Received: 14 January 2020 | Revised: 28 May 2020 | Accepted: 5 June 2020
DOI: 10.1111/cch.12793

RESEARCH ARTICLE

WILEY

The Motor skills At Playtime intervention improves children's locomotor skills: A feasibility study

Kara K. Palmer[1] | Alison L. Miller[2,3] | Sean K. Meehan[4] | Leah E. Robinson[1,3]

[1]School of Kinesiology, University of Michigan, Ann Arbor, MI, USA
[2]School of Public Health, University of Michigan, Ann Arbor, MI, USA
[3]Center for Human Growth and Development, University of Michigan, Ann Arbor, MI, USA
[4]Department of Kinesiology, University of Waterloo, Waterloo, Ontario, Canada

Correspondence
Kara K. Palmer, School of Kinesiology, University of Michigan, 401 Washtenaw Ave, Ann Arbor, MI 48109, USA.
Email: palmerka@umich.edu

Funding information
University of Michigan Rackham Graduate School, Grant/Award Number: Post-Candidacy Research Award; North American Society for the Psychology of Sport and Physical Activity, Grant/Award Number: Graduate Student Research Grant; National Heart Lung and Blood Institute of the National Institutes of Health (NIH), Grant/Award Number: R01HL132979

Abstract

Background: Interventions are needed to teach fundamental motor skills (FMS) to preschoolers. There is a need to design more practical and effective interventions that can be successfully implemented by non-motor experts and fit within the existing gross motor opportunities such as outdoor free play at the preschool. The purpose of this study was to evaluate the feasibility and efficacy of a non-motor expert FMS intervention that was implemented during outdoor free play, Motor skills At Playtime (MAP).

Methods: Participants were preschoolers from two Head Start centres (N = 46; M_{age} = 4.7 ± 0.46 years; 41% boys) and were divided into a MAP (n = 30) or control (outdoor free play; n = 16) group. Children completed either a 1,350-min MAP intervention or control condition (outdoor free play) from January to April of 2018. FMS were assessed before and after each programme using both the Test of Gross Motor Development–3rd Edition and skill outcome measures (running speed, hopping speed, jump distance, throwing speed, kicking speed and catching percentage). Intervention implementation feasibility was measured through daily fidelity checks. Fidelity was evaluated as the percentage of intervention sessions that included all explicit intervention criteria. FMS data were analysed using linear mixed modelling. Models were fit with fixed effects of time and treatment, covariates of sex and height, and a random intercept for each individual.

Results: The non-motor expert was feasibly able to implement MAP with high fidelity (>93%). There was a significant treatment effect for MAP on process and product locomotor FMS (P < 0.05) and a trend for a treatment effect for MAP on total process FMS (P = 0.07).

Conclusion: Results support that MAP was successfully implemented by a non-motor expert and led to improvements in children's FMS, especially locomotor FMS.

KEYWORDS
children, fidelity, intervention, motor skills, nonexpert

1 | INTRODUCTION

Fundamental motor skills (FMS) are an important aspect of promoting positive developmental trajectories of health (Robinson, Stodden, et al., 2015; Stodden et al., 2008) and are the building blocks for more advanced movement (Clark & Metcalfe, 2002). FMS in childhood are positively related to physical activity (Cohen, Morgan, Plotnikoff, Barnett, & Lubans, 2015; Figueroa & An, 2017; Foweather et al., 2015) and physical fitness (Utesch, Bardid, Büsch, & Strauss, 2019), as well as inversely related to weight status (D'hondt et al., 2011; D'Hondt et al., 2013). FMS include locomotor (propel the body, e.g., running) and ball skills (propel or manipulate objects in space, e.g., throwing; Ulrich, 2019). FMS need to be learned before a child can progress into more sport-specific skills associated with life-long physical activity (Clark & Metcalfe, 2002; Seefeldt, 1980; Stodden et al., 2008).

The preschool years (ages 3–5 years) are a critical period for FMS learning and development (Clark & Metcalfe, 2002). Organizations, including the National Association for the Education of Young Children (Copple & Bredekamp, 2009) and National Association for Sport and Physical Education (NASPE, 2009), recognize the importance of learning FMS during the preschool years. Preschools must provide children with opportunities to engage in a variety of gross (e.g., FMS) and fine motor activities to meet accreditation standards (Copple & Bredekamp, 2009). Most preschools meet these accreditation requirements with an unstructured outdoor free play session. However, children who do not receive motor programming or instruction (i.e., only participate in outdoor free play) do not show improvements in motor skills and perform worse as compared with children who receive programming and instruction (Logan, Robinson, Wilson, & Lucas, 2011; Wick et al., 2017). Therefore, it is recommended that FMS must be 'taught, practiced, and reinforced' (Robinson, 2011, p. 533).

