

Research article

Guided Active Play Promotes Physical Activity and Improves Fundamental Motor Skills for School-Aged Children

Asal Moghaddaszadeh and Angelo N. Belcastro ✉

Pediatric Exercise Sciences Laboratory, School of Kinesiology and Health Science, and Muscle Health Research Centre, Faculty of Health, York University, Toronto, Ontario, Canada

Abstract

Reports show that children's physical activity (PA) levels are related to FMS proficiency; however, whether PA levels directly improve FMS is uncertain. This study investigated the responses of PA levels and FMS proficiency to active play (AP) and guided active play (GAP) interventions. Three community programs (seven-weeks; 4d·wk⁻¹) were randomly assigned to: i) active play (CON); ii) locomotor skills (LOC) guided active play (GAP); and iii) object control skills (OC) GAP groups. Children's (n = 52; 6.5 (0.9) yr) interventions included continuous and/or intermittent cooperative games focused on either locomotor skills (i.e. blob tag, red-light-green-light) or object control skills i.e., hot potato, racket balloons, 4-way soccer). PA levels (accelerometers) were assessed on 2 of 4 sessions per week throughout the program. The Test of Gross Motor Development-2 (TGMD-2) was used to assess FMS scores. The changes for CON and LOC interventions for locomotor standard scores were -0.83 (2.61) vs. 2.6 (2.64) ($\alpha = 0.022$), for locomotor percentiles -9.08 (36.7) vs. 20.1 (30.4) ($\alpha = 0.033$) and for gross motor quotient percentiles -4.3 (30.3) vs. 24.1 (29.6) ($\alpha = 0.022$). Children's PA levels averaged 158.6 (6.6) kcal·55min⁻¹ for CON vs. 174.5 (28.3) kcal·55min⁻¹ for LOC ($\alpha = 0.089$) and 170.0 (20.1) kcal·55min⁻¹ for OC ($\alpha = 0.144$). Moderate-Vigorous PA was 18.4 (8.0) %, 47.9 (7.8) % ($\alpha = 0.000$) and 51.9 (6.0) % ($\alpha = 0.000$) for CON, LOC and OC, while time at sedentary/very light PA was 36.4 (9.8) %, 15.1 (4.9) % ($\alpha = 0.000$) and 14.9 (15.9) %Sed/VL ($\alpha = 0.001$) during the 7-week program. The OC intervention showed more upper body movement experiences compared to the LOC program ($p = 0.020$). A guided active play program using LOC cooperative games showed increases in energy expenditure and %MVPA and improved FMS proficiency, but active play did not. For school-aged children (5-7 yr) guided active play using cooperative games may be an effective strategy to improve FMS and promote health and fitness benefits.

Key words: Play, exercise movement techniques, performance of complex motor acts.

Introduction

The importance of improving fundamental motor skill (FMS) competency as a strategy to promote more complex (sport-skills) movements, increase physical activity (PA) participation and gain physical health-related benefits throughout childhood has been well documented (Stodden et al., 2008; Barnett et al., 2008; Barnett et al., 2009; Lubans et al., 2010). Despite their importance, FMS do not develop on their own; but rather they must be taught, and children encouraged to practice FMS to improve motor skill proficiency starting in preschoolers and continuing with school-aged children (Goodway and Branta, 2003;

Gordon et al., 2013). In an attempt to improve children's FMS different program formats have been studied ranging from relatively simple unstructured activities with no instruction (i.e., free play), to self-paced, unstructured fun activities with minimal instruction and encouraging increased energy expenditure (EE) for the majority of time (i.e. active play) (Truelove et al., 2017) to complex structured, professionally led, motor skill instructional activities with targeted outcomes (Hardy et al., 2014). Although a moderate relationship between children's daily physical activity levels and FMS proficiency exists for preschool and school-aged children, our understanding of the interactions between physical activity levels and levels of FMS with different intervention formats is unclear (Lubans et al., 2010; Logan et al., 2011; Hardy et al., 2014). With free play there is insufficient time spent on learning opportunities for FMS and to increase PA levels, while professionally delivered school-based physical education (PE) classes lack the necessary physical activity levels and practice time for FMS improvements (Gallahue et al., 2011; Logan et al., 2011; Castelli, 2019). To overcome these challenges, it has been suggested that the higher physical activity levels observed for active play may also improve FMS for preschool and school-aged children (Engelen et al., 2013; Adamo et al., 2016; Johnstone et al., 2017; Foulkes et al., 2017; Lee et al., 2020). Although the positive interaction between PA levels and FMS proficiency proposed for active play seems plausible, the effect and benefits of active play programs on increased PA levels and improved FMS remains unclear (Johnstone et al., 2018).

To increase our understanding of the effect and benefit of active play on children's physical activity and FMS levels, it is important that active play interventions include, attributes and qualities associated with active play (Truelove et al., 2017). Of these, the importance of maintaining a high proportion of time in physical activity (EE, %MVPA) with less sedentary time, and providing more learning opportunities to practice/experience motor skills, are essential (Logan et al., 2011; Adamo et al., 2016; Johnstone et al., 2017). Pyle and Daniels (2016) have reported that for play-based learning, the time for uninterrupted free (active) play, which embeds learning experiences (i.e. role modeling), is an effective method to improve student learning. It has been suggested that using other forms of active play, such as facilitated active play, purposely framed play and/or modeled/guided active play may be an effective approach to promote improvements in FMS (Fisher et al., 2013; Belcastro et al., 2015; Truelove et al., 2017). Whether a guided active play program compared to an

active play program, both focused on locomotor skills, will promote higher PA levels, more time at MVPA and improved FMS is uncertain.

