mHealth Intervention for Motor Skills: A Randomized Controlled Trial

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abstract

BACKGROUND AND OBJECTIVES: Children's motor skills are a critical foundation for physical activity. The objective was to determine the effectiveness and feasibility of a mobile app-based intervention delivered to parents to improve preschoolers' motor skills.

METHODS: This randomized controlled trial randomly assigned children to : (1) Motor Skills, including instructional lessons, peer modeling videos, behavioral scaffolding, and structured activities or 2) Free Play. Both groups received a 12-week app-based intervention informed by social cognitive theory to deliver 12 hours (12-minutes per day, 5× per week) of instruction. The children were aged 3 to 5 y; parents and children had no mobility impairments. The primary outcome variables were children's motor skills percentile score assessed with the Test of Gross Motor Development, third edition (TGMD-3) at baseline, end-of-intervention (week 12), and follow-up (week 24); and feasibility and acceptability.

RESULTS: Seventy-two children (4.0 ± 0.8 y) participated. Between baseline and week 12, children in the Motor Skills condition significantly improved total TGMD-3 percentile (+13.7 Motor Skills vs −5.3 Free Play, $P < .01$), locomotor skills percentile (+15.5 Motor Skills vs −4.8 Free Play, $P < .01$), and ball skills percentile (+8.3 Motor Skills vs −7.3 Free Play, $P < .01$) compared with children in the comparator group. Significant differences were sustained at follow-up (week 24). Adherence did not significantly differ between conditions (71% for Motor Skills; 87% for Free Play). Parents in both arms reported high scores on satisfaction, helpfulness, and ease of use.

CONCLUSIONS: Clinicians and educators may encourage parents to enhance their child's motor skills through structured at-home programs.

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WHAT'S KNOWN ON THIS SUBJECT: Motor skill development is critical in early childhood as a foundation for physical activity engagement. Interventions to improve children's motor skills have required access to motor skills experts and specialized settings and equipment.

WHAT THIS STUDY ADDS: A mobile app delivered to parents was acceptable and successful in improving preschool-aged children's motor skills over 3-months, and motor skill improvements were sustained to 6-months. Mobile apps may enable clinicians, educators, and parents to improve children's motor skills proficiency.

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Fundamental motor skills, like running and throwing, are foundational for advanced movement and physical activity.[1–3] Motor skills, including locomotor and object control skills, develop in early childhood.[4] These skills do not naturally develop but must be taught, reinforced, and practiced for children to develop competency[5] and engage in sufficient future physical activity.[2,6–9] Children with more proficient motor skills are more physically active[10–12] into adolescence[13–16] and have higher perceived movement competence[7] and self-regulation skills.[17]

Interventions to improve children's motor skills have required access to motor skills experts and specialized settings and equipment.[17] For example, children who participated in structured motor skills programs in an early childhood education setting significantly improved motor skills compared with free play.[18,19] However, few motor skills interventions used parents as the delivery agents, despite their important role in modeling behaviors and providing support and structure for their child's physical activity.[20]

Emerging evidence indicates that mobile health (mHealth) interventions (ie, on a smartphone, tablet, or iPad) may be a tool to instruct and support parents on how to increase children's physical activity,[21,22] yet are primarily used as a reward or distractor.[23] Mobile-based interventions targeting parents of children (<6 y) have used reminder or supportive calls related to physical activity but failed to use apps or text messaging.[24] One 8-week study ($n = 34$) compared an app designed to promote preschoolers' motor skills and physical activity and observed improved object control and locomotor skills, but these effects were not significantly different versus a control, and it was not possible to separate the motor skills instruction from the physical activity promotion.[25] These studies suggest a need for research that focuses specifically on development of motor skills.

Therefore, the purpose of the current study was to develop a mobile app-based motor skills intervention for preschool children utilizing parents as the mediators for behavior change, with the specific aim to determine if a 12-week Motor Skills app delivered to parents and preschool children would improve children's motor skills compared with a Free Play control app and to examine the feasibility and acceptability of the 12-week Motor Skills and Free Play apps. Additional exploratory goals included: (1) to determine if the 12-week Motor Skills intervention would improve children's physical activity levels, perceived movement competence, and self-regulation skills compared with the Free Play control and (2) to determine if the effects of the Motor Skills intervention would be sustained through week 24.