FMS interventions are an effective means for teaching FMS in preschool (Logan et al., 2011; Wick et al., 2017). FMS intervention strategies vary widely in terms of pedagogical and theoretical approaches to instruction, implementation personnel and intervention environments. One effective pedagogical and theoretical approach to FMS interventions is high-autonomy or mastery interventions where children have the freedom to self-navigate through simultaneous FMS stations (Bandeira, Souza, Zanella, & Valentini, 2017; Palmer, Chinn, & Robinson, 2017). Meta-analytic data support that the most effective interventions are implemented by motor experts (i.e., someone with graduate-level training/education in motor development; Wick et al., 2017) and delivered in an environment completely dedicated to motor skill programming (Jiménez-Díaz, Chaves-Castro, & Salazar, 2019). Unfortunately, FMS interventions that are implemented by motor experts in a specialized FMS environment are impractical because of limited availability and the high cost of these personnel and specificity and training required to create an environment dedicated solely to FMS instruction.

Hence, there is a need to design practical FMS programmes that are effective and more sustainable within the preschool setting. These FMS programmes should be feasibly implemented by non-motor experts and fit within the existing gross motor programming/schedules. Non-motor experts such as preschool teachers (Brian, Goodway, Logan, & Sutherland, 2017) and or undergraduate students (Brian & Taunton, 2018; Robinson, Webster, Logan, Lucas, & Barber, 2012) can implement effective FMS interventions with ongoing training and coaching from motor experts in specific FMS environments that replace the existing gross motor programming at the school. Interventions implemented in the free-play environment have been shown to have small but positive effects on children's FMS (Jiménez-Díaz et al., 2019), supporting more work be done to create more effective interventions to fit within the schools existing free play environment. The purpose of this study was to evaluate the feasibility and efficacy of an FMS intervention, Motor skills At Playtime (MAP), designed to be implemented by non-motor experts during outdoor free play. We hypothesized that MAP could be implemented with high fidelity (>90%) by a non-motor expert and preschoolers in MAP would improve their FMS as compared with a control (outdoor free play only) group.

Key messages

- MAP can be feasibly implemented by non-motor experts within free play (i.e., exisiting gross motor programming).
- MAP improves fundamental motor skills, especially locomotor skills in preschoolers.
- Because MAP is implemented by a non-motor expert and fits within existing gross motor programming in preschools, MAP may be a sustainable approach that could be implemented at a broader scale to teach motor skills in preschool settings.

2 | METHODS

2.1 | Participants

Institutional review board approved all study procedures. Preschoolers (N = 46 children; M_{age} = 4.7 ± 0.46 years; 41% boys) were recruited from two Head Start centres in an urban Midwestern city in the United States. Head Start is a national programme designed to promote school readiness in young children from families living in poverty. To be eligible to enroll in Head Start, children (0–5 years) must be from families who annual income is at or below the national poverty line (e.g., annual income ≤$26,200 for a family of four). Both centres in the current study did not have Early Head Start services and enrolled children from 3 to 5 years of age. All preschoolers who were 3.5 years or older at the time of enrolment and did not have a documented physical or cognitive disability were invited to participate in the study. A member of the research team worked with classroom teachers to distribute informed consent packs through backpacks, and parents who were interested in enrolling their children in the study completed and returned the forms to school. Approximately 50% of families who were invited consented to participate in the study. Parental consent and child verbal assent were obtained prior to participation. Preschoolers were assigned to one of two treatment groups: the MAP (n = 30; M_{age} = 4.7 ± 0.52 years; 51% boys; 67% African-American, 7% White, 3% Latino and 23% nondisclosed/nonreported) or control group (n = 16; M_{age} = 4.5 ± 0.25 years; 32% boys; 57% African-American, 7% White, 7% Latino and 26%

nondisclosed/nonreported). Preschoolers were assigned to groups at the level of the classroom, and more preschoolers received the intervention by request of the Head Start centres.

2.2 | Process FMS

The Test of Gross Motor Development–3rd Edition (TGMD-3; Ulrich, 2019) is a valid, reliable and normed process measures used to assesses FMS: locomotor (run, skip, gallop, slide, hop and horizontal jump) and ball FMS (catch, underhand throw, one-handed forearm strike, kick, overhand throw, dribble and strike off a tee). Children perform one practice and two test trials of each skill. A skill demonstration was administered on an electronic tablet (Robinson, Palmer, et al., 2015) before the test trial, and, if needed, a second live demonstration was provided before the first test trial.

