HOSTED BY
ELSEVIER
Available online at www.sciencedirect.com
ScienceDirect
Journal of Sport and Health Science 8 (2019) 98–105
www.jshs.org.cn

Original article

The effect of the CHAMP intervention on fundamental motor skills and outdoor physical activity in preschoolers

Kara K. Palmer [a], Katherine M. Chinn [a], Leah E. Robinson [a,b,*]

[a] *Child Movement, Activity, and Developmental Health Laboratory, University of Michigan, Ann Arbor, MI 48109-2214, USA*
[b] *Center for Human Growth and Development, University of Michigan, Ann Arbor, MI 48109-2214, USA*

Received 26 June 2018; revised 29 August 2018; accepted 20 September 2018
Available online 30 December 2018

Abstract

Purpose: Physical activity (PA) and fundamental motor skills are important components of current and future trajectories of health in young children. This study examined the effects of a 5-week motor skill intervention on preschoolers' motor skill competence and their PA behaviors while participating in the motor skill intervention or outdoor free play (recess).

Methods: A total of 102 preschoolers served as participants and were part of a motor skill intervention group ($n = 64$) or a control/outdoor free play group ($n = 38$). Children's motor skills were assessed before and after the intervention using the Test of Gross Motor Development-3rd edition. PA during the motor skill intervention and outdoor free play was assessed using accelerometers both immediately before the start (baseline, Week 0 or Week 1) and end (late, Week 5 or Week 6) of the intervention.

Results: All children significantly improved their motor skills from baseline to late assessment ($p < 0.05$). Children in the motor skill intervention demonstrated greater rates of change ($p < 0.001$) and scored higher on all motor skills at the late assessment compared with the control group ($p < 0.001$). There was no effect of group (control *vs.* intervention), but there was a significant effect of sex on children's PA during outdoor free play at baseline ($p < 0.05$). Similarly, there was no effect of group on PA during days with the movement program (intervention *vs.* outdoor free play) at either time point, but boys were more active than girls at the late assessment ($p < 0.05$). Last, children in the intervention engaged in more PA while participating in the intervention toward the end of the intervention than at the beginning.

Conclusion: The 5-week motor skill intervention was effective at improving preschoolers' motor skills and rates of change in motor skills were higher for children who completed the intervention compared with children in the control group. Preschoolers in the intervention did demonstrate PA changes while participating in the intervention, but these changes did not translate outside of the intervention setting.

Keywords: Gross motor skills; Intervention; Motor development; Pediatrics; Physical activity

1. Introduction

Promoting sustainable physical activity (PA) in children is a public health initiative because it contributes to improved cardiometabolic health and healthy weight status.[1,2] Fundamental motor skills are positively related to perceived motor competence and fitness, inversely related to weight status, and have a positive influence on PA and health.[3–5] Fundamental motor skills are building blocks for future and more advanced movement and are divided into 3 categories: locomotor (i.e., the ability to propel the body through space), ball skills (i.e., the ability to propel or manipulate objects in space), and stability skills (i.e., the ability to maintain postural control).[6] Fundamental motor skills develop in early childhood between ages 3 and 6 and contribute to developmental trajectories of health.[3,6] Owing to the wide range of health benefits that are associated with fundamental motor skills, it is critical for young children to obtain a level of proficiency in these skills.

Motor skills do not emerge in the absence of instruction, but rather they must be taught.[7] Motor skill interventions provide children with the instruction and practice necessary to develop motor skills. The literature supports the idea that children who engage in fundamental motor skill interventions learn motor skills, whereas children who only have access to outdoor free play programs (i.e., standard care and no formalized instruction) fail to learn these skills.[8,9] Motor skill interventions teach

Peer review under responsibility of Shanghai University of Sport.
* Corresponding author.
E-mail address: lerobin@umich.edu (L.E. Robinson).

https://doi.org/10.1016/j.jshs.2018.12.003
Cite this article: Palmer KK, Chinn KM, Robinson LE. The effect of the CHAMP intervention on fundamental motor skills and outdoor physical activity in preschoolers. *J Sport Health Sci* 2019;8:98–105.

fundamental motor skills using a variety of pedagogical approaches and techniques, including (a) fundamental motor skills instruction only, (b) sports and games, (c) PA, (d) active video games, (e) teachers' professional development, and (f) a multicomponent approach (for a full review, see Tompsett et al.[10]). A recent meta-analysis of 30 motor skill interventions found that, compared with children in outdoor free play programs, children in motor skill interventions significantly improved their motor skills (locomotor, ball skills, and balance) across time.[9] Collectively, the literature provides strong evidence for the effectiveness of motor skill interventions and programming for improving motor skills in young children.

Research evidence suggests numerous health benefits of PA participation in early childhood.[11] National recommendations also support the importance of PA and gross motor play in early childhood. The National Association for the Education of Young Children specifies that preschools provide children with daily opportunities for gross motor play and time for outdoor play to meet accreditation standards.[12] The National Academy of Sciences (formerly the Institute of Medicine) recommends that preschool-aged children engage in 15 min of PA per hour in schools, which totals approximately 3 h per day.[13] Unfortunately, approximately 50% of preschool children do not meet national PA recommendations,[14] and boys are more likely to meet these recommendations than girls.[14,15] Studies repeatedly report higher levels of moderate-to-vigorous PA (MVPA) by boys than girls.[16–20] Owing to the prevalence of outdoor free play in young children's daily schedule, it is important to investigate alternative approaches to improve PA levels during outdoor free play time.

