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SKIPping With PAX: Evaluating the Effects of a Dual-Component Intervention on Gross Motor Skill and Social–Emotional Development

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Improving the development of the social, emotional, and physical domains during early childhood impacts the overall trajectory of a child's well-being. However, researchers often address these independently, leaving a gap for a more integrated approach to promoting development. This study explores the effects of a dual-component intervention on changes in preschool-aged boys' and girls' gross motor and social–emotional skills. Preschoolers ($N = 475$; girls = 220 and boys = 255) ages 3–6 years completed the 9-month dual-component intervention and were randomized into control ($n = 148$) or intervention ($n = 327$) groups by classroom. Significant improvements were observed in social skills, locomotor, and total Test of Gross Motor Development-3. Additionally, boys and girls improved at the same rate in ball skills, locomotor, and total Test of Gross Motor Development-3. These results suggest that the dual-component intervention can improve preschoolers' social skills and motor skills with no differential effects.

Keywords: social skills, problem behaviors, object control skills, locomotor skills

Preschool is a crucial time for the development of self-regulation (Robson et al., 2020) and gross motor skills (Barnett et al., 2016; Bolger et al., 2021). Such skills have been linked to social, emotional, cognitive, psychological, and physical health, as well as academic success across childhood (Barnett et al., 2016; Haapala, 2013; McClelland & Cameron, 2019; Robson et al., 2020). Intervening during

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early childhood may impact the overall trajectory of a child's health and well-being. Unfortunately, intervening during early childhood is becoming more of a requisite than an option as children tend to struggle more and more with early childhood developmental milestones (Brian et al., 2019).

Developing competence in a variety of fundamental motor skills (FMS), a facet of gross motor skill development serves as a critical developmental milestone in early childhood (Clark, 1994). Such skills are necessary building blocks for more complex movements (Logan et al., 2017) and can be split into three domains: object control (e.g., kicking and striking), locomotor (e.g., running), and balance skills (e.g., standing on one foot). The development of FMS competence requires effortful, sustained, and successful practice across time (Clark, 2007). Despite state education systems' mandates on recess and physical education, FMS competency has declined (Brian et al., 2019). In fact, today's 3- to 6-year-old American children (e.g., Brian et al., 2019) and others throughout the world (e.g., Knaier et al., 2023; Rao et al., 2023; Yoshii et al., 2022) exhibit a secular decline in their FMS competency compared with normative references from 20 to 30 years ago (Brian et al., 2019). These trends show that raw scores are decreasing. What once was a raw score for the 25th percentile in the 1980's could now be interpreted as the 50–75th percentile today (Brian et al., 2019). Loosely interpreted, children's movement scores are adapting to the environments we are building (Yoshii et al., 2022).

Fortunately, the decline in motor skill development can be remediated or prevented. Interventions on FMS development in early childhood that target specific domains such as object manipulation and locomotor skills often significantly improve those skills (e.g., $p < .05$, $d = 1–3$) in as little as 6 weeks (360 min) of instructional time (Johnstone et al., 2017; Taunton et al., 2018; Van Capelle et al., 2017). Indeed, Johnstone et al. (2017) completed a 5-month intervention and saw those in the intervention group move from the 24 percentiles to the 40th percentile in locomotor and from the 21st to 36th in object control based on the Test of Gross Motor Development-2 (TGMD-2). The Successful Kinesthetic Instruction for Preschoolers (SKIP) intervention, for example, has a robust and repeated record of marked success in significantly improving ($p < .05$, $\eta^2 = .20–.89$) locomotor and object control skills (Brian et al., 2017a, 2017b; Mulvey et al., 2018; Taunton et al., 2018). For example, Brian et al. (2017a) showed a 10-point improvement in TGMD-3 skills in just 8 weeks. SKIP is an evidence-based motor skill intervention that employs developmentally appropriate instruction and practice in ecologically valid ways (Brian et al., 2017a, 2017b; Mulvey et al., 2018; Taunton et al., 2018).

Boys tend to outperform girls in object control skills (Branta et al., 1984; Brian et al., 2019; Spessato et al., 2013). These sex differences in object control skill development exist despite the biological fact that there are no anthropometric differences across sexes until after puberty. Fortunately, boys and girls demonstrate linear improvements in FMS after participating in an intervention (Palmer et al., 2020; Taunton Miedema et al., 2023). Thus, early intervention could help to prevent the gap between girls and boys regarding object control skills (Barnett et al., 2010; Palmer et al., 2020; Taunton Miedema et al., 2023), which are powerfully predictive of lifespan physical activity behaviors (Barnett et al., 2008).

While FMS development is integral to childhood development, it is only one of many domains which comprise overall child development. Social–emotional development in childhood is linked to mental health, quality of life, academic achievement, and overall success (Hall & DiPerna, 2017; Rhoades et al., 2011). Social–emotional development in childhood can have long-term mental health repercussions (Kemple et al., 2019). Programs, such as the PAX-Good Behavior Game (PAX-GBG), positively impact mental health, social skills (SS), and reduce problem behaviors (PB) in the classroom (Jiang et al., 2018; Newcomer et al., 2016). Interventions that only focus on social–emotional well-being often result in modest improvements ($p < .05$, $d = .22$) in social and emotional outcomes (Hamre et al., 2012; Murano et al., 2020). As previously mentioned, SKIP often produces large improvements in FMS ($p < .05$, range: $\eta^2 = .20–.89$; (Brian et al., 2017a, 2017b; Mulvey et al., 2018; Taunton et al., 2018). Previous intervention efforts have focused on a single-intervention strategy (e.g., only FMS or only social–emotional) and measured the solo intervention effects on multiple outcomes (Robinson et al., 2016). However, the effects on a combined FMS and social–emotional learning intervention are unknown.