All TGMD trials were recorded by video cameras on tripods, and scoring of the TGMD was done by coding recorded videos. Scoring the TGMD from video recordings is advantageous and used in this study because coders can replay trials to ensure correct scoring, and interrater reliability can be more easily established with a second coder. Each skill on the assessment is divided into three to five specific skill criteria. A child was awarded a score of 1 if he/she performed a criterion correctly or received a 0 if he/she was unable to perform the criterion during test trials, and the number of correct skill criteria was summed. Summed raw scores result in three final composite scores that were used in analyses: total (0–100), locomotor (0–46) and ball FMS (0–54). The primary coder for this research had a previously established interrater reliability of >95% with three external motor experts and established reliability with the TGMD-3 online training (https://sites.google.com/a/umich.edu/tgmd-3/reliability-videos). A second, blinded expert coder cross-coded 25% of the sample. The two coders demonstrated high interrater reliability (intraclass correlation = 0.88 locomotor, 0.93 ball FMS and 0.96 total).

2.3 | Product FMS

A total of six product FMS measures were assessed: catching percentage (caught balls out of five attempts), throwing speed, kicking speed, jumping distance, running speed and hopping speed (four trials, two each leg; True, Brian, Goodway, & Stodden, 2017). All measures are developmentally valid and sensitive discriminators of FMS (Stodden, Gao, Goodway, & Langendorfer, 2014; Stodden, True, Langendorfer, & Gao, 2013) and have been used in previous research to examine FMS of preschoolers (Palmer, Stodden, Ulrich, & Robinson, in review; Robinson, Wang, Colabianchi, Stodden, & Ulrich, 2020). Throwing and kicking speed (miles per hour) were recorded live using a Stalker radar gun (Stalker Radar, Plano, TX). Jumping distance to the nearest tenth of a centimetre was recorded live using a metric measuring tape. Running and hopping speed (metres per second) were calculated using video analysis software (Dartfish Team Pro6). Running speed was calculated as the average speed of two strides across two run trials. Hopping speed was calculated as the average speed to complete four consecutive hops (heel to heel) for two hop trials on each foot.

Aggregate product scores were created by standardizing product measures and then summing the newly created *z* scores (True et al., 2017) and were used in analyses. Aggregate scores were created for total (all six measures), locomotor (jump distance, run speed and hop speed) and ball FMS (catching percentage, throwing speed and kicking speed).

2.4 | Motor skills At Playtime—MAP

MAP is a high-autonomy intervention implemented during the existing standard practice of gross motor play at preschool centres. MAP adds both FMS stations/equipment (e.g., bats, balls, locomotor paths and throwing targets) to the free play setting and provides children with a brief skill demonstration before the start of each session. MAP utilized select components of achievement goal theory (Ames, 1992, 1995; Epstein, 1988) and implemented four of Epstein's TARGET structures (task, authority, grouping and time; Epstein, 1988) to create a pseudo-mastery intervention. MAP stations are designed to include activities that range from easy to difficult so that children of all skill levels can actively participate in the stations. Children have autonomy to engage in the skill stations, or they can choose to use the equipment in a different version of play in the outdoor setting. Children also have autonomy to self-select peer groups and the amount of time they engage in different activities on the playground (e.g., FMS stations or large play structures).

Each MAP session included adding three to four motor skill stations to the playground. Locomotor and ball skill stations were included in each session. Stations were designed so that each skill could be performed on an array of difficulty ranging from easy (e.g., large throwing target) to difficult (e.g., small throwing targets). The current MAP intervention was implemented 3 days a week for 15 weeks (30 min/day $\times$ 45 sessions = 1,350 min). Classroom teachers in the MAP group gathered the children at the beginning of the session so that children could see the demonstration of the daily FMS skills and hear a description of the stations but made no other adjustments to their daily routines. In alignment with the pseudo-mastery climate, once on the playground, children could select if they wanted to engage in the motor skill stations, continue with their outdoor free play as normal or use the motor skill equipment for non-station specific play (e.g., use a ball set up for a kicking station for throwing instead). In total, 15 skills were taught in MAP (run, gallop, slide, leap, jump, skip, hop, two-hand strike, one-hand strike, throw, underhand toss, catch, kick, roll and dribble), and each skill had equal dose in minutes across the intervention.

A non-motor expert was the primary MAP instructor and had a college degree in English but did not have a background in physical education or any expertise in paediatric motor development. This instructor participated in a 2-day, 6-h training session on FMS instruction and MAP before the start of the intervention led by a motor skills expert with a graduate degree in paediatric motor development.

