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Effects of Maths on the Move on Children's Perspectives, Physical Activity, and Maths Performance

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1 **Effects of Maths on the Move on Children's Perspectives, Physical**
2 **Activity and Maths Performance**

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20 **Abstract**

21 **Purpose:** To assess the impact of a six-week 'Maths on the Move' (MOTM) physically active
22 learning programme on primary school children's physical activity (PA) levels and maths
23 performance.

24 **Method:** Randomised control trial. Year 5 children's PA was assessed using accelerometry
25 for five consecutive school days at baseline and during the final intervention week (final
26 sample: $n=97$, age $M=9.61\pm0.29$, 52.6% female). Two maths performance tests were used;
27 one assessing mathematical content taught during MOTM and one assessing math's fluency
28 (MASSAT). Both tests were conducted at baseline and following the intervention (week
29 seven). Focus groups were conducted in week seven with intervention children ($n=12$),
30 randomly choosing an even split of children classified with pre-intervention low or high PA
31 levels.

32 **Results:** On average, during a typical 45-49 minutes MOTM lesson, children obtained an
33 additional five minutes of moderate-to-vigorous PA and 5.7 minutes of light PA counteracted
34 by a reduction of 9.5 minutes of time spent sedentary compared to children that remained in
35 the classroom (control condition). The maths attainment test performance significantly
36 improved over time for children in the MOTM compared to the control (+6.1 versus +0.9,
37 $p\leq0.0001$, $d=1.507$). No significant improvements were found in the MASSAT total score.

38 Seven emerging themes were derived from the child focus groups. Children felt the MOTM
39 sessions resulted in social and environmental improvements, which improved learning during
40 the sessions. Children described the MOTM sessions as enjoyable, fun, engaging and
41 invigorating – resulting in positive associations to learning and activity.

42 **Conclusion:** Collectively, the findings identify the MOTM programme improves pupil's PA
43 levels, academic outcomes and identifies pupil's willingness, enjoyment, and engagement.

44 **Key words:**

45 1. Academic performance

46 2. Primary school children

47 3. Elementary school

48 4. Physically active learning

49 5. Moderate-to-vigorous physical activity

50 Children's Perspectives and Performance on MOTM

51 **Introduction**

52 Moderate-to-vigorous physical activity (MVPA) levels in children are at an all-time low (1, 2).
53 In response, the UK government's Primary Physical Education (P.E.) and Sport Premium fund
54 (~£320million) supports primary schools to provide 30-minutes of in-school MVPA for all pupils
55 (3, 4). Yet, challenges persist with schools receiving little evidence-based guidance on how
56 best to allocate resources. One approach to increasing MVPA that is gaining traction through
57 practice and research alike, is physically active learning, the integration of movement within
58 academic lessons (5-7). In the recent Creating Active Schools Framework (CAS), PAL was
59 highlighted as a premium opportunity for increasing MVPA due to the expansion of MVPA into
60 a traditionally highly sedentary segments of the school day (8-10).

61 Recent systematic reviews and meta-analyses support the positive impact of PAL on MVPA
62 and subsequently, enhanced time-on-task (11), yet findings on academic performance are
63 often varied and lack consensus (12). Thus, empirical research has yet to sufficiently
64 demonstrate the efficacy of PAL lessons in improving pupils' learning (6, 11).

65 To advance the evidence base on the effects of PAL, there is a need to move beyond studies
66 which assess the reinforcement of previously learnt concepts (13), to understand the potential
67 effects of PAL in regard to learning new academic content (12). With reference to math's, PAL
68 has shown beneficial effects in both acute and chronic studies of varied durations (14-16).
69 While qualitative studies on teachers often highlight perceived pupil enjoyment and
70 engagement (17, 18), there is a limited understanding of the children's perspectives of PAL
71 engagement. Studies that have explored the perspectives of primary school children engaging
72 in PAL interventions have focused on specific interventions such as virtual field trips (19) or
73 an outdoor learning programme (20). Both interventions are quite distant from the Maths on
74 the Move (MOTM) programme, highlighting the gap in the evidence base for exploring pupil's
75 perspectives when engaging in a physically active maths programme. Furthermore, drawing

76 upon a mixed-methods approach may help highlight potential mechanisms behind
77 improvements in learning following PAL implementation.

