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[^0]A systematic review and meta-analysis of moderate-to-vigorous physical activity levels in elementary school physical education lessons.

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#### Abstract

Objective: To examine elementary school students' moderate-to-vigorous physical activity (MVPA) levels during physical education (PE) lessons.

Methods: A systematic search of nine electronic databases was conducted (PROSPERO2014:CRD42014009649). Studies were eligible if they were in English; published between 2005-April 2014; assessed MVPA levels in PE lessons of elementary school children (aged four-12 years); and used an objective MVPA measure. Two reviewers retrieved articles, assessed risk of bias, and performed data extraction. The findings were synthesised using a meta-analysis.

Results: The search yielded 5132 articles. Thirteen studies from nine countries met the inclusion criteria. Eight studies measured MVPA through observational measures, five used accelerometry and one used heart rate monitoring. The percentage of PE lesson time spent in MVPA ranged between 11.4-88.5\%. Meta-analysis of seven studies (4 direct observation; 4 accelerometers) found that children spent a mean ( $95 \% \mathrm{CI}$ ) 44.8 (28.2-61.4)\% of PE lesson time in MVPA. When measured using direct observation and accelerometers, children spent 57.6 (47.3-68.2) and 32.6 (5.9-59.3)\% of PE lesson time in MVPA, respectively. The review has limitations; the search strategy was restricted to studies in English; theses, dissertations and conference abstracts were excluded; and six studies that provided insufficient data were excluded from the meta-analysis.

Conclusion: MVPA levels during elementary school PE lessons do not meet the United States Centre for Disease Control and Prevention and the United Kingdom's Association of Physical Education recommendation ( $50 \%$ of lesson time), but is higher than estimated in the previous review (34.2\%). Interventions to increase MVPA in PE lessons are needed.


Key words: Schools, Physical education and training, Motor activity, Child.

## Abbreviations

62 Accel-Accelerometer
63 afPE - Association of Physical Education
64 ASD - Autistic Spectrum Disorders
65 BEACHES - Behaviour of Eating and Activity for Children's Health: Evaluation System
66 BMI - Body Mass Index
67 CDC - Centre for Disease Control
68 CDOM - Continuous Direct Observation Method
69 FI - Fitness Infusion
70 FMS - Fundamental Movement Skills
71 HR - Heart Rate
72 Mins - Minutes
73 MVPA - Moderate-to-Vigorous Physical Activity
74 NR - Not Reported
75 NSW - New South Wales
76 PE - Physical Education
77 PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analyses
78 RCT's - Randomised Controlled Trials
79 SAM - Simple Activity Measurement
80 SD - Standard Deviation
81 SE - Standard Error
82 SES - Socioeconomic Status
83 UK - United Kingdom
84 US - United States
85 WHO - World Health Organisation
86 SOFIT - System for Observing Fitness Instruction Time
87 95\% CI - 95\% Confidence Intervals

## Introduction

Engaging children in physical activity during childhood is important as physical inactivity has been associated with cardiovascular risk factors and obesity in children. ${ }^{1-3}$ International guidelines by the World Health Organisation (WHO) recommend that 5-17 year old children engage in 60 minutes of moderate-to-vigorous physical activity (MVPA) each day. ${ }^{4}$ However national data from the United States (US) ${ }^{5}$ collected using accelerometers, and self-report survey data from Australia ${ }^{6}$, have reported that less than half of children meet this recommendation.

Schools are a valuable setting to promote and engage children in physical activity. ${ }^{7}$ In particular, physical education (PE) lessons provide an opportunity for children to engage in MVPA and develop the fundamental movement skills (FMS), knowledge and attitudes required for a lifetime of physical activity. ${ }^{8}$ The US Centre for Disease Control (CDC) and Prevention ${ }^{9}$ and the United Kingdoms (UK) Association of Physical Education (afPE) ${ }^{10}$ have recommended that both elementary and secondary school children engage in MVPA for at least 50\% of PE lesson time.

Despite the potential for PE lessons to play a role in promoting physical activity in children from a young age, only one review has examined MVPA during elementary school PE lessons. ${ }^{11}$ The narrative review was based on 44 studies published until 2005, and included cross sectional, longitudinal and intervention studies (baseline and follow-up data of all control and intervention groups). ${ }^{11}$ The majority of studies used observational methods to measure MVPA ( $n=26$ ), while 15 studies used heart rate monitoring and nine used monitor sensors (accelerometers and pedometers). ${ }^{11}$ Six studies used a combination of physical activity measurements methods. ${ }^{11}$ The mean lesson length was 33.7 minutes. ${ }^{11}$ The review found that when data from PE lessons under both intervention and non-intervention conditions were combined ( $n=44$ ), students participated in MVPA for $37.4 \%$ of PE lesson time, with a mean of $34.2 \%$ based on non-intervention condition studies only ( $n=15$ ). ${ }^{11}$ Subgroup analyses showed that activity tended to increase with school grade, particularly between grades three and five. MVPA differed according to measurement type, with heart rate monitors reporting the highest percentage MVPA (40.4\%), followed by motion sensors such as accelerometers and pedometers (36.8\%), and observation methods (32.5\%). ${ }^{11}$ The review did not undertake an assessment of risk of bias to aid the interpretation of findings.

Given the absence of a subsequent updated review, the primary aim of this systematic review was to examine elementary school students' MVPA levels during PE lessons in studies published between 2005 and 2014. The secondary aims were to evaluate student participation in MVPA during PE lessons by: i) measurement type (accelerometer, heart rate
monitoring, pedometry or observational measure); ii) PE activities; and iii) student (e.g. sex, socioeconomic status (SES)), teacher (e.g. training) and environmental factors (e.g. country).

