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

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ABSTRACT

Purpose: This study aimed to assess the impact of a 6-wk "Maths on the Move" (MOTM) physically active learning program on primary school children's physical activity (PA) levels and math performance. **Methods:** This was a randomized controlled trial. Year 5 children's PA was assessed using accelerometry for 5 consecutive school days at baseline and during the final intervention week (final sample: n = 97; mean age = 9.61 ± 0.29 yr; 52.6% female). Two math performance tests were used, one assessing mathematical content taught during MOTM and one assessing math's fluency (Maths Addition and Subtractions, Speed and Accuracy Test). Both tests were conducted at baseline and after the intervention (week 7). Focus groups were conducted in week 7 with intervention children (n = 12), randomly choosing an even split of children classified with preintervention low or high PA levels. **Results:** On average, during a typical 45- to 49-min MOTM lesson, children obtained an additional 5 min of moderate-to-vigorous PA and 5.7 min of light PA counteracted by a reduction of 9.5 min of time spent sedentary compared with children who remained in the classroom (control condition). The math attainment test performance significantly improved over time for children in the MOTM compared with the control (+6.1 vs +0.9, $P \leq 0.0001$, d = 1.507). No significant improvements were found in the Maths Addition and Subtractions, Speed and Accuracy Test total score. Seven emerging themes were derived from the child focus groups. Children felt the MOTM sessions resulted in social and environmental improvements, which improved learning during the sessions. Children described the MOTM sessions as enjoyable, fun, engaging, and invigorating—resulting in positive associations to learning and activity. **Conclusions:** Collectively, the findings identify that the MOTM program improves pupil's PA levels and academic outcomes and identifies pupil's willingness, enjoyment, and engagement.

INTRODUCTION

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

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

To advance the evidence base on the effects of PAL, there is a need to move beyond studies that assess the reinforcement of previously learnt concepts (13) to understand the potential effects of PAL in regard to learning new academic content (12). With reference to maths, PAL has shown beneficial effects in both acute and chronic studies of varied durations (14–16). Although qualitative studies on teachers often highlight perceived pupil enjoyment and engagement (17,18), there is a limited understanding of the children's perspectives of PAL engagement. Studies that have explored the perspectives of primary school children engaging in PAL interventions have focused on specific interventions such as virtual field trips (19) or an outdoor learning program (20). Both interventions

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are quite distant from the Maths on the Move (MOTM) program, highlighting the gap in the evidence base for exploring pupil's perspectives when engaging in a physically active math program. Furthermore, drawing upon a mixed-methods approach may help highlight potential mechanisms behind improvements in learning following PAL implementation.

This study progresses our understanding by assessing the impact of PAL to deliver a specifically defined scheme of work on numeracy. This provides a step change in the focus of PAL, shifting toward assessments of specific academic outcomes. Therefore, this study will aim to (i) assess the impact of a 6-wk PAL, MOTM program on children's PA levels, and math performance, and (ii) explore children's perspectives over the MOTM program.

METHODS

Recruitment and Participants

Four two-form entry schools in Birmingham (United Kingdom) were recruited into a randomized controlled trial using a between-subject design, with randomization at the class level. Recruited schools had previously signed up to receive the free 6-wk Aspire MOTM program (https://www.aspire-sports.co.uk/program/maths-move). After headteacher consent, 225 year 5 children were invited to take part; however, one school withdrew because of poor recruitment (2/56). Across three schools, parental consent and child assent were obtained (*N* = 140: MOTM, *n* = 76; control, *n* = 64). Ethical approval was obtained by Leeds Beckett University Ethics Committee (ref. 60567).

Protocol

Data collection took place between September and December 2019. Aspire program leads were trained by the lead researcher (J.L.M.) to support data collection. On day 1 (Monday), children's' height was measured, after which they completed a familiarization of the Maths Addition and Subtractions, Speed and Accuracy Test (MASSAT) and were fitted with accelerometers. Instructions were given to children (and teachers) to ensure the accelerometers were taken off before leaving the school and put back on the following morning upon arrival. One week later, accelerometers were returned, and children completed the baseline MASSAT (21) and then the math attainment test (MAT) in the classroom after morning registration. After this, the MOTM program commenced and lasted for a duration of 6 wk. During the final delivery week, children were refitted with accelerometers. The following Monday, children completed the post-MASSAT and MAT after morning registration. Next, children in the MOTM classes (*n* = 76) were asked to express their own thoughts and opinions on MOTM using a write and draw activity (22), expressing (i) "what you do in a typical maths lesson," (ii) "how you feel during a typical maths lesson," (iii) "what you do in a MOTM lesson," and (iv) "how you feel during a MOTM lesson." Finally, following a categorization of children into high-active (>30 min MVPA) and low-active (<30 min MVPA) based on preintervention data, four children per MOTM class (two high-active, two low active; *n* = 12) were randomly selected (www.random.org) for three school-based focus groups.