These training sessions covered (1) what are motor skills, (2) why are motor skill important, (3) motor skill instruction and modelling, (4) creating motor skill interventions using achievement goal theory and (5) the MAP programme—purpose, design and implementation. The motor expert attended one session a week and observed the non-motor expert's instruction. After the observed session, the non-motor expert and motor expert would meet briefly (15 min) to discuss the session and address any concerns regarding skill demonstration, MAP implementation, or logistical concerns that may have arisen that week.

2.5 | MAP feasibility

Intervention feasibility was determined through intervention fidelity. Daily fidelity checks were created by the motor expert and completed after each MAP session. The design of these checks was based on fidelity checks used in previous research on mastery-climate motor skill interventions (Robinson, 2011; Robinson & Goodway, 2009). See Supporting Information S1 for example form. Information included on the check included (1) implementation according to curriculum and skill schedule, (2) inclusion of four TARGET structures (e.g., task, authority, grouping and time), (3) photos of all FMS stations, (4) children's use of stations for FMS practice, (5) children's use of equipment for non-motor practice and (6) unsolicited FMS instruction from classroom teachers. The non-motor expert completed a fidelity check after each session. To ensure fidelity was being reported objectively and to establish reliability, the motor expert attended one intervention session each week and completed a second, identical fidelity form. Non-motor and motor experts had high reliability (>90%) on days where both measured fidelity.

2.6 | Control

The control group made no changes to their daily routine and continued to engage in the standard practice of a daily 30-min unstructured free play on the centre-provided outdoor play space. This space included a variety of equipment including swings, play structures, slides, open grassy area (shaded and sunny), open pavement area (shaded and sunny) and daily manipulatives (e.g., balls, chalk and scarves) added at the discretion of the classroom teachers.

2.7 | Analysis

Fidelity was quantified as a percentage of sessions where predetermined intervention criteria occurred. Because of different sample sizes between the MAP and control group and the need to control for variables known to effect FMS (e.g., sex and height), within-subject and between-group differences in FMS were examined using linear mixed modelling. Models were used to examine the effects of MAP on locomotor, ball skills and total FMS for both process and product FMS measures. Models were fit with a random individual intercept and fixed effects of time and treatment * time to measure time and treatment effects separately. Final model equations were fit as

$$FMS_{i,j} = \beta_0 + \beta_1 time_{i,j} + \beta_2 time * MAP_{i,j} + \beta_3 sex_{i,j} + \beta_4 height_{i,j} + \alpha_i + \varepsilon_{i,j}.$$

Linear mixed models were completed in SPSS v 25, and alpha levels were set to 0.05 a priori.

3 | RESULTS

3.1 | MAP fidelity

MAP was implemented according to the lesson plan the majority of the time (93.2% of sessions), and skill demonstrations always included all skill elements (100% of sessions). Children used the stations for skill practice on 74.6% of sessions and used the equipment for items other than skill practice 89.8% of sessions. Classroom teachers provided unsolicited skill instruction during 33.9% of sessions.

3.2 | FMS

See Table 1 for descriptive statistics. On average, there was a significant effect of time (β_1) where all preschoolers had better product total and locomotor skills at posttest compared with pretest ($P = 0.01$; see Table 2). MAP preschoolers had lower process ball skills at the start of the intervention ($P = 0.03$) compared with the control group (see Table 2). Height was a positive predictor of total product FMS ($P = 0.04$), and boys outperformed girls on process ball skills ($P = 0.02$; see Table 2). There was a significant treatment effect (β_2) where children in MAP had greater gains above the control group in both process and product locomotor skills ($P < 0.01$), and there was a trending treatment effect where children in MAP had greater gain above the control group in process total FMS ($P = 0.07$; see Table 2).

4 | DISCUSSION

The results support that MAP is an effective intervention for improving preschoolers' FMS, especially locomotor skills. MAP was implemented by a non-motor expert within the existing gross motor programming, providing preliminary evidence that MAP is both a feasible and sustainable approach to enhancing FMS in preschoolers. To the best of our knowledge, this study is the first time that a high-autonomy, pseudo-mastery intervention was implemented by a non-motor expert with high fidelity. The non-motor expert only received minimal training (12 h) and weekly support (15 min) from a motor expert. Children engaged in the intervention and used the equipment for FMS practice. Interestingly, classroom teachers provided children with unsolicited motor skill instruction during a third of the MAP sessions. This instruction was not expected and was not a part of the

TABLE 1 Mean and standard deviations for height and FMS for MAP and control groups at pretest and posttest