Developmental theory and research have had a sustained interest in the intricate processes through which functioning in one domain, level, or system exerts influence on another system or level over time (Thelen & Smith, 1998; Ward, 1995). The cumulative effects of these intricate processes are often referred to as developmental cascades and result in spreading effects across levels, domains of the same level, and across different systems, thereby altering the course of development (Masten & Cicchetti, 2010). In theory, the effects encompassed within developmental cascades may be direct and unidirectional, direct and bidirectional, or indirect via various pathways (Masten & Cicchetti, 2010). Thus, a dual-component intervention that includes FMS and social–emotional domains may promote greater cascading effects on social–emotional outcomes, which are often difficult to shift in isolation (Figure 1).

However, dual-component efforts are not widely researched warranting the need for exploration. Furthermore, dual-component intervention may help preschool teachers optimize their classroom efforts and maximize impacts on their students' motor and social–emotional development. Therefore, the purpose of this study was to explore the effects of a dual-component FMS and social–emotional intervention on changes in FMS and SS in children. We hypothesized that the children in the experimental group would show greater improvements in FMS than those in the control group, and there would be no differential effects based on biological sex for FMS. Furthermore, we hypothesized that the experimental group would show a larger reduction in PB and greater SS improvements than those in the control group.

Methods

Procedures

This study featured a pre-, posttest, quasi-experimental study design to examine the effects of the dual-component intervention on all outcome variables. All procedures were approved by the University of South Carolina institutional review board. Students were recruited via information letter to parents at a large, rural, publicly funded early childhood center (ECC) in the southeastern region of the United States. Parents provided informed written consent, and children provided verbal assent to participate in the study. Students in intervention classroom still

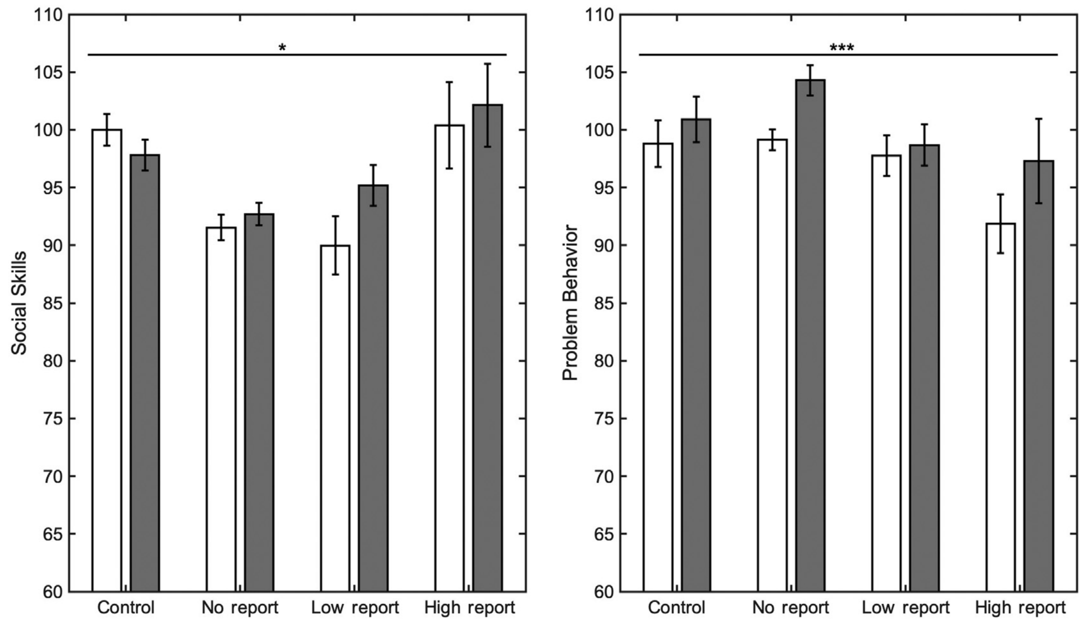

Figure 1 — SSIS–SS and PB. *Note*. Means and *SE*s are presented. The lines represent the post hoc comparisons. *$p < .01$. ***$p < .001$. SSIS = Social Skill Improvement System; SS = social skills; PB = problem behaviors.

received the intervention but were only included in the data collection if parents consented. Prior to the school year and the start of testing, all intervention group classroom teachers ($N = 14$) participated in and completed formal training (6 hr total) for the PAX-GBG program led by a certified PAX provider. Participants were eligible if they attended the ECC and were in a classroom where the teachers agreed to be a part of the study. Students in the self-contained classroom received the intervention but were excluded from the analysis.

Participants and Setting

Participants included children ages ($N = 475$; 44–79 months $M_{age} = 66.4$, $SD = 8.15$ months) enrolled in a large, rural, publicly funded ECC in the southeastern region of the United States. See Table 1 for participant details.