Experimental Condition

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

Children in the MOTM intervention engaged in one ~50-min lesson each week for 6 wk. Adhering to Aspire's typical learning approach, the class was split into two groups (*n* = ~15 children per group) and taken into a hall to complete the lessons. The qualified teacher from Aspire taught the MOTM lessons to both groups, one after the other. The MOTM program followed a standardized lesson structure, with each lesson using a specific numeracy objective from the UK Year Five National Curriculum. The final lesson recapped all objectives. Objectives included (i) problem solving with numbers up to three decimal places; (ii) identify, name, and write equivalent fractions of a given fraction, represented visually, including tenths and hundredths; (iii) read and write decimal numbers as fractions; (iv) multiply proper fractions and mixed numbers by whole numbers, supported by materials and diagrams; and (v) recognize mixed numbers and improper fractions and convert from one form to the other. Refer to Supplemental Digital Content 1 (http://links.lww.com/TJACSM/A149) for the instructor notes for an example activity from a lesson and Supplemental Digital Content 2 (http://links.lww.com/TJACSM/A150) for an example page from the workbooks pupils use during the MOTM lessons. The curricular content was combined with a range of multi-skill physical activities and challenges to create the game-based lessons. Children in the MOTM group had a workbook to facilitate the completion of the activities within the MOTM lessons. The Aspire instructor confirmed all six lessons were completed across the six groups within the three classes that took part in the MOTM program. Children in the control condition continued with usual math provisions, focusing on the same learning objectives.

Outcomes Variables

Physical activity

Physical activity was assessed during school time for 5 consecutive days using waist-worn accelerometers (right hip; combination of GT1, GT3x, GT3x+, wGT3X+, and GT9; ActiGraph, Pensacola, FL). Children wore the same monitor at both pre and post time points. High levels of compatibility between models have previously been demonstrated (23,24). Data were collected in 15-s epochs, using Evenson et al. (25) cut-points for sedentary time, light PA, and MVPA.

Data were downloaded using ActiLife (v.6; Pensacola, FL) and analyzed in KineSoft (v3.3.75; KineSoft, Loughborough, United Kingdom). Nonwear time was identified by a period of ≥60 min of zeros, which allowed for a period of 2-min nonwear time, with a total duration of these blocks representing nonwear time. Valid wear criteria were ≥3 school days (26) with a wear time of ≥300 min per school day. School timetables were used to explore activity thresholds across school day segments (e.g., MOTM lessons).

Math performance

Math fluency was assessed using the MASSAT (100% construct validity; 4-d test–retest reliability (r = 0.85), replicating a previous protocol (21). Outcomes included correct answers, errors, and a total score (correct minus errors). The 25-question (30 min) MAT assessed the MOTM learning objectives. The questions were age appropriate and aligned to the English national curriculum (27). Two versions of the MASSAT and MAT were used to enable a random counterbalanced approach to eliminate order effects. The Aspire team ensured test version difficulty was matched by (i) duplicating each question, (ii) changing the numbers within the questions, and (iii) ensuring that the level of challenge was maintained (see Supplemental Digital Content 3, http://links.lww.com/TJACSM/A151, for an example). Although the MAT is in line with similar, school-based studies (28,29), the results should be interpreted with caution. The MAT is not a research grade test and does not come with validity and reliability assessments; however, some issues were dealt with by counterbalancing the order of the tests.

Biological maturity

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

Focus groups

Focus groups were conducted in a quiet school space, lasting 22 to 32 min. Children used their write and draw activity to explore their perceptions and experiences of the MOTM program compared with their usual math lessons.

Statistical Analysis

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

Qualitative Data Analysis

Focus groups were transcribed verbatim before two authors (J.L.M. and S.J.B.) analyzed the data using Braun and Clarke (31) thematic analysis methodology. Inductive coding removed restrictions on coding in line with a prior framework (32). Reviewing and redefining the themes (J.L.M., S.B.J., and V.S.J.A.) helped ensure clear definitions and names were produced for each theme (31).

