Effect of Active Lessons on Physical Activity, Academic, and Health Outcomes: A Systematic Review

Martin, R. and Murtagh, E.M. (2017) 'Effect of active lessons on physical activity, academic and health outcomes: A systematic review', *Research Quarterly for Exercise and Sport*, 1-20 (accepted for publication 3.02.2017, See Appendix Q), http://dx.doi.org/10.1080/02701367.2017.1294244

1.1 Abstract

Purpose. To conduct a systematic review of classroom-based PA interventions which integrate academic content and assess the effectiveness of the interventions on PA, learning, facilitators of learning, and health outcomes. **Method**. Six electronic databases (ERIC; PubMed; Google Scholar; Science Direct; Cochrane Library, and EMBASE) and reference lists were searched for English language articles, published January 1990 - March 2015, reporting classroom-based interventions which deliberately taught academic content using physically active teaching methods, > 1 week duration, with PA, health, learning or facilitators of learning outcomes. Full text articles were reviewed by two authors. Data was extracted onto an Excel spreadsheet and authors were contacted to confirm accuracy of information presented. **Results.** Fifteen studies met the inclusion criteria. Six studies reporting on PA levels were found to have medium-to-large effect sizes. All four studies reporting learning outcomes reported positive effects of intervention lessons. Teachers and students were pleased with the programmes and enhanced on-task-behavior was identified (n = 3). Positive effects were also reported on students' BMI levels (n = 3). **Conclusions.** Physically active academic lessons increase PA levels and may benefit learning and health outcomes. These teaching methods are also positively received and enjoyed by both students and teachers. These findings emphasize the need for such interventions to contribute towards public health policy.

Keywords: classroom, academic content, movement integration

1.2 Introduction

Recent evidence has shown that since the 1990's an increasing number of primary school aged children are inactive (Holt *et al.* 2013, Metcalf *et al.* 2002). The World Health Organization (WHO) (2010) recommends that school aged children should accumulate at least 60 min of MVPA per day for health benefits. However, less than 20% of children worldwide are achieving these recommendations (WHO 2010). Children who participate in high levels of PA are less likely to develop cardiovascular disease, type 2 diabetes, cancer, and other chronic illnesses (Hamilton *et al.* 2008). For health improvements to occur, it has been proposed that PA should be made a public health priority throughout the world (WHO 2010).

Schools have been targeted to implement PA interventions as they are prime locations to reach the majority of children (Martin and Murtagh 2015b). However, ironically, as children are often required to remain seated to receive instruction, class time represents a significant sedentary period of their day (Holt *et al.* 2013). Globally it is recommended that all schools develop policies to address PA during the school day and not just in PE or active travel (WHO 2010). Previous reviews illustrate that there is evidence of the success of these school-based programmes (Barr-Anderson *et al.* 2011, Dobbins *et al.* 2013). However, emphasis on Literacy and Numeracy has resulted in reduced time for activity breaks and little emphasis on PE (Erwin *et al.* 2012). Therefore, in an effort to overcome these barriers it has specifically been recommended by the CDC (2010) that PA should be integrated into academic lessons since movement has been found to enhance learning while also improving students' PA levels. These physically active academic lessons intend to teach academic content through the use of physically active teaching methods (Martin and Murtagh 2015b) and are distinct from PA breaks which may be unrelated to educational outcomes.

Previous systematic reviews of PA interventions in the classroom setting examined studies which incorporated PA breaks, active transitions, standalone physical activities, and active academic lessons (Erwin *et al.* 2012, Webster *et al.* 2015). These reviews evaluate the interventions with regard to the benefits of movement integration (Webster *et al.* 2015), PA, health outcomes, and educational outcomes (Erwin *et al.* 2012, Norris *et al.* 2015). Interventions evaluating the effect of classroom-based PA breaks on health outcomes- such as posture, bone strength, bone mineral content and stress- were previously reviewed and noted positive results (Erwin *et al.* 2012). However, the effect of classroom-based PA on students' BMI was not evaluated in this review. The relationship between PA and BMI is well documented with PA deemed to be essential to achieve BMI levels within the healthy range, preventing obesity (Doak *et al.* 2006, Kimm *et al.* 2005).

In their recent comprehensive review Norris and colleagues (Norris *et al.* 2015) concluded that all studies reported improved PA in intervention groups or in specific demographics, such as least active girls, as a result of the active academic lessons. Additionally, educational outcomes reported have shown either significant improvements or no difference compared to traditional teaching (Norris *et al.* 2015). This contributes to the growing evidence supporting the link between PA and learning outcomes (Tomporowski *et al.* 2008).

However, both teacher approval and student enjoyment, which have been shown to be essential for success, have not been reviewed previously in relation to such active academic lessons. Although teaching with a physically active academic curriculum has been identified as a way of coping with barriers such as time and assessment pressures (Cothran *et al.* 2010, Naylor *et al.* 2015), to improve PA levels and reduce sedentary behavior in primary school children (Bartholomew and Jowers 2011), teachers have a fundamental role in determining the effectiveness (Fullan 2007) of such interventions. The teacher largely influences what children do in the classroom, it is therefore crucial that teachers are satisfied with the programme. Teachers' opinions, views, and attitudes towards PA have been recognized as the greatest obstacles to PA promotion in the classroom (Morgan and Hansen 2008) and executing change is ultimately an individual decision by teachers (Martin and Murtagh 2015b). Therefore, behavioral change on the part of the teacher, as well as providing them with interventions that coincide with their curriculum, schedules, and their principles and beliefs about teaching (McMullen *et al.* 2014) are required to encourage classroom teachers to adopt responsibility for integrating PA into academic lessons. Student enjoyment has also been found to influence and control the effects of PA interventions (Howie *et al.* 2014). Enjoyment has been recognized as a key component of acceptability and a prevailing motivational element for children to engage in PA (Allender *et al.* 2006). Evidence illustrates that the beneficial effects of PA interventions are determined by levels of student enjoyment with increased PA resulting from greater enjoyment (Dishman *et al.* 2005, Schneider and Cooper 2011). Teacher approval of classroom-based interventions has also been found to rely on student enjoyment (McMullen *et al.* 2014). Therefore, it is essential to consider teacher approval and student enjoyment of PA interventions.

In their recent review Norris and colleagues (2015) identified a need for further, more rigorous research in order to firmly ascertain the effects of physically active lessons. Additionally, Webster *et al.* (2015) concluded that there is a need for research which demonstrates the contribution of physically active lessons towards students' positive dispositions towards PA. Therefore, the present systematic review intends to synthesize the existing evidence base by including BMI as a health outcome and facilitators of learning outcomes such as student enjoyment and teachers' approval, which have been deemed essential in determining the success or failure of such classroom-based PA interventions (Cothran *et al.* 2010, Howie *et al.* 2014).

This paper is the first review to consider the effects of physically active academic lessons on PA, learning, facilitators of learning (to include teacher approval, student enjoyment and on-task behavior), and health (BMI) outcomes. To inform future practice and present a strong case for schools to incorporate PA into academic lessons in the classroom it is important to provide a comprehensive summary of previous interventions with regard to these outcomes. Therefore, this systematic review aims to identify existing classroom-based PA interventions which integrate academic content and assess the effect of the interventions on PA, learning, facilitators of learning, and health outcomes.

1.3 Method

The PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analysis) was followed in conducting and reporting this systematic literature review (Moher *et al.* 2009). A review protocol has not been published previously.

1.3.1 Criteria for Considering Studies for this Review

In this review the following conditions were used to select studies: (a) the intervention was applied in a school classroom setting; (b) study participants were school aged children (5-18 years) and included all children regardless of their body mass index category. Studies where PA interventions formed part of treatment programmes for participants with specific illnesses or multifactorial diseases (e.g. heart disease) were excluded; (c) interventions which deliberately taught academic content using physically active methods; (d) the intervention must be of at least one week duration; (e) one or more of the following outcomes reported: proportion of class time in moderate-to-vigorous physical activity (MVPA); duration of MVPA (time spent engaged in MVPA); learning outcomes (e.g. academic performance); facilitators of learning (e.g. behavior, enjoyment, concentration, attention); health outcomes (e.g. BMI); (f) English language articles published in peer-reviewed journals between January 1990 and March 2015. Articles reporting multicomponent interventions were excluded if the effects of the classroom-based intervention were not specified.

1.3.2 Search Methods for Identification of Studies

A systematic literature review was conducted to identify classroom-based PA interventions. This review places emphasis on the school classroom setting therefore the search focused on location (classroom-based), behavior (PA), and accumulation of PA, health benefits or educational benefits as outcome measures. A comprehensive search strategy was developed to coincide with the Cochrane Collaboration methodology for conducting literature searches (Higgins and Green 2011). The following data bases were searched ERIC; PubMed; Google Scholar; Science Direct; Cochrane Library, and EMBASE. English language studies only were included and date limits were set from January 1990 to March 2015. The search terms used to search titles/abstracts were (classroom AND (physical activity OR exercise OR physical inactivity OR sedentary) AND (school)). The search terms were slightly modified for certain databases such as Google Scholar and PubMed where the search terms were classroom AND physical activity AND school.