Children playing cooperative games may be an effective strategy to support guided active play interventions focused on increasing PA levels and motor skill levels. Cooperative games are comprised of locomotor and object control skills and have been reported to elicit a range of self-paced energy expenditures (EE) and time spend at moderate-to vigorous physical activity levels (%MVPA) that are independent of the order of presentation and reproducible one week later (Belcastro et al., 2012). Furthermore, when children's games are incorporated into an 8-week guided active play (locomotor skills) program (Belcastro et al., 2015) and/or an endurance training program, cardiorespiratory fitness is improved (Lambrick et al., 2016). Whether cooperative games used in guided active play interventions, targeting either locomotor skills (running, jumping, galloping - lower body movements) or object control skills (throwing, catching, rolling a ball - upper body movements) will result in more opportunities for practicing and experiencing locomotor versus object control skills is not clear.

Therefore, the purpose of this study was to compare an active play program (CON group) and a guided active play program (LOC group), both using cooperative games targeting locomotor skills to investigate improvements in locomotor skills and physical activity levels over 7-weeks. The effect of using cooperative games focused on object control skills in a guided active play program (OC group) to provide more opportunities to practice and experience object control skills were assessed and compared to results of the LOC group. Children's physical activity was quantified with accelerometry and used to estimate energy expenditure (EE) and intensity classifications using cutoff values to determine percent time at moderate-to-vigorous physical activity (%MVPA) and percent time at sedentary and very light physical activity (%Sed/VL) for each group. The contribution and/or opportunities for lower and upper body movements were assessed for LOC and OC groups by comparing vector outputs for the ankle (A), wrist (W) and hip (H) using multiple commercially available accelerometers. The Test of Gross Motor Development-2 was used to assess standard scores and percentile ratings for gross motor quotient (GMQ), and locomotor and object control skills for all three groups before and after the programs.

Methods

Participants and study design

Fifty-two children [mean age 6.5 (0.9) yr] participated in this study. They were recruited from information sessions before the start of a seven-week community center summer day camp. The community centre summer day camp was created to provide physical recreational activities (33 %), sport skill activities (33 %), and arts and crafts (social skills) activities (33 %) distributed over a week. Children (and their parents/guardians) were given an orientation session, after which written consent was obtained. Children

also provided their own verbal assent to participate. This study was conducted in accordance with Canada's Tri-Council Policy for the Ethical Conduct of Research Involving Humans. The University's Human Participant Research Ethics Committee granted approval for all aspects of this study.

Participants registered for one of three physical activity sessions during the seven-week community summer day camp with each session scheduled for one hour a day, 4 d·wk⁻¹. Before starting the interventions, the three physical activity sessions were randomly assigned to serve as a control group using an active play format targeting locomotor skills (CON) (n = 14), a guided active play format targeting locomotor skills (LOC group) (n = 17) and a guided active play format targeting object control skills (OC group) (n = 21). Children's anthropometric parameters and estimated oxygen consumption (mlO₂·kg·min⁻¹) were assessed before the program. Before and following the three programs fundamental motor skills (FMS) were assessed at the same time of day. Physical activity was assessed on 2 sessions per week randomly selected out of the 4 sessions over the 7-weeks from 10 children randomly selected from each group (n = 140 PA trials for each group).

Measurements/Procedures

Anthropometric and cardiorespiratory fitness: Body mass, standing height and waist circumference were determined, as previously described (Belcastro et al., 2015; Moghaddaszadeh et al., 2018). Each variable was assessed with three trials and the average determined. A 20 metre multi-stage shuttle run (MSSR) was performed to estimate VO₂max (mlO₂·kg·min⁻¹) as previously described (Belcastro et al., 2015). The proportion of children completing the 20 MSSR stages were 35.6 % (stage 0-1), 44.4 % (stage 1-2), 15.6 % (stage 2-3), 2.2 % (stage 3-4) and 2.2 % (stage >5), which agrees with a previous report (Artero et al., 2011).

Fundamental motor skills: The Test of Gross Motor Development 2 (TGMD-2) was used to assess locomotor skills (run, hop, leap, horizontal jump, slide, gallop), object control skills (striking, kicking, dribbling, catching, throwing, rolling) and gross motor quotient (GMQ). Motor skill testing was conducted with the procedures outlined in the TGMD-2 Examiners Manual (Ulrich, 2000). Since the TGMD-2 assessment requires practice, kinesiology student volunteers were trained to conduct the assessments. An interclass correlation coefficient calculated between the raters was 0.97 with a 95 % confidence interval of 0.94 to 0.99. Furthermore, the variability in FMS scoring for all assessors against standardized tasks was determined by comparing scores with those from an expert (i.e. PhD with 10-years of experience with children's assessments). The coefficient of variability for all assessors across all motor skills was 3.7 %.