Motor skill interventions have been shown to improve children's PA behaviors when participating in the intervention as well as fundamental motor skills.[20,21] However, less is known about whether participation in a motor skill intervention elicits positive changes in preschoolers' PA after the cessation of the intervention. The literature shows that a positive association exists between fundamental motor skills and PA in childhood[22,23] and adolescence.[24,25] This positive relationship is also proposed in theoretical models that support positive trajectories of health.[3,4] Therefore, it is important to know whether children who engage in motor skill interventions translate their PA behaviors and newly acquired skill set to be more active during other movement opportunities (e.g., outdoor free play) after the intervention ends. The purpose of this study was to examine changes in motor skills and PA elicited by a 5-week, 600-min motor skill intervention. The study also examined potential sex differences in children's PA engagement. Based on previous literature and theoretical models, we hypothesize that children participating in the motor skill intervention will significantly improve their motor skills over time[7,26] and will engage in more PA (1) at the end of the intervention compared with the beginning and (2) during outdoor free play at the end of the intervention compared with the beginning. We also hypothesize that children who receive the intervention will engage in more PA during outdoor free play at the end of the intervention compared with the control group. Last, we hypothesize that there will be significant sex differences in PA during both the intervention and outdoor free play, with boys being more active than girls.

2. Materials and methods

2.1. Participants

A total of 102 children served as participants (4.40 ± 0.43 years (mean ± SD), 80% African American, 10% Caucasian, 8% Hispanic or Latino/a, and 2% Asian American or others). All participants were from a single Head Start center, the largest federally funded early childhood program that serves low-income children, in a large Midwestern city in the United States. Children were randomly assigned at the level of the classroom into 2 groups: a motor skill intervention group ($n = 64$, 40 boys, 4.40 ± 0.44 years) or control/outdoor free play group ($n = 38$, 23 boys, 4.40 ± 0.41 years).

All experimental procedures were approved by the Health Science Behavioral Science Institutional Review Board at the University of Michigan and both parental consent and child assent were obtained before the start of the research project. All children were from a single Head Start center in an urban town in the Midwest.

2.2. Measures

2.2.1. Motor skills

Motor skills were assessed using the Test of Gross Motor Development-3rd edition (TGMD-3), the upcoming renormed version of the TGMD.[27] The TGMD-3 measures the performance of 13 motor skills that are divided into 2 categories: ball skills (catch, underhand throw, 1-handed forearm strike, kick, overhand throw, dribble, and strike off a tee) and locomotor skills (run, skip, gallop, slide, hop, and horizontal jump). Each skill is divided into 3−5 specific skill criteria. Children perform 2 test trials of each skill and are scored based on the number of correct criteria executed. A child is awarded a score of 1 if he or she performed a criterion correctly, or receives a 0 if he or she was unable to perform the criterion. A number of correct skill criteria are summed, resulting in raw total motor skill and subscale scores (i.e., ball skills and locomotor skills). The maximum raw score for the TGMD-3 is 100, with a higher score reflecting greater motor skill performance. All TGMD-3 performances were video recorded and later coded by a single researcher who was blinded to the purpose of the study. The researcher had a previously established interrater reliability of >95% with 3 experts in the field and an intrarater reliability of >96%.

2.2.2. PA

PA was assessed using Actigraph GT3X accelerometers (model GTX3; Actigraph LLC, Pensacola, FL, USA). Children wore the device on their waist for 7 days at 2 different time points. Data on PA were collected immediately before or at the start of the intervention (i.e., baseline PA, Week 0 or Week 1, respectively) and during the last week of the intervention or immediately after the intervention (i.e., late PA, Week 5 or Week 6, respectively). Devices were attached to the waist using an elastic belt, and children were instructed to wear the device during all waking hours and only remove it during bathing or swimming. Data were collected at 15-s epochs, and data were analyzed with the Actilife

software program (Version 6; Actigraph). The Evenson cutpoints were used to classify the time spent in PA: sedentary, ≤100 counts/min; light PA (LPA), 101−2295 counts/min; moderate PA (MPA), 2296−4011 counts/min; and vigorous PA (VPA), ≥4012 counts/min.[28] MPA and VPA were grouped as MVPA, and LPA was added to MVPA to create total PA (TPA). Data from the movement period (outdoor free play or Children's Health Activity Motor Program (CHAMP),[29] see description elsewhere in this article) were extracted using a wear-time filter and yielded 2 PA measures: outdoor PA and treatment PA. Days when all children (CHAMP and control) engaged in outdoor free play (2 days/week) were used to create the outdoor PA, and days where control children engaged in outdoor free play but CHAMP children engaged in the intervention were averaged to create the treatment PA (3 days/week). All days were cross-checked with accelerometry logs to ensure outdoor and treatment PA were measured correctly. Children's time in minutes spent in sedentary, LPA, MPA, VPA, MVPA, and TPA during outdoor free play or treatment served as the dependent variables.

2.3. Procedures

2.3.1. CHAMP

The motor skill intervention used in this study was the CHAMP. CHAMP is an evidence-based motor skill intervention grounded in achievement goal theory. Motor skill interventions grounded in achievement goal theory are an effective instructional approach for teaching motor skills in young children.[30] CHAMP teaches motor skills using a mastery, high-autonomy climate created using the 6 *TARGET* structures (*T*ask, *A*uthority, *R*ecognition, *G*rouping, *E*valuation, and *T*ime).[31] CHAMP tasks are designed to help children learn and practice both locomotor and ball skills. Each CHAMP session provides children with opportunities to choose from a variety of skill stations that each incorporate tasks to accommodate a range of fundamental motor skill levels.[21,26] During each CHAMP session, children self-select peer groups, and instructors focus on children's individual progress and improvement.[26,32] Preliminary studies demonstrate that CHAMP is effective for improving children's motor skills,[7,26] perceived motor competence,[33] and PA,[21] as well as maintaining self-regulation.[26]

In this study, children completed a 5-week CHAMP intervention. CHAMP sessions were implemented 3 days a week for 40 min/day and included (a) 2 min of warm up, (b) 3−4 min of motor skills station instruction, (c) 32−35 min of autonomy-based motor skill engagement, and (d) 2−3 min of a closure activity. The total CHAMP dosage children received was 600 min (480−525 min of motor skill engagement). All CHAMP sessions were implemented by 2 trained instructors in motor development: a Ph.D. researcher with 10 years of experience implementing high-autonomy movement programs and a Ph.D. student with 3 years of experience.