## Methods

For the purpose of this review, the term 'elementary school' (i.e. catering for children aged 412 years) will be used throughout. The systematic review protocol was registered with Prospero on the 7/5/2014 (PROSPERO2014:CRD42014009649): http://www.crd.york.ac.uk/PROSPERO/display record.asp?ID=CRD42014009649. The review adhered to the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) statement. ${ }^{12}$

A two-step search strategy was used. First, a systematic search of nine electronic scientific databases was performed in May 2014: Medline, Sport Discus, CINAHL, The Central Cochrane database, ERIC, Proquest, EMBASE, Scopus, and PsycINFO. Key search terms and their synonyms were searched using four filters identifying the i) setting (e.g. physical education), ii) target population (e.g. child), iii) measurement (e.g. MVPA), and iv) study design (e.g. prospective studies). Search terms within each filter were combined using the Boolean operator 'or', and all four filters were combined to form one search using the Boolean operator 'and'. See Appendix A for the full list of search terms and a record of the search strategy. Secondly, the reference lists of all included studies were manually searched for additional papers not already identified.

## Inclusion and exclusion criteria

The title and abstracts of the studies identified during the search were retrieved and examined by two reviewers (J.H., A.W.) to determine if the study met the inclusion criteria. The full texts of potentially eligible studies were retrieved and independently assessed by the two reviewers to determine eligibility. If there was disagreement on whether a study should be included in the review and a consensus could not be reached through discussion, a third independent reviewer was consulted (R.S.).

This review examined studies that: i) assessed the MVPA levels of elementary school children (aged four-12 years) during PE lessons; ii) used a quantitative measure of physical activity such as accelerometers, heart rate monitors, pedometers or systematic observational measures (e.g. the System for Observing Fitness Instruction time (SOFIT)); iii) studies published in English between January 2005 and April 2014; and iv) used crosssectional and prospective longitudinal quantitative study designs. For intervention studies (e.g. Randomised Controlled Trials (RCT's), non-RCT's and pre-post studies), baseline data from both intervention and control groups were included. If baseline data were not provided,
the control group follow-up data were used if no intervention was delivered to that group. Follow-up data from intervention studies were excluded as the aim was to assess MVPA in usual PE lessons rather than under intervention conditions. Studies that reported findings in abstracts, theses, dissertations, and unpublished literature were excluded from the review. The 'cut-off' date for this review was 2005 as the searches for the previous review ${ }^{11}$ took place in January 2005, and this current systematic review aimed to include all relevant studies published since the prior review.

## Risk of bias assessment

An 11-item tool to assess the methodological quality of the studies was developed (Appendix B). A new tool was created as no other risk of bias tool that assessed bias relevant to this systematic review context was identified. Existing tools ${ }^{13-15}$ assessed criteria such as participant recall bias, interviewer bias (e.g. assessor blinding), the randomisation procedure, and attrition. The existing tools also lacked detailed criteria on selection and instrument bias relevant to the school context, PE lessons and MVPA measures, which were more likely to influence the findings of this review. The tool comprised seven domains (Table 1) covering selection bias across the school, class and student level, plus selection and instrument bias related to the PE lessons and MVPA measures.

Two independent reviewers (J.H., A.W.) used the tool to examine the risk of bias of all studies that were considered eligible. Any difference in ratings was resolved through discussion between the two reviewers. If a consensus could not be reached, a third reviewer was consulted (R.S.). Each criteria was coded as 'clearly described and present' (yes), 'absent' (no), or 'unclear or inadequately described' (unclear) rating for each of the 11 items. Each domain was considered independently as recommended by PRISMA. ${ }^{12}$

## Data collection

A pre-piloted standardised data extraction table was used by one independent reviewer (A.W.) to extract study data from the included studies. A second independent reviewer (J.H.) examined the completed data extraction table and added any missing data, corrected any errors and highlighted information that was unclear. The two reviewers discussed all discrepancies and consulted a third reviewer (R.S.) where a consensus could not be reached. Missing data were requested from study authors if it would determine study eligibility and/or if insufficient data was provided for inclusion in a meta-analysis. The extracted information provided details regarding: study design, setting (region/country, school year), participants (school and student sample size, student age, sex, SES, ethnicity), teacher training, aim, recruitment, response rate, measurement type, lesson delivery, number of lessons, lesson duration, activities engaged in during the lesson, and MVPA in PE
lessons. MVPA in PE lesson time was included if it was provided as either: i) mean percentage of lesson time spent in MVPA, or ii) minutes of MVPA per lesson and length of the PE lesson so that percentage MVPA per lesson could be manually calculated.

## Data synthesis

The characteristics and findings of all included studies were synthesised narratively. Summaries of the MVPA levels in each study were presented as mean (SD/SE/95\%CI) percentage of lesson time and actual minutes, where available. The findings for percentage time spent in MVPA were pooled into a meta-analysis using Comprehensive Meta-analysis Software (version 2.2.064, July 2011) for studies that provided mean percentage of time in MVPA, a standard deviation, and number of PE lessons observed. Moderator analyses, according to the pre-specified subgroups, were planned to address the secondary aims of the review including; type of measurement instrument (accelerometry, heart rate monitoring, observation), type of physical activity, student sex, student SES, teacher training, and study country. Statistical heterogeneity was assessed through Cochran's Q and the $I^{2}$ Index tests. As a guide to interpreting the $I^{2}$ Index; 0-40\% may represent low heterogeneity; 30-60\% moderate heterogeneity; 50-90\% substantial heterogeneity; and $75 \%-100 \%$ considerable heterogeneity. ${ }^{16}$ Methodological heterogeneity was also examined through the subgroup meta-analysis that examined the method of assessing MVPA.

## Results

## Study selection

The initial database search yielded 5132 articles once duplicates were removed (Figure 1). Following title and abstract review, 74 full-text papers were retrieved and reviewed for eligibility. Fourteen papers representing 13 studies met the inclusion criteria. ${ }^{17-30}$ Seven studies ${ }^{17,18,20,21,23,29,30}$ provided sufficient data to be pooled into a meta-analysis. All study selection discrepancies between the two reviewers were resolved through discussion, and the third reviewer was not consulted. The two reviewers initially disagreed on $6.6 \%$ of the risk of bias criteria; however a consensus was reached on all criteria through discussion. There were 10 discrepancies in data collection between the two reviewers, which were all resolved by discussion.