Physical activity: ActiGraph GT3X⁺ accelerometers (ACC) were used to quantify PA for the active play (CON) and guided active play groups (LOC and OC). ACC were placed at the hip with elastic bands and outputs expressed as vector in counts/ten-second (Bonomi et al., 2009). VO₂ was estimated using a laboratory generated

linear regression equation (Moghaddaszadeh et al., 2016; Belcastro et al., 2012), with a standard error of estimate of $0.75 \text{ mlO}_2 \cdot \text{kg} \cdot \text{min}^{-1}$ for children (5-8 yr) during treadmill exercise and $3.23 \text{ mlO}_2 \cdot \text{kg} \cdot \text{min}^{-1}$ when playing active games (Moghaddaszadeh et al., 2018). To classify the volume and intensity of PA, the VO_2 estimates derived from ACC outputs were used to calculate energy expenditure (EE) per session (55 min).

Metabolic equivalents (MET) were determined using a laboratory generated linear regression equation (Moghaddaszadeh et al., 2018; Belcastro et al., 2012) with a standard error of estimate of 0.3 MET for children (5-8 yr) during treadmill exercise and 1.2 MET when playing active games. PA was classified into intensity levels: sedentary (0-1.5 MET); very light (1.6-2.9 MET); light (3-3.9 MET); moderate (4-5.9 MET); and vigorous (>6 MET). Percent of time at moderate to vigorous PA (%MVPA) and sedentary to very light activity (%Sed/VL) were calculated. Because of the intermittent (stop-start) nature of physical activity when children play self-paced cooperative games, the %Sed/VL activity was used to reflect the metabolic cost of recovery periods that range from ~ 5 to $20 \text{ mlO}_2 \cdot \text{kg} \cdot \text{min}^{-1}$, rather than movements classified by cut-off points. This increased metabolic response (i.e. metabolic recovery) occurs at a time when minimal to no movement (i.e. $<150 \text{ cnts} \cdot 10\text{s}^{-1}$) is captured by the accelerometer. The metabolic cost during recovery has been reported to be important in children's physiological adaptations to exercise (Falk and Dotan, 2006).

Lower and upper body movements: During the guided active play interventions multiple ACC vector outputs at three different body sites (hip, wrist, and ankle) were quantified from 10 randomly selected children and on one randomly chosen day each week. The contribution of children's lower and upper body movements was determined by calculating ratios for wrist-to-ankle (W:A); wrist-to-hip (W:H) and ankle-to-hip (A:H) using vector outputs from the 3-ACC sites. To assess the validity of using vector outputs for W:A, W:H, and A:H ratios to discriminate upper body from lower body movements, one week before the start of the program children performed standardized tasks wear the 3-ACC (hip, wrist, and ankle). Children completed 3 minutes for each standardized task including: 1) jogging around a gymnasium; 2) jumping rope on the spot 3) hopscotch; 4) obstacle course; 5) throwing a ball straight up into the air and catching it; 6) dribbling a basketball; and 7) catching a soccer ball. Activities were randomized and separated by at least 15 minutes to minimize fatigue between the trials. The 3-ACC multiple site vector ratios were considered valid for assessing upper and lower body movements that could discriminate them as evidenced by the range of ratios observed for jogging around the gym 0.8:1 (0.1) W:A ratio to throwing a ball in the air and catching 8.4:1 (0.2) W:A ratio ($\alpha = 0.013$). Moreover, the vector output for a single ACC placed on the hip did not differ from the hip-located ACC output when 3 multiple ACC were used ($\alpha = 0.585$), suggesting that the use of 3-ACC did not interfere with whole body movements.

Active Play and Guided Active Play Programs: the active play program (CON) was characterized by physical

activity, increased energy, gross motor movements and freely chosen participation (Truelove et al., 2017) led by a physical education specialist at a ratio of 14:1 children-to-instructor. In addition to these attributes, our guided active play also included non-instructional role models (guides) at a ratio of $\sim 5:1$ (range 4.3:1 to 5.3:1) for children-to-guide as previously reported (West and Shores, 2008). Experienced undergraduate senior kinesiology majors, with 15 hours of workshops (encouragement strategies; bullying) and simulated children's program delivery (rules of the games, practicing skills), served as positive role models provided visual encouragement to children to expand their experiences. They provided no instructions and feedback during the sessions, and no child was forced into playing games.

The active play (CON) and guided active play (LOC and OC) interventions used age appropriate cooperative games adopted from the Ready-to-Use Physical Education Activities and previous reports (Landy and Landy, 1993; Belcastro et al., 2015; Moghaddaszadeh et al., 2018; Blake et al., 2018). The cooperative games ($n = 100$) were grouped into games focused on locomotor skill activities (i.e., running, hopping, jumping, leaping, sliding, and galloping), and those focused on object control skills (i.e., striking, rolling, throwing, dribbling and catching). A sample of games exhibiting locomotor and object control skills, which were used to support activities during the interventions guided are in Table 1.