2.3.2. Study protocol

Children attended the center 5 days/week from 8:00 a.m. to 12:30 p.m. The center provided all children with a daily 40 or 45-min outdoor free play program on a large playground area with a variety of play structures (e.g., swings, slides, ladders). Children in the treatment group replaced their outdoor free play with CHAMP 3 days/week for 5 weeks and participated in the regular outdoor free play the remaining 2 days/week. Children in the control group did not make any changes to their daily routine.

Children were randomly assigned to either a CHAMP treatment or control (i.e., outdoor free play) condition. Randomization occurred at the level of the classroom owing to constraints from the preschool center, and randomization was determined using a random number generator. Four classrooms were randomized to the control (no treatment) group, and 6 classrooms were randomized to the motor skill intervention (CHAMP). The center required that as many children as possible receive the intervention, which resulted in a larger treatment group (6 treatment classrooms *vs.* 4 control classrooms).

Accelerometers were distributed to one-half of the children at a time, and each group of children wore the device for 1 week at the beginning (baseline PA, Week 0 or Week 1) and 1 week at the end (late PA, Week 5 or Week 6) of the intervention to assess preschoolers' PA. Data from both the outdoor free play and the intervention were extracted and used in the analyses. All outdoor PA data were collected from the 2 days/week that all classrooms were on the playground. Data on all treatment PA were collected from the 3 days/week when children were either in outdoor free play (control group) or the intervention (CHAMP group). All children completed the TGMD-3 before the start (baseline) and after (late) the intervention.

2.4. Statistical analysis

To account for differences in sample size, a subsample of the treatment group was selected to be used in the analysis using a random number generator. Owing to attrition in PA measures, separate treatment subsamples were created for motor skills and both PA time points (baseline and late PA). A 2-group (CHAMP and control) × 2-time (baseline−late) repeated-measures analysis of variance (ANOVA) was used to determine the effect of CHAMP on changes in motor skills. The dependent variable was the total TGMD-3 raw score, and the independent variable was the treatment group (CHAMP *vs.* outdoor free play). Because there were only 2 levels of groups and 2 levels for time, significant Group × Time interactions were decomposed using *post hoc* independent and dependent *t* tests. To gain a better insight into what skills were being affected by CHAMP, these analyses were repeated for both the locomotor and ball skill subtest raw scores.

Owing to the related nature of PA variables and the well-established sex differences in PA engagement, group differences in PA behaviors during outdoor time were examined using 2 multivariate ANOVAs (MANOVAs) at the beginning of the intervention (baseline PA) and the end of the intervention (late PA), controlling for sex. Changes in PA in the CHAMP group over time were examined using dependent samples *t* tests. A separate set of dependent samples *t* tests were conducted to determine changes in the CHAMP group's PA during the

CHAMP intervention and outdoor free play. A Bonferroni correction was applied to guard against a type I error, and the adjusted α levels were 0.01 (i.e., 0.05/5.00) for independent t tests. All data analysis was conducted in SPSS (Version 24.0, IBM Corp., Armonk, NY, USA), and α levels were set a priori at 0.05 for all tests.

3. Results

3.1. Motor skills

A total of 99 children (63 treatment, 62% boys, 4.37 ± 0.47 years; 36 control, 61% boys, 4.42 ± 0.40 years) completed baseline and late motor assessments. A sample of 36 CHAMP children (61% boys) was randomly selected using a random number generator to be compared with the control group. There were no significant differences between the randomly selected and nonselected CHAMP children regarding age and motor skills (Table 1).

3.1.1. Intervention effects

The repeated measures ANOVA for total motor skills ($F(1, 70) = 156.35$, $p < 0.001$, $\eta_p^2 = 0.69$), locomotor skills ($F(1, 70) = 168.66$, $p < 0.001$, $\eta_p^2 = 0.71$), and ball skills ($F(1,70) = 79.0$, $p < 0.001$, $\eta_p^2 = 0.53$) revealed a significant Time × Group interaction. In regards to group differences, there were no significant differences between the CHAMP and the control group at baseline for total motor skills ($t(70) = 0.48$, $p = 0.63$), locomotor skills ($t(70) = 0.36$, $p = 0.72$), or ball skills ($t(70) = 0.46$, $p = 0.65$). At the late assessment, the CHAMP group outscored the control group for total motor skills ($t(70) = 10.54$, $p < 0.001$, $d = 2.7$), locomotor skills ($t(70) = 13.0$, $p < 0.001$, $d = 3.1$), and ball skills ($t(70) = 7.76$, $p < 0.001$, $d = 1.8$). Children in both the control and CHAMP groups significantly improved their total motor skills ($t(35) = 6.14$, $p < 0.001$, $d = 1.6$; $t(35) = 24.35$, $p < 0.001$, $d = 5.7$), locomotor skills ($t(35) = 4.0$, $p < 0.001$, $d = 0.7$; $t(35) = 22.1$, $p < 0.001$, $d = 4.6$), and ball skills ($t(35) = 6.31$, $p < 0.001$, $d = 2.1$; $t(35) = 19.71$, $p < 0.001$, $d = 4.3$) over time, respectively (Table 2).