			FMS					
			Process			Product		
		Height (cm)	Total	LM	BS	Total	LM	BS
MAP	Pre	107.02 (4.91)	26.97 (9.73)	14 (7.72)	12.97 (4.21)	0.57 (3.60)	0.41 (2.38)	0.15 (1.95)
	Post	110.22 (4.82)	37.68 (10.83)	19.46 (5.90)	18.21 (7.47)	0.89 (3.68)	0.83 (1.94)	0.06 (2.22)
Control	Pre	105.65 (4.97)	29.83 (11.16)	13.89 (5.65)	15.94 (7.20)	−0.28 (3.81)	−0.26 (1.88)	−0.25 (2.54)
	Post	107.61 (5.66)	31.18 (8.55)	14.53 (4.17)	16.65 (6.32)	−1.74 (4.57)	−1.42 (2.08)	−0.11 (2.88)

Abbreviations: BS, ball skills; FMS, fundamental motor skills; LM, locomotor; MAP, Motor skills At Playtime.

MAP instructional plan but nonetheless may support that teachers value FMS programming and want to encourage children to participate in these opportunities. Cumulatively, these findings support MAP as a potentially distributable intervention where non-motor experts can implement the programme with high fidelity and minimal support.

In regard to FMS, children in MAP had greater gains in both process and product locomotor skills and a trend in total process FMS. These findings align with previous literature and support that FMS interventions improve FMS more than control/outdoor free play (Logan et al., 2011; Wick et al., 2017). These findings also support that high-autonomy interventions, in this case a pseudo-mastery intervention, are an effective approach for teaching FMS to young children, especially locomotor skills. The findings that non-motor experts improved locomotor but not ball skills does not fully align with other research on non-motor-expert-led intervention. For example, research by Brian and colleagues report that non-motor experts (e.g., preschool teachers or preservice teachers) were able to more effectively teach ball skills compared with locomotor skills (Brian et al., 2017; Brian & Taunton, 2018). It is possible that the reason the MAP programme was more effective for locomotor versus ball skills could be due to the environment where the intervention took place. Previous work with nonexpert-led motor skill interventions were conducted using an intervention curriculum that replaced, and was not a part of, outdoor free playtime (Brian et al., 2017; Brian & Taunton, 2018). Meta-analytic data support that free play movement programmes improve locomotor but not ball skills (Jiménez-Díaz et al., 2019). Therefore, the combination of outdoor free play with skill demonstration and equipment may have encouraged more engagement in continuous, locomotor tasks such as running, skipping or galloping across the outdoor space.

Unexpectedly, the current study found that the MAP programme did not yield greater process ball skills compared with the control condition. This finding is important as ball skills in childhood predict physical activity in adolescents (Barnett, Van Beurden, Morgan, Brooks, & Beard, 2009). This finding contradicts previous research that supports that novice teachers can effectively implement interventions that yield gains in ball skills (Brian et al., 2017; Brian & Taunton, 2018), as well as research that supports that high-autonomy climates can lead to changes in ball skills (Palmer et al., 2017; Robinson & Goodway, 2009). Though no treatment effect of MAP on ball skills was shown, children in MAP gained almost 5 points in the TGMD, whereas children in the control group only saw a 1-point gain in ball skills. At the preschool age, a 5-point difference could result in up to a substantial (e.g., 25%) difference in percentile ranks, whereas a 1-point difference would only result in a smaller change (e.g., 1%–9%) in percentile score (Ulrich, 2019). Despite these differences in raw ball skill gains, the linear models did not reveal a treatment effect for process ball skills. This nonfinding could be due to large variability in changes in ball skills across the study, which may have inhibited our ability to determine the overall treatment effect. Alternatively, the MAP environment may not be ideal for teaching ball skills to young children. Anecdotally, both the non-motor expert and motor expert observed that children did not spend much time engaging in the ball skill stations in meaningful practice but rather would use the balls for alternate forms for play on the playground. Learning ball skills may require more feedback and instruction during skill practice; therefore, more structured environments with more continuous or frequent feedback or instruction may create more opportunities for children to engage in purposeful practice needed to learn these discrete skills.

Lastly, this study is one of the first to use both process and product measures to assess FMS in young children. To date, most FMS intervention efficacy is determined using process measures of FMS (i.e., TGMD; Ulrich, 2017; Logan et al., 2011). Our findings revealed differences in the effects of MAP on process compared with product measures. This finding aligns with previous research comparing process and product measures, which report that these measures are not interchangeable and yield unique information about children's FMS (Logan, Barnett, Goodway, & Stodden, 2017; Ré et al., 2018).