During the first week, games for the CON, LOC and OC programs were chosen by the physical education specialist from the list of locomotor or object control games matched to the program goals. For the remainder of the program, games from the LOC and OC lists were selected by individual children (i.e. taking turns) and/or a group of children (building consensus) prior to each session. During the session, if requested, and children were supportive, a game would be removed, and a different game(s) inserted into the program for total of ~ 5 -6 different games, each lasting 5-10 minutes. Children's participation in cooperative games were freely chosen and self-paced. All PA programs were conducted in temperature controlled (20 ± 1 °C) gymnasiums.

Statistical treatment

Children in the active play and two guided active play groups were described by calculating mean(s) and standard deviation(s) for anthropometric, physiological, fundamental motor skills (FMS) and physical activity (PA) measures before and after the 7-weeks programs. The pre-post differences for active play and two guided active play groups were assessed on main and interaction effects for FMS, PA levels, lower body movement ratio and upper body movement ratio using a univariate analysis of variance (Statistical Package for Social Science v.22.0). The assumption of homogeneity of variance for all groups was checked with Levine's test of homogeneity of variance. Finally, comparisons across the active play and two guided active play groups included calculating the alpha (α) level, effect size (ES) and observed power ($1-\beta$) associated with each assessment. Significance across groups was accepted with an alpha level of 0.05.

Table 1. Selected examples of children's cooperative games used for each intervention and their associated locomotor skills (ls) and object control skills (ocs). The games were included in a menu of one hundred games available for the active play (CON) and the guided active play (GAP) locomotor (LOC) and object control (OC) interventions.

LOC	LS	OC	OCS	CON	LS
Red-light, Yellow-light	r, g, l	Ball in hula hoop	ot	Red-light, Yellow-light	r, g, h
What time is it Mr. Wolf?	r, l, s	Clear Out	k, c, ot, ur	Huckle buckle	r
Wizards, Elves & Giants	r, l, s	4-way soccer	k, c	Ship to shore	r
Crash	r, g, h, l, j, s	Ball in hula hoop	d, ot	Octopus	r, s, l, j
Fishes and Whales	r, s, l, j	Racquet balloon	st	Freeze dance	h, s
Crocodile, Crocodile	r, g, h	Elimination	ot, c, ur	Coloured Eggs	r, g, h, l, j, s
Blog Tag	r, l, s	Obstacle course	st, d, k, c, ot, ur, c	Basketball bump	r, l, d
Band-aid Tag	r, l, s	Soccer Baseball	st, c, ur	Wizards, Elves & Giants	r, l, s
Lined Tag	r, h, j	Dr. Dodgeball	ot, c, ur	European hand ball	r, l, ot, c
Zombie Tag	r, l, s	Commander (Simon Says)	ot, d, c, ur	Croquet	r, s
Arches Tag	r, l, s	Football Throw (hoop)	ot, c	Snake's Tail	r, s
Crows and Cranes	r, l, s	Pin Dodgeball	ur, c, ot	Dodgeball	r, l, ot, c
Coloured Eggs	r, g, h, l, j, s	Catch Relay	ot, c	Blog Tag	r, l, s
Jail Break	r, s, h, j	Crab Walk and Bean Bag Toss	ot	Lined Tag	r, h, j

LS: run (r); jump (j); hop (h); gallop (g); leap (l); slide (s); OCS: overhand throw (ot), kick (k); underhand roll (ur); catch (c); dribble (d); striking (st).

Table 2. Children's physical and motor skill characteristics for the active play control (CON), guided active play locomotor (LOC) and guided active play object control (OC) groups prior to the study. Anthropometric variables include; age, body mass (BM), stature (Ht), body mass index (BMI); as well as aerobic power (AP). Fundamental motor skills (FMS) include comparisons of standard scores for gross motor quotient standard score (GMQ), locomotor skills (LOC) and object control skills (OC) including alpha levels (α), effect sizes (ES) and observed power ($1-\beta$). Data are presented as means and (standard deviations).

	CON (n = 14)	LOC (n = 17)	OC (n = 21)
Age (years) ($\alpha = 0.136$)	6.5 (0.7)	6.5 (1.0)	6.5 (0.9)
BM (kg) ($\alpha = 0.186$)	29.1 (8.1)	24.7 (6.2)	26.6 (6.6)
Ht (m) ($\alpha = 0.837$)	1.26 (0.09)	1.19 (0.06)	1.20 (0.09)
BMI ($\text{kg}\cdot\text{m}^{-2}$) ($\alpha = 0.058$)	18.4 (6.2)	17.2 (3.3)	18.4 (3.5)
AP ($\text{mlO}_2\cdot\text{kg}^{-1}\cdot\text{min}^{-1}$) ($\alpha = 0.358$)	46.1 (7.9)	45.2 (2.7)	48.5 (4.0)
GMQ ($\alpha = 0.034$; ES = 0.160; $1-\beta = 0.645$)	103.3 (13.2)	87.8 (15.7) ($\alpha=0.027$)*	96.2 (14.9) ($\alpha=0.441$)*
LOC ($\alpha = 0.009$; ES = 0.214; $1-\beta = 0.808$)	10.9 (2.9)	7.1 (3.4) ($\alpha=0.007$)*	8.3 (2.8) ($\alpha=0.076$)*
OC ($\alpha = 0.282$; ES = 0.063; $1-\beta = 0.266$)	10.2 (2.7)	8.9 (2.6) ($\alpha=0.502$)*	10.5 (3.1) ($\alpha=0.940$)*

* denotes active play vs guided active play (LOC and OC groups).

