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A movement and story-telling intervention improves language and fundamental movement skills and is feasible for delivery by teachers in the first year of school

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ABSTRACT

Background: Language development is a critical precursor to written language skills and subsequent access to the curriculum, while basic movement skills are a prerequisite to later engagement with activity and sport. However, there is lack of evidence about effective programmes that address both motor and language skills that are practical and manageable for educators in primary school.
Aims: This study tested the effectiveness and implementation feasibility of MAST (Movement and Story-Telling); a 12-week, whole-class combined movement and story-telling approach, when delivered by teachers in the first year of school.
Methods: Using a cluster-randomised control design, 214 four-to-five-year-old children were assessed across nine primary schools (5 receiving MAST, 4 control) at pre- and post-test for their language, fundamental movement skills and self-regulation (an ability that underlies both skills). Also, the five teachers implementing MAST were interviewed and observed delivering the programme.
Results: There was a significant effect of MAST on language (d = 0.2) and fundamental movement skills (d = 0.65), but not effect on self-regulation. Implementation fidelity was good with four out of five schools consistently delivering all key components of MAST. Thematic analysis of interviews identified barriers to implementation, as well as factors for success.
Conclusions: MAST proved feasible for delivery by teachers in primary schools, resulting in significant improvements to language and movement skills. Implications include the need to upskill early years educators and to educate school management on the importance of teaching movement and language skills to young children.

1. Indroduction

The Early Years Foundation Stage Profile in England details statutory requirements for child development by age 5, with 'physical development' and 'communication and language' as two prime areas (DFE, 2021). Similar developmental priorities have been recommended globally (Unicef, 2024). These skills underpin positive outcomes in physical activity (Jaakkola et al., 2015), self-regulation (Haapala et al., 2017), and academic performance (Duff et al., 2014) in later childhood. However, both movement and language skills are poor in British 5-year-olds, particularly for children from disadvantaged backgrounds (Duncan, Foweather, et al., 2022; Dobinson et al., 2024). For example, pre-pandemic data indicated that in the UK, 10% of 4-to-5-year-old children were obese, rising to 20% of 11-year-olds (Health and Social Care Information Centre, 2019), and 27% of children were failing to meet expected levels in reading at the end of primary school (DFE, 2019). On a global scale, these difficulties have been exacerbated by Covid-related school closures, resulting in a widening gap between disadvantaged children and their peers with respect to early learning goals (Sutton Trust, 2024) and physical fitness (Kovacs et al., 2021). Lockdown restrictions increased sedentary behaviour and screen time, limiting opportunities to remain physically active (Sheldrick et al.,

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2022). In addition, more screen time and less reading led to less exposure to quality language (Fung et al., 2023). There is now a need for intervention, and the school environment constitutes the only reliable place where disadvantaged pupils can be provided with support (Eyre et al., 2022; Quigley, 2018).

Although there are promising interventions centring on training parents and/or practitioners in pedagogic approaches to support the development of early language outcomes (Blom-Hoffman et al., 2007; Fricke et al., 2013, 2017; Zevenbergen & Whitehurst, 2003), these can be time intensive, relying on one-to-one or small group approaches. With respect to physical development, few interventions exist to support the development of fundamental movement skills (FMS) in young children (Van Capelle et al., 2017). Although exercise programmes have typically not been found to have significant effects on academic attainment (EEF, 2019, 2021), these programmes have generally not focused specifically on teaching FMS. FMS refers to gross motor skills that enable effective participation in physical activities (e.g., running, jumping, throwing, catching and kicking; Hulteen et al., 2020).

The focus on FMS is important as the development of FMS is a stated aim of the National Curriculum for Physical Education in England (Department for Education) and the development of FMS is linked to other aspects of children's development (Martins et al., 2024). While there has been a noted increase in FMS based interventions in school settings over the last 10 years, recent expert statements from the International Motor Development Research Consortium on children's motor development in the UK and Ireland (Duncan, Foweather, et al., 2022) and on healthy development in children in the early years (Martins et al., 2024) noted that the quality of such interventions was mixed and by far the majority of FMS based interventions have been administered by trained researchers, rather than school staff, limiting the real world transferability of FMS intervention in practice.

Due to a lack of cost-effective and practical interventions to improve language and FMS, as well as a lack of knowledge on their wider benefits, such approaches are often not adopted by schools. According to Snowling et al. (2022), oral language interventions have only recently been highlighted by policymakers, with this shift not yet being visible in schools. The emphasis is still on early literacy instruction and a 'phonics first' model on schools' timetables (Vousden et al., 2022). Moreover, insufficient emphasis on teaching physical education (PE) and assessing FMS in initial teacher training negatively affects educators' efficacy, attitude and confidence in PE (Duncan, Fitton Davies, et al., 2022; Harris et al., 2012; Ma et al., 2021). For example, the majority (88%) of teachers say they recognise PE is important (TES, 2015), but an estimated 40% of newly qualified teachers begin their careers with an average of just 6 h initial training in PE (Youth Sport's Trust, 2024). This lack of training has led schools to employ external 'coaches' to teach PE, resulting in teachers becoming further de-skilled (Smith, 2015). It seems that the policy shift emphasising the value of physical activity (DFE, 2023) and language (DFE, 2021) has not yet translated into practice. It is therefore essential to up-skill teachers and develop their confidence and competence in teaching PE and language, as well as to address contextual/school-level difficulties (Eyre et al., 2022). Training in a combined programme that can be delivered to whole classes has the potential to achieve this goal.

Theory suggests that there could be developmental advantages in combining movement and language activities. First, movement and physical activity can improve cognitive processing, increase hippocampal volumes, enhance attention and increase blood flow to the brain post-activity (Donnelly et al., 2016; Voss et al., 2014). This would suggest that locating key learning activity (such as language activities) immediately after movement would benefit learning. Second, classic research has suggested that movement and language share the same underlying processes of self-regulation and executive function (Diamond & Lee, 2011), with evidence that both processes underpin both language (Clemens et al., 2023; Gooch et al., 2016; Williams & Bentley, 2021) and movement skill (Williams & Howard, 2020, Williams & Bentley, 2021) in children. The most recent review of the topic to date supports the notion that there is a relationship between motor competence and executive functioning, but not physical activity and executive functioning, during early childhood (Willoughby & Hudson, 2023). The review suggests that it is the development of motor skills, rather than simply engaging in exercise, that is associated with the development of executive functioning in childhood. This notion has recently been supported by empirical data demonstrating that performance in motor skill tasks is associated with cognitive flexibility, working memory and inhibitory control in 3–6 year olds (Zhou et al., 2024).