Papers in press were included. Where conference proceeding titles or abstracts were found authors were contacted for full-text papers. Reference lists from related review and original articles were also hand-searched for relevant papers.

1.3.3 Study Selection

The initial eligibility assessment was performed by one author who reviewed paper titles and abstracts. The full text versions of 63 articles were then reviewed independently by two authors. Where disagreements between reviewers occurred, consensus was achieved through discussion and reassessment of each of the eligibility criteria for the study. The study selection process is summarized in the PRISMA flow-

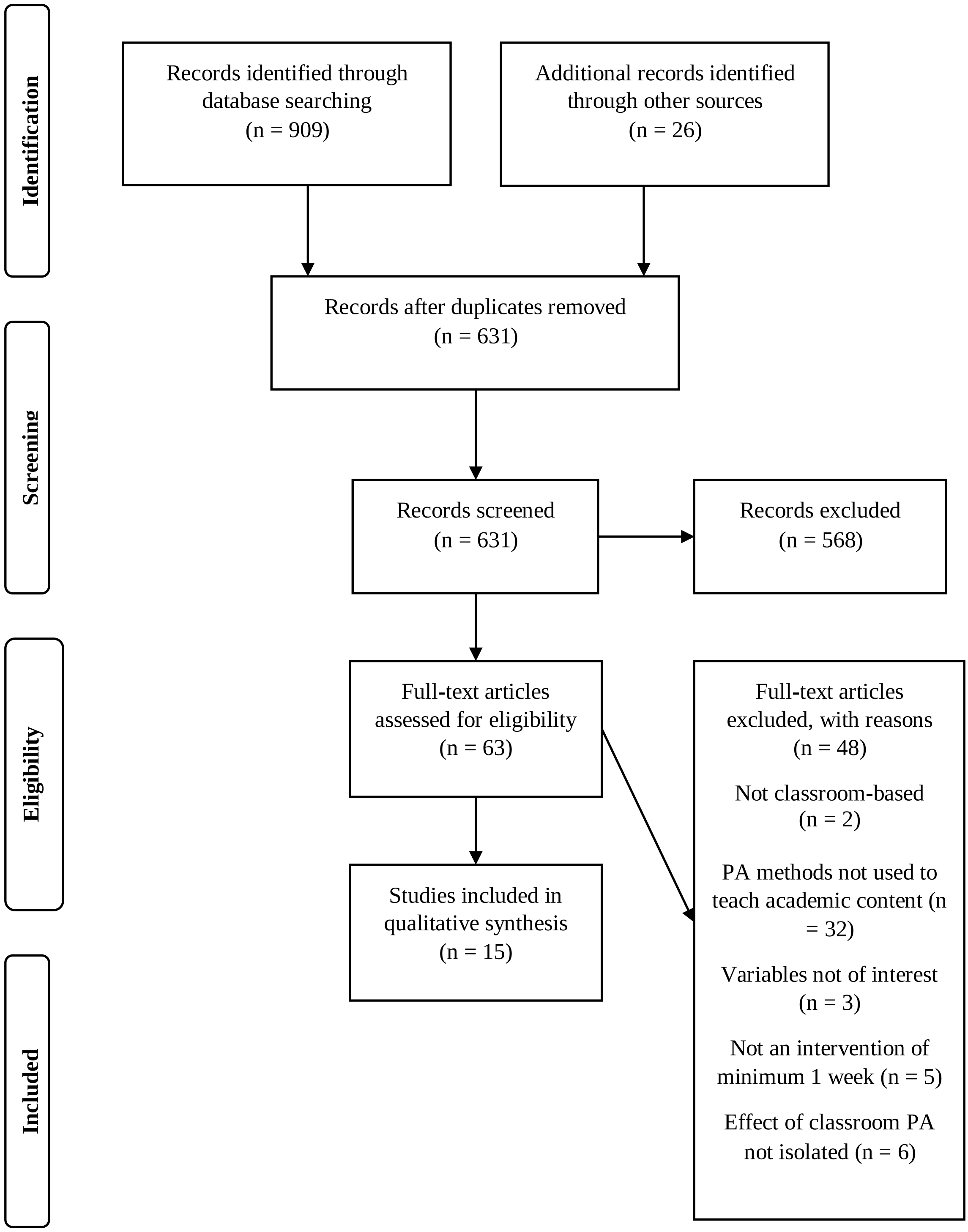

chart below (Figure 2.1).

Figure 2.1 Study Selection Process and Flow of Systematic Review

1.3.4 Data Extraction

A data extraction sheet was created in Microsoft Excel to record the following characteristics of each included study: study location, duration, and design; participants' characteristics (age/grade level); intervention characteristics; MVPA, learning, health, and facilitators of learning outcomes. One author extracted the data from included studies.

The primary outcomes of interest are the effects of classroom-based PA intervention programmes which integrate academic content on the MVPA levels, health, learning, and/or facilitators of learning of children aged 5-18 years. The effect size (ES) for each outcome of interest was calculated using the method described in Zhu (2016) within each of the included studies and recorded in Table 2.3. Cohen's d index (ES) (Cohen 1988) was calculated as the difference between treatment and control group means divided by the pooled standard deviation. In studies where pre- and post- test means and standard deviations were reported for each group, ES was calculated by subtracting pre-test ES from post-test ES (Erwin *et al.* 2012). Difference between post-test and pre-test means divided by the pooled standard deviation was used to compute ES for pre/post-test designs (Cohen 1988). In studies which evaluated difference in effect between different grade levels ES was calculated by subtracting the lower grade mean from the upper grade mean (difference between the groups) and dividing by the pooled standard deviation (Cohen 1988). Reported results were assessed in terms of Cohen's effect size standard (≥ 0.8 = large; < 0.8 to > 0.2 = medium; ≤ 0.2 = small) (Cohen 1988). Studies with secondary outcomes received separate effect size scores for each outcome. Neither Liu *et al.* (2007) nor Reed *et al.* (2010) provided sufficient information to allow effect size calculation for PA outcomes. PA was a secondary outcome in the study by Reed *et al.* (2010).

All relevant information related to the outcomes of interest was extracted from each of the included studies and inserted into an Excel spreadsheet where it was collated and analyzed.

The studies were also grouped into those which presented PA outcomes only, learning, facilitators of learning or health outcomes only or those which presented a combination of these outcomes (See Appendix B, Appendix C, and Appendix D). Authors of all included articles were contacted via email and asked to confirm that the information outlined in the appendices accurately represents their study. Thirteen authors responded confirming the accuracy of the information presented (Donnelly *et al.* 2009, Donnelly and Lambourne 2011, Erwin *et al.* 2011a, Finn and McInnis 2014, Goh *et al.* 2014, Lee and Thomas 2011, Liu *et al.* 2007, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Oliver *et al.* 2006, Reznik *et al.* 2015, Riley *et al.* 2015, Li *et al.* 2010).

1.3.5 Risk of Bias Assessment

An evaluation of study merit was carried out using the Cochrane Collaboration 'risk of bias's assessment tool (Higgins *et al.* 2011). This seven-component rating scale for trials assesses randomization, allocation blinding, blinding of participants and researchers, incomplete outcome data, discriminatory reporting, and other potential biases. High, unclear or low risk of bias were awarded in each category. A summary of the assessment is outlined in Table 2.1.

1.4 Results

1.4.1 Study Selection

A total of 909 studies were identified through the electronic databases and an additional 26 articles through searching references of relevant papers and searching studies that have cited these papers. Three hundred and four duplicates were removed. Of the 631 titles and abstracts screened 568 were excluded as they did not meet the inclusion criteria. Sixty-three full text articles were then reviewed. Fifteen of these met the inclusion conditions and were examined in the systematic review. Two of these studies reported outcome measures from the same participants so they were combined in the analysis (Donnelly *et al.* 2009, Donnelly and Lambourne 2011). Figure 2.1 outlines further details including the reasons for exclusion of the full text articles reviewed.