METHODS

Trial Design

The Promoting Lifelong Activity in Youth (PLAY) study was a randomized controlled trial that assigned each child in a 1 to 1 ratio to the Motor Skills app (intervention) or the Free Play app (control). The Pennington Biomedical Research Center Institutional Review Board approved this study (2018-041).

Participants

A convenience sample was recruited using flyers at childcare centers, e-mail listserv, social media, and community health fairs. Child inclusion criteria included: aged 3 to 5 years, physically capable of exercise, and had no parent-reported mobility limitations that could impair participation in motor skills activities. Children were excluded if their gross motor quotient was at "gifted or very advanced" based on the Test of Gross Motor Development (TGMD-3) administered at screening to avoid ceiling effects (no children were excluded for this reason). Parent eligibility criteria included smartphone ownership, willingness to download and use the assigned version of the app, no plans to move out of the area during study period (24-weeks), and no self-reported parent mobility limitations that impaired modeling of motor skills.

Procedure

The detailed protocol was previously published.[26] Parents completed a web screener and were contacted by research staff to schedule a screening visit. Assessment visits occurred at YMCAs or the Pennington Biomedical Research Center clinical facilities. At the screening visit, parents provided written consent and verified parent and child did not have mobility limitations that impaired performance (or modeling) of motor skills, and children completed the TGMD-3 and were outfitted with an activity monitor. The parent returned the activity monitor at baseline visit within 2 to 3 weeks, and the research staff confirmed the child had acceptable wear-time. The parent and child completed questionnaires, and the child's height and weight were measured. The app was downloaded onto the parent's smartphone, and research staff entered a unique passcode that enabled access to the randomly assigned version of the app (Motor Skills or Free Play). Research staff provided a brief orientation of the app to the parent.

Research staff monitored app engagement via wirelessly uploaded usage data and contacted the parent if they did not engage with the app during a 2-week period to ask if the parent experienced technical problems. Two weeks before the week 12 (end-of-intervention) and week 24 (follow-up) visits, parents were mailed an activity monitor for the child to wear. At weeks 12 and 24, the child's height and weight were measured, the parent and child completed questionnaires, and the child completed the TGMD-3. Research staff deleted the app from the parent's smartphone at the week 24 visit. Children were compensated $75 for participation, receiving $25 for each completed assessment visit.

Interventions

The interventions were previously described.[26] In brief, the research team comprised of experts in motor development and developmental psychology worked with a software development company to design the PLAY app. The PLAY app was available on the iTunes and Android stores but required a unique passcode to enter; each passcode granted access to 1 of 2 versions of the app. To standardize appearance and usability, the 2 versions were similar in design and layout. Parents in the Motor Skills condition had access to weekly motor skills instructional lessons, peer modeling videos, and activity breaks to deliver 12 hours of targeted, structured motor skills instruction time to their child over a 12-week period (12 minutes per day, 5 days per week). The dosage (12 hours) was selected to align with a prior motor skills intervention delivered face-to-face by motor skills experts that effectively improved children's motor skills.[17]

The Motor Skills app used social cognitive theory[27] and behavioral scaffolding[28] via peer modeling videos and activities that taught parents how to model, practice, and reinforce motor skills with their child. The intervention curriculum focused on 6 motor skills (hop, throw, slide, kick, jump, and catch). Parents in the Free Play condition had access to lessons and videos on the app that promoted the equivalent amount (12 minutes per day, 5 days per week) of unstructured physical activity that is not dictated or guided by parents. Topics included strategies to make time for and create an environment conducive to the child's free play: setting goals, reinforcing physical activity, being active indoors and outdoors, and reducing sedentary behavior. Free Play was selected as this approach has increased children's physical activity levels[22] but does not provide structured lessons to model and improve motor skills.

All parents received automated push notifications 5 times per week to remind them to access the content on the app and ensure their child attained the 12 minutes per day, 5 days per week goal. A point system was built in for the child to select a star for each 12-min period completed, earning up to 5 stars each week.