Third, embodied cognition approaches suggest that sensorimotor experiences gained through bodily actions within the environment are important and useful for developing cognitive capabilities and processing (Engel et al., 2013). Within the conceptualization of embodied cognition, the six views of embodied cognition proposed by Wilson (2002) should also be noted. Wilson (2002) suggested that embodied cognition comprises both on-line and off-line aspects, both of which apply to the potential of combined movement and language programmes. Notably, the concept that in on-line embodied cognition the mind works to serve the needs of the body in interacting within a real world environment and in situations that require perception and action, while in off-line embodied cognition, sensorimotor experiences, in the form of mental representations, can strengthen the mind via the body (Wilson, 2002).

Research investigating the potential benefits of combining language work with movement suggests that it has additive benefits compared to language or movement alone. Duncan et al. (2019) developed a six-week, whole-class programme for FMS and language development in 3-to-4-year-olds (preschool), based on a popular children's book. Each session focussed on a different character and associated the movements of that character to a locomotor skill. These sessions were compared to sessions which only included the storytelling elements (language work) and sessions which included the movement activities without reference to a story narrative (motor skills). Duncan et al. (2019) found that the combined programme was more effective than teaching the skills separately, resulting in additive benefits for both motor skills ($d = 0.45$) and expressive vocabulary ($d = 0.54$) at immediate post-test.

Although found to be effective for children in the early years, the Duncan et al. (2019) study relied on researchers to deliver the programme rather than early years practitioners. There was therefore a need to demonstrate whether it would be equally effective if the sessions were delivered by educators. Moreover, we wanted to examine whether it had potential application in more formal, school-based settings the year children start school (age 4-to-5 years-old, Reception class). Consequently, this paper reports the outcomes of a feasibility trial, in which a 12-week version of the programme reported in Duncan et al. (2019) was evaluated in the context of teacher-led lessons in Reception classes in England.

1.1. The current study

In this study, we developed the Duncan et al. (2019) programme for teacher-delivery and included an additional six weeks of language and object skills. It is referred to as MAST, standing for Movement and Storytelling. We trained Reception teachers (first year of school in the UK) on MAST in a subset of schools and compared the progress of their pupils in language and movement to that of Reception children in other schools who received 'business-as-usual'. We also assessed the feasibility of MAST in practice by interviewing and observing teachers to identify factors that impacted successful delivery and implementation fidelity. In addition, due to self-regulation being a common process underlying movement and language (Diamond & Lee, 2011), we also measured whether self-regulation was improved by the programme.

This project therefore addressed the following principal research questions:

1. Does MAST positively impact movement and language skills in Reception children?
2. To what extent was the MAST programme delivered as planned? What were the barriers to successful implementation, and what factors contributed to successful adoption?

2. Method

2.1. Design

This study was a cluster-randomised control trial. Nine schools were recruited to the study from the East Midlands and North-West of England. Eight schools were pair-wise matched as closely as possible on the following characteristics, in order of priority: location, size, pupil premium %,[1] national reading and writing tests at age 7, and English as an additional language (EAL) %. One school from each pair was randomly assigned to MAST delivery, and the other acted as a control school. Randomisation was conducted mid-way through pre-test (to allow time for teachers to organise cover for the training day) by the first author using a coin toss. The ninth school was allocated to the MAST programme. Children in all schools were pre- and post-tested for FMS and language skills, and self-regulation. Additionally, teachers in the MAST schools were interviewed, and lessons observed to establish implementation fidelity, factors for success and barriers to implementation. The research questions were pre-published on the project website in June 2022 (URL project website).

2.2. Ethics

All parents/carers of the students who took part returned consent forms before testing took place, and children assented to participate in the study, the study was approved by the University's ethical review board (Schools of Business, Law and Social Sciences Research Ethics Committee, project number 1445708). There were no exclusionary criteria such as having English as an Additional Language or Special Educational Needs.

2.3. Child participants

The purpose of this study was to assess the feasibility of MAST for teacher-delivery; therefore a formal power calculation was not required. However, prior research suggests 75 children per group would be enough for a feasibility study targeting small effect sizes (see extension of the 2010 CONSORT statement; Eldridge et al., 2016). Therefore, we aimed to recruit at least 180 children to account for a potential dropout of 20% of the children (Foulkes et al., 2017).

The parents of all the children in Reception from the nine primary schools were invited to participate. Consent forms were returned for 238 children out of 391 representing a 57% consent rate. 15 children were excluded as they were either a) persistently absent from school, or b) had behavioural difficulties such that the teacher deemed them not to be suitable for testing. A further 9 children changed school between pre- and post-test, leaving a final sample of 214 assessed at both time points (mean cluster size = 23.7, range 6–32). There were 133 children in the MAST group (mean age 4 years, 9 months) and 81 in the control group (mean age 4 years, 8 months). Groups were well-matched for age, pupil premium percentage, height and weight. However, there was a higher percentage of EAL pupils in the control group and fewer boys (see Table 1).

[1] Pupil premium is a financial supplement given to schools if a pupil's family has experienced financial hardship in the last 6 years or if the child has been fostered or adopted at any point. It is used here to indicate socioeconomic vulnerability.

Table 1
Participant characteristics at baseline.

Variable	Intervention (M(SD)/%)	Control (M(SD)/%)
Age (months)	56.4 (3.8)	57.0 (4.4)
Gender (boys)	56.4%	46.9%
Pupil Premium	22.6%	23.5%
EAL	24.1%	42.0%
Height (cm)	107.5 (16.4)	109.5 (5.2)
Weight (kg)	19.1 (3.0)	18.6 (2.7)

Note. Intervention n = 133, Control n = 81.

2.4. Teacher participants

Four qualified teachers and one teaching assistant across the five MAST schools participated in the implementation analysis. All attended a one-day training day and delivered MAST to their Reception classes. Two had less than 5 years' teaching experience, while three had over 8 years' experience.