Table 2.1 Risk of Bias Assessment of Identified Studies

	Random Sequence Generation	Allocation Concealment	Blinding of participants	Blinding of outcome assessment	Incomplete outcome data	Free of Selective Reporting	Other bias
Donnelly *et al.* (2009)	unclear	unclear	high	low	low	unclear	low
Donnelly and Lambourne (2011)	unclear	unclear	unclear	low	unclear	unclear	unclear
Dunn *et al.* (2012)	high	high	high	low	low	unclear	high
Erwin *et al.* (2011a)	high	high	unclear	unclear	high	unclear	high
Finn and McInnis (2014)	high	high	unclear	unclear	unclear	unclear	high
Goh *et al.* (2014)	high	high	unclear	unclear	low	unclear	high
Lee and Thomas (2011)	high	high	unclear	unclear	unclear	unclear	high
Li *et al.* (2010)	unclear	unclear	unclear	low	low	unclear	low
Liu *et al.* (2007)	high	high	unclear	unclear	unclear	high	high
Mahar *et al.* (2006)	unclear	unclear	high	high	unclear	unclear	high
Mullender-Wijnsma *et al.* (2015)	high	high	unclear	unclear	unclear	unclear	high
Oliver *et al.* (2006)	high	high	high	high	low	unclear	high
Reed *et al.* (2010)	unclear	unclear	unclear	unclear	high	unclear	high
Reznik *et al.* (2015)	unclear	unclear	high	high	low	unclear	low
Riley *et al.* (2015)	low	unclear	high	high	low	unclear	low

1.4.2 Study Characteristics

All 15 studies selected for this review are classroom-based interventions of at least 1 week duration which integrate PA and academic content. Study sizes ranged from n = 47 (Finn and McInnis 2014) to n = 4700 (Li *et al.* 2010). A total of 9,067 students were tested across included studies however, this does not include one study which reported the number of classrooms (n = 144) rather than the number of participants in the study (Dunn *et al.* 2012). Overall 2,554 students were assessed for MVPA outcomes, n = 2,173 for learning outcomes, n = 416 for facilitators of learning outcomes and n = 6,980 students were assessed for health outcomes. All participants were aged between 5 and

12 years with all studies taking place in primary schools. No intervention based in a secondary school setting met the inclusion criteria. One study had female participants only (Finn and McInnis 2014). Sex of participants ranged from 42.9% males (Donnelly *et al.* 2009) to 58.7% males (Erwin *et al.* 2011a). Three studies did not report participants' sex (Dunn *et al.* 2012, Lee and Thomas 2011, Mahar *et al.* 2006).

Nine studies took place in the U.S. with the remaining studies located in China, Netherlands, New Zealand, and Australia. Six studies conducted randomised controlled trials (Donnelly *et al.* 2009, Mahar *et al.* 2006, Reed *et al.* 2010, Reznik *et al.* 2015, Riley *et al.* 2015, Li *et al.* 2010) while the other studies used non-randomised controlled trials or employed pre/post-test designs with baseline, intervention, and post-intervention assessments. One study did not use a comparative group (Finn and McInnis 2014). The included studies evaluate a range of primary and secondary outcomes which are summarized in Table 2.2 along with the aforementioned study characteristics.

1.4.3 Intervention

To be included in this review, the intervention duration was set at a minimum of one week. This included interventions which took place on five consecutive weekdays. Table 2.2 outlines the intervention durations which ranged from 2 weeks (Lee and Thomas, 2011) to 3 academic years (Donnelly *et al.* 2009). The majority of studies (8) were in the range of 2 to 8 weeks. All included interventions were required to involve the teaching of academic lessons with the integration of PA. The classroom-based PA intervention was the sole intervention of all included studies. Five interventions were based on the principles of TAKE 10! which comprises 10 min of PA integrated into core academic lessons at least once a day (Donnelly *et al.* 2009, Goh *et al.* 2014, Liu *et al.* 2007, Mullender-Wijnsma *et al.* 2015, Li *et al.* 2010). Move-To-Improve (Dunn *et al.* 2012), Energizers (Mahar *et al.* 2006), the EASY Minds study (Riley *et al.* 2015), and the studies by Erwin *et al.* (2011a) and Reed *et al.* (2010) also involve the integration of PA into core curricular content from once a day to three times a week. Two interventions involved the use of PA data objectively collected from the students to teach math and science content (Finn and McInnis 2014, Lee and Thomas 2011). The CHAM JAM intervention consisted of educational focused aerobic activities taught through the use of a CD, for 10 min three times a day (Reznik *et al.* 2015). The final study involved virtually walking around New Zealand which integrated educational content and the tracking of steps taken by individual students to reach each destination city (Oliver *et al.* 2006). Tables 2.2 and 2.3 summarize the data which was extracted and present effect sizes for outcome measures. Appendix B, Appendix C and Appendix D provide more detailed information on the individual studies.

Implementation of the interventions varied with some research teams implementing the active lessons themselves (Riley *et al.* 2015), other research teams assisting teachers with design and execution of the lessons (Donnelly *et al.* 2009, Lee and Thomas 2011), specialist teachers were hired and trained to deliver the *F&V* programme (Mullender-Wijnsma *et al.* 2015) while classroom teachers implemented physically active lessons themselves in the eleven remaining studies. Seven studies provided classroom teachers with training on the intervention programmes (Donnelly *et al.* 2009, Dunn *et al.* 2012, Erwin *et al.* 2011a, Goh *et al.* 2014, Mahar *et al.* 2006, Reed *et al.* 2010, Li *et al.* 2010). This training varied in duration and frequency between the studies from 45 min of once off training (Mahar *et al.* 2006) to 6 hours at the beginning of each academic year (Donnelly *et al.* 2009). No teacher training was specified in the other studies. Resources provided to teachers also varied. Some studies did not provide any resources at all (Donnelly *et al.* 2009, Erwin *et al.* 2011a, Liu *et al.* 2007, Mullender-Wijnsma *et al.* 2015, Oliver *et al.* 2006, Reed *et al.* 2010, Riley *et al.* 2015) whereas 30 fitness breaks and equipment kits were provided to participating teachers in one study (Dunn *et al.* 2012). Lee and Thomas (2011) supplied Physical Activity Data (PAD) technologies for student use and many studies supplied teachers with lesson plans and web links to their respective programmes (Finn and McInnis 2014, Goh *et al.* 2014, Mahar *et al.* 2006, Reznik *et al.* 2015, Li *et al.* 2010). Incentives for participation in the PA intervention were provided in four studies. Two studies used tracking posters and stickers to motivate student participation (Liu *et al.* 2007, Li *et al.* 2010), a third study awarded students with sports center passes and teachers with an undisclosed payment for their participation and compliance with the programme (Erwin *et al.* 2011a) while the fourth study awarded teachers with a professional development stipend of $68.14 (Dunn *et al.* 2012). Riley *et al.* (2015) specified that no incentives were used in their project. No other paper referred to whether incentives or rewards were used or not. Six studies outline the detail of intervention lessons (Erwin *et al.* 2011a, Oliver *et al.* 2006, Riley *et al.* 2015) or include web links to the lessons allowing them to be replicated (Goh *et al.* 2014, Mahar *et al.* 2006, Reznik *et al.* 2015). Only three studies mention that theoretical frameworks guide their intervention designs. Erwin *et al.* (2011a) discuss the Ecological Model with emphasis on the impact of community and surroundings on the behavior of individuals. Mullender-Wijnsma *et al.* (2015) describe the theory of 'brain-based learning' which places emphasis on grounding teaching methods in the neuroscience of learning and Reznik *et al.* (2015) use the RE-AIM framework to guide their design. This places emphasis on the "Reach, Effectiveness, Adoption, Implementation, and Maintenance" of an intervention programme.

Nine studies reported the use of subgroups for analysis of outcomes. Four of these included subgroups to assess PA levels (Donnelly *et al.* 2009, Erwin *et al.* 2011a, Goh *et al.* 2014) or energy expenditure (Liu *et al.* 2007) using PA monitors. Four studies observed on-task behavior of subgroups (Donnelly *et al.* 2009, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010) and two studies selected subgroups to participate in focus group or individual interviews to assess learning and enjoyment (Finn and McInnis 2014, Lee and Thomas 2011). Of the studies which featured subgroups, only one (Mahar *et al.* 2006) described the selection of participants by randomization. All other subgroups were preferentially selected by teachers or researchers or by means not specified in the study.

1.4.4 Intervention Fidelity and Implementation

Direct observation by the researchers and teacher self-report records were used to evaluate intervention fidelity and/ or teacher compliance in six studies (Donnelly *et al.* 2009, Goh *et al.* 2014, Mahar *et al.* 2006, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010, Reznik *et al.* 2015). Teacher self-report questionnaires revealed that PAAC schools achieved 50-83% of the target 90 minutes of MVPA (Donnelly *et al.* 2009). Teachers reported that an average of one ten minute TAKE 10! activity per school day can be successfully implemented (Goh *et al.* 2014). Eighty nine percent of teachers were found to comply with performing Energizers activities once a day (Mahar *et al.* 2006). Implementation and fidelity of the F&V (Mullender-Wijnsma *et al.* 2015) programme was assessed using observations, teacher-reports and heart rate monitors. Results indicate lessons lasted close to the intended 20-30 minutes, 98% of the lesson content was discussed, on-task behaviour was above 70%, and the students were moderate-to-vigorous physically active for 64% of the lesson time. Similar process measures from the CHAM JAM study report that teachers implemented an average of 60-83% of the target activities at Time 2. Finally, to monitor fidelity of their intervention delivery Reed *et al.* (2010) state that random audits by direct observation were carried out, however, they do not provide a report of these observations.