## Study characteristics

The characteristics and outcomes of the studies are shown in Tables 2 and 3. Publication dates ranged from $2005^{22}$ to $2014 .{ }^{21}$ The studies were conducted in the US $(n=2)^{21,23}$, UK $(n=2)^{24,}{ }^{30}$, Belgium ( $\left.n=1\right)^{29}$, Switzerland $(n=1)^{19}$, Mexico $(n=1)^{26}$, Canada $(n=1)^{20}$, Brazil $(n=1)^{18}$, Australia ( $\left.n=1\right)^{27,28}$ and Hong Kong ( $n=1$ ). ${ }^{17}$ Two studies did not report the study location. ${ }^{22,25}$ The majority of studies were of cross-sectional design $(n=8)^{17-24}$ and the
remaining five studies were RCT's. ${ }^{25-30}$ Baseline intervention and control group data were included in the review for two of the five RCT studies ${ }^{26,29}$, whereas only control group data could be obtained for the remaining three studies. ${ }^{25,} 27,28,30$ The number of student participants in the individual studies ranged from $13^{22}$ to $830^{26}$, and the number of schools included in studies ranged from one ${ }^{25}$ to $42^{17}$. All 13 studies monitored both male and female students, and only one study reported results by sex. ${ }^{20}$

Eight studies ${ }^{17,} 21-24,26-29$ measured MVPA through direct observational measures, five used accelerometry ${ }^{18-20,29,30}$ and one used heart rate monitoring. ${ }^{25}$ One study used both accelerometry and direct observation. ${ }^{29}$ The number of PE lessons observed in each study ranged from two ${ }^{23}$ to $374 .{ }^{24} \mathrm{PE}$ lesson length varied between $24^{21}$ and 50 minutes. ${ }^{23,26,29}$ Seven studies employed specialist PE teachers to deliver the PE lesson ${ }^{17,19, ~ 20, ~ 23, ~ 25, ~ 26, ~} 29$, one study used classroom teachers with little or no PE training ${ }^{27,}{ }^{28}$, and two studies employed both specialist PE teachers and classroom teachers. ${ }^{21,30}$ Three studies did not specify the teacher delivering the lessons. ${ }^{18,22,24}$ Only five ${ }^{17,19,23-25}$ of the 13 studies specified the types of activities the children were engaged in during the lesson. The activities within each study varied and included ball games, fitness activities and movement activities (e.g. dance and gymnastics). The random effects models were used for all analyses as there was considerable heterogeneity among the studies ( $G=1043$, df = 6 ( $p \leq 0.01$ ); $I^{2}=99 \%$ ). The subgroup analysis consisting of four studies that measured MVPA by accelerometry was also found to be highly heterogeneous ( $G=704$, $\mathrm{df}=3$ ( $p \leq 0.01$ ); $I^{2}=100 \%$ ), as was the analysis for the four studies that measured MVPA through observational methods (G = 71 , df = 3 ( $\mathrm{p}=<0.01$ ); $\mathrm{I}^{2}=96 \%$ ).

## Risk of bias

Table 4 shows the risk of bias assessment for all included studies. For many studies, it was unclear if the school sample was representative ( $n=8$ ) and whether the classes selected to be measured were representative of all classes ( $\mathrm{n}=8$ ). The nature of the physical activities observed was not reported in eight studies and the number of PE lessons observed was not described in seven studies. All studies adequately described the student eligibility criteria and the demographic characteristics of the class sample. The majority of studies used an objective measure of physical activity or cited validation studies ( $n=10 / 13$ ) and stated reliability data ( $n=11 / 13$ ), reducing the risk of instrument bias.

## MVPA in elementary school PE lessons

Of the 13 studies included in the systematic review, the percentage of PE lesson time spent in MVPA ranged between $11.4 \%$ and $88.5 \%$. The mean percentage of PE lesson spent in MVPA was greater than $50 \%$ in five of the 13 studies. In one study ${ }^{29}$, children met the CDC
and afPE recommendation when accelerometers were used to measure MVPA, but not when SOFIT observations were used. Seven studies provided sufficient data for inclusion in meta-analysis. The pooled analysis of these seven studies found that children spent a mean ( $95 \% \mathrm{CI}$ ) of 44.8 (28.2-61.4)\% of PE lesson time in MVPA (Figure 2).

## Moderator analyses

## i) Measurement type: accelerometer or observational measure

Of the seven studies that were included in the meta-analysis, four studies measured MVPA with accelerometers ${ }^{18,20,29,30}$ and four using observational measures (three used SOFIT, and one used Simple Activity Measurement (SAM)). ${ }^{17,21,23,29}$ One study measured MVPA using both accelerometers and SOFIT. ${ }^{29}$ When measured using accelerometers and observational measures, children spent a mean (95\%CI) 32.6 (5.9-59.3)\% (Figure 3) and 57.6 (47.3-68.2)\% (Figure 4) of PE lesson time in MVPA, respectively.

## ii) PE activities

Moderator analyses to assess the percentage of PE lesson time spent in MVPA according to different activities could not be conducted due to the lack of information on the PE activities performed. Only two studies ${ }^{17,23}$ in the meta-analysis provided information on the physical activities performed, and the activities performed varied greatly (i.e. ball games, fitness activities, and movement activities e.g. dance and gymnastics).

## iii) Student, teacher and environmental factors

Moderator analyses to examine the percentage of PE lesson time spent in MVPA according to student, teacher and environmental factors were not conducted due to the lack of information provided on these factors. Few studies in the meta-analysis provided information on the SES of school communities ( $n=3 / 7$ ), and only one study reported results separately by student sex. In terms of teacher PE training, four studies employed specialist PE teachers ${ }^{17,20,23,29}$, two studies employed both specialist PE teachers and classroom teachers ${ }^{21,30}$, and one study did not specify the teacher delivering the lessons. ${ }^{18}$ The seven studies in the meta-analysis were conducted across seven different countries.