Table 1
Age, motor skills, and total PA between randomly selected and nonrandomly selected CHAMP groups (mean ± SD).

	Selected	Not selected	t	p
Motor skills				
n	36	27		
Age (year)	4.30 ± 0.45	4.46 ± 0.41	1.46	0.15
Locomotor	9.42 ± 5.17	9.11 ± 5.09	−0.23	0.82
Ball skills	9.83 ± 6.05	9.07 ± 4.14	−0.56	0.58
Total	19.25 ± 9.85	18.19 ± 8.00	−0.46	0.65
Baseline PA				
n	27	21		
Age (year)	4.40 ± 0.45	4.34 ± 0.42	−0.49	0.63
Sedentary (min)	13.12 ± 3.20	14.92 ± 5.55	1.36	0.18
LPA (min)	8.76 ± 1.44	8.34 ± 1.27	−1.06	0.29
MPA (min)	8.58 ± 1.70	8.15 ± 2.14	−0.79	0.44
VPA (min)	14.50 ± 3.67	13.60 ± 0.75	−0.84	0.41
MVPA (min)	23.08 ± 3.57	21.75 ± 5.07	−1.07	0.29
TPA (min)	31.84 ± 3.32	30.08 ± 5.55	−1.37	0.18
Late PA				
n	17	27		
Age (year)	4.30 ± 0.49	4.36 ± 0.42	−0.43	0.67
Sedentary (min)	14.50 ± 7.15	14.07 ± 5.26	−0.23	0.82
LPA (min)	7.74 ± 2.11	7.81 ± 1.53	0.12	0.91
MPA (min)	7.15 ± 1.67	8.05 ± 1.95	1.58	0.12
VPA (min)	15.60 ± 6.57	14.73 ± 3.72	−0.56	0.58
MVPA (min)	22.75 ± 7.21	22.78 ± 4.73	0.02	0.99
TPA (min)	30.50 ± 7.15	30.59 ± 5.30	0.05	0.96

Abbreviations: CHAMP = Children's Health Activity Motor Program; LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; PA = physical activity; TPA = total physical activity; VPA = vigorous physical activity.

3.1.2. Rate of change

Because all children improved their motor skills across time, we compared the rate of change among children in the CHAMP and control groups. A change score was calculated (late score−baseline score) for the total, locomotor, and ball skill measures. The change scores were used in an independent t test to determine if the groups had significantly different rates of change. To prevent a type I error, a Bonferroni correction was applied and the adjusted p value was < 0.017 (0.05/3.00). Results show that children in the CHAMP group had significantly greater rates of improvement compared with children in the control group. This was true for all of the TGMD-3 scores: total ($t(70) = 12.50$, $p < 0.001$, $d = 2.9$), locomotor ($t(70) = 13.00$, $p < 0.001$, $d = 3.1$), and ball skills ($t(70) = 8.89$, $p < 0.001$, $d = 2.1$) (Table 2).

3.2. PA

A total of 75 children (48 CHAMP, 62.5% boys; 27 control, 55.6% boys) completed the baseline PA measures and 61 children (44 CHAMP, 70.5% boys; 17 control, 52.9% boys) completed the late PA measure. We randomly selected a CHAMP sample matched according to sex for the baseline PA measure (27 CHAMP children, 55.6% boys) and the late PA measure (17 CHAMP children, 52.9% boys). There were no differences between the selected and nonselected groups regarding age, baseline PA, or late PA (Table 1).

3.2.1. Between-group differences: outdoor PA

The MANOVA examining group differences in outdoor PA at baseline did not show a significant effect of treatment ($p = 0.32$), but revealed a significant effect of sex ($F(3, 49) = 3.35$, $p = 0.03$, $\eta_p^2 = 0.17$). *Post hoc* independent samples t tests showed that at baseline boys engaged in less LPA ($t(52) = -3.11$, $p = 0.003$, $d = 0.9$) and more VPA ($t(52) = 2.23$, $p = 0.03$, $d = 0.6$) in outdoor free play compared with girls, regardless of their treatment group. Similarly, the MANOVA examining group differences at the late PA assessment only showed a marginal effect of treatment ($p = 0.08$), but did reveal a significant effect of sex ($F(3, 29) = 3.03$, $p = 0.047$, $\eta_p^2 = 0.24$). *Post hoc* independent samples t tests failed to find any statistically significant

Table 2
Pre, post, and change in motor skills of randomly selected CHAMP and control groups (mean ± SD).

	Pre			Post			Change		
	LM	BS	Total	LM	BS	Total	LM	BS	Total
CHAMP ($n = 36$)	9.41± 5.2	9.83 ± 6.1	19.25 ± 9.9	32.25 ± 7.2*	33.94 ± 8.9*	66.19 ± 13.3*	22.83 ± 6.2	24.11 ± 7.3	46.94 ± 11.6
Control ($n = 36$)	9.00 ± 4.7	9.28 ± 4.0	18.28 ± 7.1	13.03 ± 5.2*	17.50 ± 9.1*	30.53 ± 13.3*	4.03 ± 6.1	8.22 ± 7.8	12.25 ± 12.0
Difference	0.41	0.55	1.03	19.22#	16.44#	35.66#	18.80#	15.89#	34.69#

* $p < 0.001$, significant within-group change; # $p < 0.001$, significant between-group difference.
Abbreviations: BS = ball skills; CHAMP = Children's Health Activity Motor Program; LM = locomotor skills.

differences in PA engagement between boys and girls during the outdoor time at the late PA assessment, but did reveal several marginal effects ($p = 0.06$) (Table 3).