Table 2.2 Summary of Characteristics of Included Studies

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Donnelly et al. (2009), Donnelly and Lambourne (2011)	USA	3 years	x	x		cluster	BMI	PA (mins/day) Academic Achievement Process Measures: (Delivery, intensity & modelling)
Dunn et al. (2012)	USA	6 months			CT		PA daily	
Erwin et al. (2011)	USA	13 days		x			school day PA math class PA	math class PA intensity
Finn and McInnis (2014)	USA	7 weeks			Explor		Teachers' perceptions Students' perceptions	Feasibility of movement integration into science lessons
Goh et al. (2014)	USA	12 weeks (4 B, 8 I)		x		no control	school day PA (steps & intensity/day)	Teacher fidelity

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Lee and Thomas (2011)	USA	2 weeks		x	DTCT		student knowledge	
Li et al. (2010)	China	1 year, 1 year FU	x	x		cluster	BMI	Weight, height, BMI z scores, fat free mass, fat mass, % body fat
Liu et al. (2007)	China	1 year		x	CT		EE, PA (duration &intensity/day)	Height, weight & BMI Prevalence of overweight & obesity EE & PA intensity per session
Mahar et al. (2006)	USA	4 & 8 weeks	x	x		cluster multi-b (TOT)	PA levels (steps/school day)	On-task behaviour

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Mullender-Wijnsma et al. (2015)	Netherlands	21 weeks		x	Q-Exp	with control	academic achievement	Implementation measures: On-task behaviour MVPA levels of lessons
Oliver et al. (2006)	New Zealand	4 weeks		x		no control	PA levels (steps/day)	
Reed et al. (2010)	USA	3 months	x	x		cluster	Fluid Intelligence Academic Achievement	PA (steps/day) PA between groups Fitness performance
Reznik et al. (2015)	USA	8 weeks	x	x		cluster	school day PA (steps/day)	Anthropometric assessment PE class, trip, recess frequency Intervention implementation & process measures

Table 2.2 Summary of Characteristics of Included Studies (cont'd)

Study	Location	Duration	Study Design				Outcomes Assessed	
			RCT	P&PT	Other	Add. Info.	Primary Outcomes	Secondary Outcomes
Riley et al. (2014)	Australia	6 weeks	x				school day PA (% time/day) math class PA (% time/day)	On-task behaviour Teacher & Student Satisfaction (Feasibility)

Abbreviations: Add. Info. Additional Information; B Baseline; Conv Convenience Sample; CT Controlled Trial; DTCT Delayed Treatment Controlled Trial; EE energy Expenditure; Explor Exploratory; FU Follow-up; I Intervention; multi-B Multiple Baseline; PA physical activity; PE Physical Education; P&PT Pre- & post-test; Q-Exp Quazi Experiment; TOT time-on-task

Table 2.3 Summary of Classroom-Based PA Interventions and their Overall Effects on PA, BMI and Academic Outcomes

Study	Classroom-based PA intervention elements		Outcomes (Effect Size Reported as Cohen's d)			
	PA integrated into core academic subjects	Active learning & using PA data	PA	BMI	Learning	Facilitators of Learning
Donnelly et al. (2009), Donnelly & Lambourne (2011)	x		0.65 ↑	0.01 • ↔	[a]↑	
Dunn et al. (2012)	x		1.24 • ↑			
Erwin et al. (2011)	x		1.84[b] • ↑ 0.54[c] • ↑			
Finn and McInnis (2014)		x				q/d [d] •
Goh et al. (2014)	x		- 0.11[e] • ↔ 0.24[f] • ↑			
Lee and Thomas (2011)		x			0.48[g] • ↔ 1.51[h] • ↑	
Li et al. (2010)	x			- 0.13 • ↓		
Liu et al. (2007)	x		• ↑[a]	↓[a]		
Mahar et al. (2006)	x		0.49 • ↑			0.6 ↑

Table 2.3 Summary of Classroom-Based PA Interventions and their Overall Effects on PA, BMI and Academic Outcomes (cont'd)

Study	Classroom-based PA intervention elements		Outcomes (Effect Size Reported as Cohen's d)			
	PA integrated into core academic subjects	Active learning & using PA data	PA	BMI	Learning	Facilitators of Learning
Mullender-Wijnsma et al. (2015)	x				[i]- 0.66, 0.7 [j] - 0.16, 0.53 • ~	
Oliver et al. (2006)		x[k]	0.09 • ↔			
Reed et al. (2010)	x		↔ [a]		0.3[l] ↑ [a] ↑[m], ↔[n] • ~	
Reznik et al. (2015)	x		0.16 • ↑			
Riley et al. (2014)	x		2.48[b] • ↑ 1.62[c] • ↑			0.9 ↑

Note. • = primary outcome; ↑ = reported as statistically significant increase; ↓ = reported as statistically significant decrease; ↔ = no significant change; ~ = mixed results; q/d = qualitative data

[a] not enough information provided to calculate; [b] Math class; [c] whole school day; [d] no comparative group; [e] change in daily steps; [f] change in intensity; [g] learning; [h] reasoning; [i] Maths grade 2, grade 3; [j] Reading grade 2, grade 3; [k] virtual walk; [l] fluid intelligence; [m] Social Studies; [n] Maths, Science & English

1.5 Outcomes

1.5.1 Physical Activity

As illustrated in Table 2.3 ten studies reported the effects of interventions on PA outcomes. Accelerometers (Donnelly *et al.* 2009, Riley *et al.* 2015), pedometers (Mahar *et al.* 2006, Oliver *et al.* 2006, Reed *et al.* 2010, Reznik *et al.* 2015), and both accelerometers and pedometers (Erwin *et al.* 2011a, Goh *et al.* 2014) were used to evaluate PA intensity levels and step counts in eight studies. Dunn *et al.* (2012) used observation to evaluate minutes spent in PA per day. Donnelly *et al.* (2009) used the System for Observing Fitness Instructional Time (SOFIT) to evaluate the intensity of classroom PA. Energy expenditure was assessed using Zhi-Ji UX-01 PA monitors and time spent in PA was evaluated using a self-report questionnaire completed by students in one study (Liu *et al.* 2007). In addition to using pedometers, Reed *et al.* (2010) also used the Previous Day Physical Activity Recall (PDPAR) questionnaire to evaluate students' PA levels. Two additional studies incorporated the use of heart rate monitors and pedometers to collect PA data however, the data was used for educational purposes within the classroom and was not evaluated by the researchers (Finn and McInnis 2014, Lee and Thomas 2011).

Of the ten studies reporting PA outcomes for physically active academic lesson interventions on students' daily PA levels, three were found to exceed Cohen's convention for a large effect (Cohen's $d \geq 0.8$) (Dunn *et al.* 2012, Erwin *et al.* 2011a, Riley *et al.* 2015). Effect sizes for all ten studies are outlined in Table 2.3.

1.5.2 Learning Outcomes

Four studies assessed the effect of physically active academic lessons on academic attainment (Donnelly *et al.* 2009, Lee and Thomas 2011, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010). Standardized assessments were used in three of these studies. Donnelly *et al.* (2009) used the Wechsler Individual Achievement Test-2nd Edition (WIAT-II-A; The Psychological Corporation 2001) to assess achievement in literacy skills and math. Reed *et al.* (2010) evaluated student achievement using the Palmetto Achievement Challenge Test (PACT) authorized by the South Carolina Education Accountability Act of 1998 and the U.S. government No Child Left Behind Act of 2001. Mullender-Wijnsma *et al.* (2015) assessed academic achievement in math through the use of a Tempo-Test-Rekenen (Speed Test Arithmetic), and the E´en-Minuut-Test (1-Minute Test) assessed the students' reading ability.

Lee and Thomas (2011) alternatively used a researcher and teacher designed written test and structured interviews to evaluate the students' learning of math and science topics.

Effect sizes for the studies reporting learning outcomes are outlined in Table 2.3. The PAAC study did not provide sufficient information to calculate effect size for active academic lessons on student's academic achievement however, the authors report a statistically significant improvement (Donnelly *et al.* 2009, Donnelly and Lambourne 2011).

1.5.3 Facilitators of Learning Outcomes

Three of the included studies evaluated facilitators of learning. Three main facilitators were considered: teacher approval (Finn and McInnis 2014, Riley *et al.* 2015), student enjoyment (Finn and McInnis 2014, Riley *et al.* 2015), and on-task behavior (Mahar *et al.* 2006, Riley *et al.* 2015). The nature of qualitative data collected for these outcomes did not allow for effect size calculations.

Teacher approval was evaluated using survey (Riley *et al.* 2015) and interview techniques (Finn and McInnis, 2014). Two teachers completed a 5-point Likert scale to evaluate the timing, instructor quality, appropriateness of programme content, and programme impact of the EASY Minds study (Riley *et al.* 2015). It was revealed that teachers were highly satisfied with the EASY Minds programme and its impact. They also indicated that the programme was well received by the children and that they would feel comfortable teaching the programme. Two teachers participated in semi structured interviews to evaluate the feasibility and teacher approval of the Active Science Curriculum (Finn and McInnis, 2014). They reported that the programme improved students' science inquiry skills, promoted enjoyment of PA, provided opportunities to use technology, and provided opportunities to incorporate PA into academic lessons.