2.5. MAST

MAST was designed by the authors; a group of sport and exercise scientists and developmental psychologists. The programme comprised 12 weeks of lessons concerning a whole-class programme designed to be run in the hall or other suitable large space for or 35 min per lesson. Basic PE equipment was needed (e.g., hula hoops, balls, and beanbags). Teachers were told to run MAST once a week with the option to run it twice a week if they chose (during the second session they would repeat the same lesson). The first six weeks covered locomotor skills and the book chosen to refer to was 'The Gruffalo' (Donaldson & Scheffler, 1999). The following six weeks covered object control skills and referenced 'Stick-man' (Donaldson & Scheffler, 2008). This differed from the pilot version of MAST (Duncan et al., 2019) which just covered the first six weeks of locomotor skills and was researcher delivered. Each of the sessions followed the same structure – an initial 'priming' section, which centred on reviewing the story (5 min), a period of physical activity where a character's movements were rehearsed through activities (25 min), and a final 'embedding' period where the children revisited the story narrative and vocabulary (5 min). Language work in the last 5 min was intended to capitalise on the post-activity window of increased blood flow to the brain.

Each week focused on a different event in the story and a link was made between this event and an FMS, which was then taught and practised in the movement section. The final week of each story was devoted to practising all the movements from that story in the context of acting out the story as a whole. Ten FMS were covered (5 locomotor skills and 5 object skills). Key vocabulary and comprehension skills were introduced and reinforced during the language work by discussing book illustrations. Language work during priming and embedding phases were guided by example questions produced in a Teacher Guide. Questions followed a regular format each week (see Supplementary Material).

The conceptual framework underpinning MAST is Achievement Goal Theory (AGT, Rudisill, 2016). AGT describes the goals and attributions that individuals adopt when learning and the subsequent effect these have on approaches and engagement in learning environments. MAST centres on developing a mastery orientation within the sessions. Individuals who adopt a mastery orientation engage in tasks for the intrinsic value of learning and measure improvement using self-referenced standards (e.g., comparing current and previous performances). A mastery approach is associated with positive outcomes such as more effort (Ames & Archer, 1988), intrinsic interest and time on learning activities (Meece et al., 1988), and positive attitudes toward learning (Ames, 1992). Latterly, AGT has been applied to movement-related intervention with children (See Palmer et al., 2017). In the case of MAST, mastery is facilitated using the TARGET structure

(i.e. task, authority, recognition, grouping, evaluation, and time, see Supplementary Resources) that is commonly employed in AGT interventions (Palmer et al., 2017).

2.6. Training

Educators from MAST schools attended a one-day training event, and reviewed a Teacher's Guide (which included lesson plans for the 12-week programme), planned a lesson, saw an example lesson taught by one of the authors, practiced teaching part of their own planned lesson, and discussed 'what-if?' scenarios with the research team (i.e., use of equipment, integration of children with special needs, behavioural management).

Teaching staff were given the Teacher's Guide, Key Vocabulary cards, copies of the Gruffalo and Stick-Man books, a toy Gruffalo, and a toy Stick-Man. The guide included links to videos of an adult and child performing each movement. Practitioners were additionally provided with a peer-support forum via WhatsApp, which was used to enable the research team to provide 'just-in-time' support during programme delivery (i.e. answering questions as they occurred, providing specific support and advice).

2.7. Child outcome measures

2.7.1. Language

Language Screen (Hulme et al., 2024) was individually-administered in a quiet area of the school. This was a 10-min, online test, delivered on a tablet. It comprised 4 sub-tests: expressive vocabulary (naming a series of pictures), receptive vocabulary (matching spoken words to a series of four pictures); listening comprehension (listening to 3 stories and answering questions tapping literal and inferential comprehension), and sentence repetition. Scoring was automated and results uploaded to a secure website (LanguageScreen.com) which generated standard scores for each sub-test as well as for the whole test. Published reliability for Language Screen is high (Cronbach's $\alpha = 0.84$, Hulme et al., 2024). Standard scores for the whole test (based on adding the total correct for each sub-test) were used for the analysis.

2.7.2. Fundamental movement skills

The Test of Gross Motor Development-3 (TGMD-3; Ulrich, 2020) was used to assess Fundamental Movement Skills (FMS). This was administered in groups of about 8 children per researcher. First, height (cm) and weight (kg) were measured. Then, the children were videoed as they undertook a series of movements. Eight FMS were measured (4 locomotor and 4 object): run, jump, hop skip (locomotor), underarm throw, overarm throw, catch, kick (object control). These 8 skills were chosen to reflect a broad balance of locomotor and object control skills whilst recognising that run, jump, throw and catch are explicitly mentioned as key skills within the national curriculum for PE in England. Run, jump and hop, kick, underarm and overarm throw were coded out of 8 (4 dimensions across two trials) while skip and catch were coded out of 6 (3 dimensions across two trials), resulting in a maximum score of 60. Researchers with experience in assessing children's movement analysed the videos and were trained during a 1-h session where they watched and rated example video clips. Following this, trainees coded 10% of already coded footage by the lead researchers. Congruent with prior research (Barnett, Minto, Lander, & Hardy, 2014), training was considered complete when each observer's scores for the two trials differed by no more than one unit from the instructor score for each skill (>80% agreement). Percentage agreement across all skills reached 89%. A composite score based on all eight FMS skills (max score = 60) was used for the analysis.

2.7.3. Self-regulation

Children were asked to play a game in which they had to do the opposite of what the researcher said (the *Heads-Toes-Knees-Shoulders* (HTKS). This was conceptualised by Ponitz et al. (2008) as a measure of inhibitory control, working memory and attentional focus. The children were told to touch their head (or their toes), but instead of following the command, they had to do the opposite and touch their toes (or their head). If children passed the head/toes part of the task, they completed an advanced trial where the knees and shoulders were added. Two points were given for each correct trial, 1 point if the child self-corrected, and 0 if incorrect. There were 30 trials (max. score 60), and the task was stopped after the first 10 trials if all were incorrect. Published reliability for HTKS is high (Cronbach's $\alpha = 0.94$, McClelland et al., 2014). Total correct was used for the analysis.