The results of this feasibility study provide initial support that MAP is a feasible and effective nonexpert-implemented intervention to improve FMS in young children. This research is important and timely as there is a need for effective and practical FMS intervention that can be implemented by non-motor experts. This study included multiple objective FMS assessments resulting in a more robust understanding of the effects of MAP on FMS. Lastly, all data collection and intervention took place at the preschool enhancing the ecological validity of the results.

Despite the strengths of the study, there were also limitations. This was a small feasibility study that used a relatively small cohort of participants. The limited sample size meant there was not significant

TABLE 2 Parameter estimates, standard error and confidence intervals for FMS models

		Total				LM				BS			
		ß	SE	*P*	95% CI	ß	SE	*P*	95% CI	ß	SE	*P*	95% CI
Process	$ß_0$	−12.30	28.03	0.66	(−68.34, 43.75)	−6.03	15.72	0.70	(−37.57, 25.51)	4.63	16.03	0.77	(−27.45, 36.72)
	Sex	0.50	2.79	0.86	(−5.12, 6.12)	−2.77	1.52	0.08**	(−5.83, 0.29)	3.77	1.56	0.02*	(0.63, 6.91)
	Height	0.40	0.26	0.13	(−0.12, 0.92)	0.20	0.15	0.18	(−0.09, 0.49)	0.10	0.15	0.52	(−0.2, 0.39)
	Time ($ß_1$)	0.15	2.12	0.94	(−4.11, 4.42)	−0.11	1.55	0.94	(−3.22, 3.00)	0.01	1.35	1.00	(−2.7, 2.72)
	Pretest differences	−3.62	3.12	0.25	(−9.9, 2.65)	0.13	2.03	0.95	(−3.95, 4.22)	−3.65	1.59	0.03*	(−6.86, −0.44)
	Treatment effect ($ß_2$)	5.96	3.19	0.07**	(−0.45, 12.38)	4.88	1.70	0.01*	(1.46, 8.3)	1.25	2.17	0.57	(−3.12, 5.61)
Product	$ß_0$	−22.13	9.48	0.02	(−41.02, −3.25)	−12.18	5.70	0.04*	(−23.59, −0.77)	−8.62	6.07	0.16	(−20.75, 3.52)
	Sex	1.14	1.01	0.27	(−0.9, 3.17)	0.13	0.56	0.82	(−1.01, 1.26)	0.95	0.61	0.13	(−0.28, 2.18)
	Height	0.19	0.09	0.04*	(0.01, 0.36)	0.10	0.05	0.06**	(−0.01, 0.21)	0.08	0.06	0.18	(−0.04, 0.19)
	Time ($ß_1$)	1.75	0.59	0.01*	(0.56, 2.95)	1.29	0.46	0.01*	(0.36, 2.21)	−0.06	0.44	0.89	(−0.94, 0.82)
	Pretest differences	0.42	1.04	0.69	(−1.67, 2.52)	0.52	0.65	0.43	(−0.79, 1.83)	0.14	0.65	0.82	(−1.16, 1.45)
	Treatment effect ($ß_2$)	1.73	1.17	0.14	(−0.62, 4.08)	1.80	0.63	0.01*	(0.52, 3.07)	−0.27	0.72	0.71	(−1.72, 1.18)

Abbreviations: BS, ball skills; CI, confidence interval; FMS, fundamental motor skills; LM, locomotor; SE, standard error.

*$P < 0.05$.

**$P < 0.10$.

statistical power to detect smaller effects associated with the MAP intervention and may have limited the ability to detect significant differential changes in ball skills in the MAP group post intervention. This study also took place in a Head Start centre, and findings may not generalize to non-Head Start preschool centres or preschoolers not living in poverty. Further, children were assigned to a group at the level of the classroom, not at the level of the individual, which may have led to unaccounted-for heterogeneity in the data (i.e., nesting). Future work should repeat this pilot study using a rigorous, fully powered controlled trial design that could account for classroom effects and include a long-term follow-up to examine the effects of MAP on motor skill learning. Future work should also examine having preschool teachers implement MAP to make the programme more sustainable.

ACKNOWLEDGEMENTS

The authors would like to thank Laurie Catanzaro, Katherine M. Chinn and Katherine Q. Scott-Andrews for their assistance with the data collection.

FUNDING INFORMATION

This research was supported by the National Heart Lung and Blood Institute of the National Institutes of Health (NIH) under Award Number R01HL132979; the North American Society for the Psychology of Sport and Physical Activity (NASPSPA) Graduate Student Research Grant; and the University of Michigan Rackham Graduate School Post-Candidacy Research Award. The content do not necessarily represent the official views of the NIH, NASPSPA and University of Michigan.