Outcomes

Motor Skills

Children's motor skills (ie, fundamental motor skills) were assessed with the TGMD-3, an internationally used[29] and validated direct observation assessment for children's performance of motor skills, specifically locomotor and ball skills.[30–32] The TGMD-3 is used for research, evaluation of programming, assessment of individual progress, instructional planning, and identification of delay.[30,31] This systematic observation protocol examines developmentally appropriate execution of 13 motor skills (locomotor skills: run, gallop, skip, hop, jump, and slide; ball skills: 2-hand strike, 1-hand strike, dribble, catch, kick, overhand throw, and underhand throw). Trained administrators demonstrated the appropriate technique of completing the skill to the child. Children were allowed 1 practice trial followed by 2 trials that were filmed for later scoring as per the manual guidelines.[30] Children were assessed individually and took approximately 15 minutes.

Each skill is scored on a set of 3 to 5 performance criteria that reflects the appropriate movement execution (eg, stepping with the opposite foot in an overhand throw); a score of "0" indicates the child did not accurately perform the criterion and "1" if the criterion is appropriately demonstrated. Trained administrators, unaware of the treatment condition, scored the video recordings and previously established 99% reliability with the TGMD-3 author. Raw TGMD-3 scores range from 0 to 100; higher values indicate better motor skill performance. Percentile scores, based on age- and sex-specific normative data, and descriptive terms (ie, impaired or delayed, borderline impaired or delayed, below average, average, above average, superior, and gifted or very advanced) were used in the analyses.[30]

Feasibility and Acceptability

Feasibility (adherence) was measured as the number of stars selected, ie, activity period self-reported as complete. Acceptability was measured with parent report over the app at weeks 4, 8, and 12 on 4 domains (satisfaction, helpfulness, ease of use, and likely to recommend to a friend) using a Likert-type scale (Very unsatisfied, Unhelpful, Hard, or Unlikely "1" to

Very satisfied, Helpful, Easy, or Likely "5"). At the week 12 visit, parents completed the 10-item System Usability Scale[33] (eg, "I thought the system was easy to use").

Exploratory Outcomes

Children's physical activity was measured using a hip-worn objective physical activity monitor (accelerometer; Actigraph GT3x+BT) for 7 days using 15-second periods.[34] The minimum wear time was 4 days with ≥10 hours per day (≥1 weekend day). Moderate-to-vigorous physical activity (MVPA) was classified according to Pate cutpoints,[35] and sedentary time was classified using Evenson cutpoints.[36] Children completed the Pictorial Scale of Perceived Movement Skill Competence, which aligns with the skills measured by the TGMD-3 (range 0-52; higher scores reflect higher perceptions of motor competence),[37,38] and parents completed the Devereux Early Childhood Assessment for Preschoolers (DECA-P2) to report child's self-regulation.[39,40]

Other Characteristics

Parents reported child's age and biological sex. Child's height and weight were measured while barefoot using a stadiometer and portable scale and recorded to the nearest 1.0 cm and 0.1 kg, respectively, to calculate BMI z-score.[41]

Sample Size and Power Calculation

A meta-analysis of motor skill interventions informed the estimated effect size (overall effect size $d = 0.39$)[5,42] for a planned group size of 28 children per arm, allowing for 80% power to detect an effect size of 0.33 for change in motor skills score between baseline and week 12 ($\alpha = 0.05$). The research team enrolled 72 children to allow for attrition.

Randomization

The biostatistician created a stratified block randomization scheme taking into account sex and baseline motor skills (split at the 50th percentile). At baseline visit after assessments were complete, an unblinded research staff member revealed the assigned condition to the parent using the randomization module on the REDCap secure online platform.[43] Thirty-five children were randomized to the Motor Skills app intervention, and 37 children were randomized to the Free Play app.

Blinding

Data assessors, investigators, and the TGMD-3 raters were blinded to treatment assignment. Parents and children knew their treatment arm but did not know the primary outcomes or hypotheses of the study.

Statistical Analysis

The associations between the treatment group and total TGMD-3, locomotor, and ball skills percentiles were assessed using an intent-to-treat analysis controlling for child age, sex, and baseline TGMD-3 score. These mixed effect models were repeated with the following dependent variables: motor skill percentile at week 24 and exploratory outcomes at weeks 12 and 24. χ^2 analysis compared proportion of participants rated below average versus average or higher between treatment groups. A secondary analysis using mixed effect linear models examined the skills targeted and not targeted in the app curriculum controlling for sex. DECA-P2 scores were examined as percentile rank for total protective factor and each subcomponent. Statistical significance was defined as $\alpha = 0.05$. Feasibility (adherence) and acceptability were summarized using descriptive statistics. Statistical analyses were conducted using SAS 9.4 (Cary, NC).