## Discussion

## Summary of the evidence

This study sought to examine elementary school students' MVPA levels during PE lessons in studies published between 2005 and 2014. Of the 13 studies included in the systematic review, percentage time spent in MVPA varied, ranging from $11.4 \%$ to $88.5 \%$ of PE time. The meta-analysis of seven studies found that children spent $44.8 \%$ of lesson time in MVPA. Promisingly, the estimated percentage of MVPA in PE lessons was higher than estimated in
the previous review ${ }^{11}$, which found that elementary school students participated in MVPA for $34.2 \%$ of PE time in non-intervention studies. However, the mean percentage of time spent in MVPA still falls short of the US CDC and UK's afPE recommendation of $50 \%$ of PE class time. ${ }^{9,10}$

A plausible explanation for the increase in the proportion of lesson time spent in MVPA since the previous review is that six of the seven studies pooled into the meta-analysis either solely or partially employed specialist PE teachers to deliver the lessons. ${ }^{17,20,21,23,29,30}$ Specialist PE teachers produce higher levels of MVPA than usual classroom teachers. ${ }^{11,32}$ The previous review ${ }^{11}$ did not outline teacher training for classes taught under nonintervention conditions, therefore a comparison between the two reviews cannot be made. Different accelerometer cut-points used in the studies may also have contributed to the variation in findings. While different MVPA accelerometer cut-points were used in the studies (e.g. $>2000^{18-20,29,30}$ and $>3500^{18,19}$ counts/minute) in the current review, accelerometer cutpoints were not reported in the previous review ${ }^{11}$ therefore this hypothesise cannot be confirmed. Only one study used accelerometry to assess MVPA in the previous review ${ }^{11}$ which is likely the reason that accelerometer cut-points were not reported.

## Summary of the moderator analyses

The review found a $25 \%$ difference in the percentage of PE time spent in MVPA between studies that reported MVPA using accelerometers (33\%) and observational measures (58\%). Conversely, the previous review ${ }^{11}$ found that heart rate monitors reported the highest percentage MVPA (40.4\%), followed by motion sensors (i.e. accelerometers and pedometers) (36.8\%), and observation methods (32.5\%). Although estimates were similar for accelerometers, there was a large increase in the proportion of MVPA time as measured by observational methods between the previous and current review. As the previous review did not assess risk of bias, it is difficult to comment on the relative merits and limitations of the component studies. Due to insufficient study detail on PE activities, and student, teacher, and environmental factors, other moderator analyses were not undertaken.

There are methodological issues which could explain the discrepancy in MVPA through different measurement methods. While observational measures such as SOFIT have been found to be reliable and valid ${ }^{31}$, they do have limitations and may over-estimate the time students spend in MVPA. ${ }^{32}$ Since different measurement methods measure different elements of physical activity (e.g. observation methods measure MVPA through movement categories, and accelerometers through the number of counts above certain cut-points), the calculation of MVPA differs accordingly. ${ }^{11}$ For example SOFIT considers walking as a moderate activity, whereas non-brisk walking is unlikely to be categorised as MVPA by
accelerometers. Another reason for the difference could be the between-study discrepancy in the definition of 'monitored PE lesson length', which is discussed in more detail below.

## Risk of bias of included studies

Limited information provided on the school and class sample mean that it is unclear whether the findings are representative of usual PE lessons. Given the limited information reported on the physical activities observed, the small number of studies pooled in to the metaanalysis and the considerable heterogeneity between studies, the findings may not be generalizable to usual elementary school PE lessons and caution should be taken in interpreting the meta-analysis results.

While secondary schools typically employ qualified PE teachers to instruct PE lessons, elementary school PE lessons are often led by classroom teachers with little or no training in physical activity. ${ }^{33}$ In eight ${ }^{17,19, ~ 20, ~ 23, ~ 25, ~ 26, ~ 29, ~} 30$ of the 13 studies in the review, a PE specialist or qualified PE teacher led the lesson, while just two studies stated that lessons were led by classroom teachers with either minimal ${ }^{27,28}$ or some training. ${ }^{21}$ Evidence indicates that employing PE specialist teachers or intensively training elementary school teachers may be one approach to improve FMS outcomes ${ }^{34}$ and increase MVPA in PE lessons. ${ }^{11,35}$ As most studies ( $n=8$ ) employed PE specialists, the findings may not be representative of the MVPA levels achieved in PE lessons led by elementary classroom teachers.

Another major methodological inconsistency between the studies was the definition for the length of the monitored PE lesson. While three studies measured the lesson for the entire scheduled PE lesson (such as a 50 minute lesson) ${ }^{19,} 20,23$, six studies measured the lesson from the time that physical activity commenced or for the time that $51 \%$ of the class were in attendance. ${ }^{17,18, ~ 21, ~ 26-29 ~ F i v e ~ s t u d i e s ~}{ }^{22,} 24,25,29,30$ did not state whether the scheduled lesson length was measured or another criteria for the recording period was used. This betweenstudy discrepancy in lesson length may have distorted the results reported by the studies resulting in information bias. For example, the mean scheduled lesson length in one study ${ }^{17}$ was 43.4 minutes; however the study reported only measuring physical activity when $51 \%$ of the class were in attendance resulting in a mean PE lesson monitoring time of 31.7 minutes and $27 \%$ of the scheduled PE lesson time unmonitored. As a result, the reported lesson time spent in MVPA was 15.8 minutes or $50.7 \%$ of the lesson, implying that the children's physical activity levels met the CDC and afPE physical activity recommendation. If the scheduled PE lesson length had been applied in the calculation, $36.4 \%$ of time spent in MVPA would have been reported. The lack of consistency in these calculations across the studies made it difficult to compare findings between the studies.

Strengths and limitations

The review has a number of strengths. It updates an important body of evidence that has not been reviewed since 2005. The review employed a comprehensive search strategy across numerous databases. A detailed data extraction instrument and collection technique enabled a comprehensive comparison across all included studies. The review provides insight on how to improve the quality of future PE lesson research, particularly in regards to measurement methods, reporting results and sub-analyses of interest.