3.2.2. Between-group differences: treatment PA

The MANOVA examining group differences between CHAMP and outdoor free play at the baseline PA assessment revealed there were no significant effects of sex ($p = 0.18$) or treatment ($p = 0.11$). The MANOVA examining group differences between CHAMP and outdoor free play at the late PA assessment found no effect of treatment ($p = 0.44$), but did find a significant effect of sex ($F(3, 10) = 4.62$, $p = 0.03$, $\eta_p^2 = 0.58$). Results of the *post hoc* independent *t* tests found that at the late PA assessment boys in both settings (CHAMP and outdoor free play) engaged in less LPA ($t(13) = 3.62$, $p = 0.003$, $d = 1.9$) and more VPA ($t(13) = -3.39$, $p = 0.005$, $d = 1.8$), MVPA ($t(13) = -3.38$, $p = 0.005$, $d = 1.8$), and TPA ($t(13) = -2.23$, $p = 0.04$, $d = 1.2$) compared with girls (Table 4).

3.2.3. Within CHAMP group changes outdoor and treatment PA

A total of 19 children (5 girls) completed the PA assessment during CHAMP at baseline and late PA. Compared with baseline, children were engaged in less LPA ($t(18) = 3.16$, $p = 0.005$, $d = 0.7$) and more VPA ($t(18) = -3.35$, $p = 0.004$, $d = 0.7$) and MVPA ($t(18) = -3.39$, $p = 0.003$, $d = 0.6$) during CHAMP at the end of the intervention (late PA). There were no changes in outdoor free play PA across the 5 weeks for the CHAMP group.

4. Discussion

Research demonstrates that PA is an important factor in decreasing cardiometabolic risk factors in children, but children are not meeting daily recommendations for health-enhancing PA.[1,2,13] Additionally, on average preschool girls accumulate less MVPA than boys and are less likely to meet the daily PA recommendations.[16–20] Motor skills are

Table 3
PA in minutes during outdoor free play by group and sex (mean ± SD).

	Group			Sex		
	CHAMP	Control	Difference	Boys	Girls	Difference
Baseline						
n	27	27		30	24	
Days recorded	3.04 ± 1.7	3.26 ± 1.7		3.03 ± 1.7	3.29 ± 1.6	
Sedentary	12.99 ± 4.3	14.44 ± 4.7	−1.45	13.53 ± 4.8	13.95 ± 4.2	−0.42
LPA	8.42 ± 2.5	8.75 ± 2.2	−0.33	7.78 ± 2.3	9.60 ± 1.9	−1.82**
MPA	7.83 ± 1.9	8.29 ± 1.9	−0.46	7.64 ± 1.7	8.58 ± 2.0	−0.94
VPA	15.76 ± 5.7	13.51 ± 4.9	2.25	16.05 ± 5.5	12.87 ± 4.9	3.18*
MVPA	23.59 ± 5.4	21.81 ± 5.1	1.78	23.69 ± 5.5	21.45 ± 4.7	2.24
TPA	32.01 ± 4.3	30.56 ± 4.7	1.45	31.47 ± 4.8	31.05 ± 4.2	0.42
Late						
n	17	17		18	16	
Days recorded	2.81 ± 1.1	3.06 ± 1.1		2.89 ± 1.1	2.94 ± 1.2	
Sedentary	15.45 ± 8.3	12.47 ± 4.7	2.98	13.34 ± 7.1	14.60 ± 6.6	−1.26
LPA	7.80 ± 2.6	7.68 ± 2.4	0.12	7.00 ± 2.6	8.58 ± 1.9	−1.58†
MPA	6.88 ± 2.3	8.34 ± 2.2	−1.46	6.90 ± 1.7	8.41 ± 2.7	−1.51†
VPA	14.87 ± 7.5	16.51 ± 5.8	−1.64	17.72 ± 7.8	13.41 ± 4.1	4.31†
MVPA	21.75 ± 8.3	24.85 ± 5.5	−3.10	24.62 ± 7.9	21.82 ± 5.9	2.80
TPA	29.55 ± 8.3	32.53 ± 4.7	−2.98	31.62 ± 7.2	30.40 ± 6.6	1.22

* $p < 0.05$, ** $p < 0.01$; † $p = 0.06$.
Abbreviations: CHAMP = Children's Health Activity Motor Program; LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; PA = physical activity; TPA = total physical activity; VPA = vigorous physical activity.

Table 4
PA in minutes during treatment days group and sex (mean ± SD).