Dual-Component Intervention

The intervention in the present study consists of the combination of two existing programs: (a) PAX-GBG, a classroom-based positive behavior program (Johansson et al., 2020) and (b) SKIP, a gross motor skill intervention. Both programs were implemented within the physical education classroom. Additionally, PAX-GBG was implemented in the general education classroom. PAX-GBG is a classroom-based behavior management style that uses a caring classroom environment framework and promotes repeated opportunities to practice good behavior and positive SS. The PAX-GBG intervention consists of evidence-based PAX kernels, including PAX Leader, PAX Quiet, PAX Voices, PAX Vision, Beat the Timer, and PAX Hands and Feet, that act as cues and strategies to focus students' attention on specific positive behaviors. Previous use of the PAX-GBG framework in elementary school and beyond has demonstrated increases in prosocial behaviors, improvements in academic skills, and reduction in undesirable or negative behaviors among students (Jiang et al., 2018; Newcomer et al., 2016), as well as simultaneous improvements related to teacher well-being, self-efficacy, and stress-related outcomes (Hopman et al., 2018). This is the first study of its kind, to our knowledge, to utilize the PAX-GBG in ECC settings with children ages

Table 1 Participant Demographics

	Control	Intervention
Total	148	327
Girls	75	145
Boys	73	182
Mean age (months)	61	63
White	97	208
African American/Black	20	63
Hispanic	25	25
Asian	0	2
Other	6	12

3–6 years. Developmentally appropriate modifications were made to the protocol of PAX-GBG. All 13 *kernels* (i.e., main behavior concepts) were included in the curriculum, but they only focused on three or less per lessons/game. PAX Games, used to reinforce and practice the concepts, were also shortened to allow for 2.5–5 min (standard is 5 min). This allowed them to build up their competency in the behaviors addressed (i.e., hands to yourself and how to use your voice).

SKIP is a gross motor skill intervention that provides a process-based motor learning environment where the children can learn their FMS. During the SKIP intervention, children are provided with FMS instruction in an environment structured with movement opportunities to practice developmentally appropriate tasks. The SKIP intervention procedures have consistently elicited increases in FMS with large effect sizes (Brian et al., 2017a, 2017b; Taunton et al., 2018) through diverse groups of implementers including researchers, physical education teachers, classroom teachers, and parents. Additional details of SKIP procedures can be found elsewhere (Brian & Taunton, 2018).

Control Condition

Participants in the control condition received the center's business-as-usual curriculum both in the classroom and during recess. The center's current curriculum matches that of the requirements for the state. Recess is provided to each classroom for 30 min, twice per day, using a block schedule and alternating locations between the playground and a grass field. Daily recess times are unstructured and provide designated "free play" time for children without teacher instruction. Various pieces of equipment (e.g., stationary playground, tricycles, balls, sandbox, sidewalk chalk, and toys) are available to children, although engagement with equipment is not required.

Instrumentation

Test of Gross Motor Development, Third Edition

The TGMD-3 is both a normative and criterion-referenced motor assessment for children ages 3–10 years, 11 months (Ulrich, 2019), and was used in this study to measure FMS competence. The TGMD-3 includes a locomotor skill subscale with six items (run, gallop, hop, horizontal jump, skip, and slide) and a ball skill subscale with seven items (two-hand strike, one-hand strike of a self-bounced ball, dribble, two-hand catch, kick, overhand throw, and underhand toss). Standardized TGMD-3 procedures include a verbal description and physical demonstration of each item by the assessor, followed by two performance trials by the child. If the child appears to misunderstand the skill or to perform a different skill than demonstrated, the child receives a second demonstration. When scored, each of the TGMD-3 skills is evaluated on the presence of three to five criteria in each trial, consisting of a total skill score range of 6–10 points per item. The raw scores for each skill are summed to generate raw locomotor (0–46) and ball skill (0–54) subtest scores, and the subtest scores can be combined to create an overall GMS score (0–100). The raw subtest and overall motor scores are converted into reference standards, including age-equivalents, scaled scores, and percentile ranks, to serve as a normative performance reference. For this study, the raw scores are presented. The TGMD-3 holds strong psychometric properties for preschoolers and young children, and additional details can be found in other literature (Ulrich, 2019). Test–retest reliability had high intraclass correlation (ICC) agreements for the locomotor (ICC = .97), ball skills (ICC = .95), and total TGMD-3 (ICC = .97). For validity measures, the TGMD-3 had above acceptable item difficulty (range = .43–.91; Webster & Ulrich, 2017).

Social Skill Improvement System

The Social Skill Improvement System (SSIS) rating scale is a teacher report survey measure that assesses social–emotional skill domains important for social interaction (Gresham & Elliott, 2008). The SSIS computer entry teacher form was used in this study and consists of a paper booklet that teachers complete by answering questions related to a single student. While the booklet includes survey items across three subscales, only items related to the SS and PB subscales were used (omitting the academic competence scale). Survey items in both subscales are rated on a 4-point response scale measuring how often a student displays the target behavior: (a) *never*, (b) *seldom*, (c) *often*, or (d) *almost always* (Gresham & Elliott, 2008). PB subscales include externalizing (e.g., tantrums, defiance, and vandalism; 12 items), bullying (five items), internalizing (e.g., social withdrawal, loneliness, anxiety, and depression; 10 items), and hyperactivity (seven items). Overall, PB has a mean of 100 ($SD = 15$) points with lower scores equaling fewer PB. SS subscales include communication (seven items), cooperation (six items), assertion (seven items), responsibility (six items), empathy (six items), engagement (seven items), and self-control (seven items). Overall, SS has a mean of 100 ($SD = 15$) points with higher scores equaling higher SS. Test–retest reliability is .81–.84 (Gresham & Elliott, 2008). For this study, the raw scores are presented.