Results

Children participating in the active play (CON) and guided active play (LOC and OC) interventions showed minimal differences in age, sex and anthropometric measures (Table 2). The composition of boys and girls across the three groups were compared for age ($\alpha = 0.959$), body mass ($\alpha = 0.172$), stature ($\alpha = 0.173$), body mass index ($\alpha = 0.423$), and aerobic power ($\alpha = 0.490$). The fundamental motor skills were different at the start of the program among the three groups with the CON group having a) higher GMQ ($\alpha = 0.027$) than the LOC group, and b) higher locomotor standard scores compared to the LOC ($\alpha = 0.007$) and OC groups ($\alpha = 0.076$) (Table 2). As a result, the impact of active play and guided active play

programs on FMS were performed using post minus pre-changes (post-pre).

Active play and guided active play interventions:

Following 7-weeks, the guided active play (LOC) intervention resulted in larger changes for all FMS scores and percentiles compared to active play and guided active play (OC) programs (Figure 1). Changes in the active play and guided active play locomotor standard scores were -0.83 (2.61) vs. 2.6 (2.64) ($\alpha = 0.022$; ES = 0.193; $1-\beta = 0.650$). A similar response was observed for the changes in locomotor skill percentiles following the active play with -9.08 (36.7) percentile and guided active play with 20.1 (30.4) percentile programs ($\alpha = 0.033$; ES = 0.170; $1-\beta = 0.581$). The changes in gross motor quotient percentiles were -4.3 (30.3) vs. 24.1 (29.6) percentile ($\alpha = 0.022$; ES = 0.189; $1-\beta = 6.58$) for active play and guided active play (LOC) programs. The changes observed for the object control skills across all groups were smaller than those observed for locomotor and GMQ scores (Figure 1).

During the 7-weeks the average estimated energy expenditures were 158.6 (16.6) $\text{kcal}\cdot 55\text{min}^{-1}$ and 174.5 (28.3) $\text{kcal}\cdot 55\text{min}^{-1}$ ($\alpha = 0.107$; ES = 0.114; $1-\beta = 0.362$) for the active play and guided active play (LOC) and 170.0 (20.1) $\text{kcal}\cdot 55\text{min}^{-1}$ ($\alpha = 0.144$; ES = 0.094; $1-\beta = 0.305$) for the OC interventions (Figure 2). The proportion of time at MVPA for active play was 18.4 (11.5) %MVPA compared to 47.9 (4.8) %MVPA ($\alpha = 0.000$; ES = 0.753; $1-\beta = 0.995$) for guided active play (LOC) program and 51.9 (6.0) %MVPA ($\alpha = 0.000$; ES = 0.784; $1-\beta = 0.997$) for the OC intervention. The proportion of time at sedentary/very light activity for the active play intervention was 36.4 (9.8) %Sed/VL compared to 15.1 (2.9) %Sed/VL ($\alpha = 0.000$; ES = 0.552; $1-\beta = 0.999$) for the guided active play (LOC) intervention and 14.9 (15.7) %Sed/VL ($\alpha = 0.001$; ES = 0.389; $1-\beta = 0.947$) for the OC intervention.

Guided active play LOC versus OC interventions:

Comparison of the 7-week post-pre-changes for the two guided active play interventions (LOC vs. OC) showed improved FMS standard scores and percentiles and small effect sizes (<0.1). The changes in locomotor skills

standard scores for the LOC and OC groups were 2.60 (2.64) vs. 1.53 (1.93) ($\alpha = 0.669$; ES = 0.030), respectively. The object control skills standard scores changed by 1.3 (3.8) compared to 2.00 (1.90) ($\alpha = 0.817$; ES = 0.015) for the LOC group. GMQ standard scores for the LOC and OC groups were 4.20 (4.78) and 2.53 (5.27) ($\alpha = 0.856$; ES = 0.04). Similar trends were observed for FMS percentiles following the interventions (Figure 1).