	Group			Sex		
	CHAMP	Control	Difference	Boys	Girls	Difference
Baseline						
n	25	24		26	23	
Days recorded	2.48 ± 1.70	1.75 ± 0.90		2.19 ± 1.50	2.04 ± 1.40	
Sedentary	12.25 ± 3.40	15.49 ± 5.40	−3.24	12.93 ± 3.80	14.88 ± 5.30	−1.95
LPA	9.19 ± 1.80	8.53 ± 2.00	0.66	8.67 ± 1.80	9.09 ± 2.00	−0.42
MPA	9.54 ± 2.00	8.69 ± 3.00	0.85	9.04 ± 2.20	9.22 ± 2.90	−0.18
VPA	14.01 ± 4.40	12.28 ± 3.30	1.73	14.36 ± 4.10	11.81 ± 3.40	2.55
MVPA	23.55 ± 3.90	20.98 ± 4.40	2.57	23.40 ± 3.80	21.03 ± 4.60	2.37
TPA	32.74 ± 3.40	29.51 ± 5.40	3.23	32.07 ± 4.00	30.12 ± 5.30	1.95
Late						
n	8	7		8	7	
Days recorded	3.42 ± 0.90	3.45 ± 0.80		3.75 ± 0.50	2.86 ±1.10	
Sedentary	12.76 ± 4.00	9.32 ± 3.50	3.44	9.24 ± 3.60	13.35 ± 3.50	−4.11*
LPA	8.56 ± 1.90	8.16 ± 2.60	0.40	6.99 ± 1.50	9.96 ± 1.60	−2.97**
MPA	7.95 ± 1.00	7.99 ± 2.60	−0.04	7.50 ± 2.00	8.49 ± 1.60	−0.99
VPA	15.73 ± 4.60	19.53 ± 7.20	−3.80	21.27 ± 5.20	13.20 ± 3.80	8.07**
MVPA	23.68 ± 4.80	27.52 ± 5.50	−3.84	28.78 ± 4.10	21.69 ± 3.90	7.09**
TPA	32.24 ± 4.00	35.68 ± 3.50	−3.44	35.76 ± 3.60	31.65 ± 3.50	4.11*

* $p < 0.05$, ** $p < 0.01$.
Abbreviations: CHAMP = Children's Health Activity Motor Program; LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; PA = physical activity; TPA = total physical activity; VPA = vigorous physical activity.

behaviors that contribute to positive trajectories of health[3,4] and PA.[5] Motor skill interventions improve motor skills in young children.[8,9,34] The purpose of this study was to examine changes in motor skills and PA elicited by a motor skill intervention, and to determine whether PA changes in the intervention translated to the outdoor free play setting.

Results from this study partially supported our initial hypotheses. All children's motor skills, CHAMP and control groups, significantly improved over time. The finding that children in CHAMP significantly improved their motor skills aligns with previous work that supports the belief that motor skill interventions are an effective means for motor skill learning in young children.[8,9] Coupled with previous work on CHAMP that used an earlier edition of the TGMD (TGMD-2), these findings add to the body of literature that CHAMP is an effective intervention for improving motor skills in preschool-aged children.[7,26,35] Interestingly, the present study also found that children in the control group demonstrated significant motor skill improvements over time. This finding has been seen in other intervention studies where children who receive no planned or formalized instruction demonstrated gains in skills.[26,36] A recent study that used the TGMD-2 to measure changes in motor skills reported a significant increase in the control group's motor skills.[26]

As it relates to the changes in children's motor skills, it is important to consider not only the statistically significant differences across time, but also the practical implications for findings. Children in the control group only exhibited an increase of 9 raw points (i.e., that equates to an improvement of 9 of the 100 criteria), whereas the increase in raw scores was 5 times higher for children who received the CHAMP intervention (i.e., 45 points; 45 of the 100 criteria). Although both groups statistically improved, the practical differences between 9 and 45 points demonstrate the importance of motor skill instruction in learning these fundamental motor skills. When this article was written, the normative data for the TGMD-3 were not yet released; therefore, it is not possible to translate gains in motor skills into a metric such as a standard score or percentile ranking. The TGMD-3 results from this study were translated into standard deviations to better understand the overall findings. Children in CHAMP exhibited gains >3 standard deviations from baseline to late assessment whereas children in the control group exhibited <1 standard deviation. These motor skill gains are comparable with or greater than those reported by other studies.[26,37,38] Further, at the late assessment, children in CHAMP outscored the control group in both subtests and total TGMD-3 scores. There was a difference of 35 raw points between the control group (i.e., 25 points) and children in CHAMP (i.e., 60 points). These findings add support to the idea that children in CHAMP exhibited a large gain in motor skills that is likely to translate into practical behavioral changes, whereas the changes seen in children in the control group may or may not reach practical significance. These findings support the use of motor skill interventions for teaching motor skills to preschoolers.

These findings also add to the knowledge of the effects of motor skill interventions on PA. Our findings partially supported our original hypotheses regarding changes in PA. Results examining within group changes in PA behavior during CHAMP showed that at the end of the intervention (Week 5), children engaged in less LPA and more VPA and MVPA. These findings support a shift to more healthy PA behaviors across time within the CHAMP intervention. Conversely, no changes in PA behaviors during outdoor free play were seen from

baseline to late PA in children who completed the CHAMP intervention. Proposed theoretical models indicate that motor skills are an important component of the developmental trajectories of health and support children's engagement in PA behaviors (e.g., Robinson and Stodden models).[3,4] Although no changes in behaviors were seen outside of the intervention in this particular study, we propose several possible reasons for this null finding. First, the dose (5 weeks, 600 min) may be insufficient to see translational changes in PA from the intervention to different settings. Children were well-acclimated to the intervention climate at the end of the 5 weeks, but they may need additional time either in an intervention setting or between the end of the intervention and assessments (e.g., retention phase) to translate their new skills into PA engagement in an outdoor setting. To our knowledge, no studies have examined the effect of an intervention dose on PA engagement outside of the intervention in preschoolers, and only limited work exists that examines PA changes in an outdoor setting after an intervention. More research is needed as it relates to intervention duration, dose, and strategies for translating learned motor skills and PA across settings (e.g., from intervention to the playground), with a particular emphasis on the preschool years. This intervention also took place from October to December 2016, and it is unclear how the shift in the weather may have affected children's PA during the outdoor free play sessions. Although the temperature was rather mild for Midwestern standards (i.e., no snow or temperatures that prevented the children from going outside), the timing of the intervention could have introduced other factors (e.g., various preschool-related events like field trips, book mobiles, and child−parent events) that might have influenced PA behaviors.