RESULTS

Children were recruited and enrolled in May through August 2019. A total of 126 parents completed the screening phone call, and 77 children completed the screening visit (see Fig 1). The final week 24 follow-up visit was conducted between November 2019 and February 2020. Seventy-two children completed a baseline visit, 68 children completed week 12 visit, and 69 children completed week 24 visit. On average, children were 4.0 ± 0.8 years of age at baseline, 57% were girls; 63% were White and 26% were African American (Table 1). There were no significant differences by treatment arm or between dropouts versus completers in regard to baseline characteristics.

Primary Outcome: Motor Skills

Children's motor skills were low at baseline, with an average TGMD-3 percentile of 17.0 ± 12. Between baseline and week 12, children in the Motor Skills condition significantly improved in total TGMD-3 percentile (+13.7 Motor Skills vs −5.3 Free Play, $P < .01$) and for both locomotor skills percentile (+15.5 Motor Skills vs −4.8 Free Play, $P < .01$) and ball skills percentile (+8.3 Motor Skills vs −7.3 Free Play, $P < .01$) (Table 2). Significantly more participants were rated average or higher, according to their TGMD-3 score, in the Motor Skills group at week 12 and week 24 compared with the Free Play group ($P < .0001$), whereas there were no baseline differences. TGMD-3 scores significantly improved for all skills (even those not included in the app), compared with the comparator

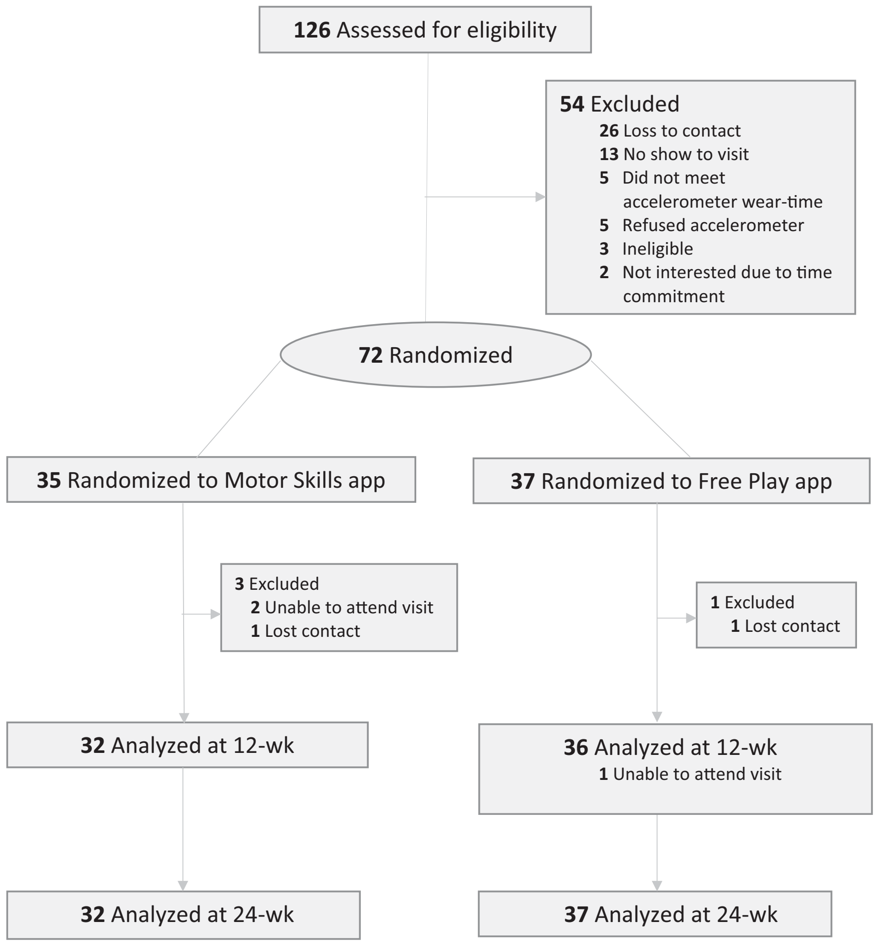

FIGURE 1
CONSORT diagram.

group, from baseline to weeks 12 and 24 (Table 3).