ORCID

Kara K. Palmer https://orcid.org/0000-0003-0587-6776

REFERENCES

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology*, *84*(3), 261–271. https://doi.org/10.1037/0022-0663.84.3.261

Ames, C. (1995). Achievement goals, motivational climate, and motivational processes. In G. C. Roberts (Ed.), *Motivation in sport and exercise* (pp. 161–176). Champaign, IL: Human Kinetics.

Bandeira, P. F. R., Souza, M. S. D., Zanella, L. W., & Valentini, N. C. (2017). Impact of motor interventions oriented by mastery motivational climate in fundamental motor skills of children: A systematic review. *Motricidade*, *13*, 50–61.

Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., & Beard, J. R. (2009). Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health*, *44*(3), 252–259. https://doi.org/10.1016/j.jadohealth.2008.07.004

Brian, A., Goodway, J. D., Logan, J. A., & Sutherland, S. (2017). SKIPing with teachers: An early years motor skill intervention. *Physical Education and Sport Pedagogy*, *22*(3), 270–282. https://doi.org/10.1080/17408989.2016.1176133

Brian, A., & Taunton, S. (2018). Effectiveness of motor skill intervention varies based on implementation strategy. *Physical Education and Sport Pedagogy*, *23*(2), 222–233. https://doi.org/10.1080/17408989.2017.1413709

Clark, J. E., & Metcalfe, J. S. (2002). The mountain of motor development: A metaphor. *Motor Development: Research and Reviews*, *2*, 163–190.

Cohen, K. E., Morgan, P. J., Plotnikoff, R. C., Barnett, L. M., & Lubans, D. R. (2015). Improvements in fundamental movement skill competency mediate the effect of the SCORES intervention on physical activity and cardiorespiratory fitness in children. *Journal of Sports Sciences*, *33*(18), 1908–1918. https://doi.org/10.1080/02640414.2015.1017734

Copple, C., & Bredekamp, S. (2009). *Developmentally appropriate practice in early childhood programs serving children from birth through age 8*. Washington DC: National Association for the Education of Young Children.

D'Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuij, I., Vaeyens, R., Philippaerts, R., & Lenoir, M. (2013). A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity*, *37*(1), 61–67. https://doi.org/10.1038/ijo.2012.55

D'hondt, E., Deforche, B., Vaeyens, R., Vandorpe, B., Vandendriessche, J., Pion, J., … Lenoir, M. (2011). Gross motor coordination in relation to weight status and age in 5-to 12-year-old boys and girls: A cross-sectional study. *International Journal of Pediatric Obesity*, *6*, e556–e564.

Epstein, J. L. (1988). Effective schools or effective students: Dealing with diversity. In R. Haskins & D. MacRae (Eds.), *Policies for America's public* (pp. 89–126). Westport, CT: Ablex Publishing.

Figueroa, R., & An, R. (2017). Motor skill competence and physical activity in preschoolers: A review. *Maternal and Child Health Journal*, *21*, 136–146. https://doi.org/10.1007/s10995-016-2102-1

Foweather, L., Knowles, Z., Ridgers, N. D., O'Dwyer, M. V., Foulkes, J. D., & Stratton, G. (2015). Fundamental movement skills in relation to weekday and weekend physical activity in preschool children. *Journal of Science and Medicine in Sport*, *18*(6), 691–696. https://doi.org/10.1016/j.jsams.2014.09.014

Jiménez-Díaz, J., Chaves-Castro, K., & Salazar, W. (2019). Effects of different movement programs on motor competence: A systematic review with meta-analysis. *Journal of Physical Activity and Health*, *1*(ahead of print), 1–10.

Logan, S. W., Barnett, L. M., Goodway, J. D., & Stodden, D. F. (2017). Comparison of performance on process-and product-oriented assessments of fundamental motor skills across childhood. *Journal of Sports Sciences*, *35*(7), 634–641. https://doi.org/10.1080/02640414.2016.1183803

Logan, S. W., Robinson, L. E., Wilson, A. E., & Lucas, W. A. (2011). Getting the fundamentals of movement: A meta-analysis of the effectiveness of motor skill interventions in children. *Child: Care, Health and Development*, *38*(3), 305–315.

National Association for Sport and Physical Education. (2009). *Active start: A statement of physical activity guidelines for children birth-age 5*. Reston, VA: National Association for Sport and Physical Education Publications.

Palmer, K. K., Chinn, K. M., & Robinson, L. E. (2017). Using achievement goal theory in motor skill instruction: A systematic review. *Sports Medicine*, *47*(12), 2569–2583. https://doi.org/10.1007/s40279-017-0767-2

Palmer, K. K., Stodden, D. F., Ulrich, D. A., & Robinson, L. E. (in review). Comparing process and product measures of fundamental motor skills across an intervention.