Another factor that could have contributed to the lack of change in PA during the outdoor free play sessions was the teacher−student interactions on the playground. The CHAMP intervention was directed by 2 trained researchers and was highly interactive. CHAMP focuses on keeping children engaged in movement activities throughout the program. Conversely, teachers may not have continued this encouragement during outdoor free play. Indeed, qualitative research indicates that preschool teachers perceive their roles to be primarily supervisory during outdoor free play and they aim to maintain children's safety while providing children with the opportunity to partake in unstructured, exploratory experiences.[39] With outdoor free play/recess being required in early childhood settings,[40] there is a need to understand the role that this time plays in relation to PA and other behaviors. Also, more research on how teachers shape these behaviors is needed.

The findings demonstrated no group differences in PA behaviors during outdoor free play or treatment at either PA measure (baseline and late). However, there were significant effects by sex. Boys engaged in more PA on the playground at baseline and late assessments in both conditions (outdoor free play and CHAMP) than the girls. It is important to note that, owing to the accelerometer schedule, only 15 children wore accelerometers during the treatment days at the late PA assessment. The results at this time point should be interpreted with caution. Nonetheless, these findings do align with the literature and support the idea that preschool-aged boys are more active than their female counterparts.[16−20]

The present study included several strengths. The study used a previously established motor skill intervention, CHAMP. Using an established intervention helped to alleviate concerns about using a novel instrument to measure motor skills. All motor skill performances were coded by a single researcher who was blinded to the original purpose of the study. The researcher had strong interrater reliability, and using a single researcher mitigated concerns regarding interrater reliability. This study also had some limitations. The generalizability of the results are limited because all data were collected from a single Head Start preschool in the Midwestern United States. Future work should expand these findings and replicate the study in different populations, such as populations of older children or children from families having a high socioeconomic status. This study was also limited in that trained research personnel implemented all intervention sessions. Training teachers to implement motor skill interventions effectively would expand the results to apply to real-world settings. Lastly, owing to time and economic constraints, it was not possible to include a follow-up or retention test to examine the longitudinal intervention effects. There were also limitations regarding the accelerometer schedule and compliance. Due to a limited number of devices, not all children were able to wear the device in the same week. Moreover, the compliance rate for wearing the devices ranged from 38% to 75%, and many children lost or refused to wear the devices during the late PA assessment, resulting in a substantially smaller sample size.

5. Conclusion

The promotion of health-enhancing and sustainable PA is a public health concern owing to the increasing childhood obesity rates, which continue increasing through adulthood.[13] Fundamental motor skills are the building blocks for more advanced movement, and behaviors and data indicate that these skills are essential components in helping individuals to engage in life-long PA. Motor skill interventions are an avenue to promote motor skills. This study demonstrated that a 5-week motor skill intervention was effective in promoting motor skills in preschoolers compared with outdoor free play. This study also examined whether motor behaviors learned in a motor skill intervention translate to more PA during an outdoor free play setting. Results demonstrate that there is not a translational effect of a 5-week motor skill intervention on children's PA during outdoor free play, but that children did engage in more PA in CHAMP at the end of the intervention. The latter finding about PA aligns with previous evidence indicating that children engage in more health-enhancing PA when participating in CHAMP.[20,21] Regarding practical implications, these findings support the use of motor skill interventions to improve preschoolers' motor skills and PA during planned movement experiences in early childhood education. More work is needed to understand the long-term effects of motor skills and motor skill interventions on children's PA engagement.

Authors' contributions

KKP implemented the intervention, oversaw and participated in data collection, and analyzed the data and drafted the manuscript;

KMC drafted the manuscript and completed the references; LER conceptualized the study, assisted with the implemented of the intervention, data collection, and data analysis, and provided financial support for the project and revised/reviewed the manuscript. All authors have read and approved the final version of the manuscript, and agree with the order of presentation of the authors.

Competing interests

The authors declare that they have no competing interests.