Data Collection

Two weeks prior to the intervention, trained members of the research team pretested all intervention and control participants on the TGMD-3 using standardized procedures and digitally recorded all trials. The research team implemented the TGMD-3 on-site at the ECC. All classroom teachers completed the SSIS rating scales for each of their students within a 2-week period prior to the start of the intervention. Following the return of the SSIS rating scales from all teachers, researchers tallied the scores for each student. The same data collection procedures for TGMD-3 and SSIS occurred within 2 weeks after the completion of the intervention (e.g., posttest).

After pretesting, trained physical education teachers implemented SKIP with all lessons digitally recorded. To ensure the SKIP intervention was implemented with fidelity, a member of the research team randomly selected and coded 30% of the digitally recorded SKIP lessons using a SKIP Fidelity checklist (e.g., Brian et al., 2017b). Based on the checklist, the physical education teachers implemented SKIP with 85%–100% fidelity throughout the intervention.

Dual-Component Intervention Procedures

After pretest data collection ended, experimental procedures began for the 14 classrooms in the intervention group. The 9-month intervention took place during the typical school day. Intervention group participants received 30 min of SKIP with PAX-GBG, twice per week, in the ECC gymnasium, during two of their daily scheduled recess blocks. Additionally, participating classroom teachers were asked to implement PAX-GBG protocols into their daily classroom routine for the entire school year. Teachers were given forms to complete every time they completed a PAX-GBG. These forms were collected as self-reported fidelity by the teachers. From these data, we categorized responses into three distinct groups. For the teachers who did report the use of GBGs, we applied a median-split approach to create our first two categories: (a) low-report, this group included teachers who reported between one and eight GBGs ($n = 83$). (b) high-report, this group comprised teachers who reported 10 or more GBGs ($n = 33$). The application of a median split helped ensure a balanced distribution within these categories. (c) Our final no-report group consisted of teachers who did not report the use of GBGs with students ($n = 122$). These groupings provided additional insight into the social–emotional data and were used to indicate the estimated dose of PAX-GBG.

During the 3 nonintervention days, the children in the experimental group received the same, business-as-usual recess (30 min of unstructured free play) as the control group.

Business-as-Usual Procedures

The control group received the typical classroom management practices employed at the school. During recess, they would have access to the same equipment as the intervention group. Recess was provided twice daily, 5 days per week for 30 min each day.

Data Coding

All TGMD-3 trials were coded by data collectors who were blinded to time and condition. All coders demonstrated at least 85% agreement with an expert coder on a 10% of the videos prior to individually coding a randomly assigned allotment of participant videos.

Statistical Analysis

For each dependent measure, hierarchical linear models were conducted using R (version 4.2.1; R Core Team, 2022) and R Studio (version 2022.07.2.576; RStudio Team, 2022). The best-fit hierarchical linear model for each dependent measure was selected by using model selection. The raw scores were used for TGMD and SSIS. In each model, we controlled for random effects (i.e., subject and PAX-GBG classroom teacher). Fixed effects included Condition (control and intervention), Dose, Sex, and Time (pre or post). The best-fit model was selected for each variable. Follow-up *t* tests were used to examine the significant main effects and interactions. The level of significance was set to $p < .05$ for all analyses. The level of variance allowed was set at <10% (Hox & Roberts, 2011).

The nested design was selected due to the interclass correlations. An intraclass correlation was conducted to understand the amount of variance in the SS and PB scores that was due to the teacher's rating. The variance attributed to teacher rating was 17%, therefore not meeting the <10% allowed. Thus, the teacher became a nested random effect for PB and SS.

The dependent variables (DVs) included the raw subscale score of PB and SS from the SSIS. PB included the categories: externalizing symptomologies, bullying, hyperactivity, and internalizing. SS included communication, cooperation, assertion, responsibility, empathy, engagement, and self-control. For the motor skill assignment, raw scores from the TGMD were used including total TGMD score and the two subscales, object control and locomotor. The independent variables were sex, time, dose, and condition.

Model Selection. For DVs, model selection was conducted by starting with the base model, DV∼1 + (∼1|teacher). From there, each model was built and compared with the one that had the lower Akaike information criterion. The model selected for each DV is as follows: PB and its subscales DV∼Time × Dose + (∼1|teacher/id), SS, and DV∼Time × Condition + (∼1|teacher/id), and TGMD and all the subscales DV∼Time × Condition × Sex+ (∼1|id).

Results

PB and Subscales. For PB (Figure 1), within the nested model, children scored significantly worse across time ($\beta = 3.81$), $t(363) = 4.0$, $p < .0001$, $\eta^2 = .06$. This was mainly driven by the no-report group which was significantly worse from pre- to posttest ($\beta = -5.565$), $t(360) = -5.208$, $p < .0001$. No other group reached significance from pre to post in any other group. The no-report group was worse than the control group regardless of time ($\beta = 3.81$), $t(404) = 2.646$, $p = .03$, $\eta^2 = .03$. No other groups were significantly different.