RESULTS

Quantitative Results

Ninety-seven children provided complete data (mean (*M*) age = 9.61 ± 0.29 yr, 52.6% female) and are included in all subsequent analyses (Fig. 1, consort flow diagram; Table 1, baseline characteristics).

Physical activity levels

Table 2 highlights the number of minutes spent in each activity threshold during the school day. Based on the number of daily minutes varying, the percentage of time spent in activity threshold was calculated and used for analyses. There was a significant interaction between time and condition for the percentage of time spent in school-based MVPA (b = 1.49, SE = 0.70; 95% confidence interval (CI), 0.13–2.86; P = 0.036, d = 458); This was due to higher levels of MVPA during week 6 of the MOTM condition (b = 1.79, SE = 0.82; 95% CI, 0.20–3.38; P = 0.031, d = 2.12). There were no significant interactions in light physical activity (LPA; P = 0.177, d = 0.289) or sedentary time (P = 0.106, d = 0.348).

Fifty-nine percent of children achieved the 30-min in-school MVPA guideline on the MOTM day compared with 34% on a non-MOTM day, showing a 28% increase. Children were significantly more active in MOTM lessons compared with control traditional lessons, with children accumulating 5-min additional MVPA (M = 6.4 ± 3.6 min, M = 1.4 ± 2.1 min, retrospectively; P < 0.0001), 5.7-min additional LPA (M = 19.8 ± 5.2, M = 14.1 ± 7.7 min, retrospectively; P = 0.0002), and reducing sedentary time by 9.5 min (M = 18.0 ± 7.5, M = 27.5 ± 9.9; P < 0.0001).

Math performance

Math Attainment Test

With a greater performance improvement for children in the MOTM condition compared with the control (+6.7 vs +0.9, retrospectively), there was a significant interaction between time and condition for math test scores (b = 5.85, SE = 0.81; 95% CI, 4.26–7.43; $P \leq 0.0001$, d = 1.507). On closer inspection, this was due to a larger significant effect over time in the MOTM condition (b = 6.99, SE = 0.67; 95% CI, 5.66–8.31; $P \leq 0.0001$, d = 1.480) in comparison to the control condition (b = 1.14, SE = 0.42; 95% CI, 0.31–1.97, P = 0.010, d = 0.426). There was also a significant difference between the post math test scores between conditions (b = 7.09, SE = 1.12; 95% CI, 4.91–9.26; $P \leq 0.0001$, d = 1.301).

Maths Addition and Subtraction, Speed, and Accuracy Test

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

Qualitative Results

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

Facilitated learning

Many of the children discussed the role that MOTM played in *improving their own learning*. For example, Rafie suggested that MOTM offers three benefits: enhanced learning, increased engagement in PA, and teamwork: "So, I think the first one, number one rule is based on getting smarter, number two is getting smarter whilst getting active and number three is getting along with partners I think that's what it means."