References

1. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act* 2010;**7**:1–16.
2. Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA* 2012;**307**:704–12.
3. Robinson LE, Stodden DF, Barnett LM, Lopes VP, Logan SW, Rodrigues LP, et al. Motor competence and its effect on positive developmental trajectories of health. *Sports Med* 2015;**45**:1273–84.
4. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: an emergent relationship. *Quest* 2008;**60**:290–306.
5. Logan SW, Webster EK, Getchell N, Pfeiffer KA, Robinson LE. Relationship between fundamental motor skill competence and physical activity during childhood and adolescence: a systematic review. *Kinesiol Rev* 2015;**4**:416–26.
6. Payne VG, Isaacs LD. *Human motor development: a lifespan approach*. New York, NY: McGraw-Hill; 2017.
7. Robinson LE, Goodway JD. Instructional climates in preschool children who are at-risk. Part I: object-control skill development. *Res Q Exerc Sport* 2009;**80**:533–42.
8. Logan SW, Robinson LE, Wilson AE, Lucas WA. Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. *Child Care Health Dev* 2011;**38**:305–15.
9. Wick K, Leeger-Aschmann CS, Monn ND, Radtke T, Ott LV, Rebholz CE, et al. Interventions to promote fundamental movement skills in childcare and kindergarten: a systematic review and meta-analysis. *Sports Med* 2017;**47**:1–24.
10. Tompsett C, Sanders R, Taylor C, Cobley S. Pedagogical approaches to and effects of fundamental movement skill interventions on health outcomes: a systematic review. *Sports Med* 2017;**47**:1–25.
11. Vazou S, Mantis C, Luze G, Krough JS. Self-perceptions and social-emotional classroom engagement following structured physical activity among preschoolers: a feasibility study. *J Sport Health Sci* 2017;**6**:241–7.
12. NAEYC. *Early Learning Program accreditation standards and assessment items*. Available at: https://bit.ly/2SEQwdo; [accessed 06.09.2018].
13. Institute of Medicine. *Early childhood obesity prevention policies: goals, recommendations, and potential action*. Washington, DC: National Academies Press; 2013.
14. Pate RR, O'Neill JR, Brown WH, Pfeiffer KA, Dowda M, Addy CL. Prevalence of compliance with a new physical activity guideline for preschool-age children. *Child Obes* 2015;**11**:415–20.
15. Pate RR, O'Neill JR. Physical activity guidelines for young children: an emerging consensus. *Arch Pediatr Adolesc Med* 2012;**166**:1095–6.
16. Pate RR, Pfeiffer KA, Trost SG, Ziegler P, Dowda M. Physical activity among children attending preschools. *Pediatrics* 2004;**114**:1258–63.
17. Pate RR, McIver K, Dowda M, Brown WH, Addy C. Directly observed physical activity levels in preschool children. *J Sch Health* 2008;**78**:438–44.
18. Trost S, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, et al. Age and gender differences in objectively measured physical activity in youth. *Med Sci Sports Exerc* 2002;**34**:350–5.
19. Hinkley T, Salmon J, Okely AD, Crawford D, Hesketh K. Preschoolers' physical activity, screen time, and compliance with recommendations. *Med Sci Sports Exerc* 2012;**44**:458–65.
20. Robinson LE, Palmer KK, Webster EK, Logan SW, Chinn KM. The effect of CHAMP on physical activity and lesson context in preschoolers: a feasibility study. *Res Q Exerc Sport* 2018;**89**:265–71.
21. Palmer KK, Matsuyama AL, Robinson LE. Impact of structured movement time on preschoolers' physical activity engagement. *Early Child Educ J* 2017;**45**:201–6.
22. Williams HG, Pfeiffer KA, O'Neill JR, Dowda M, McIver KL, Brown WH, et al. Motor skill performance and physical activity in preschool children. *Obesity* 2008;**16**:1421–6.
23. Wrotniak BH, Epstein LH, Dorn JM, Jones KE, Kondilis VA. The relationship between motor proficiency and physical activity in children. *Pediatrics* 2006;**118**:e1758–65.
24. Lima RA, Pfeiffer K, Larsen LR, Bugge A, Moller NC, Anderson LB, et al. Physical activity and motor competence present a positive reciprocal longitudinal relationship across childhood and early adolescence. *J Phys Act Health* 2017;**14**:440–7.
25. Venetsanou F, Kambas A. Can motor proficiency in preschool age affect physical activity in adolescence? *Pediatr Exerc Sci* 2017;**29**:254–9.
26. Robinson LE, Palmer KK, Bub KL. Effect of the Children's Health Activity Motor Program on motor skills and self-regulation in head start preschoolers: an efficacy trial. *Front Public Health* 2016;**4**:1–12.
27. Ulrich DA. *Test of gross motor development*. 3rd ed. Austin, TX: Pro-Ed; in press.
28. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *J Sports Sci* 2008;**26**:1557–65.
29. Ames C. Classrooms: goals, structures, and student motivation. *J Educ Psychol* 1992;**84**:261–71.
30. Palmer KK, Chinn KM, Robinson LE. Achievement goal theory in motor skill interventions: a systematic review. *Sports Med* 2017;**47**:2569–83.
31. Epstein JL. Family structures and student motivation: a developmental perspective. In: Ames C, Ames R, editors. *Research on motivation in education*. 3rd ed. San Diego, CA: Academic Press; 1989.p.259–95.
32. Epstein JL. Effective schools or effective students: dealing with diversity. In: Haskins R, MacRae D, editors. *Policies for America's public*. Westport, CT: Ablex Publishing; 1988.p.89–126.
33. Robinson LE, Rudisill ME, Goodway JD. Instructional climates in preschool children who are at-risk. Part II: perceived physical competence. *Res Q Exerc Sport* 2009;**80**:543–51.
34. van Capelle A, Broderick CR, van Doorn N, Ward RE, Parmenter BJ. Interventions to improve fundamental motor skills in pre-school aged children: a systematic review and meta-analysis. *J Sci Med Sport* 2017;**20**:658–66.
35. Robinson LE, Palmer KK, Meehan SK. Dose-response relationship: the effect of motor skill intervention duration on motor performance. *J Mot Learn Dev* 2017;**5**:1–18.
36. Bovin A, Barral J, Kakebeeke TH, Kriemler S, Longchamp A, Schindler C, et al. Effect of a governmentally-led physical activity program on motor skills in young children attending child care centers: a cluster randomized controlled trial. *Int J Behav Nutr Phys Act* 2013;**10**:90–102.
37. Bardid F, Lenoir M, Huyben F, De Martelaer K, Seghers J, Goodway JD, et al. The effectiveness of a community-based fundamental motor skill intervention in children aged 3−8 years: results of the "Multimove for Kids" project. *J Sci Med Sport* 2017;**20**:184–9.
38. Valentini NC, Pierosan L, Rudisill ME, Hastie PA. Mastery and exercise play interventions: motor skill development and verbal recall of children with and without disabilities. *Phys Educ Sport Pedagogy* 2017;**22**:349–63.
39. McClintic S, Petty K. Exploring early childhood teacher's beliefs and practices about preschool outdoor play: a qualitative study. *J Early Child Teach Educ* 2015;**36**:24–43.
40. Copple C, Bredekamp S. *Developmentally appropriate practice in early childhood programs serving children from birth through age 8*. 3rd ed. Washington, DC: National Association for the Education of Young Children; 2009.