78 This study progresses our understanding by assessing the impact of PAL to deliver a
79 specifically defined scheme of work on numeracy. This provides a step-change in the focus of
80 PAL, shifting towards assessments of specific academic outcomes. Therefore, this study will
81 aim to (i) assess the impact of a six-week PAL, MOTM programme on children's PA levels
82 and maths performance, and (ii) explore children's perspectives over the MOTM programme.

83 **Method**

84 **Recruitment and Participants**

85 Four two-form entry schools in Birmingham (UK) were recruited into a randomised controlled
86 trial using a between-subjects design, with randomisation at the class level. Recruited schools
87 had previously signed up to receive the free six-week Aspire Maths on the Move (MOTM)
88 programme (<https://www.aspire-sports.co.uk/programme/maths-move>). Following
89 headteacher consent, 225 Year Five children were invited to take part; however, one school
90 withdrew due to poor recruitment (2/56). Across three schools, parental consent and child
91 assent was obtained ($N=140$, MOTM $n=76$; Control $n=64$). Ethical approval was obtained by
92 Leeds Beckett University Ethics Committee (Ref:60567).

93 **Protocol**

94 Data collection took place between September-to-December 2019. Aspire programme leads
95 were trained by the lead researcher (JLM) to support data collection. On day one (Monday)
96 children's height was measured, after which they completed a familiarisation of the Maths
97 Addition and Subtractions, Speed and Accuracy Test (MASSAT) and were fitted with
98 accelerometers. Instructions were given to children (and teachers) to ensure the
99 accelerometers were taken off before leaving the school and put back on the following morning

100 upon arrival. One week later, accelerometers were returned, and children completed the
101 baseline MASSAT (21) and then the maths attainment test (MAT) in the classroom following
102 morning registration. After this, the MOTM programme commenced and lasted for a duration
103 of six weeks. During the final delivery week, children were re-fitted with accelerometers. The
104 following Monday, children completed the post MASSAT and MAT after morning registration.
105 Next, children in the MOTM classes ($n=76$) were asked to express their own thoughts and
106 opinions on MOTM using a write and draw activity (22), expressing; (i) 'what you do in a typical
107 maths lesson', (ii) 'how you feel during a typical maths lesson', (iii) 'what you do in a MOTM
108 lesson' and (iv) 'how you feel during a MOTM lesson'. Finally, following a categorisation of
109 children into high-active (>30 mins MVPA) and low-active (<30 mins MVPA) based on pre-
110 intervention data, four children per MOTM class (two high-active, two low active, $N=12$) were
111 randomly selected (www.random.org) for three school-based focus groups.

112 **Experimental Condition**

113 The MOTM intervention has been designed to offer primary schools additional support to
114 enhance maths outcomes. As aforementioned, primary schools within the UK are given
115 Primary P.E. and Sport Premium funding from the government (3, 4) to support increases in
116 MVPA levels. Resultantly, interventions such as the MOTM can be sought to increase physical
117 activity levels while also contributing to educational outcomes.

118 Children in the MOTM intervention engaged in one ~50-minute lesson each week for six
119 weeks. Adhering to Aspire's typical learning approach, the class was split into two groups.
120 (~ $n=15$ children per group) and taken into a hall to complete the lessons. The qualified teacher
121 from Aspire taught the MOTM lessons to both groups, one after the other. The MOTM
122 programme followed a standardised lesson structure, with each lesson using a specific
123 numeracy objective from the UK Year Five National Curriculum. The final lesson recapped all
124 objectives. Objectives included: (i) problem solving with numbers up to three decimal places,
125 (ii) identify, name and write equivalent fractions of a given fraction, represented visually,

126 including tenths and hundredths, (iii) read and write decimal numbers as fractions, (iv) multiply
127 proper fractions and mixed numbers by whole numbers, supported by materials and diagrams,
128 (v) recognise mixed numbers and improper fractions and convert from one form to the other.
129 Refer to Supplemental Digital Content 1 for the instructor notes for an example activity from a
130 lesson and Supplemental Digital Content 2 for an example page from the workbooks pupils
131 use during the MOTM lessons. The curricular content was combined with a range of multi-
132 skills physical activities and challenges to create the game-based lessons. Children in the
133 MOTM group had a workbook to facilitate the completion of the activities within the MOTM
134 lessons. The Aspire instructor confirmed all six lessons were completed across the six groups
135 within the three classes that took part in the MOTM programme. Children in the control
136 condition and continued with usual maths provisions, focusing on the same learning
137 objectives.