Both studies (Finn and McInnis 2014, Riley *et al.* 2015) which evaluated student enjoyment of active academic lessons used student questionnaires. Finn and McInnis (2014) adapted the Physical Activity Enjoyment Scales (PACES) questionnaire (Kendzierski and DeCarlo 1991) and also conducted focus group discussions with a sub-sample of students. They reported that students enjoyed the integration of PA into science lessons and that the students felt they gained academically from the active lessons. The evaluation questions in the EASY Minds study (Riley *et al.* 2015) applied a 5 point Likert scale ordered from 1 (strongly disagree) to

5 (strongly agree). Results revealed that students were highly satisfied with the programme, that they found the programme highly enjoyable, and enjoyed engaging in PA during their lessons.

Both studies (Mahar *et al.* 2006, Riley *et al.* 2015) which evaluated on-task behavior used momentary time sampling procedures to observe a sub-sample of students. Both studies also assigned two trained observers to simultaneously observe 6 students at a time on a rotational basis. Students were observed at 15 second intervals over a 30 min period (Mahar *et al.* 2006, Riley *et al.* 2015). Periods the students were observed varied between the studies. Students were observed in a 1 hour time slot at baseline, midpoint, and post-test during the EASY Minds study (Riley *et al.* 2015). Intervention lessons were taking place within this observational time at midpoint and post-test. Alternatively, on-task behavior was evaluated for 30 min during regular lessons directly pre and post student participation in *Energizers* activities (Mahar *et al.* 2006), by one observer throughout the *Energizers* study. However, the second observer only observed 40% of all classes. Both studies were found to have positive effects of physically active academic lessons on students' on-task behavior. The EASY Minds study (Riley *et al.* 2015) was found to have a large effect for change in students' on-task behavior between intervention and control groups from pre- to post-intervention. *Energizers* (Mahar *et al.* 2006) were found to have a medium effect on on-task behavior from pre- to post- *Energizers*, across all classes, during the study period.

1.5.4 Health Outcome (BMI)

Three studies included in this review evaluated health outcomes as a result of implementing physically active academic lessons in the classroom (Donnelly *et al.* 2009, Liu *et al.* 2007, Li *et al.* 2010). All three studies evaluated the intervention effect on students' BMI levels and defined BMI categories based on age- and sex-specific BMI calculations (Group of China Obesity Task Force 2004, Kuczmarski *et al.* 2002, Multicenter Growth Reference Study Group, World Health Organization 2006). Weight and height measurements were taken with stadiometers and digital scales. Donnelly *et al.* (2009) obtained height and weight measures at the beginning and end of each of their 3 intervention years. Liu *et al.* (2007) collected age, sex, height, and weight data pre- and post- intervention. Li *et al.* (2010) collected measures at baseline, 1 year later during the intervention and the following year at follow-up. Li *et al.* (2010) reported that students fasted the night before measurements took place.

All three studies evaluating BMI noted small effect sizes. Although no significant difference was identified in the prevalence of overweight and obesity between control and intervention groups in the Happy 10! studies (Li *et al.* 2010, Liu *et al.* 2007), a small effect size was calculated for change in both BMI and BMI z-scores between the groups in Li *et al.* (2010). In this report Happy 10! was found to have a similar effect on boys (-0.06) and girls (-0.08) with a more pronounced effect among obese children at baseline (-0.07) (Li *et al.* 2010). The Liu *et al.* (2007) report however, did not provide sufficient information to compute effect sizes. In the PAAC study (Donnelly *et al.* 2009) a small effect was found for change in BMI between PAAC and control schools from baseline to year three. However, change in BMI was influenced by exposure to PAAC, with a moderate correlation reported for BMI change and average weekly PAAC minutes. Schools that participated in ≥ 75 min of PAAC/week had statistically significant lower increases in BMI at 3 years in comparison to those that participated in < 75 min of PAAC/week ($r^2 = 0.42$, $p = .02$).

1.6 Discussion

This systematic literature review suggests that physically active academic lessons in the classroom can improve MVPA levels of children. There is also evidence that BMI, academic performance, and facilitators of learning may be improved by teaching academic content using physically active methods. Readers should be cognizant however of the great variances that were identified between the studies with regard to number of study participants, intervention duration, training and resources provided, implementation personnel, use of theoretical frameworks, and outcomes. With only six of the included studies using randomised controlled trials to evaluate their primary outcomes (See Table 2.2), this review demonstrates the need to undertake more robust research to evaluate the effects of physically active academic lessons on health and academic outcomes. Nevertheless, the body of evidence presented supports recommendations by the Comprehensive School Physical Activity Program (CSPAP) (Centers for Disease Control and Prevention 2010) to integrate PA into academic lessons since results indicate that improvements occurred in students' PA levels in addition to enhancing their learning. Suggestions that short stints of PA throughout the school day can contribute towards health benefits (Barr-Anderson *et al.* 2011) are also supported. This implies that if implemented long-term and widely, such interventions may result in health improvements reducing the risk of early death and the problem of non-communicable diseases (WHO 2010).

Of the ten studies reporting PA outcomes, six were found to have medium-to-large effects (Cohen 1988) of the physically active lessons on student PA levels. A variety of data collection instruments were used to gather PA data across the studies. These ranged from objective tools such as accelerometers, pedometers, heart rate and PA monitors, and direct observation (SOFIT) which provide measures of PA intensity and/or duration, to self-report questionnaires and Previous Day Physical Activity Recall questionnaires (PDPAR). It has been argued that each measurement tool has its strengths and limitations and that there will always be a compromise between "practicality and accuracy when it comes to… PA measurement… among children" (Trost 2007, p. 299). Baranowski *et al.* (1984) evaluated the use of self-report instruments with children and reported that children younger than 10 years were unable to accurately recall activities or quantify the duration of the activities. Nevertheless, self-report measures have been deemed valid and reliable instruments to observe changes in PA behavior in children (Pate *et al.* 2005) since they provide detailed information on the nature and circumstances of PA along with being inexpensive. Objective measures have been recommended (Trost 2007) as more acceptable for young children since they are unobtrusive and not subject to recall bias. However, they too have their limitations such as being expensive and logistically difficult to administer. Therefore, the positive results which have emerged, considering the strengths and limitations of the range of measurement tools used, demonstrate that there is potential in such interventions to improve the PA levels of primary school children.

Several reports have emphasized the importance that teacher and student attitudes play in determining the success or failure of classroom-based PA interventions (Cothran *et al.* 2010, Fullan 2007, McMullen *et al.* 2014). This review found that students enjoyed physically active lessons and that teachers expressed positive attitudes towards their implementation and outcomes (Finn and McInnis 2014, Riley *et al.* 2015). These findings are reconcilable with previous work which examined teacher approval and student enjoyment of school- and classroom-based PA programmes (Cothran *et al.* 2010, Dishman *et al.* 2005, McMullen *et al.* 2014, Schneider and Cooper 2011). Cothran *et al.* (2010) and McMullen *et al.* (2014) reported that teachers were most satisfied with PA breaks that incorporate academic content and support what they had planned to teach rather than being additional activities. Teachers approved lessons which were easy to implement, enhanced learning, and which lead to student enjoyment. Teachers in the Cothran *et al.* (2010) and McMullen *et al.* (2014) studies also reported that integrating PA increased attentiveness in academic lessons while also motivating and exciting students to participate academically. Schneider and Cooper (2011) and Dishman *et al.* (2005) previously emphasized that interventions should target student enjoyment and aim to promote successful PA experiences which incorporate small group interaction and deemphasize competition. This evidence (Allender *et al.* 2006, Cothran *et al.* 2010, Howie *et al.* 2014, McMullen *et al.* 2014) suggests that it is essential to evaluate teacher approval and student enjoyment with regard to PA interventions, however these outcomes have only been evaluated in two included studies. What children do in the classroom is mainly controlled by the teacher, as students cannot be physically active in the classroom without teacher approval (Martin and Murtagh 2015b). Therefore, teachers' behavior and attitudes play a fundamental role in influencing the effectiveness (Fullan 2007) of classroom-based interventions. Changing their teaching methods is a personal decision by the teacher and decisions to participate are influenced by their approval of intervention programmes (Cothran *et al.* 2010). Since student enjoyment has also been found to influence and control the effect of PA interventions (Howie *et al.* 2014), as well as being identified as a dominant motivational factor to participate in PA and the primary element of student acceptability of PA programmes (Allender *et al.* 2006), it is an outcome which should not be overlooked. Teacher approval of classroom-based PA interventions also relies on this enjoyment (McMullen *et al.* 2014, Martin and Murtagh 2015b). Therefore, to develop effective PA interventions it is essential that both teachers and students are satisfied with the programme and perhaps these are outcomes which should be considered in similar studies in the future.