2.8. Implementation measures

2.8.1. Observations

The second author conducted observations of two MAST sessions at each school (one during the first six weeks and one during the second six weeks), to evaluate teachers' adherence to the guidelines, activities and structure of the MAST sessions as covered in the training. Field notes were taken on the process of delivery, the layout of the room and teachers' degree of compliance to key components of the intervention. In addition, notes were taken on frequency of delivery, duration and structure of the sessions (see Supplementary Materials for the observation checklist). Ten observations lasting approximately 45 min were completed.

2.8.2. Interviews

One-to-one semi-structured interviews lasting approximately an hour were conducted to explore factors that enabled and hindered delivery (see Supplementary Materials for interview schedule). The interviews covered teachers' experiences, confidence and attitudes towards MAST delivery and the training, perceptions of barriers and facilitators to delivery, perceived impact and suggestions for improvement, and pupils' experiences of taking part in the programme. The interviews were conducted online approximately 6 weeks into the intervention and were recorded.

2.9. Analyses

2.9.1. Child outcome analyses

To address the question of whether MAST had beneficial short-term effects on language skills and motor development, two multiple hierarchical linear regressions were undertaken. To allow for the nonindependence of observations arising from the clustering of children within schools, we used robust (Huber-White) standard errors. This type of analyses is commonly used for the evaluation of educational RCTs in the literature (Johnson et al., 2019; West et al., 2024). The first assessed the impact of MAST on language skills while the second assessed the impact of MAST on FSM. An additional exploratory regression was performed to assess the impact of MAST on self-regulation (HTKS). Baseline characteristics (pre-test scores, age, gender and pupil premium status) were controlled for in Step 1 while Group (MAST = 1, Control = 0) was added in Step 2. Analyses were performed in R using the lm (linear model), cluster.vcov (clustering of standard errors) and coeftest (t-tests taking into account clustered standard errors) commands from the *stats, lmtest,* and *mutliwayvcov* packages (R Core Team, 2021). There was no multicollinearity (all VIFs close to 1).

2.9.2. Implementation analyses

In this analysis, we sought to answer the research question concerning factors behind successful MAST delivery and barriers. The interviews were transcribed verbatim, and the transcripts anonymised. The study adhered to the consolidated criteria for reporting qualitative research (COREQ) checklist (Tong et al., 2007; see Supplementary Materials). Deductive thematic analysis was employed (Braun & Clarke, 2006) and two overarching themes *"Barriers"* and *"Facilitators",* were

pre-set. The identification of themes and sub-themes within this broad categorisation followed a step-by-step analytical process involving data familiarisation through transcribing, reading, and re-reading the data, code generation whereby short descriptive labels were assigned to the data set, categorisation where similar descriptive labels formed categories, searching and reviewing the themes, and defining and naming themes. When the identification of new themes was not achieved, we took this as indicative of data saturation (Guest et al., 2006). All the teachers who delivered MAST participated in the interviews.

3. Results

3.1. Child outcome measures

Children's pre and post-test scores for self-regulation, language, and FMS are presented in Table 2 along with Ns at each time point. Of the 214 children tested at Time 1 and 2, there were complete data at pre- and post-test for 204 children for language, 202 for self-regulation and 129 for all eight FMS skills. Missing data for language and self-regulation were caused by repeated absenteeism and/or child refusal. The higher level of missing data for FMS was caused mainly by a group of children who struggled to complete the motor assessments (particularly at Time 1) and therefore could not be scored. This is likely due to the fact that in the UK motor skills are below the level typically expected, and this has worsened since the pandemic (Duncan, Foweather, et al., 2022). There was no significant difference in pre-test language, $F(203) = .33$, $p = .57$ or self-regulation, $F(201) = .69$, $p = .41$ between those children with and without complete data for FMS.

Independent samples t-tests showed that there were no significant differences between groups at baseline for self-regulation ($t(210) = .-.12$, $p = .90$), language ($t = .50$, $p = .96$), or FMS ($t = 1.22(143)$, $p = .22$). There was a significant correlation at pre-test between self-regulation and language ($r = .54$, $p < .001$). There was no significant relationship between FMS and language skills ($r = .05$, $p = .54$), or between FMS and self-regulation ($r = .09$, $p = .31$) (see Appendix for a correlation table).

Table 3 presents the results of multiple regression predicting post-test scores. The overall model for the regression predicting post-test language was significant, $F(5,198) = 80.43$, $p < .001$, $R^2 = 0.67$. Group significantly predicted post-test language once the effects of baseline characteristics were controlled; Change$R^2 = .01$, $p < .05$. This meant that there was a significant positive effect of MAST on language scores (effect size $d = 0.2$[2]).

The overall model for the regression predicting post-test FMS scores was significant, $F(5,123) = 9.61$, $p < .001$, $R^2 = 0.28$. Group significantly predicted post-test FMS once the effects of baseline variables had been controlled; Change$R^2 = .10$, $p < .001$. There was a significant large positive effect of the intervention on FMS scores (effect size $d = 0.65$[2]). Gender also had a significant effect on FMS (boys had better FMS than girls).

The overall model predicting post-test HTKS (self-regulation) scores was significant, $F(5,196) = 41.56$, $p < .001$, $R^2 = 0.51$. Group did not significantly predict post-test HTKS once the effects of controls had been accounted for; Change$R^2 = .00$, $p = .62$.

3.2. Implementation analysis

Table 4 summarises adherence to key components of MAST at each site. Adherence is based on the component being observed across the two observation visits per school conducted by the second author. Overall, the programme was faithfully followed in four out of five school sites.

Below, we outline the results of the deductive thematic analysis which are represented in Fig. 1.

3.2.1. Facilitators

3.2.1.1. I am well-equipped

3.2.1.1.1. Ongoing support. Teachers provided positive feedback on MAST during the interviews. All teachers felt satisfied with the level of support received by the research team and the materials provided to deliver the programme. Although different from what they were used to, most described gaining confidence in their competence to deliver MAST following the training. The structure of the training was praised, with educators indicating that the applied part of the training day prepared them well for implementing the programme.

> *'So at the at the beginning, I was a little bit scared and nervous, but after the first, you know the session with you in the university act, I thought it's like, yeah, I can do it. Why not, you know? So it's like now I think yes, after the training, I thought it's just the first, like the description what will you expect from me and I thought oh it is going to be difficult it will bounce back but in the end I really enjoyed'* (Site 3).