138 **Outcomes Variables**

139 ***Physical Activity***

140 Physical activity was assessed during school-time for five consecutive days using waist worn
141 accelerometers (right hip; combination of GT1, GT3x, GT3x+, wGT3X+ and GT9; ActiGraph,
142 Pensacola, FL). Children wore the same monitor at both pre and post timepoints. High levels
143 of compatibility between models has previously been demonstrated (23, 24). Data were
144 collected in 15-second epochs, using Evenson (25) cut-points for sedentary time, light PA and
145 MVPA.

146 Data were downloaded using ActiLife (v.6, Pensacola, FL, USA) and analysed in KineSoft
147 (v3.3.75, KineSoft, Loughborough, UK). Non-wear time was identified by a period of ≥ 60
148 minutes of zeros which allowed for a period of 2-minute non-wear time, with a total duration of
149 these blocks representing non-wear time. Valid wear criteria was ≥ 3 school days (26) with a

150 wear time of ≥ 300 minutes per school day. School timetables were used to explore activity
151 thresholds across school day segments (e.g., MOTM lessons).

152 ***Maths Performance***

153 Maths fluency was assessed using the MASSAT (100% construct validity; four-day test-retest
154 reliability ($r=0.85$); replicating a previous protocol (21). Outcomes included correct answers,
155 errors, and a total score (correct minus errors). The 25 question (30 minutes) MAT assessed
156 the MOTM learning objectives. The questions were age-appropriate and aligned to the English
157 national curriculum (27). Two versions of the MASSAT and MAT were used to enable a
158 random counterbalanced approach to eliminate order effects. The Aspire team ensured test
159 version difficulty was matched by (i) duplicating each question, (ii) changing the numbers
160 within the questions, and (iii) ensuring that the level of challenge was maintained (see
161 Supplemental Digital Content 3 for an example). While the MAT is in line with similar, school-
162 based studies (28, 29), the results should be interpreted with caution. The MAT is not a
163 research grade test, and does not come with validity and reliability assessments, however,
164 some issues were dealt with by counterbalancing the order of the tests.

165 ***Biological Maturity***

166 Biological maturity (offset maturity) was established using the standing height simplified
167 equations for age from peak height velocity for boys and girls (30).

168 ***Focus Groups***

169 Focus groups were conducted in a quiet school space, lasting 22 to 32 minutes.
170 Children used their write and draw activity to explore their perceptions and experiences
171 of the MOTM programme compared to their usual maths lessons.

172 **Statistical Analysis**

173 Data analysis was conducted in RStudio (v.1.2.5033). To estimate the effect of MOTM on
174 maths performance over time (continuous variable: MAT total score; MASSAT correct
175 responses, errors, and total score), a series of two-level regression models were conducted,
176 controlling for offset maturity. Models allowed for nesting of measurement occasions (level 1),
177 within pupils (level 2) and random slopes for the time.

178 **Qualitative Data Analysis**

179 Focus groups were transcribed verbatim before two authors (JLM and SJB) analysed the
180 data using Braun and Clarke (31) thematic analysis methodology. Inductive coding
181 removed restrictions on coding in line with a prior framework (32). Reviewing and re-defining
182 the themes (JLM, SBJ and VSJA) helped ensure clear definitions and names were produced
183 for each theme (31).

184 **Quantitative Results**

185 Ninety-seven children provided complete data (age $M=9.61\pm0.29$, 52.6% female) and are
186 included in all subsequent analysis (Figure 1, consort flow diagram; Table 1, baseline
187 characteristics).