For externalizing symptomologies (Figure 2), within the nested model, children scored significantly worsen across time ($\beta = 1.14$), $t(354) = 4.0$, $p = .0003$, $\eta^2 = .04$. This was mainly driven by the no-report group which was significantly worse from pre- to posttest ($\beta = -1.74$), $t(351) = -3.97$, $p = .002$. No other group reach significance from pre to post in any other group.

For bullying (Figure 2), within the nested model, children scored significantly worsen across time ($\beta = 0.72$), $t(354) = 5.92$, $p < .0001$, $\eta^2 = .09$. This was mainly driven by the no-report group which were significantly worse from pre- to posttest ($\beta = -1.18$), $t(351) = -6.97$, $p < .0001$ and the high-report ($\beta = -0.60$), $t(351) = -1.94$, $p = .05$. The no-report group was significant worse than the control group at posttest ($\beta = -0.71$), $t(351) = -3.14$, $p < .01$. No such difference occurred at pretest.

For hyperactivity (Figure 2), there were no time-related changes; however, low-report was worse than high-report regardless of time ($\beta = 0.72$), $t(354) = 5.92$, $p < .0001$, $\eta^2 = .09$.

For internalizing (Figure 2), within the nested model, children scored significantly worse across time ($\beta = 0.63$), $t(354) = 3.50$ $p < .001$, $\eta^2 = .03$. This was mainly driven by the no-report group which were significantly worse from pre- to posttest ($\beta = -1.04$), $t(351) = -6.97$, $p < .0001$. The no-report group was significant worse than the low group at posttest ($\beta = -1.64$), $t(351) = -3.29$, $p = .006$. No such difference occurred at pretest.

SS and Subscales

For SS (Figure 1), within the nested model, there was a Time × Condition effect ($\beta = 3.40$), $t(356) = 2.02$, $p = .04$, $\eta^2 = .01$. All groups that were in the intervention

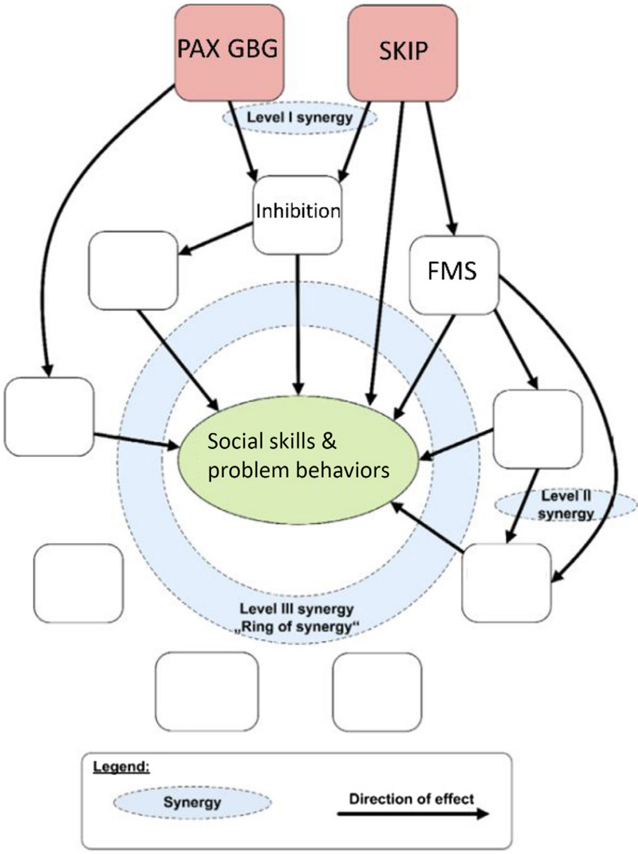

Figure 2 — Dual-component intervention.

improved their SS from pre to post (β = 1.97), $t(356) = 2.16$, $p = .03$. No such improvements were seen in the control group.

For communication (Figure 3), within the nested model, there was a Time × Dose effect (β = 2.10), $t(351) = 1.94$, $p = .05$, $\eta^2 = .03$. This was driven by the low-report group that improved significantly from pre- to posttest (β = 1.53), $t(351) = 2.83$, $p < .01$. For cooperation (Figure 3), within the nested model, there was a Time × Dose effect (β = 2.39), $t(351) = 2.55$, $p = .01$, $\eta^2 = .03$. This was driven by the high-report group (β = −1.81), $t(351) = 2.23$, $p = .03$, and the control group (β = –0.69), $t(351) = 2.08$, $p = .04$, getting significantly worse from pre- to posttest. For assertion (Figure 3), within the nested model, there was a Time × Dose effect (β = 2.47), $t(351) = 2.52$, $p = .01$, $\eta^2 = .02$. This was driven by the higher-report group (β = 1.39), $t(351) = 4.68$, $p < .0001$, that improved significantly from pre- to posttest. For responsibility (Figure 3), within the nested model, there was a Time × Dose effect (β = 1.98), $t(351) = 2.03$, $p = .02$, $\eta^2 = .03$.