This review has limitations which need to be acknowledged. In addition to those mentioned previously, the review limited the search of studies to those published in English and found within a prominent database. Theses, dissertations and conference abstracts were not included in this systematic review. Despite making numerous efforts to contact the authors of studies, three studies were excluded from the systematic review as sufficient data to determine eligibility were not provided. Six studies were excluded from the meta-analysis as the authors could not be contacted or were unable to provide additional data to enable the results to be pooled. Studies that identified the physical activity lesson as 'school sport', 'fitness' or 'gym/dance' were excluded as it was unclear if the session was PE or another aspect of the curriculum/school activity, and were considered outside the scope of the review.

## Recommendations for future research

There is a need to standardise the definition of 'PE lesson time' to ensure that a consistent comparison between studies can be made. The US CDC 'recommends that students engage in MVPA for at least 50\% of the time they spend in PE class' while the UK afPE health position paper states that 'pupils be actively moving for at least $50 \%$ of the available learning time', but neither clarifies whether the monitoring time occurs for the length of the scheduled PE class, or whether another criteria for the monitoring period can be used (e.g. when $51 \%$ of the class are in attendance). One solution could be reporting MVPA for lessons that monitor within a pre-specified proportion of lesson time (such as $\geq 90 \%$ ), separately from lessons that monitor for a smaller proportion of the scheduled lesson (<90\%). Consistency in lesson monitoring protocols will reduce between-study discrepancy in lesson length, making it easier to compare and summarise findings between the studies.

It is important to measure as many lessons as feasible from a representative spread of classes to increase the likelihood that the monitored lessons are representative of MVPA during usual PE lessons. Efforts can be made to ensure that teachers and students are blinded to the monitoring schedule since teachers may plan the lesson to ensure a higher level of activity, however in reality this may be difficult to achieve. Ideally, all consenting children and classes would be measured however, if this is not feasible, then children and
classes could be randomly selected for monitoring. In the previous review ${ }^{11}$, the authors recommended transparent reporting on the structure, delivery, content and environment of the lessons to facilitate in-depth analysis. Only five ${ }^{17,19,23-25}$ of the 13 studies in this review provided detail on the types of physical activities performed. The authors of this review support the former review recommendation ${ }^{11}$ on the importance of transparent reporting on the types of activities performed.

Many intervention study results were excluded from the review as they measured the PE lesson post intervention and did not measure MVPA during usual (or pre-intervention) PE lessons. Future intervention studies should aim to report PE lesson MVPA prior to intervention delivery and, at minimum, state the mean MVPA percentage of the lesson, a measure of variation (e.g. standard deviation), and the number of lessons examined so that data can be pooled into a meta-analysis.

Future systematic reviews on this topic should aim to investigate PE lesson MVPA in elementary school students by: i) measurement tool, as there are inconsistencies in MVPA between measurement methods ${ }^{11,32}$, ii) sex, since studies indicate that girls may be less active than boys ${ }^{36}$, and iii) the physical activities performed as evidence suggests that certain activities promote more vigorous activity. ${ }^{37}$ Other sub-analyses of interest include: iv) teacher training, since evidence indicates that specialist PE teachers lead more active lessons than generalist elementary school teachers ${ }^{27}$, and v) the study country, as it may impact on MVPA ${ }^{18,19}$ and reduce the generalisability of the findings. Assessing variability between countries will be of particular importance if the aggregate MVPA level meets the US CDC and UK afPE recommendation in the future.

## Recommendations for practice in elementary school PE lessons

Since strong evidence has demonstrated that physical activity levels decline with age through childhood and adolescence ${ }^{38,39}$, maximising physical activity and refining FMS during elementary school PE is crucial. ${ }^{34}$ Schools report numerous challenges in incorporating high activity levels in elementary school PE classes. Policy and infrastructure barriers may impact on physical activity in PE lessons. ${ }^{40}$ Low teacher confidence in their PE teaching ability, a lack of content knowledge, and limited expertise in teaching active lessons may lead to poorer quality lessons with less MVPA. ${ }^{41}$ Given that traditional PE lessons often require students to cease activity to observe demonstrations, listen to instructions and organise equipment, it is unsurprising that maintaining high MVPA levels is challenging for teachers. ${ }^{11}$ Curriculum integration is another issue that elementary school teachers face when trying to maximise MVPA in PE whilst also meeting other curriculum outcomes, which may not be synonymous with MVPA.

The competing demands for lesson time allocation in elementary schools across a broad curriculum ${ }^{42}$ means that it is unlikely that PE lesson time will increase, so maximising the existing allocated time should be a priority. A recent systematic review on interventions to increase physical activity in PE lessons found that strategies such as i) supplementing usual PE lessons with high-intensity activity (e.g. fitness infusion), and ii) teacher professional learning focusing on organisation, management and instruction, were effective in increasing MVPA in PE by approximately $10 \% .{ }^{35}$ While PE teachers could achieve high levels of MVPA by instructing students to 'run laps of an oval for the duration of the lesson', this approach is unlikely to engage students in meaningful learning experiences and assist them to develop the FMS and attitudes required for a lifetime of physical activity. ${ }^{35}$ This approach may also negatively impact on student's motivation and enjoyment of physical activity which may influence long term physical activity engagement. ${ }^{43}$

## Conclusion

The proportion of time spent in MVPA during elementary school PE lessons does not meet the US CDC or UK afPE recommendation. Despite methodological differences between the reviews, the findings suggest a possible increase in the percentage of PE lesson time in which students are engaged in MVPA. Interventions to increase MVPA time in PE lessons are needed. Future PE lesson intervention and observational studies should ensure that the recommendations made in this review, particularly regarding measurement method, reporting results and sub-analyses of interest, are considered in the study design. This will enable researchers, health professionals and policy makers to accurately monitor the progress of elementary school PE lessons towards the MVPA target in the future.

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## Conflicts of interest

The authors declare that there are no conflicts of interest.

## Author Contributions

All authors were responsible for the design of the study and the development of the search strategy. JLH and AJW acted as first and second reviewer, respectively, and screened the
studies, performed the risk of bias assessments and extracted study data. RS acted as third reviewer, resolved any disagreements and conducted the meta-analysis. NN developed the data extraction tool. JLH drafted the initial paper. All authors contributed to the interpretation of the results and all drafts of the manuscript.