Feasibility and Acceptability

On average, parents reported completing 47 of the 60 prescribed activity breaks (~564 minutes), with similar (not statistically different) adherence in the Motor Skills group (71%) and Free Play group (87%). Parents in both groups found the app acceptable, with high scores (>4.0 of 5.0) across all 3 time points on satisfaction, helpfulness, ease of use, and recommending to a friend. Overall, the app was rated highly usable (27.4 ± 4.0 of 32 raw score or 85.8 ± 12.5 of 100 weighted score), and good to excellent for user friendliness (5.6 ± 0.8 of 7 points).

Exploratory Outcomes

The motor skills differences favoring the intervention condition were sustained at follow-up (week 24). There were no differences by condition in exploratory outcomes at week 12 or week 24 (Table 3).

Safety

Four adverse events were reported, but none were deemed related to the study intervention or procedures.

DISCUSSION

This 12-week mHealth intervention delivered to parents improved children's motor skill proficiency versus an app that promoted free play, and the motor skill improvements were sustained through 6 months. The improvement was sizable, with children in the intervention group improving their motor skills percentile score by 15.5 points, moving them from the "below average" category (baseline = 18.6) to the "average" category (end-of-intervention = 32.3). The intervention also improved motor skills that were not directly targeted in the app, indicating transferability to a more global set of skills that are imperative for future movement behaviors. Importantly, parents and children remained engaged with both versions of the app, and parents reported high usability and acceptability. This home-based

TABLE 1 Characteristics of Children at Baseline

	Motor Skills Intervention(n = 35)		Free Play Control(n = 37)		Total Sample(n = 72)	
	Mean ± SD	*n*	Mean ± SD	*n*	Mean ± SD	*n*
Children						
Age, *y*	3.8 ± 0.8	—	4.1 ± 0.8	—	4.0 ± 0.8	—
Boys	—	15	—	16	—	31
Race						
White	—	21	—	24	—	45
African American	—	8	—	11	—	19
Other	—	6	—	2	—	8
Ethnicity						
Hispanic	—	2	—	1	—	3
Non-Hispanic	—	33	—	36	—	69
Maternal education						
Less than high school	—	0	—	0	—	0
High school	—	5	—	9	—	14
Associate's or bachelor's	—	16	—	17	—	33
Graduate or professional	—	14	—	11	—	25
Household income, $						
< 29 999	—	0	—	5	—	5
30 000 − 69 999	—	8	—	11	—	19
70 000 − 109 000	—	7	—	10	—	17
>110 000	—	18	—	9	—	27
Prefer not to answer	—	2	—	2	—	4
Height, cm	104.4 ± 5.4	—	107.0 ± 7.9	—	105.7 ± 6.9	—
Wt, kg	18.3 ± 3.3	—	18.9 ± 5.0	—	18.6 ± 4.2	—
BMI percentile	65.1 ± 26.7	—	57.3 ± 29.8	—	61.1 ± 28.4	—
BMI z-score	0.5 ± 1.2	—	0.3 ± 1.5	—	0.4 ± 1.3	—

There were no statistically significant differences between conditions.

intervention was safe with no related adverse events. Considering motor skills form the foundation for children's future physical activity pursuits[1–3,13–16] and are linked to improved perceived competence[7] and self-regulation skills,[17] this app intervention provided a low burden, acceptable strategy for parents to improve their children's skills without relying on specialized equipment or expertise.