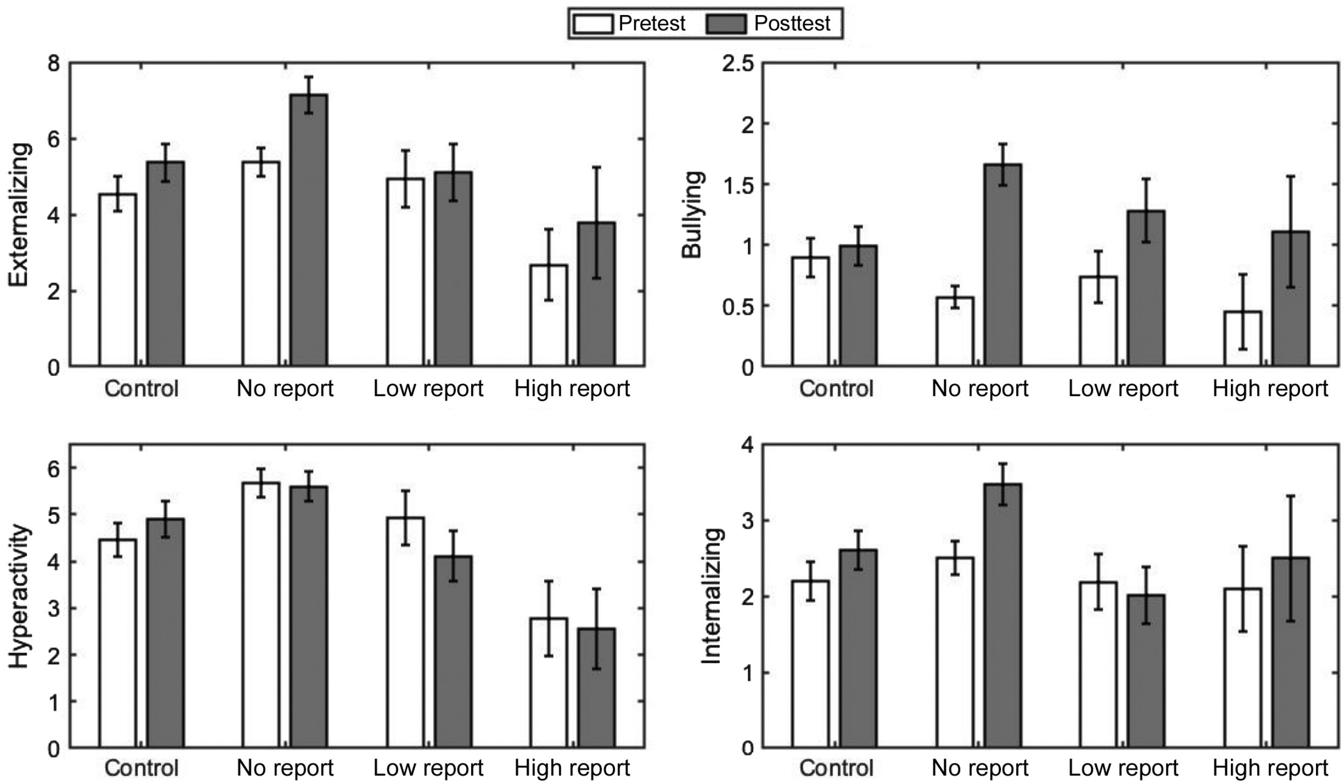

Figure 3 — SSIS–PB subscales. SSIS = Social Skill Improvement System; PB = problem behaviors.

For empathy (Figure 3), within the nested model, there was a Time × Dose effect ($\beta = 2.39$), $t(351) = 2.23$, $p = .03$, $\eta^2 = .03$. This was driven by the low-report group ($\beta = 1.49$), $t(351) = 2.78$, $p < .01$, and no-report group ($\beta = 0.87$), $t(351) = 2.96$, $p < .01$, that improved significantly from pre- to posttest. For engagement (Figure 3), there were no significantly changes or differences. For self-control (Figure 3), there were no significantly changes or differences.

Test of Gross Motor Development, Third Edition

For object control (Figure 4), there was a significant effect of Time ($\beta = 3.53$), $t(366) = 4.51$, $p < .0001$, $\eta^2 = .64$, Sex ($\beta = 5.37$), $t(388) = 3.72$, $p < .0001$, $\eta^2 = .12$, and a Condition × Time interaction ($\beta = 9.30$), $t(366) = 10.17$, $p < .0001$, $\eta^2 = .22$. Follow-up *t* tests revealed that both the control condition, $t(366) = -4.513$, $p = .0001$, $d = 0.60$, and the intervention condition, $t(366) = -27.271$, $p < .0001$, $d = 2.11$, improved their overall scores (see Figure 3). Examining further, the intervention condition improved more than the control condition creating the Condition × Time interaction. Both girls, $t(366) = -27.271$, $p < .0001$, $d = 2.337$, and boys, $t(366) = -27.822$, $p < .0001$, $d = 2.330$, in the intervention condition improved from pre- to posttest (see Figure 4). Boys were better than girls regardless of time, $t(388) = -5.37$, $p < .0001$, $d = .90$. However, boys and girls improved at the same rate across the intervention.

For locomotor skills (Figure 4), time ($\beta = 1.64$), $t(370) = 2.07$, $p = .04$, $\eta^2 = .46$, and a Condition × Time interaction ($\beta = 7.77$), $t(364) = 8.44$, $p < .0001$, $\eta^2 = 16$. Follow-up *t* tests revealed that the intervention condition significantly improved their scores, $t(370) = -19.700$, $p < .0001$, $d = 1.68$, while the control group did not, $t(370) = -2.076$, $p = .1628$. There were no significant differences between boys and girls. Additionally, on average boys, and girls improved at the same rate across the intervention.