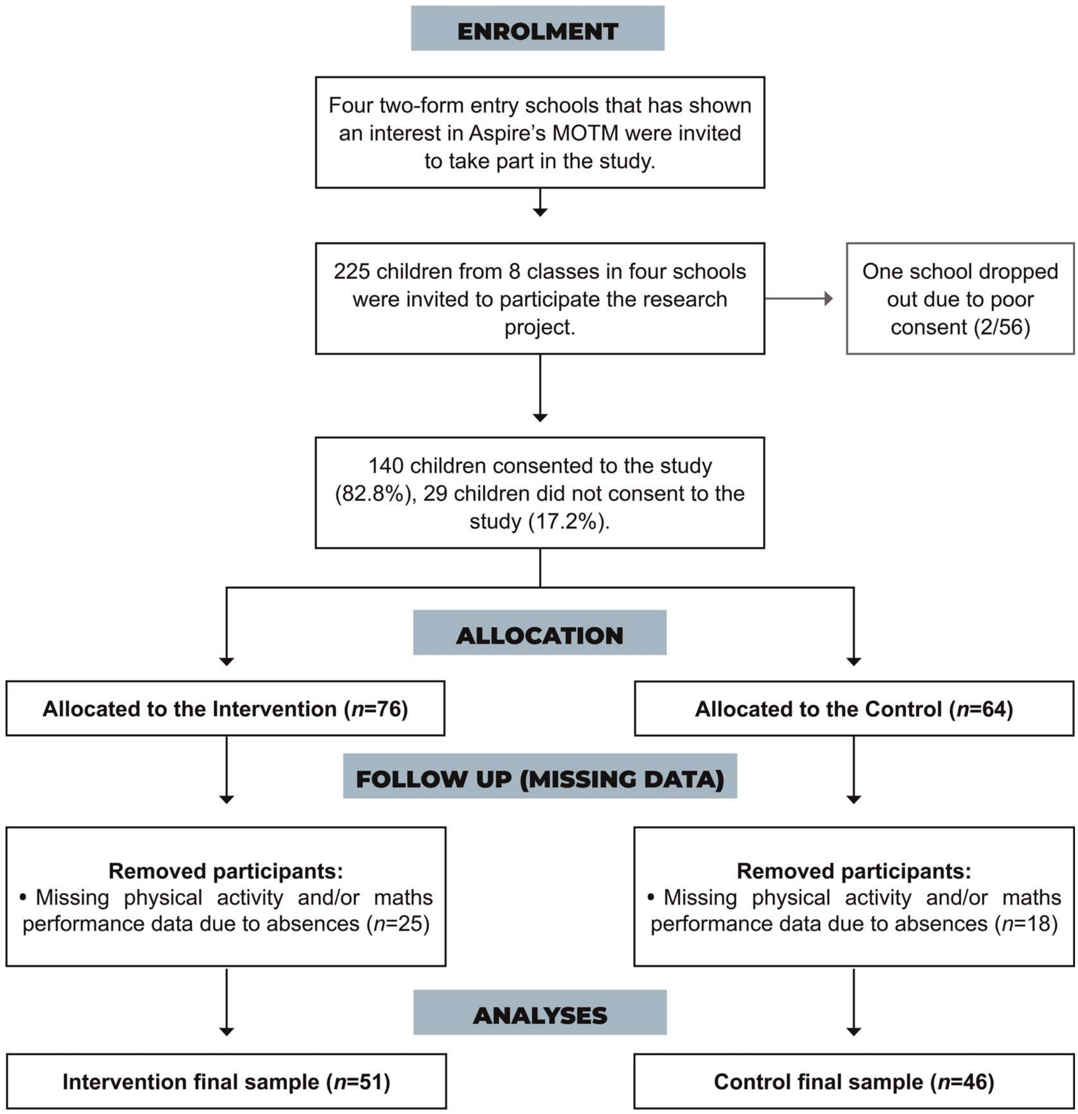

Figure 1: Consort flow diagram.

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

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

BUILDING CONFIDENCE IN MATHS AND PHYSICAL ACTIVITY

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

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

FOSTERING COOPERATION AND COMPETITIVENESS

Within this theme, there were two subthemes: (i) teamwork and social support, and (ii) healthy competition. In the first

TABLE 1.
Children's Baseline Characteristics.

	MOTM (n = 51), M (SD)	Control (n = 46), M (SD)
Age (yr)	9.64 (0.29)	9.57 (0.28)
Sex	25 boys/26 girls	21 boys/25 girls
Height (cm)	149.71 (86.19)	134.21 (6.80)
Offset maturity (yr)	−2.19 (3.04)	−2.89 (1.27)

MOTM, Maths on the Move; M, mean; SD, standard deviation.

TABLE 2.
Minutes of Time Spent in Each Activity Threshold at Baseline and Week 6.

	Sedentary Minutes		LPA Minutes		MVPA Minutes	
	Baseline, M (SD)	Week 6, M (SD)	Baseline, M (SD)	Week 6, M (SD)	Baseline, M (SD)	Week 6, M (SD)
MOTM	256.4 (27.9)	208.7 (53.9)	105.3 (20.5)	145.1 (57.3)	25.1 (10.4)	38.2 (19.3)
Control	249.3 (42.2)	189.1 (44.4)	103.4 (28.7)	111.8 (40.8)	24.8 (12.0)	27.3 (15.6)

It is important to consider the total wear time across each time point and the conditions differ. In particular, the wear time for the control in week 6 was substantially lower than the others.

LPA, light physical activity; M, mean; MOTM, Maths on the Move; MVPA, moderate-to-vigorous physical activity; SD, standard deviation.

subtheme, children explained how they worked together and, in some instances, helped one another learn something new.