TABLE 2 Changes in Motor Skills and Exploratory Outcomes in Young Children

	Motor Skills Intervention			Free Play Control			Group Mean Difference in Change	*P*
	BL	W12	Δ	BL	W12	Δ		
Primary Outcome: Fundamental Motor Skills (TGMD-3)								
Locomotor raw scores	10.6 ± 0.9	16.1 ± 1.1	5.5 ± 0.7	13 ± 0.9	11.8 ± 1	−1.2 ± 0.7	6.8 ± 1.0	<.01
Locomotor percentile rank	13.9 ± 2.0	29.4 ± 3.3	15.5 ± 2.9	13.8 ± 1.9	9.0 ± 3.1	−4.8 ± 2.8	20.3 ± 4.0	<.01
Ball skills raw scores	16.1 ± 1.1	18.9 ± 1.2	2.7 ± 0.8	16.1 ± 1.1	15.1 ± 1.1	−1.0 ± 0.8	3.7 ± 1.1	<.01
Ball skills percentile rank	33.9 ± 3.5	42.2 ± 3.1	8.3 ± 3.2	26.7 ± 3.3	19.4 ± 3	−7.3 ± 3.0	15.6 ± 4.4	<.01
Total raw scores	26.7 ± 1.9	35 ± 2.1	8.3 ± 1.0	29.2 ± 1.8	27 ± 2.0	−2.2 ± 1.0	10.5 ± 1.4	<.01
Total percentile rank	18.6 ± 2.3	32.3 ± 3.0	13.7 ± 2.2	14.9 ± 2.1	9.6 ± 2.9	−5.3 ± 2.1	18.9 ± 3.1	<.01
Gross motor index	84.3 ± 1.5	91.4 ± 1.9	7.1 ± 1.4	82.6 ± 1.4	77.1 ± 1.8	−5.5 ± 1.3	12.6 ± 1.9	<.01
Exploratory outcomes								
Sedentary behavior	423.1 ± 9.9	436.6 ± 9.7	13.6 ± 10.3	442.1 ± 9.5	457.0 ± 9.5	14.9 ± 10.0	−1.3 ± 14.4	.93
Light PA	273.8 ± 5.8	281.6 ± 6.7	7.8 ± 5.7	278.2 ± 5.6	279.7 ± 6.6	1.5 ± 5.5	6.3 ± 7.9	.42
MVPA	102.1 ± 5.4	94.1 ± 4.2	−8.1 ± 4.7	103.2 ± 5.2	95.5 ± 4.1	−7.7 ± 4.5	−0.4 ± 6.5	.95
Light PA + MVPA	375.7 ± 9.0	375.4 ± 9.3	−0.3 ± 8.5	381.3 ± 8.7	375.4 ± 9.1	−5.9 ± 8.2	5.6 ± 11.0	.64
Perceived movement skill competence	41.9 ± 1.3	43.1 ± 1.2	1.2 ± 1.2	42.2 ± 1.3	42.3 ± 1.2	0.02 ± 1.1	1.2 ± 1.6	.45
DECA-P2 percentile rank	50.1 ± 4.4	52.2 ± 4.5	2.0 ± 4.0	48.9 ± 4.3	47.4 ± 4.3	−1.5 ± 3.8	3.5 ± 5.5	.53
Total protective factor self-regulation	48.5 ± 5.0	52.6 ± 4.7	4.1 ± 4.1	43.7 ± 4.8	48.8 ± 4.5	5.1 ± 3.9	−1.1 ± 5.7	.85

PA, physical activity.
Values are mean ± SEM.

TABLE 3 Changes in Fundamental Motor Skills and Exploratory Outcomes in Young Children.

Primary Outcome	Motor Skills Intervention W24	Motor Skills Intervention Δ W24 − BL	Free Play Control W24	Free Play Control Δ W24 − BL	Group Mean Difference in Change W24 − BL	P
Fundamental Motor Skills (TGMD-3)						
Locomotor raw scores	16.5 ± 1.1	5.9 ± 0.7	12.5 ± 1.0	−0.5 ± 0.6	6.5 ± 0.9	<.01
Locomotor percentile rank	24.9 ± 2.4	11.0 ± 2.2	9.1 ± 2.3	−4.7 ± 2.0	15.7 ± 3.0	<.01
Ball skills raw scores	19.2 ± 1.0	3.1 ± 0.8	15.3 ± 1.0	−0.8 ± 0.7	3.9 ± 1.0	<.01
Ball skills percentile rank	38.0 ± 2.8	4.0 ± 3.0	17.3 ± 2.6	−9.4 ± 2.8	13.4 ± 4.1	<.01
Total raw scores	35.7 ± 1.9	9.0 ± 0.9	27.8 ± 1.8	−1.3 ± 0.9	10.3 ± 1.3	<.01
Total percentile rank	27.8 ± 2.4	9.2 ± 1.7	8.8 ± 2.2	−6.1 ± 1.6	15.3 ± 2.3	<.01
Gross motor index	89.7 ± 1.6	5.4 ± 1.1	77.0 ± 1.5	−5.6 ± 1.1	11.0 ± 1.6	<.01
Exploratory outcomes						
Sedentary behavior	438.3 ± 10.1	15.2 ± 10.0	441.9 ± 10.2	−0.2 ± 10.0	15.4 ± 14.1	.28
Light PA	272.1 ± 7.4	−1.7 ± 6.7	284.0 ± 7.4	5.8 ± 6.6	−7.5 ± 9.4	.43
MVPA	100.8 ± 4.8	−1.3 ± 5.3	99.5 ± 4.8	−3.8 ± 5.1	2.5 ± 7.4	.74
Light PA + MVPA	372.8 ± 9.6	−3.0 ± 10.3	383.9 ± 9.7	2.5 ± 10.1	−5.5 ± 14.4	.70
Perceived movement skill competence	44.8 ± 1.0	2.9 ± 1.2	44.7 ± 0.9	2.5 ± 1.2	0.4 ± 1.7	.83
DECA-P2 percentile rank	48.5 ± 4.6	−1.6 ± 3.7	49.0 ± 4.4	0.2 ± 3.5	−1.7 ± 5.1	.73
Total protective factor self-regulation	47.7 ± 4.8	−0.8 ± 4.2	49.0 ± 4.6	5.4 ± 4.0	−6.2 ± 5.8	.29