For TGMD-3 (Figure 4), there was a significant effect of time ($\beta = 5.19$), $t(364) = 4.28$, $p < .0001$, $\eta^2 = .69$, Sex ($\beta = 4.71$), $t(388) = 3.72$, $p < .0001$, $\eta^2 = .03$, and a Condition × Time interaction ($\beta = 17.10$), $t(364) = 12.07$, $p < .0001$, $\eta^2 = .29$. Follow-up *t* test revealed that both the control condition, $t(364) = -4.283$, $p = .0001$, $d = .60$, and the intervention condition, $t(364) = -30.514$, $p < .0001$, $d = 2.625$, improved their overall scores TGMD-3 scores from pre- to posttest (Figure 4). Examining further, the intervention condition improved more than the control condition creating the Condition × Time interaction. In the intervention group, both girls, $t(364) = -22.259$, $p < .0001$, $d = 2.51$, and boys, $t(364) = -22.1$ $p < .0001$, $d = 2.50$, in the intervention condition improved from pre- to posttest. Boys were better than girls regardless of time, $t(388) = -3.772$, $p = .0013$, $d = 0.70$. However, boys and girls improved at the same rate across the intervention.

Discussion

The purpose of this study was to explore the effects of a dual-component intervention on changes in FMS and social–emotional skills in children ages 3–6 years. Results from the present study support the hypothesis that the children who received the dual-component intervention would show greater improvements in FMS than those in the control group. Additionally, there were no differential

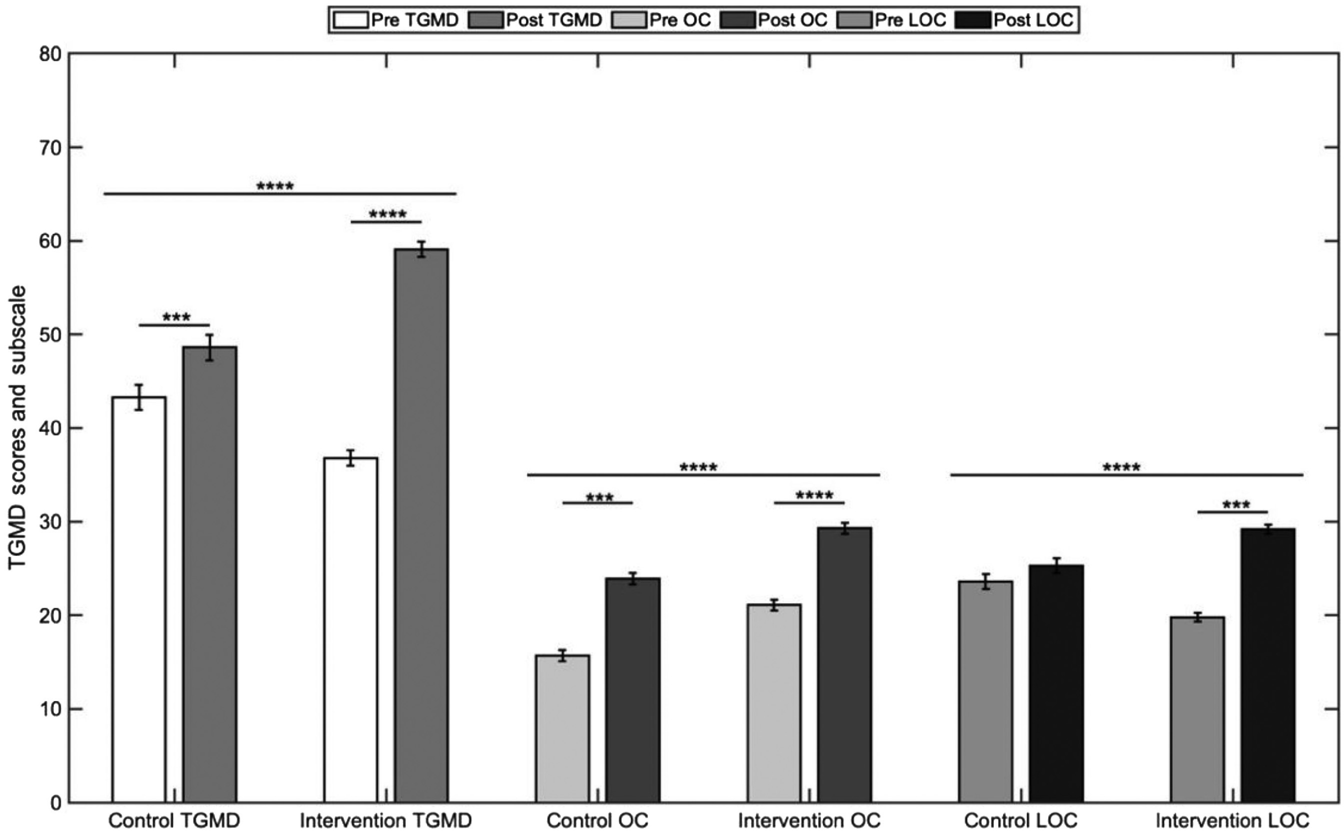

Figure 4 — TGMD-3 and subscales. *Note*. Means and *SE*s are presented. The lines represent the post hoc comparisons. ***$p < .001$. ****$p < .0001$. TGMD = Test of Gross Motor Development combine score; OC = Object Control/Ball Skills; LOC = Locomotor Skills.

effects of FMS improvement based on biological sex. Our hypothesis that the dual-component intervention would improve SS and reduce PB was partially supported.