## Appendices

## Appendix A.

Search filter one identified the setting such as 'physical education', 'lesson*', 'class*’. Search filter two referred to the target population including 'child', 'adolesc*' and 'student'. Measurement terms were identified using search filter three such as 'motor activity', 'exercise' and 'MVPA'. Search filter four identified the study design including 'prospective studies', 'longitudinal studies', 'non-randomized'.

## Database:

Name of Host:
Number of results:
Date searched:

## MEDLINE

## OVID

1128 (1058 after de-duplication)
$20^{\text {th }}$ May 2014


| 15 Motor Activity/ | 77414 |
| :---: | :---: |
| 16 physical activity.mp. | 50654 |
| 17 Exercise/ | 66233 |
| 18 fitness.mp. or Physical Fitness/ <br> ((Moderate or vigorous) adj5 (physical activity or exercise)).mp. [mp=title, abstract, original title, name of | 49372 |
| 19 substance word, subject heading word, keyword heading word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier] | 9696 |
| 20 MVPA.mp. | 994 |
| 21 Movement/ | 59073 |
| 2215 or 16 or 17 or 18 or 19 or 20 or 21 | 262721 |
| 23 randomized controlled trial.pt. | 373289 |
| 24 controlled clinical trial.pt. | 88322 |
| 25 randomized.ab. | 271822 |
| 26 randomised.ab. | 54401 |
| 27 randomly.ab. | 193034 |
| 28 trial.ab. | 281901 |
| 29 groups.ab. | 1241003 |
| 30 Cross-Sectional Studies/ | 174920 |
| 31 prospective longitudinal quantitative studies.mp. | 0 |
| 32 Prospective Studies/ | 365188 |
| 33 Longitudinal Studies/ | 85628 |
| 34 non randomized.ab. | 3820 |
| 35 non randomised.ab. | 1748 |
| 36 pre-post.mp. | 3932 |
| 3723 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 | 2238313 |
| 387 and 14 and 22 and 37 | 1466 |
| 39 limit 38 to yr="2005-Current" | 1183 |
| 40 limit 39 to english language | 1128 |

## Database:

## EMBASE

Name of Host:
OVID
Number of results:
2595 (1806 after de-duplication)
Date searched:
$20^{\text {th }}$ May 2014


| 31 prospective longitudinal quantitative studies.mp. | 0 |
| :--- | :--- |
| 32 prospective study/ | 249489 |
| 33 longitudinal study/ | 66210 |
| 34 non randomized.ab. | 6672 |
| 35 non randomised.ab. | 2444 |
| 36 pre-post.mp. | 7135 |
| 3723 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 | 2761230 |
| 387 and 14 and 22 and 37 | 3116 |
| 39 limit 38 to yr="2005 -Current" | 2693 |
| 40 limit 39 to english language | 2595 |

## Database:

Name of Host:
Number of results:
Date searched:

## PsycINFO

## OVID

322 (120 after de-duplication)
$20^{\text {th }}$ May 2014


| 148 or 9 or 10 or 11 or 12 or 13 | 550695 |
| :---: | :---: |
| 15 Motor Activity.mp. | 5483 |
| 16 exp Physical Activity/ | 23610 |
| 17 exp Exercise/ | 16598 |
| 18 exp Physical Fitness/ or fitness.mp. | 11650 |
| 19 <br> ((Moderate or vigorous) adj5 (physical activity or exercise)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests \& measures] | 2247 |
| 20 MVPA.mp. | 506 |
| 21 Movement.mp. | 77278 |
| 2215 or 16 or 17 or 18 or 19 or 20 or 21 | 114143 |
| 23 randomized controlled trial*.mp. | 12477 |
| $24 \exp$ Clinical Trials/ | 7555 |
| 25 randomized.ab. | 38271 |
| 26 randomised.ab. | 4619 |
| 27 randomly.ab. | 50644 |
| 28 trial.ab. | 61644 |
| 29 groups.ab. | 359321 |
| 30 Cross-Sectional Stud*.mp. | 12396 |
| 31 prospective longitudinal quantitative studies.mp. | 0 |
| 32 exp Prospective Studies/ | 421 |
| 33 exp Longitudinal Studies/ | 15241 |
| 34 non randomized.ab. | 453 |
| 35 non randomised.ab. | 147 |
| 36 pre-post.mp. | 3703 |
| 3723 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 | 485402 |
| 387 and 14 and 22 and 37 | 394 |
| 39 limit 38 to yr="2005-Current" | 326 |
| 40 limit 39 to english language | 322 |

## Database:

Name of Host:
Number of results:
Date searched:

## CINAHL

## EBSCO

632 (246 after de-duplication)
$20^{\text {th }}$ May 2014

| \# | Query | Results |
| :---: | :---: | :---: |
| S38 | S7 AND S14 AND S22 AND S37 (English and 2005+) | 632 |
| S37 | S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR S34 OR S35 OR S36 | 579,673 |
| S36 | pre-post | 1,989 |
| S35 | AB non randomised | 684 |
| S34 | $A B$ non randomized | 880 |
| S33 | "Longitudinal Studies" | 2,000 |
| S32 | (MH "Prospective Studies") | 232,563 |
| S31 | "prospective longitudinal quantitative stud*" | 0 |
| S30 | (MH "Cross Sectional Studies") | 88,432 |
| S29 | AB groups | 152,441 |
| S28 | AB trial | 52,874 |
| S27 | $A B$ randomly | 32,891 |
| S26 | $A B$ randomised | 14,040 |
| S25 | AB randomized | 53,314 |
| S24 | (MH "Clinical Trials") | 113,492 |
| S23 | (MH "Randomized Controlled Trials") | 31,119 |
| S22 | S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 | 74,744 |
| S21 | (MH "Movement") | 8,319 |
| S20 | MVPA | 368 |
| S19 | ((Moderate or vigorous) n 5 (physical activity or exercise)) | 3,013 |
| S18 | (MH "Physical Fitness") OR "fitness" | 17,646 |
| S17 | (MH "Exercise") | 28,327 |
| S16 | (MH "Physical Activity") | 20,008 |
| S15 | (MH "Motor Activity") | 7,141 |