PA, physical activity.
Values are mean ± SEM.

Children's low baseline TGMD-3 scores align with prior data that 77% of US children scored below the 25th percentile,[44] indicating the need for effective motor skill interventions. Ancillary analysis indicated that those children who started at below average or lower improved their TGMD-3 scores to a greater magnitude (14.7 ± 5.6 increase) at end of intervention versus those who stayed in the average or higher category (6.6 ± 6.9 increase; data not shown), though the study was not powered to detect these differences and future research is warranted.

There was no difference between conditions in the exploratory outcomes, including physical activity levels, child's self-rated motor skill competence, and child's self-regulation. Children in this sample were physically active (101 min per day MVPA and 377 min per day total physical activity) at baseline, which meets recommendations of a minimum of 60 min per day MVPA and 180 min per day total PA[45] and aligns with prior studies when taking into account total wear-time and the use of Pate cutpoints.[46] Therefore, it is not surprising that physical activity levels did not change at the end of the intervention, as there was likely a ceiling effect among this group of children. Further, the evidence is inconclusive if there is[10] or is not[47] a correlational link between motor skills and physical activity during preschool. We hypothesize that changes in physical activity engagement will be more pronounced later in childhood; a recent study found that almost 90% of children with low motor skills did not meet physical activity guidelines in late childhood.[2] This finding is similar to a prior study that observed no change in children's physical activity levels after undergoing an 8-week app-based intervention promoting motor skills compared with a wait-list control group.[25] Notably, the lack of difference for physical activity between treatment arms reiterates the ability of the PLAY app to specifically target and improve motor skills independent from a change in the child's physical activity levels. Future work may examine ways in which an app-based intervention can also strengthen the child's perceived motor competence and self-regulation because of their potential relationship to future physical activity engagement.

Strengths of the study include potential for widespread dissemination. A limitation was the relatively homogenous sample (eg, SES, race or ethnicity) and the inability to objectively monitor the child's participation in the 12 hours of prescribed activity beyond parent-report. Measuring participants' fidelity to an intervention is challenging in app-based interventions; asking parents to periodically film their child performing the activity may provide more objectivity yet increases burden on the family. Because motor skills continue to develop throughout childhood, a future direction of research is to examine if parents continue to become more involved with the motor development of their child after completing the 12-week intervention. Also, the app could be further tailored to provide video feedback based on child's progress.

CONCLUSIONS

Compared with children whose parents received app-based instruction on Free Play, children whose parents were instructed on motor skill development significantly improved their motor skills over 12-weeks, and this effect was sustained through 6-months. Based on the results of this trial, clinicians and educators can encourage parents to enhance their child's motor skill proficiency through structured at-home programs. Furthermore, healthcare providers should support parents to engage in activities that will reinforce children's motor skill development especially during the preschool years.

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ABBREVIATIONS

BMI: body mass index
DECA-P2: Devereux Early Childhood Assessment for Preschoolers – 2nd edition
MVPA: moderate-to-vigorous physical activity
PLAY: Promoting Lifelong Activity in Youth
TGMD-3: Test of Gross Motor Development – 3rd edition

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