Fundamental Motor Skills

Consistent with previous studies (Brian et al., 2017a, 2017b; Brian & Taunton, 2018; Mulvey et al., 2018; Taunton et al., 2018), the intervention group demonstrated large changes in TGMD-3 scores, including both subscales (ball and locomotor skills). These large changes mark the continued success of the intervention across the 9-month period. Trained physical education teachers rather than researchers implemented the SKIP intervention to emphasize a more ecological approach.

We observed a difference in skill levels between boys and girls (i.e., gender gap) in object control skills at the pretest which aligns with previous literature (Barnett et al., 2010; Brian et al., 2019; Spessato et al., 2013). Additionally, we found no such differences in locomotor skills. Additionally, boys and girls in the intervention group both increased their object control skills and locomotor skills at the same rate. These comparable changes are in line with recent research that shows boys and girls demonstrate linear improvements in FMS before and after a motor skill intervention (Palmer et al., 2020; Taunton Miedema et al., 2023). Our results add to the growing evidence that early intervention in preschool may help address sex differences in levels of FMS competence if researchers only intervene on girls or intervene prior to the appearance of sex differences.

These sex differences occur despite minimal anthropometrical and physiological differences between biological sex until after the onset of puberty. Our dual-component approach demonstrated significant improvements in FMS regardless of biological sex and may also serve to remediate developmental motor delays for girls. While our intervention did not close the sex gap, the equal rate of change between boys and girls supports early identification and intervention for girls as a viable method for preventing a sex gap from occurring.

Social Skills

Although PAX-GBG has been vetted for elementary, middle, and high school-aged students with marked success (Embry, 2002), this is the first study to implement PAX-GBG with preschool students. Furthermore, this is the first study of its kind to implement the PAX-GBG with an FMS intervention (SKIP) on SS and PB in addition to expected improvements in FMS.

SKIPping with PAX began during the COVID-19 pandemic as students returned to preschool (Fall 2020). For many children, COVID-19 caused a reduction in SS development and a worsening in problematic behaviors (Barnett & Jung, 2021). The results of the current study show that SKIPping with PAX may have provided a protective effect for the students. Within the intervention group, teachers reported varying degrees of implementation of PAX-GBG. Interestingly, there appeared to be somewhat of a quadratic relationship among teacher-reported game play and SS improvements. Those in low-report revealed the most benefit compared with high-report and no-report. Conversely, the control group saw a slight, but not significant, decrease in SS. These results may indicate that the dual-component intervention helps to protect the students from SS decline. Additionally, low-report teachers saw the largest improvements indicating that between one and eight games may be the optimal dose to gain the maximum benefit of PAX-GBG in preschool-age children. Low-report may have had the most accurate reporting of their participation suggesting that the teachers implemented the intervention with more fidelity.

Regarding PB, there was an overall increase in PB during the intervention. However, this increase was driven by a large surge in PB from the no-report intervention group. No-report was supposed to receive the intervention, yet the teachers did not complete their reports for PAX-GBG. Meaning these teachers did not provide PAX-GBG with fidelity to their class including the kernels that target reductions in PB. The changes in the other groups, including the control, were not significant; however, all group mean scores slightly increased PB (e.g., worsened). This indicates that providing PAX-GBG with fidelity might be protective against children exhibiting PB.

Regarding PAX-GBG participation, students in no-report classrooms scored significantly higher in internalizing and externalizing behaviors than those in Groups 1 and 2. Teachers who struggled to implement the intervention may have negatively impacted internalization and externalizing behaviors as teacher behaviors have been shown to influence student behaviors (Finch et al., 2023).

Limitations

The present study was implemented with two cohorts from Fall 2020 to Spring 2022, which coincided with the height of the COVID-19 crisis and consequently includes several limitations. First, our classroom and physical education teachers were under unprecedented amounts of stress which varied the implementation of the interventions from class to class. While we were able to use the reports to glean some understanding of their fidelity, it is unclear how strongly the teachers implemented the full PAX-GBG. Additionally, because the three groups (low-, high-, and no-report) were not randomly assigned and were a result of teacher implementation, it is unclear whether there is systematic difference between this groups. As such, the information regarding changes to PB and SS by group should be examined within this lens. Next, we did not directly measure student absences across the school year due to quarantines at the classroom and school level throughout the study. Future research should examine dose–response effects of the dual-component intervention to determine optimal intervention doses for targeted outcomes. Furthermore, examining potential solutions for helping teachers provide effective and efficient evidence-based interventions that target multiple developmental domains is imperative to combat children's declining mental health (Mojtabai & Olfson, 2020). Future research should examine ways to assist teachers in the implementation of dual-component interventions.

Conclusions

Dual-component approaches that target multiple developmental domains such as motor, cognitive, and social–emotional skills may optimize teacher classroom efforts and maximize impacts on student development. The purpose of this study was to explore the effects of a dual-component approach on changes in preschool-aged boys' and girls' fundamental motor and social–emotional skills during the COVID-19 pandemic. Our intervention provided a protective effect on students' PB at a time when children across the globe experienced increases in PB (Barnett & Jung, 2021). In addition, our intervention improved both boys and girls FMS and SS at equal rates which may serve as a viable tool for reducing sex differences in early childhood. Future research should continue to explore the impact of PAX-GBG in early childhood as well as examining the effects of dual-component interventions on other dimensions of physical and psychological health in early childhood.

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