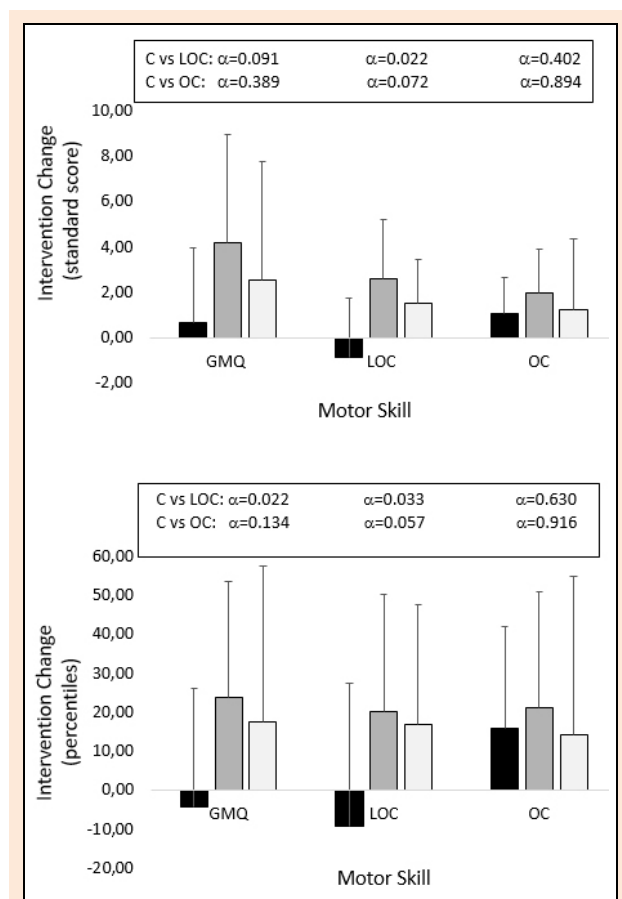


Figure 1. Changes (post-minus-pre-differences) in fundamental motor skills for children (6.5 (0.9) yr) following seven-weeks of an active play (C-dark bars) (n=14) and two guided active play (GAP) intervention programs using cooperative games targeting locomotor (LOC-grey bars) (n=16) and object control (OC-light bars) (n=19) skills. Children's motor skills were assessed by the TGMD-2 for gross motor quotient (GMQ), locomotor skills and object control skills reported for standard scores (top panel) and percentiles (lower panel). Statistical comparisons between the C group and the LOC and OC groups are provided – error bars are standard deviations.

During the 7-weeks, physical activity per session averaged 174.5 (28.3) kcal·55min⁻¹ and 170.0 (20.1) kcal·55min⁻¹ ($\alpha = 0.658$; ES = 0.009; 1- $\beta = 0.071$) for the LOC and OC guided active play interventions. The proportion of time at MVPA were 47.4 (4.8) %MVPA and 51.9 (6.0) %MVPA ($\alpha = 0.086$; ES = 0.128; 1- $\beta = 0.404$) for LOC and OC guided active play programs. The proportion of time at sedentary/very light activity for were 15.1 (7.4) %Sed/VL and 14.9 (15.7) %Sed/VL ($\alpha = 0.972$; ES = 0.000; 1- $\beta = 0.005$) for the LOC and OC guided active play interventions (Figure 2).

The usefulness of cooperative games to provide more opportunities for lower and/or upper body movements was observed by comparing ACC vector outputs at the ankle (lower body) and wrist (upper body) during guided active play interventions. The average ratios of ACC vector outputs from upper body and lower body sites for the OC group were 1.9:1 (0.1) (W:A) versus the LOC group at 4:1 (0.1) W:A ratio ($\alpha = 0.020$; ES = 0.127; 1- $\beta = 0.655$) over the 7-weeks.

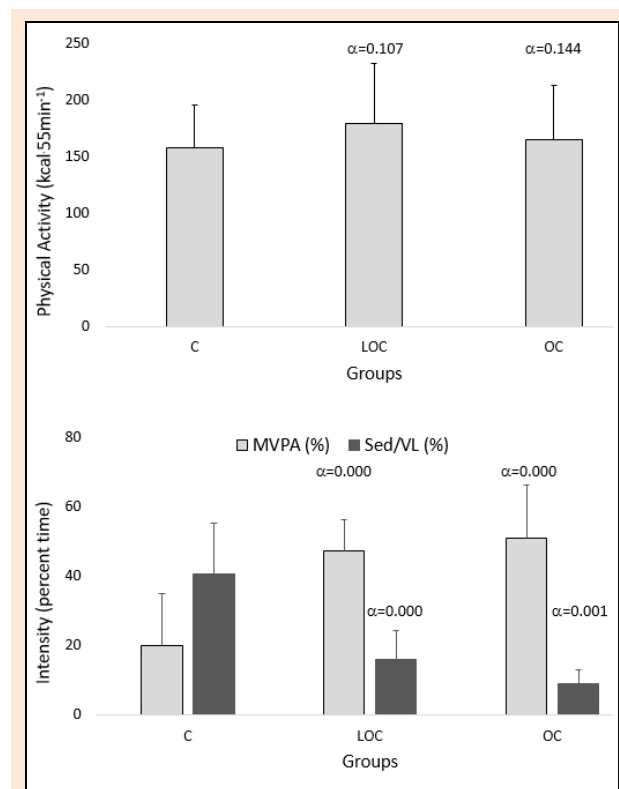


Figure 2. Children's (6.5 (0.9) yr) estimated energy expenditure (kcal·55min⁻¹) (top panel) and intensity levels (lower panel) using percent time at moderate-to-vigorous PA (%MVPA) and percent time at sedentary and very light activity (%Sed/VL). Physical activity for each group was assessed on 140 trials (i.e., 2 out of 4 session per week for 7 weeks) from 10 children randomly selected within the active play (CON) and LOC and OC guided active play interventions. Statistical comparisons (α -values) between the C group and the LOC and OC groups are provided for energy expenditure, %MVPA and %Sed/VL – error bars are standard deviation.