| S14 | S8 OR S9 OR S10 OR S11 OR S12 OR S13 | 471,711 |
| :--- | :--- | :--- |
| S13 | ((primary or secondary or high or middle or elementary) n5 (school* or student*)) | 27,256 |
| S12 | (MH "Child") | 276,395 |
| S11 | "teenager*" | 3,398 |
| S10 | adolesc * | 310,214 |
| S9 | "youth" | 17,555 |
| S8 | (MH "Adolescence") | 300,000 |
| S7 | S1 OR S2 OR S6 | 4,438 |
| S6 | (S3 or S4) and S5 | 551 |
| S5 | (MH "Schools") OR (MH "Schools, Elementary") OR (MH "Schools, Middle") OR (MH |  |
| S4 | (Mchools, Secondary") OR (MH "Schools, Nursery") | 13,762 |
| S3 | (MH "Physical Education and Training") | 28,327 |
| S2 | school n3 sport* | 1,769 |

## Database:

## SPORTDISCUS

Number of results:

## EBSCO

1547 (1315 after de-duplication)
Date searched: $\quad 20^{\text {th }}$ May 2014
510

| $\#$ | Query | Results |
| :--- | :--- | :--- |
| S38 | S7 AND S14 AND S22 AND S37 and English and 2005+ | 1,547 |
| S37 | S23 OR S24 OR S25 OR S26 OR S27 OR S28 OR S29 OR S30 OR S31 OR S32 OR S33 OR |  |
|  | S34 OR S35 OR S36 | 143,126 |
| S36 | pre-post | 619 |
| S35 | AB non randomised | 93 |


| S34 | $A B$ non randomized | 203 |
| :---: | :---: | :---: |
| S33 | Longitudinal Stud* | 4,217 |
| S32 | Prospective Stud* | 8,093 |
| S31 | prospective longitudinal quantitative studies | 0 |
| S30 | Cross-Sectional Stud* | 4,814 |
| S29 | $A B$ groups | 101,653 |
| S28 | $A B$ trial | 29,438 |
| S27 | $A B$ randomly | 10,704 |
| S26 | $A B$ randomised | 2,571 |
| S25 | $A B$ randomized | 11,587 |
| S24 | Clinical Trial* | 10,209 |
| S23 | randomized controlled trial* | 7,029 |
| S22 | S15 OR S16 OR S17 OR S18 OR S19 OR S20 OR S21 | 328,852 |
| S21 | Movement | 49,594 |
| S20 | MVPA | 519 |
| S19 | ((Moderate or vigorous) n5 (physical activity or exercise)) | 4,479 |
| S18 | fitness | 148,806 |
| S17 | Exercise | 190,080 |
| S16 | Physical Activity | 44,363 |
| S15 | Motor Activity | 1,988 |
| S14 | S8 OR S9 OR S10 OR S11 OR S12 OR S13 | 158,680 |
| S13 | ((primary or secondary or high or middle or elementary) n 5 (school* or student*)) | 36,787 |
| S12 | Child | 90,756 |
| S11 | teenager* | 34,903 |
| S10 | adolesc* | 27,005 |
| S9 | youth | 23,120 |


| S8 | Adolescence | 8,127 |
| :--- | :--- | :---: |
| S7 | S1 OR S2 OR S6 | 41,453 |
| S6 | (S3 or S4) and S5 | 33,194 |
| S5 | Schools | 148,418 |
| S4 | Exercise | 190,080 |
| S3 | Physical Education and Training | 55,166 |
| S2 | school n3 sport* | 14,522 |
| S1 | $($ (physical education or PE or physical activity or PA) n5 (lesson* or class* or program* or <br> curricul* or school* or instruct*)) | 1 |

## Database:

Name of Host:
Number of results:
Date searched:

## Cochrane Database of Systematic Reviews

Wiley
6 (3 after de-duplication)
$20^{\text {th }}$ May 2014
'(("physical education" OR PE OR "physical activity" OR PA) NEAR/5 (lesson* OR class* OR program* OR curricul* OR school* OR instruct*)) OR (school NEAR/3 sport*) OR (exercise NEAR/5 school*) in Title, Abstract, Keywords and Adolesce* OR teenager* OR youth OR child OR ((primary OR secondary OR high OR middle OR elementary) NEAR/5 (school* OR student*)) in Title, Abstract, Keywords and "Motor Activity" OR "physical activity" OR exercise OR fitness OR ((Moderate OR vigorous) NEAR/5 ("physical activity" OR exercise)) in Title, Abstract, Keywords in Cochrane Reviews'

Database: CENTRAL (Cochrane Central register of Controlled Trials)

Name of Host:
Number of results:
Date searched:

Wiley
410 (62 after de-duplication)
$20^{\text {th }}$ May 2014

## Cochrane Central Register of Controlled Trials : Issue 4 of 12, April 2014

There are 410 results from 789657 records for your search on '(("physical education" OR PE OR "physical activity" OR PA) NEAR/5 (lesson* OR class* OR program* OR curricul* OR school* OR instruct*)) OR (school NEAR/3 sport*) OR (exercise NEAR/5 school*) in Title, Abstract, Keywords and Adolesce* OR teenager* OR youth OR child OR ((primary OR secondary OR high OR middle OR elementary) NEAR/5 (school* OR student*)) in Title, Abstract, Keywords and "Motor Activity" OR "physical activity" OR exercise OR fitness OR ((Moderate OR vigorous) NEAR/5 ("physical activity" OR exercise)) in Title, Abstract, Keywords in Trials'

## Database:

## Name of Host:

Number of results:
Date searched:

## ERIC

## Proquest

192 (81 after de-duplication)
20 th May 2014

```
(("physical education" OR PE OR "physical activity" OR PA) NEAR/5 (lesson* OR class* OR program* OR curricul* OR
school* OR instruct*)) OR (school NEAR/3 sport*) OR (exercise NEAR/5 school*)
AND
Adolesce* OR teenager* OR youth OR child OR ((primary OR secondary OR high OR middle OR elementary) NEAR/5
(school* OR student*))
And
"Motor Activity" OR "physical activity" OR exercise OR fitness OR ((Moderate OR vigorous) NEAR/5 ("physical activity" OR
exercise))
AND
("randomized controlled trial*" OR "clinical trial*" OR randomized OR randomised OR randomly OR trial OR groups OR
"Cross-Sectional Stud*" OR "prospective longitudinal quantitative stud*" OR "Prospective Stud*" OR "Longitudinal Stud*" OR
"non randomized" OR "non randomised")
```


## Database:

Name of Host:
Number of results:
Date searched:

## SCOPUS

SCOPUS
1468 (517 after de-duplication)

```
(("physical education" OR PE OR "physical activity" OR PA) W/5 (lesson* OR class* OR program* OR curricul* OR school*
OR instruct*)) OR (school sport*)
AND
Adolesce* OR teenager* OR youth OR child OR ((primary OR secondary OR high OR middle OR elementary) W/5 (school*
OR student*))
And
"Motor Activity" OR "physical activity" OR exercise OR fitness OR ((Moderate OR vigorous) W/5 ("physical activity" OR
exercise))
AND
("randomized controlled trial*" OR "clinical trial*" OR randomized OR randomised OR randomly OR trial OR groups OR
"Cross-Sectional Stud*" OR "prospective longitudinal quantitative stud*" OR "Prospective Stud*" OR "Longitudinal Stud*" OR
"non randomized" OR "non randomised")
```


## Appendix B. Assessment of methodological quality for PE lesson MVPA systematic review

Study number:
Review type:

Authors:
Year of publication:

| Assessment of methodological quality criteria | Answer |
| :---: | :---: |
| School level |  |
| 1. Did the study adequately describe the key demographic characteristics of the school sample? i.e. SES and/or geographical location. <br> $\mathrm{Y}=$ yes, the study adequately described the school characteristics including SES and/or geographical location; $\mathrm{N}=$ no, the study did not adequately describe the school characteristics; $\mathrm{U}=$ unclear. |  |
| 2. Was the school sample representative of the population? i.e. schools randomly selected from region. <br> $\mathrm{Y}=$ yes, the school/s were randomly selected from the population or all schools from a region were invited to participate; $\mathrm{N}=$ no, the school/s were not randomly selected e.g. convenience sampling or if stated they were not representative; $\mathrm{U}=$ unclear. |  |
| Class level |  |
| 3. Was the class chosen representative of all school classes? i.e. class of students randomly selected or an entire grade/s invited to participate. <br> $\mathrm{Y}=$ yes, the class/es were randomly selected or all classes from a grade/s were invited to participate; $\mathrm{N}=$ no, the class/es were not randomly selected e.g. convenience sampling; $\mathrm{U}=$ unclear. |  |
| 4. Did the study adequately describe the key demographic characteristics of the class sample? i.e. grade, sex breakdown. <br> $\mathrm{Y}=$ yes, the study adequately described the class characteristics (i.e. grade, sex breakdown); $\mathrm{N}=$ no, the study did not adequately describe the class characteristics; $\mathrm{U}=$ unclear. |  |
| Student level |  |
| 5. Did the study adequately describe the participant eligibility criteria? i.e. grade, age. $\mathrm{Y}=$ yes, the study adequately described the participant eligibility; $\mathrm{N}=$ no, the study did not adequately describe the participant eligibility criteria; $\mathrm{U}=$ unclear. |  |
| 6. Did the study adequately describe the key demographic characteristics of the student sample? i.e. number of participants and their mean age (or age range) and sex breakdown. <br> $\mathrm{Y}=$ yes, the study adequately described the number of students who participated, mean age (or age range) and sex; $\mathrm{N}=$ no, the study did not adequately describe the number of participants, mean age (or age range) and/or sex; $\mathrm{U}=$ unclear. |  |
| 7. Was the student sample representative of the population? i.e. students measured were randomly selected or an entire grade/s invited to participate/measured. <br> $\mathrm{Y}=$ yes, the students were randomly selected from the population or all participants from a grade/s invited to participate/measured; $\mathrm{N}=$ no, the students were not randomly selected e.g. convenience |  |


| sampling; U = unclear. |  |
| :---: | :---: |
| PE lesson observation |  |
| 8. Did the study adequately describe the number of PE lessons observed? <br> $\mathrm{Y}=$ yes, the study adequately described the number of PE lessons observed; $\mathrm{N}=$ no, the study did not adequately describe the number of PE lessons observed; $\mathrm{U}=$ unclear. |  |
| 9. Did the study use an objective measure of physical activity (i.e. accelerometers, heart rate monitors, pedometers) or did the study cite validation studies or state validity data for observational measures in the study population (e.g. elementary and secondary school children). <br> $\mathrm{Y}=$ yes, the study used an objective measure of physical activity, or used an objective measure in a sub-sample of students, or used observational measures and cited validation studies/stated validity data in the study population being examined; $\mathrm{N}=\mathrm{no}$, the study did not used objective measures, or did not cite a validation study/validation data in the population being studied; $\mathrm{U}=$ unclear. |  |
| 10. Did the study use an objective measure of physical activity (i.e. accelerometers, heart rate monitors, pedometers) or did the study state reliability data or cite reliability studies for observational measures in the study population (e.g. elementary and secondary school children). <br> $Y=$ yes, the study used an objective measure of physical activity, or used an objective measure in a sub-sample of students, or used observational measures and cited reliability studies/stated reliability data in the study population being examined (inter-rater reliability: ICC > . 70 is considered acceptable); $\mathrm{N}=$ no, the study did not used objective measures, or did not cite reliability study/data in the population being studied; $\mathrm{U}=$ unclear. |  |
| 11. Did the study report the nature of the physical activities observed? $\mathrm{Y}=$ yes, the study reported the type of activities observed (e.g. type of sport or game); $\mathrm{N}=\mathrm{no}$, the study did not reported the type of activities observed; $\mathrm{U}=$ unclear. |  |

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