There was overall satisfaction with the variety and quantity of resources provided, with teachers highlighting the alignment of the materials with their teaching needs and practices.

> *'Really helpful. It's good to have the visual images. It's good to have the vocabulary cards and the story books and pictures are really helpful as well'* (Site 2)

> *'I found the little bit of background that you gave me about I thought it's kind of ties in quite well with how I sort of approach PE anyway and so I think it kind of fitted in with that sort of style of how we're kind of would teach it'* (Site 4).

The teachers emphasised the ongoing support provided as important for successful delivery. According to all, their call for more practical guidance was responded to, with the research team offering additional information when needed.

> *'It was brilliant that you showed examples because sometimes when you read it, you can't actually understand what exactly what does it mean. But if you have both, you know a version of showing a practical one and then write it you know and then it's brilliant. So the links that was sent you know and how showing examples of that game or example of that. It was definitely it was brilliant'* (Site 3).

3.2.1.1.2. Handy lesson plans. Most of the staff thought the lesson plans were clearly articulated, well-structured, and easy to follow. They acknowledged that they required minimum preparation and time investment, with some highlighting the advantage of having 'ready-made' lessons to follow.

> *'I think I like it because it's already everything is planned I easily I don't need actually think in advance. Oh my God. What I'm going to do what? It's everything it's prepared now already did one session and it's actually I'm very happy to carry on this even after this project would finish because then I know that we'll teach them every skill and everything is prepared …. So I think it's just very easy for me just to jump and be independent and do it that session'* (Site 3).

3.2.1.2. The utility value of MAST

3.2.1.2.1. Visible benefits for pupils. Teachers referred to MAST's relevance to their pupils' developmental needs as a motivation to continue implementing the programme, with some arguing for its importance for disadvantaged learners.

> *'I know a lot of our children don't have gardens and probably don't have the opportunity to be using those gross motor skills as much as you'd probably get in a village school and so I think it is very important. So I think it's really important for our children to be accessing high-quality gross motor lessons'*

[2] Based on conversion of R^2 change to d using equation.

Table 2
Descriptive Statistics for child outcome measures.

			Pre-test			Post-test		
Variable	Cron-bach's α	Max. score	N	Intervention *M (SD)*	Control *M (SD)*	N	Intervention *M (SD)*	Control *M (SD)*
HTKS	.96	60	202	26.30 (15.71)	26.01 (17.39)	206	34.07 (16.59)	33.09 (15.35)
Language	.92	–	214	94.20 (13.14)	94.28 (13.28)	205	98.98 (13.34)	96.50 (12.44)
FMS	.87	60	145	25.00 (6.21)	26.50 (8.56)	181	31.84 (8.75)	26.91 (7.81)

Note. N = number of participants with complete data at each time point. Language variables indicate standardised scores. HTKS = Heads-Toes-Knees-Shoulders (i.e. self-regulation). FMS = catch, throw (underarm and overarm), kick, jump, run, skip, and hop. Cronbach's alphas are based on post-test scores.

Table 3
Regressions predicting post-test scores.

Outcome	Post-test Language				Post-test FMS				Post-test HTKS			
Predictor	b	SE	t	ΔR^2	b	SE	t	ΔR^2	b	SE	t	ΔR^2
Intercept	17.76	8.29	2.14*	0.66**	5.67	12.96	0.43	0.19**	36.62	15.35	2.38*	0.51**
1. Pre-test score	0.79	0.04	19.95**		0.42	0.17	2.41*		0.71	0.09	7.48**	
1. Age	0.12	0.16	0.76		0.20	0.22	0.92		−0.37	0.31	−1.19	
1. Gender	−0.76	1.58	−0.48		3.38	1.53	2.20*		−0.12	1.04	−0.12	
1. Pupil premium	−2.15	1.23	−1.74		−1.60	1.88	−0.85		2.57	1.74	−1.48	
2. Group	2.67	0.96	2.77**	0.01**	5.62	0.96	5.84**	0.10**	1.02	2.04	0.50	0.00

Note. *p ≤ .05, **p < .001. N = complete data at pre- and post-test. N = 204 (Language), 129 (FMS), 202 (HTKS). Pre-test score represents the post-test outcome variable at pre-test. Language represents standard scores. FMS = Fundamental movement skills. HTKS = Heads-Toes-Knees-Shoulders. Age is age at pre-test in months. Intra-class correlations at post-test: Language = 0.13, FMS = 0.37, HTKS = 0.08.

Table 4
Adherence to key components of MAST.

	Session overall					Priming and Embedding Phase			Movement Phase			
Site	Dosage ≥1/ week	Length (≥35′)	Structure (story–movement -story)	Act in character	Learning Objective	Resources	Questioning/ Probing	Key vocabulary	Warmup	Practice activities	Teaching the skill (using teaching cues)	Cooldown
Site 1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Site 2	✓		✓		✓	✓	✓	✓		✓	✓	
Site3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Site 4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Site 5	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	

Lessons at the four sites adhered to all key components apart from structure. All schools delivered MAST at least once a week for the full 12 weeks with one school delivering it twice a week. Overall, implementation fidelity was good, with the cool-down (administered by only two sites) being the main area for improvement.

(Site 1).

Some educators admitted being reluctant at first but gained confidence later when they witnessed its effects on their class. Pupils' endorsement of MAST acted as motivation for the teachers who observed their pupils' engagement.

'*So it's when sometimes I think it's like Ohh didn't go very well but the children still they love it. I think when I hear like you heard one of the kids it was like telling you I LOVE GRUFFALO PE!!'* (Site 3).

Additionally, the observed improvement in language and movement skills encouraged most teachers to invest in its delivery.

'The thing I enjoy most about it is doing the movement bit and teaching them the skills cause I can see progression there' (Site 5)

Teachers also saw improvements in the children's language skills.

'I have a girl that she came with no English whatsoever and now she's able to say whole sentences from the book where in normal language she just was saying, she was only using the simple words maximum like two words together. And now she actually she said whole sentence, you know from the book.' (Site 3).

3.2.1.2.2. Visible benefits for teachers. Many of the teachers discussed the positive impact MAST delivery had on their professional development and their confidence and competence in teaching PE.