Given that it is well documented that girls are much less active than boys (Riddoch *et al.* 2004, Sherar *et al.* 2007) it is quite surprising that only one study (Oliver *et al.* 2006) reported sex specific findings of PA data. In an evaluation of sedentary behavior and PA levels of 10 to 14-year-old children during the segmented school day, Bailey *et al.* (2012) reported that the least amount of MVPA was accumulated during class time (Boys 11.2%, Girls 10.2%) and the majority of class time was spent in sedentary (Boys 69.4%, Girls 71.2%) with no significant differences between the sexes for either. However, during their classroom-based intervention Oliver *et al.* (2006) reported that least active students, especially girls, significantly increased their PA levels. Similarly, in an evaluation of PA breaks in the classroom, Erwin *et al.* (2011b) found that the intervention was particularly effective for those in the high risk, low-active groups and had the same effect for boys and girls. Erwin *et al.* (2011b) concluded that the insignificant difference between the sexes may have been because the intervention was carried out in the confined space of the classroom where all children participated equally in the opportunities presented to them. Martin and Murtagh (2015b) also report no significant difference in the PA levels accumulated during intervention lessons between the sexes. It has been reported that in less structured school-based time periods such as recess and lunch, boys have been found to accumulate more MVPA (Bailey *et al.* 2012) therefore, under structured guidance such as during classroom interventions girls seem to be likely to make similar gains to their male counterparts. This indicates that classroom-based PA interventions hold great promise in increasing the PA levels of all students, regardless of sex. These interventions could also especially benefit least-active children who need to be facilitated with more structured opportunities to be active.

The extensiveness of childhood obesity has reached pandemic proportions in the US (Ogden *et al.* 2014), the UK (Stamatakis *et al.* 2010), and in European countries (Wang and Lobstein 2006) with over 22% of 7 to 17-year-old children now considered overweight/obese. This is also seen in Ireland with 26% of 9 and 13-year-old children considered overweight/obese (Layte and McCrory 2011). Since childhood obesity continues into adulthood and significantly increases the risk of disease and premature death, prevention has become a matter of urgency (WHO 2010). Increasing PA has been identified as an important strategy for the prevention of childhood obesity as it reduces BMI through increased energy expenditure and fat oxidation (Epstein and Goldfield 1999). The results presented in the current review indicate potential for classroom-based PA programmes in improving future public health. All three studies which examined intervention effects on students' BMI reported some positive results (Donnelly *et al.* 2009, Liu *et al.* 2007, Li *et al.* 2010). This can be supported by other investigations which examined the link between PA and BMI. Kimm *et al.* (2005) reported that increased PA is linked to decreased weight gain in adolescents and children. They found that children who engaged in more MVPA had a reduced risk of obesity than their sedentary peers. A systematic review of the literature by Doak *et al.* (2006) concluded that simple PA intervention programmes, such as incorporating daily PA into the school curriculum (Dwyer *et al.* 1983) and increasing PA during school break times (Sallis *et al.* 1993), are capable of preventing obesity in children. The evidence presented lends promise to the use of classroom-based PA interventions in contributing towards the improvement of children's health by striving to achieve BMI levels which are within the range for optimum health benefits.

With schools facing challenges in designating time for PA throughout the school day due to emphasis on core academic subjects, it is important to illustrate that incorporating PA into the classroom does not detract from academic performance but may enhance it. It has been proven that PA has a positive impact on cognitive development (Hillman *et al.* 2008), cognitive skills, attitudes, and academic behavior, such as memory and concentration which are all important elements of enhanced academic performance (Centers for Disease Control and Prevention 2010). Of the studies evaluating the impact of physically active academic lessons on student learning in the current review, all four studies reported some positive effects (Donnelly *et al.* 2009, Lee and Thomas 2011, Mullender-Wijnsma *et al.* 2015, Reed *et al.* 2010). Students were examined mainly in math, reading, writing, and science. Lee and Thomas (2011) argue that the lack of difference in academic achievement between control and intervention groups in their study indicates that similar learning content was being covered in the traditional classroom and the classroom using PAD technologies. However, the authors claim that the PAD activities facilitate students to work with more complex data than their textbooks provide and consequently this intervention was found to have a large effect on reasoning tasks with contextualized data between the groups.

Of note is that all of the studies administered different assessments which limits comparability across interventions. Direct observation was used in both studies examining the relationship between the active lessons and time-on-task (Mahar *et al.* 2006, Riley *et al.* 2015). Medium and large effect sizes for behavior and time-on-task both during and following the active lessons were demonstrated in these studies. The findings presented support several previous publications which summarized the effect of active lessons on educational outcomes (Barr-Anderson *et al.* 2011, Bartholomew and Jowers 2011, Centers for Disease Control and Prevention 2010). Furthermore, implementing the interventions did not negatively affect students' learning, which provides counter-argument to some teachers' beliefs that increasing time spent teaching PA adversely affects students' academic achievements (Morgan and Hansen 2008).

The variances outlined across the studies with regard to duration of student exposure to physically active lessons, proportion of PA incorporated into lesson time, frequency of implementation, types of activities, teacher training, provision of resources and implementation personnel (teacher or researchers) highlights the need to rigorously examine and develop specific guidelines for teachers on how best physically active academic lessons should be implemented in the classroom in order to be effective in achieving health and educational gains.

1.7 Limitations

There are several limitations of note. First, the search strategy was limited to English-language publications. Second, no studies with children over 12 years old met the inclusion criteria so results are limited to interventions which took place in primary schools only. Third, there is a limited number of studies included in the review particularly for BMI, learning and/or facilitators of learning outcomes and consequently conclusions are drawn based on a small number of articles. Many of the included studies were assessed to be of high risk of bias in many areas according to the Cochrane Collaboration assessment tool (Higgins *et al.* 2011) or did not include sufficient information to make firm judgements about bias. Therefore, the results reported must be interpreted with caution since less rigorous studies may be biased toward overestimating or underestimating true intervention effects (Higgins *et al.* 2011). Fourth, as also noted in an earlier review (Norris *et al.* 2015), only three of the included studies considered theoretical frameworks in the development of their interventions (Erwin *et al.* 2011a, Mullender-Wijnsma *et al.* 2015, Reznik *et al.* 2015). There is evidence that PA interventions guided by behavior change theories are more effective and have more enduring results (Michie and Abraham 2004) than those that are not. Grounding future interventions in behavior change theories will ensure that they are provided with a valid foundation for their development (Norris *et al.* 2015). Fifth, only six studies provided detailed information regarding the active lessons implemented (Erwin *et al.* 2011a, Goh *et al.* 2014, Mahar *et al.* 2006, Oliver *et al.* 2006, Reznik *et al.* 2015, Riley *et al.* 2015) which limits the extent to which the components of the interventions can be fully examined or replicated. Variation in the duration of the interventions, which range from 1 week to 3 academic years, is an additional limitation. This great variance in student exposure to physically active academic lessons makes comparisons across the studies difficult since students received different total volume and frequency of active lessons. Sixth, not all of the authors contacted responded to confirm the accuracy of information presented regarding their studies. Seventh, since nine of the fourteen studies were carried out in the U.S. it may be problematic to generalize results to educational systems of other countries. Though it is worth noting that the US-based TAKE 10! programme was successfully adapted for China (Liu *et al.* 2007, Li *et al.* 2010) and Netherlands (Mullender-Wijnsma *et al.* 2015). Finally, we acknowledge that our findings are based on the published evidence available. It is possible that studies suggesting a beneficial intervention effect or a larger effect size are published, while a similar amount of data pointing in the other direction remains unpublished (Sterne *et al.* 2011). Such publication bias could overestimate the impact of classroom-based PA interventions on health and/or academic outcomes.

1.8 Conclusions

This review illustrates the important role that physically active academic lessons can play in increasing PA levels of schoolchildren. Additionally, potential benefits for education and health outcomes, and facilitators of learning were observed. Several recommendations with regard to study design and reporting have been identified. Specifically, this review demonstrates the need for future research to involve more robust designs, i.e. randomized controlled trials, and adhere to reporting standards, e.g. CONSORT (Schulz *et al.* 2010) so that conclusions can be drawn from well designed and reported, high quality studies. The results reported are of relevance for policy-makers, educational administrators, and teachers. Our findings provide evidence for the valuable contribution that physically active teaching methods can make to school-based health promotion.

1.9 What Does This Article Add?

This review evaluates existing classroom-based PA interventions which integrate academic content with respect to four major outcomes in this area. Although a previous review has been carried out which evaluates the effect of such interventions on PA levels and academic attainment, this is the first review to consider these outcomes as well as, health (BMI) and facilitators of learning outcomes. Facilitators of learning outcomes such as teacher approval and student enjoyment have previously been identified as essential in determining the success of classroom-based PA interventions and although a limited number of studies were available to assess this outcome in the current review, results support these previous findings and indicate that evaluations of teacher approval and student enjoyment should be included in future intervention studies. Results also indicate the potentially positive contribution accumulating PA through these interventions can make to the health of students. This review also demonstrates the need for researchers to undertake more robust research designs such as randomized controlled trials in their evaluation of such interventions to reduce the potential for bias and avoid misleading conclusions being drawn. Notwithstanding the aforementioned limitations regarding risk of bias in studies and the limited number of studies available, this review illustrates the positive effects physically active academic lessons can have on PA levels, health, learning, and facilitators of learning outcomes. It also highlights how such interventions can assist teachers in coping with barriers to improve PA levels of their students without negatively affecting academic teaching time. The evaluation of these outcomes in this review provides emerging evidence for the implementation of such interventions and makes a valuable contribution to the existing body of knowledge in this area.