Ré, A. H., Logan, S. W., Cattuzzo, M. T., Henrique, R. S., Tudela, M. C., & Stodden, D. F. (2018). Comparison of motor competence levels on two assessments across childhood. *Journal of Sports Sciences*, *36*(1), 1–6. https://doi.org/10.1080/02640414.2016.1276294

Robinson, L. E. (2011). Effect of a mastery climate motor program on object control skills and perceived physical competence in preschoolers. *Research Quarterly for Exercise and Sport*, *82*(2), 355–359. https://doi.org/10.1080/02701367.2011.10599764

Robinson, L. E., & Goodway, J. D. (2009). Instructional climates in preschool children who are at-risk. Part I: Object-control skill development. *Research Quarterly for Exercise and Sport*, *80*(3), 533–542. https://doi.org/10.1080/02701367.2009.10599591

Robinson, L. E., Palmer, K. K., Irwin, J. M., Webster, E. K., Dennis, A. L., Brock, S. J., & Rudisill, M. E. (2015). The use of multimedia demonstration on the test of gross motor development–second edition: Performance and participant preference. *Journal of Motor Learning and Development*, *3*(2), 110–122. https://doi.org/10.1123/jmld.2014-0064

Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., & D'Hondt, E. (2015). Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine*, *45*(9), 1273–1284. https://doi.org/10.1007/s40279-015-0351-6

Robinson, L. E., Wang, L., Colabianchi, N., Stodden, D. F., & Ulrich, D. A. (2020). Protocol for a two-cohort randomized cluster clinical trial of a motor skills intervention: The Promotoing Activity and Trajectories of Health (PATH) study. *BMJ Open*, *10*, 1–14. https://doi.org/10.1136/bmjopen-2020-037497

Robinson, L. E., Webster, E. K., Logan, S. W., Lucas, W. A., & Barber, L. T. (2012). Teaching practices that promote motor skills in early childhood settings. *Early Childhood Education Journal*, *40*, 79–86.

Seefeldt, V. (1980). Developmental motor patterns: Implications for elementary school physical education. In C. Nadeau, W. Holliwell, K. M. Newell, & G. C. Roberts (Eds.), *Psychology of motor behavior and sport* (pp. 314–323). Champaign, IL: Human Kinetics.

Stodden, D. F., Gao, Z., Goodway, J. D., & Langendorfer, S. J. (2014). Dynamic relationships between motor skill competence and health-related fitness in youth. *Pediatric Exercise Science*, *26*(3), 231–241. https://doi.org/10.1123/pes.2013-0027

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, *60*(2), 290–306. https://doi.org/10.1080/00336297.2008.10483582

Stodden, D. F., True, L. K., Langendorfer, S. J., & Gao, Z. (2013). Associations among selected motor skills and health-related fitness: Indirect evidence for Seefeldt's proficiency barrier in young adults? *Research Quarterly for Exercise and Sport*, *84*(3), 397–403. https://doi.org/10.1080/02701367.2013.814910

True, L., Brian, A., Goodway, J., & Stodden, D. (2017). Relationships between product-and process-oriented measures of motor competence and perceived competence. *Journal of Motor Learning and Development*, *5*(2), 319–335. https://doi.org/10.1123/jmld.2016-0042

Ulrich, D. A. (2017). Introduction to the special section: Evaluation of the psychometric properties of the TGMD-3. *Journal of Motor Learning and Development*, *5*(1), 1–4. https://doi.org/10.1123/jmld.2017-0020

Ulrich, D. A. (2019). *Test of gross motor development—3rd edition*. Austin, TX: Pro-Ed.

Utesch, T., Bardid, F., Büsch, D., & Strauss, B. (2019). The relationship between motor competence and physical fitness from early childhood to early adulthood: A meta-analysis. *Sports Medicine*, *49*(4), 541–551. https://doi.org/10.1007/s40279-019-01068-y

Wick, K., Leeger-Aschmann, C. S., Monn, N. D., Radtke, T., Ott, L. V., Rebholz, C. E., … Puder, J. J. (2017). Interventions to promote fundamental movement skills in childcare and kindergarten: A systematic review and meta-analysis. *Sports Medicine*, *47*(10), 2045–2068.

SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

How to cite this article: Palmer KK, Miller AL, Meehan SK, Robinson LE. The Motor skills At Playtime intervention improves children's locomotor skills: A feasibility study. *Child Care Health Dev*. 2020;46:599–606. https://doi.org/10.1111/cch.12793