'*I do feel fairly confident now, but maybe I should have maybe have been a bit more ignorant before and been thought well, I know how to run so I can teach them how to and I know how to throw or something so I can teach you how to throw. But actually reminding people as a correct way and an incorrect way to do things and I think yeah, most people could probably do with just that refresher'* (Site 4).

3.2.1.3. Why MAST works

3.2.1.3.1. 'Pitched at my class. The design of the programme was considered one of the most powerful elements of MAST, with all the teachers finding MAST content *'aiming at the right children and the right age group'* (Site 2). They also had the flexibility to adapt the sessions for their mixed-ability groups, enabling them to create an inclusive lesson.

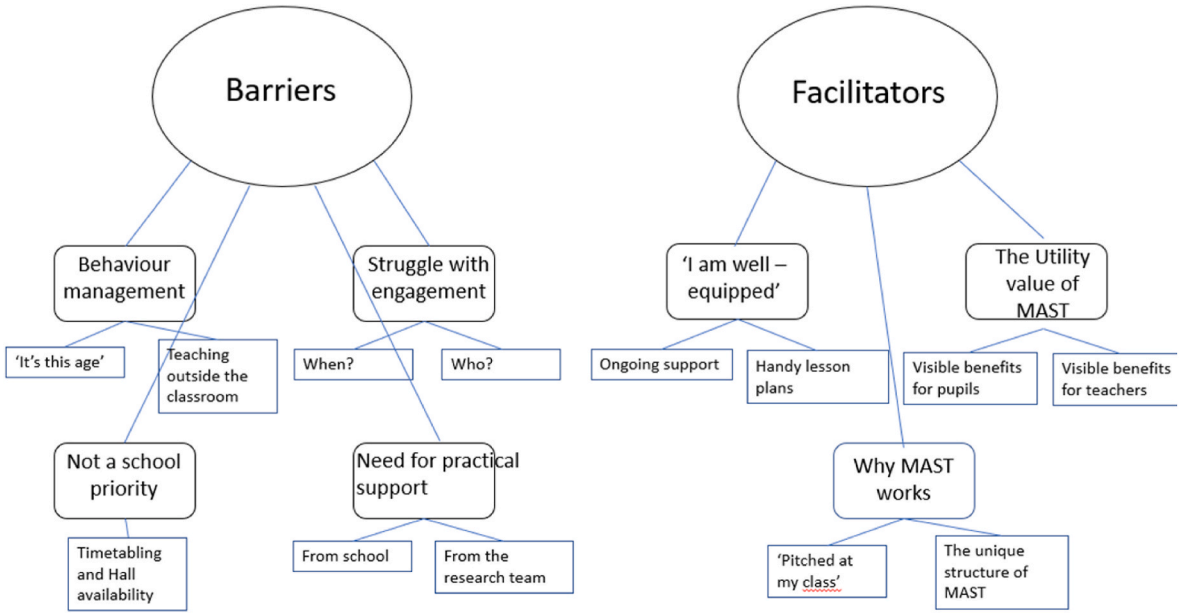

Fig. 1. Deductive thematic analysis of the teacher interviews.

'So like on last week we did throwing and catching, so some children that they couldn't do it, so I gave them a high ability child so they could actually follow their instruction as well. So it's when you put the high and low ability child there, the low ability child is learning as well' (Site 3).

3.2.1.3.2. The unique structure of MAST. The consistent structure of MAST lessons (story-movement-story) was found to be beneficial for the children's learning and engagement.

'If every sort of session was kind of approached in a completely different way and wasn't so clearly structured, then it wouldn't work as well. But I think because it does, I think it helps the children feel more relaxed because they know they've done something similar before and also helps them know what's gonna happen next week' (Site 4).

The combination of movement and storytelling was successful. Most teachers argued that children's familiarity with the books contributed to their engagement with vocabulary learning, while by acting out the book characters, participation and confidence in physical activity improved.

'I think because they like that it's a story they're familiar with. I think everyone, even if they've not, read the story, everyone's aware of the story and it feels quite safe as well you know, it's so it's kind of if everyone's acting out in reception, If everyone is acting a role and you know, all of your classmates are doing it and in reception, even if you're maybe kind of quite shy, reserved it's like, well, everybody's doing it' (Site 4).

3.2.2. Barriers

3.2.2.1. Behaviour management

3.2.2.1.1. Teaching outside the classroom. Teachers described difficulty maintaining control of their classes during the MAST sessions, highlighting behaviour management as the biggest challenge they experienced. According to the teachers, locating the lessons in the hall or playground was the reason behind the children's hyperactivity and difficulties following instructions.

'I think it having the whole class does create some challenges and particularly with reception and I think often when you go into the hall, they get very excited and it's more the challenges was like getting them to listen to what they're supposed to be doing rather than just like running around or anything' (Site 2).

3.2.2.1.2. 'It's this age.'. All the teachers attributed difficulties in listening and following instructions to the pupils' age and corresponding social skills. Pupils were described as non-school-ready by most teachers who referred to the impact of the pandemic as the reason behind this.

' … we have to lose adults because we've got to go out and somebody's had a nappy accident or there's injuries and things like that. So that's the only thing every lesson that seems to be something that does stops it running completely fluidly. There's lots of children needing the toilet, things like that I think that probably be the case in every early years.' (Site 1).

3.2.2.2. Struggle with engagement

3.2.2.2.1. Who?. Following a whole-class approach seemed to challenge staff, with some expressing their disappointment in failing to engage all pupils in the session and particularly the ones *'that needed it the most'* (Site 5). The difficulty with differentiation to accommodate the learning pace and needs of less able and less confident pupils constituted one of the barriers to teaching MAST fluidly.

'Just like time getting in the hall, getting them all to listen and getting the ones to speak who you know, need to be speaking cause some of the ones who are confident always putting their hand up. But the ones that need to practice that vocabulary and that language, they're the ones that need to be doing it and they don't join in' (Site 2).

3.2.2.2.2. When?. All five teachers highlighted the limited engagement of pupils after the movement part of a session as an issue. Tiredness and hyperactivity after high-intensity activity along with enjoyment of the physical activities were amongst the prominent explanations behind pupils' reduced concentration in the post physical activity part of the MAST session.