We had to work as a team because you had to tell everybody like… you can write this, and then you had to… I mean you had to like interact with other people to know what they got.—Laila

Through the use of mixed groups, MOTM promoted interaction with new children, which in turn increased the inclusivity of the session. Sabir highlighted this nicely: "I like it because some people don't have any friends in their group, where it's better just mixed because you get to interact with other people." These comments highlighted the importance of changing the social environment to support new social interactions and collaborations.

In the second subtheme, children felt MOTM encouraged healthy competition between peers. In some of the activities, they were racing against each other to win against another team, as described by Aisha: "It makes me feel competitive because…to me, it feels like we're racing, whoever can find all the emojis first."

Environmental modifications transforming learning

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

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

Welcoming the cognitive challenge

Children suggested seated, traditional math lessons were quite boring, were repetitive, and lacked sufficient challenge:

I have one simple sentence… like watching paint dry. —Eva

Sometimes it's not much fun because it's basically just writing sums… Sometimes I'm excited if we get to learn something new, and it's sometimes boring and it's too easy and it's challenging, and I have different feelings depending on my mood.—Sana

Children wanted to be challenged and felt the MOTM lessons offered that. For example, Aisha said: "When they challenge us it's better though… you can push yourself to, like, if you

TABLE 3.
MASSAT Scores Stratified by Time and Condition with Multilevel Modeling Regression Analysis.

		MOTM, M (SD)	Control, M (SD)	*b* (SE)	95% CI	*P*	*d*
MASSAT total score	Baseline	30.1 (11.1)	24.6 (13.4)	– 1.97 (1.74)	– 5.38, 1.44	0.2607	0.237
	Week 6	33.0 (12.7)	29.0 (12.2)				
MASSAT correct	Baseline	32.1 (10.7)	29.3 (9.9)	1.45 (1.35)	– 1.19, 4.08	0.2856	0.227
	Week 6	36.0 (11.5)	31.3 (10.5)				
MASSAT errors	Baseline	2.0 (1.9)	4.3 (4.7)	3.02 (0.83)	1.40, 4.64	**0.0004**	**0.801**
	Week 6	2.8 (3.0)	2.3 (2.8)				

Analyses include the time (post) by condition (MOTM) interaction analyses with adjustments for offset maturity.

Boldface statistics represent statistical significance.

b, unstandardized beta coefficient; CI, confidence interval; *d*, Cohen's d effect size; MASSAT, Maths Addition and Subtraction, Speed and Accuracy Test; MOTM, Maths on the Move; SD, standard deviation; SE, standard error.

think that you don't know that and if you do it you'll be able to like gain more." However, other children wanted more challenges, with more progressions to keep everyone engaged:

All I want is for Maths on the Move to be more challenging…. I like the extensions' part, they're nice…. In the booklet, yeah, once you did like the post…once you used the postings because they're extensions, and they're way harder, only some people did it.—Matteo

Inclusion improving fitness

The MOTM sessions offer an inclusive approach to getting all children involved in PA. Contrary to P.E., where some children felt left out because of "not being good enough." MOTM prevented isolation from occurring and was inclusive for all.

Sometimes I just don't like it [sport] because some people are…like, don't include other people who aren't that good in games.—Sabir

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

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

Positive feelings toward MOTM

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

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

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

Children also emphasized how they did not want the sessions to end, feeling sad that they would not receive any more sessions. For example: "The sad thing is that it is ending." (Rafie). Other children saw the benefits of MOTM not just in the short term, but looking forward and in helping their grades, and even helping them toward a better future.

If it continues [MOTM] it will help us learn more Maths, it would help us generate even better grades, and soon we also get a better future as well.—Rafie

DISCUSSION

The dual aims of the current study were to assess the impact of a 6-wk MOTM program on children's PA levels and math performance, and to explore children's perspectives of the MOTM program. The MOTM program increased MVPA levels, securing an additional 5 min in comparison to traditionally seated math's lessons, equating to one-sixth of the in-school daily MVPA guidelines. Furthermore, the proportion of children achieving the guidelines increased by 28% on MOTM days. Although no change was observed in math fluency scores, the MOTM program resulted in large positive and significant effects on math performance—assessed by the MAT. Children perceived that MOTM facilitated improvements in learning and building confidence in maths and PA. The engaging social and physical environment within MOTM sessions helped foster learning and encourage new social dynamics within the class. Consistently, children highlighted that engaging in MOTM resulted in a range of positive feelings: building confidence, having fun, working with peers, and encouraging healthy competition.