1.10 References

Allender, S., Cowburn, G., & Foster, C. (2006). 'Understanding participation in sport and physical activity among children and adults: A review of qualitative studies', *Health Education Research, 21*(6), 826-835. doi:10.1093/her/cyl063

Bailey, D. P., Fairclough, S., Savory, L., Denton, S., Pang, D., Deane, C., & Kerr, C. (2012). 'Accelerometry-assessed sedentary behavior and physical activity levels during the segmented school day in 10–14-year-old children: The HAPPY study', *European Journal of Pediatrics, 171*(12), 1805-1813. doi:10.1007/s00431-012-1827-0

Baranowski, T., Dworkin, R. J., Cieslik, C. J., Hooks, P., Clearman, D. R., Ray, L., . . . Nader, P. R. (1984). 'Reliability and validity of self-report of aerobic activity: Family Health Project', *Research Quarterly for Exercise and Sport, 55*(4), 309-317.

Barr-Anderson, D. J., AuYoung, M., Whitt-Glover, M. C., Glenn, B. A., & Yancey, A. K. (2011). 'Integration of short bouts of physical activity into organizational routine: A systematic review of the literature', *American Journal of Preventive Medicine, 40*(1), 76-93. doi:10.1016/j.amepre.2010.09.033

Bartholomew, J. B., & Jowers, E. M. (2011). 'Physically active academic lessons in elementary children', *Preventive Medicine, 52*(Suppl. 1), S51-54. doi:10.1016/j.ypmed.2011.01.017

Centers for Disease Control and Prevention [CDC]. (2010). *The association between school-based physical activity, including physical education, and academic performance.* Atlanta, GA: US Department of Health and Human Services.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). New York, NY: Psychology Press.

Cothran, D. J., Kulinna, P. H., & Garn, A. C. (2010). 'Classroom teachers and physical activity integration', *Teaching and Teacher Education, 26*(7), 1381-1388. doi:10.1016/j.tate.2010.04.003

Dishman, R. K., Motl, R. W., Saunders, R., Felton, G., Ward, D. S., Dowda, M., & Pate, R. R. (2005). 'Enjoyment mediates effects of a school-based physical-activity intervention', *Medicine and Science in Sports and Exercise, 37*(3), 478-487. doi:10.1249/01.MSS.0000155391.62733.A7

Doak, C., Visscher, T., Renders, C., & Seidell, J. (2006). 'The prevention of overweight and obesity in children and adolescents: A review of interventions and programmes', *Obesity Reviews, 7*(1), 111-136. doi:10.1111/j.1467-789X.2006.00234.x

Dobbins, M., Husson, H., DeCorby, K., & LaRocca, R. L. (2013). 'School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18', *Cochrane Database Systematic Review, 2*(2). CD007651. doi: 10.1002/14651858.CD007651.pub2

Donnelly, J., Greene, J., Gibson, C., Smith, B., Washburn, R., Sullivan, D., . . . Williams, S. (2009). 'Physical activity across the curriculum (PAAC): A randomized controlled trial to promote physical activity and diminish overweight and obesity in elementary school children', *Preventive Medicine, 49*(4), 336-341. doi:10.1016/j.ypmed.2009.07.022

Donnelly, J. E., & Lambourne, K. (2011). 'Classroom-based physical activity, cognition, and academic achievement', *Preventive Medicine, 52*(Suppl. 1), S36-42. doi:10.1016/j.ypmed.2011.01.021

Dunn, L. L., Venturanza, J. A., Walsh, R. J., & Nonas, C. A. (2012). 'An observational evaluation of Move-to-Improve, a classroom-based physical activity program, New York City schools, 2010', *Preventing Chronic Disease, 9*(9), E146. doi:10.5888/pcd9.120072

Dwyer, T., Coonan, W. E., Leitch, D. R., Hetzel, B. S., & Baghurst, R. (1983). 'An investigation of the effects of daily physical activity on the health of primary school students in South Australia', *International Journal of Epidemiology, 12*(3), 308-313.

Eather, N., Morgan, P. J., & Lubans, D. R. (2013). 'Improving the fitness and physical activity levels of primary school children: Results of the Fit-4-Fun group randomized controlled trial', *Preventive Medicine, 56*(1), 12-19. doi:10.1016/j.ypmed.2012.10.019

Epstein, L. H., & Goldfield, G. S. (1999). 'Physical activity in the treatment of childhood overweight and obesity: Current evidence and research issues', *Medicine and Science in Sports and Exercise, 31*(Suppl. 11), S553-559.

Erwin, H., Abel, M., Beighle, A., & Beets, M. (2011a). 'Promoting children's health through physically active math classes: A pilot study', *Health Promotion Practice, 12*(2), 244-251. doi:10.1177/1524839909331911

Erwin, H., Beighle, A., Morgan, C., & Noland, M. (2011b). 'Effect of a low-cost, teacher-directed classroom intervention on elementary students' physical activity', *Journal of School Health, 81*(8), 455-461. doi:10.1111/j.1746-1561.2011.00614.x

Erwin, H., Fedewa, A., Beighle, A., & Ahn, S. (2012). 'A quantitative review of physical activity, health, and learning outcomes associated with classroom-based physical activity interventions', *Journal of Applied School Psychology, 28*(1), 14-36. doi:10.1080/15377903.2012.643755

Finn, K. E., & McInnis, K. J. (2014). 'Teachers' and students' perceptions of the active science curriculum: Incorporating physical activity into middle school science classrooms', *Physical Educator, 71*(2), 234-253.

Fullan, M. (2007). *The new meaning of educational change* (4th ed.). London, UK: Routledge.

Goh, T. L., Hannon, J., Webster, C. A., Podlog, L. W., Brusseau, T. A., & Newton, M. (2014). 'Effects of a classroom-based physical activity program on children's physical activity levels', *Journal of Teaching in Physical Education, 33*(4), 558-772.

Group of China Obesity Task Force. (2004). 'Body mass index reference norm for screening overweight and obesity in Chinese children and adolescents', *Zhonghua Liu Xing Bing Xue Za Zhi, 25*(2), 97-102.

Hamilton, M., Healy, G., Dunstan, D., Zderic, T., & Owen, N. (2008). 'Too little exercise and too much sitting: Inactivity physiology and the need for new recommendations on sedentary behavior', *Current Cardiovascular Risk Reports, 2*(4), 292-298. doi:10.1007/s12170-008-0054-8

Higgins, J., & Green, S. (2011). 'Cochrane handbook for systematic reviews of interventions Version 5.1. 0 [updated March 2011]', *The Cochrane Collaboration, 5*(0). Retrieved from http://www.cochrane-handbook.org.

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., Moher, D., Oxman, A. D., . . . Sterne, J. A. (2011). 'The Cochrane Collaboration's tool for assessing risk of bias in randomised trials', *The BMJ, 343*. doi: http://dx.doi.org/10.1136/bmj.d5928

Hillman, C. H., Erickson, K. I., & Kramer, A. F. (2008). 'Science and society: Be smart, exercise your heart: Exercise effects on brain and cognition', *Nature Reviews: Neuroscience, 9*(1), 58-65. doi:10.1038/nrn2298

Holt, E., Bartee, T., & Heelan, K. (2013). 'Evaluation of a policy to integrate physical activity into the school day', *Journal of Physical Activity & Health, 10*(4), 480-487.

Howie, E. K., Newman-Norlund, R. D., & Pate, R. R. (2014). 'Smiles count but minutes matter: Responses to classroom exercise breaks', *American Journal of Health Behavior, 38*(5), 681-689.

Kendzierski, D., & DeCarlo, K. J. (1991). 'Physical Activity Enjoyment Scale: Two validation studies', *Journal of Sport & Exercise Psychology, 13*(1), 50-64.

Kimm, S. Y., Glynn, N. W., Obarzanek, E., Kriska, A. M., Daniels, S. R., Barton, B. A., & Liu, K. (2005). 'Relation between the changes in physical activity and body-mass index during adolescence: A multicenter longitudinal study', *The Lancet, 366*(9482), 301-307. doi:10.1016/S0140-6736(05)66837-7

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., . . . Johnson, C. L. (2002). '2000 CDC Growth Charts for the United States: Methods and development', *Vital and Health Statistics. Series 11, Data from the National Health Survey, 11*(246), 1-190.