'I think possibly the after the lesson, when they're all quite hyped up, I think getting them to cool down and listen to another tiny input at the end. I think that I've been struggling with that and they're just feeling like I want to go home now yeah, I think that's a little bit challenging in that bit' (Site 1).

3.2.2.3. Not a school priority

3.2.2.3.1. Timetabling and hall availability. Most of the teachers struggled with the practical organisation of MAST sessions, with some

referring to time restrictions due to their heavy timetable and others stating hall availability as a challenge. There were a few times when teaching other subjects that were a higher priority (e.g., phonics) meant that MAST was not delivered that day or only part of the lesson was delivered; '*I've been trying to do it sort of first thing like 9:00 o'clock because then we have 'cause we have phonics at 9:30'* (Site 2).

> *'I think it's the timetabling of the whole slots is the trickiest thing because that involves a lot of staff and it's like, for example, one of our hall sessions, science coordinator said Ohh It's science week, so we're having a visitor, so the hall will be out of use for your PE session. Hadn't asked first, just said that is, so that's tricky then, because then you've got to find another slot because you've got you're doing the programme'* (Site 5).

3.2.2.4. Need for practical support

3.2.2.4.1. From school. The need for an 'extra pair of hands' emerged as the first common topic of discussion from most of the teachers, who expressed difficulty teaching alone. The teachers seemed to acknowledge that school staff shortages constituted an obstacle that affected MAST delivery.

> *'So teaching assistants quite often there would be a teaching assistant in a reception class as good practice, but now budgets can't afford to have a teaching assistant just helping out in class and it's tricky then running interventions because a lot of teaching assistants are just working one-to-one with high level needs children, and because that's all the budget will cover, and so running interventions like this year is very difficult'* (Site 5).

Sport equipment shortages constituted another area of need that affected implementation. Some of the teachers discussed the limited resources provided by the school, compromising their ability to follow the proposed activities for the whole class.

> '*I think the resources, it's something that I should get from my school. I would just say as well, if you want me to do this again from September, I need these resources'* (Site 3).

3.2.2.4.2. From the research team. Most of the teachers asked for a more applied guidance on the sessions. Prescribed information on how to enhance the language part of the intervention was the most prominent comment in the interviews, with most of them expressing the need for a list of specific questions they could use with pupils during storytelling.

> '*I mentioned it in the WhatsApp the questions after the PE session, what we should be asking and whether I was asking the right sort of things' (Teacher Site 5).*

Some teachers suggested that a mock lesson could be delivered in their schools by the research team, highlighting again teachers' need for 'hands-on' information.

It seems that teachers struggled with taking initiative and acting freely within the overall structure of MAST, despite being told on the training day that they were free to 'make it their own'. The call for prescribed guidance shows that either that message was not transferred clearly enough or that the teachers found it difficult to adjust to such a process. A feeling of insecurity about deviating from the Teacher's Guide and a 'fear of doing it wrong' frequently emerged as an obstacle.

> *'I was very worried about going off script because I didn't want it to affect the outcome of the project, but I needed to make it my own a little bit'* (Site 5).

A lack of confidence and self-efficacy on the part of the teachers may be at the root of this desire for more support. Most of the teachers on the project had not received any formal PE training until MAST, and other programmes they deliver such as systematic synthetic phonics tend to be highly prescriptive.

4. Discussion

We found that a 12-week version of MAST, delivered by reception teachers, was effective at significantly improving 4-to-5-year-old children's language scores (d = .02) and fundamental movement skills (d = .65). There was no effect of the intervention on self-regulation. Implementation fidelity was good, with four out of five settings consistently delivering all key components of MAST. Factors contributing to its successful deployment included visible benefits of the programme for staff and pupils, the fact that the programme was seen to be pitched at the right developmental level for the children with a predictable structure and good support from the training and resources provided. Barriers to effective implementation related to a lack of practical support from the schools, limited availability of PE equipment, behaviour management challenges and the need for ongoing support especially in relation to language work. As such this paper represents the first study to demonstrate that early year's teachers can be trained successfully to deliver a novel integrated programme of language and motor skills instruction, such that there was significant impact on the children's development in both domains.

Interview data provided some insights into the more modest impact of the programme on language scores (d = 0.2) compared to that observed previously for 3-to-4-year-old children (d = 0.54 for vocabulary) reported in Duncan et al. (2019). The teachers' relative lack of confidence in implementing the language work without the provision of specific questions, combined with difficulties in class management during the post-exercise period may have resulted in more modest growth in relation to oral language development compared to when the intervention was delivered by the research team. The current study also included a broader measure of language than then pilot which only measured expressive vocabulary. In addition, one of the largest control schools reported that it was placing significant emphasis on language work in the early years that year, including a lot of focussed work, and this therefore set a robust 'business as usual' comparison against which to test the impact of MAST.

In contrast, improvements in FMS were better in this trial (d = 0.65) compared to those reported by Duncan et al. (2019; d = .45) with teachers reporting increased confidence in and knowledge of how to teach FMS, and directly observing improvements in their children's motor competence. Another reason for the larger effect is that the Duncan et al. (2019) study was just six weeks long, and focussed on locomotor skills, so the inclusion of six weeks on object skills is likely to have boosted the effect on FMS. It is noteworthy that MAST, when delivered by teachers was at least equally effective for improving motor skills as when delivered by researchers. This is important as most motor interventions in the literature were researcher-led (Duncan, Foweather, et al., 2022; Martins et al., 2024). Our evidence suggests that these interventions could be implemented on a wider scale through practitioner-delivery.

The significant effects on language and FMS demonstrate that it is effective to combine movement and language work in one intervention. This provides support for the theories outlined in the introduction such as increased blood flow to the brain during the post-activity window (Donnelly et al., 2016; Voss et al., 2014), and the theory of embodied cognition, which suggests that sensorimotor experiences enhance cognition (Engel et al., 2013). However, additional measures would be necessary to provide direct support for these theories as it is possible that another variable e.g. engagement, is reponsible for the positive effects. The idea that movement and language share common underlying processes of self-regulation (Diamond & Lee, 2011) was not supported as there was no correlation between self-regulation and motor skills, and the intervention did not improve self-regulation. However, this is only the case for self-regulatory skills tapped by the HTKS test (physical and mental switching and inhibition). Other aspects of executive function such as cognitive flexibility and working memory were not tested and may have been implicated by MAST. However, it is important to note

that at the young age of the participants, executive function is more of a unitary construct (Laureys et al., 2022), and therefore different aspects would be difficult to measure. It was interesting that there was a significant correlation between language and self-regulation in our study, showing that HTKS was tapping an aspect of executive function important for language (Clemens et al., 2023; Gooch et al., 2016; Williams & Bentley, 2021).