Discussion

An active play program has been suggested to provide increased physical activity levels and improved FMS proficiency for preschoolers' and school-aged children (Lubans et al., 2010; Adamo et al., 2016; Johnstone et al., 2017). This study demonstrated that a guided active play versus an active play program, both using cooperative games focused on locomotor skills, results in greater post-pre-differences for GMQ and LOC standard scores and percentile shifts after the seven weeks. Our data also indicated that children participating in a guided active play program, compared to an active play program, had greater energy expenditure levels, spend more time at MVPA and

less time at Sed/VL activities. When comparing children in the LOC and OC groups, the post-pre-differences for standard scores and percentiles for GMQ, locomotor and object control skills showed slightly higher levels for the LOC group. The two guided active play interventions had comparable levels of energy expenditures, %MVPA and %Sed/VL. The findings of this study support the inclusion of guided active play interventions using cooperative games for improving in FMS and increasing physical activity levels of school-aged children (5-7 yr).

Studies that have examined the impact of an active play intervention for school-aged children on physical activity levels have reported minimal post-pre-differences in total volume of physical activity and/or %MVPA performed per day, when compared to control groups (Tortella et al., 2016; Engelen et al., 2013). The limited time (one-hour week) and types of activities used during the active play interventions, which included free play time, equipment and other materials, may have contributed to the nonsignificant changes in physical activity levels. Given that children in the active play program had a session average EE of $158 \text{ kcal} \cdot 55 \text{ min}^{-1}$ over the 7-weeks (or an average of $632 \text{ kcal} \cdot \text{wk}^{-1}$), we anticipated that this level of physical activity would have been accompanied by improvements in FMS. An explanation for this observation may be related to the lower amount of time spend at MVPA (<20 %MVPA) and higher amount of the time spent in sedentary or very light activities (>40 %Sed/VL), which may contribute to less time for experiencing and practicing motor skills Logan et al., 2011. Our study results, like previous studies (Foulkes et al., 2017; Lee et al., 2020), observed high PA levels with minimal changes in FMS for children (4-7 yr) after 6-to-8 weeks in active play interventions. Although FMS improvements were not reported for active play, our data provide direct evidence that higher EE levels are not necessarily compromised during an active play program using children's cooperative games. This is important to recognize especially since higher levels of EE are important for children's (5-12 yr) health and fitness benefits (Colley et al., 2011).

An active play-based learning strategy should have more time allowed to engage children in skill acquisition by providing opportunities to model skill behaviours (Pye and Daniels, 2016). In the current study, our guided (modeled) active play format was similar to a previous study (West and Shores, 2008) where university students served as role models or guides (in a 5:1 ratio of children-to-guide) and who were visibly active and participating with children, while not offering instructions. Although the use of guides or models in our programs were similar to those of West and Shores (2008), we incorporated self-paced cooperative (social) games targeting children's (5-7 yr) locomotor and object control skills, rather than sport specific skills for children (6-11 yr). Our PA results for the two guided active play interventions (LOC and OC groups) were observed to have >30 % more time at MVPA and <20 % less time at Sed/VL activities with similar EE levels, when compared to the active play (CON) program. The LOC and OC interventions were accompanied by increases in FMS post-pre-differences for LOC standard scores and

percentiles; as well as and GMQ percentiles compared to the active play program (CON group). These results support the requirement for greater MVPA levels to improve locomotor skills, which are possible within a guided active play program, but not an active play program. The small effect on OC standard scores and percentiles are similar to previous reports for children (3-5 yr) and supports the contention that object control skills require more targeted approaches over locomotor skills (Zask et al., 2012; Adamo et al., 2016). In light of these suggestions, we anticipated the OC guided active play intervention to show improvements in object control skills and GMQ scores; however, we did not see this in the OC group, despite the observations that they had more upper body movements (1.9 W:A ratio) and high levels of physical activity similar to those for LOC group. An explanation of this unexpected result for the object control skill differences may be related to the poor performances (i.e., lack of consistently) observed for children participating in cooperative games focused on object control skills. Although the OC program included cooperative games with catching, throwing, and striking; children in OC group were observed to have difficulty in maintaining consistent control of balls/rackets/balloons during OC activities. This lack of a consistent performance required the children chase after objects, which we believe contributed to the increased energy expenditure, %MVPA and locomotor skill scores for the OC group, without contributing to significant improvements in object control skill scores. Future studies using a guided active play format focused on providing effective object control experiences with cooperative games are needed to understand the interaction between object control skills intervention and FMS improvements.

Limitations

Generalizability of our study is limited due to the use of relatively small samples and group randomization challenges typical of community programs, where children are not randomly assigned to treatment groups. The observation that the FMS scores for the active play (CON) group were higher at the onset may have influenced the large standard deviations for groups changes observed during active play. Therefore, observations need to be confirmed with randomized and/or matched groups and the use of larger sample sizes to evaluate both group and individual treatment effects of active and guided active play interventions. Our sample sizes limited our ability to examine the interaction influences of sex, existing level of FMS, habitual physical activity levels and sedentary behaviours, which are known to impact motor skill proficiency and physical activity levels (Logan et al., 2011; Iivonen and Saakslanti, 2014; Engel et al., 2018).