188 **Physical Activity Levels**

189 Table 2 highlights the number of minutes spent in each activity threshold during the school
190 day. Based on the number of daily minutes varying, the percentage of time spent in activity
191 threshold were calculated and used for analyses. There was a significant interaction between
192 time and condition for the percentage of time spent in school-based MVPA ($b=1.49$, $SE=0.70$,
193 95% CI: 0.13, 2.86, $p=0.036$, $d=458$); This was due to higher levels of MVPA during week six
194 of the MOTM condition ($b=1.79$, $SE=0.82$, 95% CI: 0.20, 3.38, $p=0.031$, $d=2.12$). There were
195 no significant interactions in LPA ($p=0.177$, $d=0.289$) or sedentary time ($p=0.106$, $d=0.348$).

196 Fifty-nine percent of children achieved the 30-minute in-school MVPA guideline on the MOTM
197 day compared to 34% on a non-MOTM day, showing a 28% increase. Children were
198 significantly more active in MOTM lessons compared to control traditional lessons, with
199 children accumulating five mins additional MVPA ($M=6.4\pm3.6$ minutes, $M=1.4\pm2.1$ minutes,
200 retrospectively, $p<0.0001$), 5.7 minutes additional LPA ($M=19.8\pm5.2$, $M=14.1\pm7.7$ minutes,
201 retrospectively, $p=0.0002$) and reducing sedentary time by 9.5 minutes ($M=18.0\pm7.5$,
202 $M=27.5\pm9.9$, $p<0.0001$).

203 **Maths Performance**

204 ***Maths Attainment Test***

205 With a greater performance improvement for children in the MOTM condition compared to the
206 control (+6.7 versus +0.9, retrospectively), there was a significant interaction between time

207 and condition for maths test scores ($b=5.85$, $SE=0.81$, 95% CI: 4.26, 7.43, $p\leq 0.0001$,
208 $d=1.507$). On closer inspection this was due to a larger significant effect over time in the MOTM
209 condition ($b=6.99$, $SE=0.67$, 95% CI: 5.66, 8.31, $p\leq 0.0001$, $d=1.480$) in comparison to the
210 control condition ($b=1.14$, $SE=0.42$, 95% CI: 0.31, 1.97, $p=0.010$, $d=0.426$). There was also a
211 significant difference between the post maths test scores between conditions ($b=7.09$,
212 $SE=1.12$, 95% CI: 4.91, 9.26, $p\leq 0.0001$, $d=1.301$).

213 ***Maths Addition and Subtraction, Speed and Accuracy Test***

214 Baseline and post scores for the MASSAT can be found in Table 3, revealing no significant
215 interactions between time and condition for MASSAT correct responses ($p=0.288$, $d=0.227$)
216 or total score ($p=0.261$, $d=0.237$). For the total errors made, there was a significant interaction
217 between time and condition ($b=3.02$, $SE=0.83$, 95%: 1.40, 4.65, $p=0.0005$, $d=0.801$). This was
218 due to a significant decrease in the number of errors made over time for the control condition
219 ($p=0.004$, $d=0.081$) and a significant difference between the condition in the baseline scores
220 ($p=0.004$, $d=0.633$).

221 **Qualitative Results**

222 Analysis of the focus groups transcripts revealed seven key themes: (i) facilitating learning,
223 (ii) building confidence in maths and PA, (iii) fostering cooperation and competitiveness, (iv)
224 environmental modifications, transforming learning, (v) welcoming cognitive and physical
225 challenges, (vi) inclusion improving fitness, (vii) positive feelings towards MOTM.

226 ***Facilitated learning***

227 Many of the children discussed the role that MOTM played in *improving their own learning*.
228 For example, Rafie suggested MOTM offers three benefits: enhanced learning, increased
229 engagement in PA and teamwork: “So, I think the first one, number one rule is based on getting

230 *smarter, number two is getting smarter whilst getting active and number three is getting along*
231 *with partners I think that's what it means."*

232 Another child felt MOTM helped improve their maths, learning in a different way: *"I've learnt*
233 *like a different way to work things out."* Matteo. Children also touched on the structure of
234 MOTM lessons, suggesting the integration of movement and teaching enhanced their
235 learning:

236 *"We do maths at the same time and we kind of do the same ways of learning*
237 *[to] what we do in P.E. instead... we learn maths in this way.... it's like maths*
238 *and P.E."* Aisha

239 ***Building confidence in maths and physical activity***

240 Children expressed newfound confidence during MOTM, which was transferred back into the
241 classroom. For example, some children felt more confident putting their hand up in class:

242 *"I want to say like... kind of boosts up my confidence because some of [the]*
243 *questions I don't know, and I never used to put my hand up, but some things*
244 *I know now, and I can put my hand up in class then."* – Aisha

245 ***Fostering cooperation and competitiveness***

246 Within this theme there were two sub-themes: (i) *teamwork and social support*, and (ii) *healthy*
247 *competition*. In the first sub-theme, children explained how they worked together, and in some
248 instances helped one another learn something new.

249 *"We had to work as a team because you had to tell everybody like... you*
250 *can write this, and then you had to... I mean you had to like interact with*
251 *other people to know what they got."* – Laila

252 Through the use of mixed groups, MOTM promoted interaction with new children which, in
253 turn, increased the inclusivity of the session. Sabir highlighted this nicely: *"I like it because*
254 *some people don't have any friends in their group, where it's better just mixed because you*

255 *get to interact with other people.*” These comments highlighted the importance of changing
256 the social environment to support new social interactions and collaborations.

257 In the second sub-theme, children felt MOTM encouraged healthy competition between peers.
258 In some of the activities, they were racing against each other to win against another team, as
259 described by Aisha: *“It makes me feel competitive because... to me, it feels like we’re racing,*
260 *whoever can find all the emojis first.”*

261 ***Environmental modifications transforming learning***

262 Children identified that working in half classes (~15 children) had positively affected the
263 learning environment. Smaller numbers promoted group cohesion, resulting in a more fun and
264 enjoyable session. Some children felt if the whole class were together, it would be too loud
265 and chaotic. Moreover, children suggested that the disruptive behaviour of some children
266 could negatively impact the learning experience.

267 *“These boys [in our class].. they’re always being silly and [one of them is]*
268 *always rocking on his chair or walking across while we’re supposed to be*
269 *sitting down. And he kind of ruins [the] fun because half the lesson is*
270 *basically him being told off and his friends, because they’re either talking or*
271 *being silly.” Sana*

272 ***Welcoming the cognitive challenge***

273 Children suggested seated, traditional maths lessons were quite boring, repetitive, and lacked
274 sufficient challenge:

275 *“I have one simple sentence... like watching paint dry.” Eva*

276 *“Sometimes it’s not much fun because it’s basically just writing sums...
277 Sometimes I’m excited if we get to learn something new, and it’s sometimes
278 boring and it’s too easy and it’s challenging, and I have different feelings
279 depending on my mood.” Sana*

280 Children wanted to be challenged and felt the MOTM lessons offered that. For example, Aisha
281 said: *“When they challenge us it's better though... you can push yourself to, like, if you think*
282 *that you don't know that and if you do it you'll be able to like gain more.”* However, other
283 children wanted more challenges, with more progressions to keep everyone engaged:

284 *“All I want is for maths on the move to be more challenging..... I like the*
285 *extensions' part, they're nice..... In the booklet, yeah, once you did like the*
286 *post... once you used the postings because they're extensions, and they're*
287 *way harder, only some people did it.”* Matteo

288 ***Inclusion improving fitness***

289 The MOTM sessions offer an inclusive approach to getting all children involved in PA. Contrary
290 to P.E., where some children felt left out due to “not being good enough”, MOTM prevented
291 isolation from occurring and was inclusive for all.

