develop children’s physical skills and activity within the ‘hidden curriculum’ of school playgrounds during break periods (Hyndman Benson and Telford 2014). The physical activity intensity outcomes from the AIM-PLAY study merit further evaluation of movable/recycled materials on a wider public health scale within elementary school settings.
The findings from the AIM-PLAY study reveal that older children engaged in lower proportions of high intensity physical activity and higher proportions of sedentary behavior compared to younger children. Similar findings have revealed that an increased age can have a negative association with children’s MVPA and vigorous physical activity during both morning and lunch breaks (Ridgers, Fairclough, and Stratton 2010; Ridgers et al. 2012). It has also been discovered that older elementary school children participate in a higher proportion of sedentary behavior or light accelerometer-determined physical activity than younger children within the school playground during break periods (Lopes, Vasques, and de Oliveira Pereira 2006). Older elementary school children have also been reported to have lower enjoyment levels across a range of school playground activities (Hyndman 2015b). Further investigation into why elementary children’s activity intensities in the playground can decline with age is warranted.

The AIM-PLAY study findings of boys being more active than girls during school breaks is also consistent with previous literature reviews of preschool (Hinkley et al. 2008), childhood (Sallis, Prochaska, and Taylor 2000) and adolescence (Van Der Horst et al. 2007). As boys’ physical activity intensities during lunch breaks were again lower than girls (including higher proportion of sedentary behavior), further strategies within the school playground during break periods need to be considered. Recent findings have revealed that girls often possess a significantly higher enjoyment than boys across many playground activities (Hyndman 2015b), yet girls’ physical activity often doesn’t reflect such enjoyment levels (Ridgers et al. 2012). It is suggested that girls often view school playground during break periods as an opportunity to socialize (Pellegrini and Bohn 2005), therefore strategies promoting playground physical activities in which girls can be more social and physically active should be a high priority in future school playground interventions. Future research is also needed to examine the correlates of boys’ and girls’ physical activity individually within the school playground during break periods, rather than simultaneously (Ridgers et al. 2012).

Strengths of the AIM-PLAY study include responding to a range of recommendations for school-based physical activity interventions (Kriemler et al. 2011) including the application of valid objective physical activity measures, providing sufficient data on school children’s physical activity participation and a longer-term follow-up. Accelerometer data were collected using five second epochs, which captures the sporadic nature of children’s physical activity behavior (Nilsson, Ekelund, and Sjostrum 2002) and Freedson/Trost cut points were applied which are demonstrated to have substantial agreement with children’s MVPA (Trost et al. 2011). The long-term patterns of physical activity identified from the AIM-PLAY study could help inform public policy and debate regarding school playground environments during break periods (Ridgers, Fairclough, and Stratton 2010). Understanding children’s physical activity
behaviors within the school context is important (Nettlefold et al. 2010, Dobbins et al. 2013, Kriemler et al. 2011), however there is an absence of research examining how children’s physical activity can change over time, especially in response to a modified school playground during break periods (Hyndman 2015).

There were several limitations to the study. Firstly, it should be acknowledged that the physical activity intensity effects of introducing movable/recycled materials within the school playground were intended to be assessed 13 weeks after baseline, however due to the highest rainfall for the region on record, researchers could only complete data collection at two phases after baseline (7-weeks and 8-months). As the accelerometer data were collected during school lunch breaks, the findings may not be reflective of playground physical activity during morning or afternoon school breaks. The intervention school was free from any fixed playground equipment (e.g. slides, monkey bars) and it is possible that children may have been more engaged with the movable/recycled materials than in a school with a fixed school playground. Although it has been revealed that conventional, fixed school playground equipment can restrict diverse play opportunities (Dyment, Bell, and Lucas 2009), future research could examine the physical activity of school children with access to both movable/recycled materials and conventional, fixed playground equipment. As the movable/recycled materials intervention were implemented within a single elementary school, any generalising of the findings should be done so with caution. Similar to a host of studies using accelerometer measurements during school break periods that have had sample sizes under 100 participants (Huberty et al. 2011, Wickel and Eisenmann 2007, Pan 2008, Howe et al. 2012, Erwin et al 2013, Saint Maurice et al. 2011), the significant costs associated with accessing accelerometers (Dollman et al. 2009) resulted in a reduced sample size (including absence of power analysis) and not all consenting children were able to participate. The randomized allocation of accelerometers also resulted in the mean age of participants from both elementary schools being slightly lower. Furthermore, we were unable to objectively measure the physical benefits of lifting and dragging the movable/recycled materials around the school playground.

Due to the cost and access of accelerometer motion sensors, not all consenting participants were able to participate in the AIM-PLAY study. A reduced access to accelerometers in the intervention school during week one of baseline resulted in slightly smaller sample of intervention school students wearing accelerometers during the AIM-PLAY study. As school lunch breaks at the intervention elementary school totalled 30 minutes, only children’s contribution towards the national physical activity guidelines of 60 minutes of MVPA were able to be assessed. Research has recently emerged noting that even shorter epoch lengths (1 second) are now being used (Choi et al. 2011), therefore with such advances in accelerometer technology it is possible that very short bouts of activity
could be overlooked. Further demographic variables (e.g. body mass index and socio-economic status of the students) could also have provided additional insight into effects of the movable/recycled materials intervention on children. During the follow-up (8-months), the control school also installed two small sized playground areas (synthetic soccer court and a vacant natural play area with minimal features). However, minor changes to school environment features can be expected within a real world setting such as a school (Hyndman et al. 2014).

Overall, movable/recycled materials innovatively provide a cost-effective option for schools that do not have access to funding for expensive school playground designs. It is difficult for children to engage in imaginative school playground physical activity options within bleak, hard surfaced areas (Hyndman Benson and Telford 2015). Importantly, as movable/recycled materials are found within the home and community, the physical activity benefits from such an intervention can be replicated beyond school settings to continue to enhance children’s physical skills and activity levels. Whilst there are a number of benefits of implementing movable/recycled materials into the school playground, there is a need for further research to examine such a concept in adolescence and across all elementary year levels in multiple school playgrounds. Although the proportion of school lunchtime children spent in MVPA was marginally lower at the 8-month follow-up (42.4%) in comparison to the 7-week post-test (38.8%), the strategy of introducing movable/recycled materials shows promise as a long-term intervention strategy to improve children’s intensity of physical activity within school playgrounds of both metropolitan (Engelen et al 2013) and regional elementary schools (Hyndman, Benson, and Telford, 2014).

Conclusion
Children in the intervention elementary school had significantly higher counts per minute and spent a significantly greater proportion of lunch breaks in moderate and MVPA at post-test (7-weeks) and follow-up (8-months) than children in the control elementary school. Children within the intervention school also spent a significantly lower proportion of time during lunch breaks in sedentary behavior compared to control school children over the same time points. Examining the effects of this school playground intervention over a school year suggests that the introduction of movable/recycled materials can have a significant, positive long-term intervention effect on children’s engagement in higher intensity playground physical activity during school lunch breaks. The physical activity implications identified from the AIM-PLAY study provide emphasis for schools to consider widespread implementation of movable/recycled materials to move beyond conventional, fixed school playgrounds.

Competing interests
The authors declare that they have no competing interests.
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