4.1. Limitations

The findings are promising but this study does have some limitations. First, sample sizes were mismatched across groups with more children in the intervention than the control group. However, the statistical tests that we used were robust to this, and the groups well-matched for background characteristics which gives us confidence that this did not affect the findings. Additionally, the two groups were not well-matched for EAL (42% control, 24% intervention), but the fact that the standardised language scores for both groups were similar at pre-test means that the EAL children did not have significantly poorer language skills to start with meaning that this was unlikely to have affected the results. Also, we had 30–40% missing data for FMS. This was due to logistical difficulties with testing whole classes of children simultaneously, which necessitated four members of research staff. However, the large effect sizes observed for FMS that we found clearly indicate that MAST can have a positive effect of motor skills. Lastly, even though we found an intervention effect, in line with prior research, the effect sizes that we found should be interpreted with caution. Due to being a feasibility study, the current study was underpowered (power = 56%; Raudenbush et al., 2011), and randomisation was imperfect (FMS data not missing at random and the ninth school non-randomly allocated). Therefore, a fully powered randomized controlled trial would be needed to confirm the evidence of promise found.

4.2. Implications

Youth Sport's Trust (2024) published a survey of PE teachers which, similar to our qualitative findings, found that the reduction in PE in schools was likely due to a combination of factors which included issues like timetabling, prioritisation, competition with core subjects and the pressure to 'catch-up' on Covid-related learning losses. We suggest that cross-subject initiatives like MAST show promise to increase time spent on physical activity and language in schools whilst simultaneously addressing school management prioritisation and lack of teacher confidence in teaching PE. In short, MAST would enable many of the barriers to PE identified by the Youth Sport's Trust (2024) and our own data to be overcome, at least in the Early Years.

In England, The National Curriculum for PE mandates that teachers include lessons that develop FMS, and that by age 7 children should have 'mastered' their FMS (DFE, 2022). However, data consistently suggest that children in the UK are not mastering the FMS by this point (Duncan, Foweather, et al., 2022). The motor activities that MAST develops are explicitly linked to the FMS that teachers are expected to work on in England. Consequently, MAST addresses a key need and is aligned with the requirement of the curriculum, but in a way that is holistic and develops language skills too.

Although developed in the UK to address current educational needs, MAST has wider application in other country contexts with similar challenges and curricular frameworks for child development. For example, the Early Years Learning Framework (EYLF) for Australia (ACECQA, 2022) makes multiple references to both language and movement skills as key skills underpinning five learning outcomes, seeing both as part of a broadly defined notion of 'literacy', which "incorporates a range of modes of communication, including music, movement, dance, storytelling, visual arts, media and drama, as well as talking, listening, viewing, reading and writing." (p57). FMS are explicitly referenced, as is the need for 'holistic, integrated and interconnected approaches' (p.20) to how the learning outcomes are met. Within this framework, both skills are fundamentally linked to children's developing sense of identity and culture. By operationalising MAST in the context of children's stories that reference aspects of children's cultural identities, it has the potential to not just teach language and movement holistically as basic skills that are foundational to later progress in formal curricula, but that also enable exploration of the children's own cultural identities and those of others.

In conclusion, the current study demonstrates significant effects of MAST, when delivered by teachers, on the movement and language skills of children in their first year of school. Evidence of promise is further demonstrated by a high degree of fidelity of implementation (4 out of 5 settings delivered all key components) and factors for success highlighted by teachers such as the utility value of MAST. However, more work needs to be done to address barriers to implementation such as a low value placed on early movement and language skills by school leaders.

CRediT authorship contribution statement

Anna J. Cunningham: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Violeta Baikousi:** Writing – review & editing, Writing – original draft, Validation, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Emma Eyre:** Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization. **Michael Duncan:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Matteo Crotti:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Data curation. **Ricardo Martins:** Writing – review & editing, Validation, Resources, Methodology, Data curation. **Clare Wood:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization.

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Declarations of competing interest

None.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.learninstruc.2025.102110.

Appendix

Correlation table of child outcome measures.

Variable	1	2	3	4	5	6	7	8	9	10	11
1. HTKS	69**	.52**	.48**	.44**	.56**	.09	.05	.09	.28**	−.15	−.11
2. Listening comprehension	.49**	.59**	.54**	.59**	.82**	.03	.05	.07	−.04	−.11	−.12
3. Sentence repetition	.51**	.56**	.63**	.54**	.75**	.03	−.07	.02	.00	−.14*	−.08
4. Expressive vocabulary	.42**	.57**	.58**	.77**	.85**	.05	.01	.03	−.03	.01	−.12
5. Language	.56**	.79**	.77**	.89**	.81**	.06	.01	.05	−.03	−.10	−.17*
6. Locomotor skills	.10	.19**	.10	.22**	.22**	.35**	.28**	.80**	.10	−.03	−.07
7. Object skills	.13	.09	.01	.12	.09	.44**	.31**	.80**	.16	.14	.06
8. FMS	.13	.16*	.05	.18*	.17*	.84**	.85**	.37**	.18*	.03	.04
9. Age	.08	.00	−.01	−.02	−.01	.09	.21**	.17*	–	.05	.07
10. Gender	−.12	−.10	−.17*	−.10	−.14*	−.03	.23**	.14	.05	–	.11
11. Pupil Premium	−.16*	−.19**	−.23**	−.15*	−.20**	−.02	−.05	−.05	.07	.11	–

Note. Pre-test correlations are shown above the diagonal and post-test correlations are shown below the diagonal. Between time-point correlations are shown on the diagonal. *p ≤ .05, **p < .001. Language represents standard scores. FMS = Fundamental movement skills. HTKS = Heads-Toes-Knees-Shoulders. Age is at pre-test in months.

Data availability

Data is deposited in the NTU Archive https://doi.org/10.17631/rd-2024-0008-ddat

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