292 *“Sometimes I just don't like it [sport] because some people are... like, don't*
293 *include other people who aren't that good in games.”* – Sabir

294 Another child felt that improving their fitness provided a coping mechanism for emotion in
295 response to bullying:

296 *“Maths on the Move helps you stretch your muscles, and you can get more*
297 *physical so you can actually cope with people bullying you as well. It helps*
298 *with bullying as well and it helps you with your emotions as well.”* Rafie

299 ***Positive feelings towards MOTM***

300 Children reported immediate and longer term, positive feelings towards participating in MOTM.
301 Children often described feeling happy, excited, and having fun. This was typically due to the
302 games they played to learn and solve maths problems:

303 *“I drew a picture of me with a big grin on my face because I'm happy, I also*
304 *drew me running, and I also drew stick men dancing and having fun because*
305 *that's what it was like, we had fun.”* – Zia

306 In addition, some children associated enjoyment levels with their ability to learn new things.
307 Laila described this nicely: *“I wrote here that I feel really excited. It’s the most funnest lesson
308 I do in school, and I learn new things, and I feel happy.”*

309 Children also emphasised how they didn’t want the sessions to end; feeling sad that they
310 would not receive any more sessions. For example: *“The sad thing is that it is ending.”* – Rafie.
311 Other children saw the benefits of MOTM not just in the short term, but looking forward and in
312 helping their grades, and even helping them towards a better future.

313 *“If it continues [MOTM] it will help us learn more Maths, it would help us
314 generate even better grades, and soon we also get a better future as well.”*
315 – Rafie

316 **Discussion**

317 The dual aims of the current study were to assess the impact of a six-week MOTM programme
318 on children’s PA levels and maths performance, and to explore children’s perspectives of the
319 MOTM programme. The MOTM programme increased MVPA levels, securing an additional
320 five minutes in comparison to traditionally seated math’s lessons, equating to one sixth of the
321 in-school daily MVPA guidelines. Furthermore, the proportion of children achieving the
322 guidelines increased by 28% on MOTM days. While no change was observed in math fluency
323 scores, the MOTM programme resulted in large positive and significant effects on math
324 performance - assessed by the MAT. Children perceived that MOTM facilitated improvements
325 in learning and building confidence in maths and PA. The engaging social and physical
326 environment within MOTM sessions helped foster learning and encourage new social
327 dynamics within the class. Consistently, children highlighted that engaging in MOTM resulted
328 in a range of positive feelings: building confidence, having fun, working with peers, and
329 encouraging healthy competition.

330 In agreement with previous PAL research, the MOTM programme significantly improved levels
331 of MVPA (33, 34). Specifically, the five additional minutes of MVPA resulted in an additional

332 30% of children meeting the in-school MVPA guidelines of 30-minutes a day. Such findings
333 expand the research understanding of PAL, confirming that when teaching new academic
334 content, the MOTM lessons made a substantial contribution to pupils' in-school MVPA levels.
335 These outcomes are of great importance; lessons involving maths and English have recently
336 been deemed the most inactive period of a child's day (8).

337 Similar to previous studies on the impact of PAL on learning performance (e.g., 14), the current
338 study observed large effects on the number of correct answers in the MAT. The findings
339 support other maths-based PAL interventions that found improvements in maths performance
340 when taking part in active maths lessons compared to a control condition (16). The
341 improvements in the MAT may be due to a combination of the MOTM programme consisting
342 of smaller teaching groups, a workbook and physically active delivery. Further research is
343 warranted to understand the impact of each element. However, these results support the use
344 of PAL to teach new academic material and move beyond the heavy focus on repetition of
345 previously learnt material. However, no improvements were observed within maths fluency,
346 unlike studies that showed performance immediately following an acute bout of walking/
347 running (e.g., 21). These findings may be explained by the lack of a PA immediately prior to
348 the testing and/or the short- duration of the MOTM program being insufficient to lead to chronic
349 adaptations seen in longer-term studies. Further studies are required to confirm these
350 assumptions.

351 In agreement with previous PAL studies, pupils perceived that the MOTM lesson revealed a
352 richer learning experience compared to classroom lessons (35, 36). Moving beyond the
353 previous literature, the current study provides pupils insights that may explain the observed
354 improvements in maths performance. The findings align to previous studies that used time on-
355 task (37), intrinsic motivation inventory (15) and perceived enjoyment scales (38). While this
356 study did not test enhanced self-efficacy, confidence and pupil engagement, the qualitative
357 findings of children's perceptions of MOTM suggest it may have the potential to engage those

358 pupils who typically disengage in traditional classroom settings. Furthermore, the combined
359 quantitative and qualitative insights support some previous studies (15, 37, 38) that PAL
360 improves children's confidence, engagement, and academic performance. These insights are
361 essential in communicating the impact of PAL programmes to the different school
362 stakeholders.