Layte, R., & McCrory, C. (2011). *Growing up in Ireland: National longitudinal study of children: Overweight and obesity among 9-year-olds*. Dublin, Ireland: Government Publications.

Lee, V., & Thomas, J. (2011). 'Integrating physical activity data technologies into elementary school classrooms', *Educational Technology Research and Development, 59*(6), 865-884. doi:10.1007/s11423-011-9210-9

Li, Y. P., Hu, X. Q., Schouten, E. G., Liu, A. L., Du, S. M., Li, L. Z., . . . Ma, G. S. (2010). 'Report on childhood obesity in China (8): Effects and sustainability of physical activity intervention on body composition of Chinese youth', *Biomedical and Environmental Sciences, 23*(3), 180-187. doi:10.1016/s0895-3988(10)60050-5

Lipsey, M. W., & Wilson, D. B. (2001). *Practical meta-analysis* (Vol. 49): Sage publications Thousand Oaks, CA.

Liu, A., Hu, X., Ma, G., Cui, Z., Pan, Y., Chang, S., . . . Chen, C. (2007). 'Report on childhood obesity in China (6): Evaluation of a classroom-based physical activity promotion program', *Biomedical and Environmental Sciences, 20*(1), 19-23.

Mahar, M., Murphy, S., Rowe, D., Golden, J., Shields, A., & Raedeke, T. (2006). ‘Effects of a classroom-based program on physical activity and on-task behavior’, *Medicine & Science in Sports & Exercise, 38*(12), 2086-2094.

Martin, R. and Murtagh, E. M. (2015a) 'An intervention to improve the physical activity levels of children: Design and rationale of the ‘Active Classrooms’ cluster randomised controlled trial', *Contemporary Clinical Trials*, 41(0), 180-191.

Martin, R. and Murtagh, E. M. (2015b) 'Preliminary findings of Active Classrooms: An intervention to increase physical activity levels of primary school children during class time', *Teaching and Teacher Education,* 52, 113-127.

McMullen, J., Kulinna, P. H., & Cothran, D. (2014). ‘Physical activity opportunities during the school day: Classroom teachers’ perceptions of using activity breaks in the classroom’, *Journal of Teaching in Physical Education, 33*(4), 511-527.

Metcalf, B., Voss, L., & Wilkin, T. (2002). ‘Accelerometers identify inactive and potentially obese children (EarlyBird 3)’, *Archives of Disease in Childhood, 87*(2), 166-167. doi:10.1136/adc.87.2.166

Michie, S., & Abraham, C. (2004). ‘Interventions to change health behaviors: Evidence-based or evidence-inspired?’, *Psychology & Health, 19*(1), 29-49. doi:10.1080/0887044031000141199

Moher, D., Liberati, A., Tetzlaff, J., & Altman, D. G. (2009). ‘Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement’, *Annals of Internal Medicine, 151*(4), 264-269.

Morgan, P., & Hansen, V. (2008). ‘Classroom teachers' perceptions of the impact of barriers to teaching physical education on the quality of physical education programs’, *Research Quarterly for Exercise and Sport, 79*(4), 506-516.

Mullender-Wijnsma, M. J., Hartman, E., de Greeff, J. W., Bosker, R. J., Doolaard, S., & Visscher, C. (2015). ‘Improving academic performance of school-age children by physical activity in the classroom: 1-year program evaluation’, *Journal of School Health, 85*(6), 365-371. doi:10.1111/josh.12259

Multicenter Growth Reference Study Group, World Health Organization. (2006). ‘WHO Child Growth Standards based on length/height, weight and age’, *Acta Paediatrica, 95*(Suppl. 450), 76-85. doi:10.1080/08035320500495548

Naylor, P., Nettlefold, L., Race, D., Hoy, C., Ashe, M., Wharf Higgins, J., & McKay, H. (2015). ‘Implementation of school based physical activity interventions: A systematic review’, *Preventive Medicine, 72*, 95-115. doi:10.1016/j.ypmed.2014.12.034

Norris, E., Shelton, N., Dunsmuir, S., Duke-Williams, O., & Stamatakis, E. (2015). ‘Physically active lessons as physical activity and educational interventions: A systematic review of methods and results’, *Preventive Medicine 72,* 116-125. doi:10.1016/j.ypmed.2014.12.027

Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2014). ‘Prevalence of childhood and adult obesity in the United States, 2011-2012’, *Journal of the American Medical Association, 311*(8), 806-814.

Oliver, M., Schofield, G., & McEvoy, E. (2006). ‘An integrated curriculum approach to increasing habitual physical activity in children: A feasibility study’, *Journal of School Health, 76*(2), 74-79. doi:10.1111/j.1746-1561.2006.00071.x

Pate, R. R., Ward, D. S., Saunders, R. P., Felton, G., Dishman, R. K., & Dowda, M. (2005). 'Promotion of physical activity among high-school girls: A randomized controlled trial', *American Journal of Public Health, 95*(9), 1582-1587. doi:10.2105/AJPH.2004.045807

Raven, J. C., Raven, J. C., & De Lemos, M. M. (1958). *Standard progressive matrices*. London, UK: Lewis.

Reed, J. A., Einstein, G., Hahn, E., Hooker, S. P., Gross, V. P., & Kravitz, J. (2010). 'Examining the impact of integrating physical activity on fluid intelligence and academic performance in an elementary school setting: A preliminary investigation', *Journal of Physical Activity & Health, 7*(3), 343-351.

Schulz, K. F., Altman, D. G., & Moher, D. (2010). 'CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials', *Trials, 11,* 32. doi:10.1186/1745-6215-11-32

Sterne, J. A., Egger, M., & Moher, D. (updated March 2011). Chapter 10: Addressing reporting biases. In: Higgins, J.P.T. & Green, S. (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions* Version 5.1.0. The Cochrane Collaboration, 2011. Available from www.handbook.cochrane.org.

Reznik, M., Wylie-Rosett, J., Kim, M., & Ozuah, P. O. (2015). 'A classroom-based physical activity intervention for urban kindergarten and first-grade students: A feasibility study', *Childhood Obesity, 11*(3), *314-324.*

Riddoch, C., Bo, A., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L., . . . Ekelund, U. (2004). 'Physical activity levels and patterns of 9- and 15-year-old European children', *Medicine & Science in Sports & Exercise, 36*(1), 86-92.

Riley, N., Lubans, D. R., Morgan, P. J., & Young, M. (2015). 'Outcomes and process evaluation of a programme integrating physical activity into the primary school mathematics curriculum: The EASY Minds pilot randomized controlled trial', *Journal of Science and Medicine in Sport, 18*(6), 656–661. doi:10.1016/j.jsams.2014.09.005

Sallis, J. F., McKenzie, T. L., Alcaraz, J. E., Kolody, B., Hovell, M. F., & Nader, P. R. (1993). 'Project SPARK. Effects of physical education on adiposity in children', *Annals of the New York Academy of Sciences, 699*(1), 127-136.

Schneider, M., & Cooper, D. M. (2011). 'Enjoyment of exercise moderates the impact of a school-based physical activity intervention', *International Journal of Behavioral Nutrition & Physical Activity, 8*(1), 64-64. doi:10.1186/1479-5868-8-64

Sherar, L. B., Esliger, D. W., Baxter-Jones, A. D., & Tremblay, M. S. (2007). 'Age and gender differences in youth physical activity: Does physical maturity matter?', *Medicine & Science in Sports & Exercise, 39*(5), 830-835. doi:10.1249/mss.0b013e3180335c3c

Stamatakis, E., Wardle, J., & Cole, T. J. (2010). 'Childhood obesity and overweight prevalence trends in England: Evidence for growing socioeconomic disparities', *International Journal of Obesity, 34*(1), 41-47. doi:10.1038/ijo.2009.217

Tomporowski, P., Davis, C., Miller, P., & Naglieri, J. (2008). 'Exercise and children's intelligence, cognition, and academic achievement', *Educational Psychology Review, 20*(2), 111-131. doi:10.1007/s10648-007-9057-0

Trost, S. G. (2007). ‘State of the art reviews: Measurement of physical activity in children and adolescents’, *American Journal of Lifestyle Medicine, 1*(4), 299-314. doi:10.1177/1559827607301686

Wang, Y., & Lobstein, T. (2006). ‘Worldwide trends in childhood overweight and obesity’, *International Journal of Pediatric Obesity, 1*(1), 11-25. doi:10.1080/17477160600586747

Webster, C., Russ, L., Vazou, S., Goh, T., & Erwin, H. (2015). ‘Integrating movement in academic classrooms: Understanding, applying and advancing the knowledge base’, *Obesity Reviews, 16*(8), 691-701. doi:10.1111/obr.12285

World Health Organization [WHO] (2010) *Global recommendations on physical activity for health,* Geneva, Switzerland: World Health Organization.

Zhu, W. (2016). ‘p< 0.05,< 0.01,< 0.001,< 0.0001,< 0.00001,< 0.000001, or< 0.0000001…’, *Journal of Sport and Health Science, 5*(1), 77-79.