In agreement with previous PAL research, the MOTM program significantly improved levels of MVPA (33,34). Specifically, the 5 additional minutes of MVPA resulted in an additional 30% of children meeting the in-school MVPA guidelines of 30 min a day. Such findings expand the research understanding of PAL, confirming that when teaching new academic content, the MOTM lessons made a substantial contribution to pupils' in-school MVPA levels. These outcomes are of great importance; lessons involving maths and English have recently been deemed the most inactive period of a child's day (8).

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

In agreement with previous PAL studies, pupils perceived that the MOTM lesson revealed a richer learning experience compared with classroom lessons (35,36). Moving beyond the previous literature, the current study provides pupils insights that may explain the observed improvements in math performance. The findings align to previous studies that used time on task (37), intrinsic motivation inventory (15), and perceived enjoyment scales (38). Although this study did not test enhanced self-efficacy, confidence, and pupil engagement, the qualitative findings of children's perceptions of MOTM suggest it may have the potential to engage those pupils who typically disengage in traditional classroom settings. Furthermore, the combined quantitative and qualitative insights support some previous studies (15,37,38) that PAL improves children's confidence, engagement, and academic performance. These insights are essential in communicating the impact of PAL programs to the different school stakeholders.

Although previous studies have focused on the importance of directly assessed measures of academic performance and cognition to influence teacher adoption of PAL, the perceptions of the pupils provide further evidence of the wider benefits PAL may offer for pupil health and broader academic development. Children described the MOTM sessions as enjoyable, fun, engaging, and invigorating—resulting in positive associations to learning and activity. Furthermore, the different—more open—learning environment sparked inclusivity and cooperative learning. Instead of working with their peers all the time, children felt they had an opportunity to work with new peers, which also sparked healthy competition throughout the various math activities. Similar themes around quality learning environments and the benefits of working together during group activities emerged in the Easy Minds program (36). In line with Fredricks et al.'s (39) conceptualization over school-based engagement, the MOTM children highlighted the alternative physical and social environment facilitated greater engagement. Children were engaged based on the positive feelings described about the support from the instructors learning the MOTM sessions, facilitating their learning and giving them a sense of accomplishment. Pupil's perceptions around greater learning during MOTM were akin to a similar math-based PAL intervention revolving around children perceiving a deeper understanding of concept multifaceted activities (36).

Strengths and Limitations

The current study was able to objectively assess children's MVPA using accelerometers at baseline and week 6 of the intervention, providing a detailed understanding of the impact of the intervention. A further strength of the study was to utilize a class-level randomized controlled study design. In comparison to individual-level randomization, class-level randomization reduces contamination of the intervention, which may reduce the probability of a type II error by increasing the point estimate of the intervention effectiveness (40). However, a limitation of this approach may be problems of recruitment bias (selecting different sorts of participants for different arms of the trial defeats the objective of randomization) and needing larger sample sizes (41). The current study did not conduct an *a priori* power equation, which may have resulted in type II error. This may have been exacerbated with one school dropping out before the evaluation commenced. Although this study did not attempt to blind either the children or the researchers of the study condition, such an attempt was unfeasible given the study design used. As physical activity was assessed during the final week of the intervention, the increases in MVPA levels for MOTM pupils may have increased because of the implementation effect of the intervention, which we cannot confidently discount from the analysis. Moreover, as the math tests took 35 min to complete, there may have been a potential fatigue effect; however, the testing battery was identical at each time point so any fatigue is likely to have been consistent.

Conclusions

In conclusion, the MOTM PAL program improved MVPA and had a large positive effect on math performance aligned with the learning content. Pupils perceived that the MOTM lessons increased enjoyment and engagement with the learning content. This was facilitated through learning in a more open environment and having the opportunity to interact with different peers. The combined quantitative and qualitative understanding presented in the current study suggests the wide beneficial impact of the MOTM program on PA, health, and academic outcomes. For policy and practice, the study emphasizes the central role that PAL can play in supporting schools to improve PA levels for all children (9). To progress the evidence-base, a full-scale control trial is warranted to assess the impacts of the MOTM program on PA and academic performance.

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