363 While previous studies have focussed on the importance of directly assessed measures of
364 academic performance and cognition to influence teacher adoption of PAL, the perceptions of
365 the pupils provides further evidence of the wider benefits PAL may offer for pupil health and
366 broader academic development. Children described the MOTM sessions as enjoyable, fun,
367 engaging and invigorating – resulting in positive associations to learning and activity. Further
368 the different- more open- learning environment- sparked inclusivity and cooperative learning.
369 Instead of working with their peers all the time, children felt they had an opportunity to work
370 with new peers which also sparked healthy competition throughout the various maths
371 activities. Similar themes around quality learning environments and the benefits of working
372 together during group activities emerged in the Easy Minds Programme (36). In line with
373 Fredricks, Blumenfeld (39) conceptualisation over school-based engagement, the MOTM
374 children highlighted the alternative physical and social environment facilitated greater
375 engagement. Children were engaged based on the positive feelings described about the
376 support from the instructors learning the MOTM sessions, facilitating their learning and giving
377 them a sense of accomplishment. Pupil's perceptions around greater learning during MOTM
378 were akin to a similar maths-based PAL intervention revolving around children perceiving a
379 deeper understanding of concepts multifaceted activities (36).

380 **Strengths and limitations**

381 The current study was able to objectively assess children's MVPA using accelerometers at
382 baseline and week six of the intervention, providing a detailed understanding of the impact of

383 the intervention. A further strength of the study was to utilise a class-level randomised
384 controlled study design. In comparison to individual level randomisation, class-level
385 randomisation reduces contamination of the intervention which may reduce the probability of
386 a type II error by increasing the point estimate of the intervention effectiveness (40). However,
387 a limitation of this approach may be problems of recruitment bias (selecting different sorts of
388 participants for different arms of the trial defeats the objective of randomisation) and needing
389 larger sample sizes (41). The current study did not conduct an a priori power equation which
390 may have resulted in type II error. This may have been exacerbated with one school dropping
391 out before the evaluation commenced. While this study did not attempt to blind either the
392 children or the researchers of the study condition, such an attempt was unfeasible given the
393 study design used. As physical activity was assessed during the final week of the intervention,
394 the increases in MVPA levels for MOTM pupils may have increased due to the implementation
395 effect of the intervention, which we cannot confidently discount from the analysis. Moreover,
396 as the maths tests took 35 minutes to complete, there may have been a potential fatigue effect,
397 however, the testing battery was identical at each time point so any fatigue is likely to have
398 been consistent.

399 **Conclusion**

400 In conclusion, the MOTM PAL programme improved MVPA and had a large positive effect on
401 maths performance aligned with the learning content. Pupils perceived that the MOTM lessons
402 increased enjoyment and engagement with the learning content. This was facilitated through
403 learning in a more open environment and having the opportunity to interact with different
404 peers. The combined quantitative and qualitative understanding presented in the current study
405 suggests the wide beneficial impact of the MOTM programme on PA, health, and academic
406 outcomes. For policy and practice, the study emphasises the central role that PAL can play in
407 supporting schools to improve PA levels for all children (9). To progress the evidence-base, a

408 full-scale control trial is warranted to assess the impacts of the MOTM programme on PA and
409 academic performance.

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414 **Conflict of Interest (COI) and Source of Funding**

415 There are no conflicts of interest.

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- 541

542 **Figures**

543 Figure 1: Consort flow diagram

544

545 **Supplemental Digital Content**

546 Supplemental Digital Content 1: Maths on the Move Lesson Example. The example covers
547 identifying equivalent fractions. The supplement is in PDF format.

548

549 Supplemental Digital Content 2: Maths on the Move Example from Y5 booklet. The lesson
550 example covers fractions and decimals. The supplement is in PDF format.

551

552 Supplemental Digital Content 3: Maths Attainment Test (MAT) example of how the difficulty of
553 each question across the two versions (blue and red) were matched. The supplement is in
554 PDF format.