Our study used cooperative games with characteristic energy expenditure levels, which are reproducible when performed in a simulated environment (Belcastro et al., 2012). Although the cooperative games used for our study were like those in previous studies (Belcastro et al., 2015; Moghaddaszadeh et al., 2018); the importance of ensuring that learning opportunities and

experiences provided from cooperative games are reproducible within a guided active play-based learning program remains a challenge. Since self-paced physical activity and freely chosen experiences with few instructions help to define active play (Truelove et al., 2017), the effect of selecting cooperative games, from a menu of like games that can be substituted for each other is important. Thus, future work should focus on guided active play interventions aimed at describing and characterizing cooperative games useful for programming community centre and/or school activities.

Our study showed the effect of incorporating well-trained guides (university students), who were visibly active and participating with children at a ratio of 5:1 for children-to-guides, on increasing PA levels and improving FMS for school-aged children. Since a FMS intervention program located in a community setting, as used in our study, has been described as necessary for educated professionals when faced with the task of providing school-aged children both a PA experience as well as FMS opportunities (Johnstone et al., 2018) future studies should investigate training programs for undergraduate students and/or community centre staff to model skilled behavior, as well as the effect of different ratios of children-to-guides on improving FMS proficiency.

Although a ratio of vector outputs for ACCs placed on the wrist and/or ankle (W:A ratio) quantified and distinguished upper body versus lower body movements for standardized motor tasks; its usefulness for assessing the quality of movements and/or experiences is unclear. Our data identified significantly more upper body movement by the OC group but without improvements to object control skills and/or gross motor quotient. Therefore, future studies should aim to identify and quantify FMS experiences provide by cooperative games during a guided active play intervention.

Conclusion

For school-aged children (5-7 yr) the need to engage in opportunities that support higher physical activity levels and provide quality learning experiences to improve FMS are vital. Results from this study demonstrate that using cooperative games focused on locomotor skills in a guided active play intervention provides play-based learning experiences, which provide higher physical activity levels and increased locomotor skills than an active play program. The OC guided active play intervention was not effective in promoting increase object control skills, despite higher levels of physical activity. Since OC skills are related to increased physical activity participation and cardiorespiratory fitness levels for children and adolescents (Barnett et al., 2008; 2009), more research targeting object control guided active play programs are warranted.

Acknowledgements

The Faculty of Health Internal Research Grants program at York University provided funding to support this study. Author contributions: A.B. conception and design of research; A.M. conducted the interventions; A.B and A.M. analyzed ACC data, interpreted results of experiments, prepared figures and prepared manuscript; A.B. and A.M. approved final version of manuscript. The authors would like to

acknowledge the support of the Driftwood Community Recreation Centre for their contribution of time and space to complete this study and KinKids: Children's Guided Active Play Program for serving as volunteers. The experiments comply with the current laws of the country in which they were performed. The authors have no conflict of interest to declare. The datasets generated during and/or analyzed during the current study are not publicly available, but are available from the corresponding author who was an organizer of the study.

References

- Adamo, K.B., Wilson, S., Harvey, A.L., Grattan, K.P., Naylor, P.J., Temple, V.A. and Goldfield, G.S. (2016) Does intervening in childcare settings impact fundamental movement skill development? *Medicine & Science in Sport & Exercise* **48**, 926-932.
- Artero, E.G., España-Romero, V., Castro-Piñero, J., Ortega, F.B., Suni, J., Castillo-Garzon, M.J. and Ruiz, J.R. (2011) Reliability of field-based fitness tests in youth. *International Journal of Sports Medicine* **32**, 159-69.
- Barnett, L.M., Morgan, P.J., van Beurden, E. and Beard, J.R. (2008) Perceived sports competence mediates the relationship between childhood motor skill proficiency and adolescent physical activity and fitness: a longitudinal assessment. *International Journal of Behavioral Nutrition and Physical Activity* **40**(5), doi:10.1186/1479-5868-5-40.
- Barnett, L.M., van Beurden, E., Morgan, P.J., Brooks, L.O. and Beard, J.R. (2009) Childhood motor skill proficiency as a predictor of adolescent physical activity. *Journal of Adolescent Health* **44**, 252-259.
- Belcastro, A.N., Mofidi, D.M., Ahmadi, Y. and Moghaddaszadeh, A. (2015) Correlates of psychosocial health-related quality of life measures for normal weight and obese children participating in an active play program. *Journal of Child & Adolescent Behaviour* **3**(5), DOI: 10.4172/2375-4494.1000242.
- Belcastro, A.N., Morrison, K.S., Hicks, E. and Matta, H. (2012) Cardiorespiratory and metabolic responses associated with children's physical activity during self-paced games. *Canadian Journal of Physiology and Pharmacology* **90**, 1269-1276.
- Blake, M., Senechal, M., Comeau, M., Smith, S. and Bouchard, D. (2018) The impact of exercise intensity feedback using technology for children during active play: pilot study. *JMIR Pediatrics and Parenting* **1**, 1-7.
- Bonomi, A.G., Goris, A.H.C., Yin, B. and Westerterp, K.L. (2009) Detection of type, duration, and intensity of physical activity using an accelerometer. *Medicine & Science in Sport & Exercise* **41**, 1770-1777.
- Castelli, D.M. (2019) Motor performance or opportunities to move? What do children need the most? *Journal of Sport and Health Science* **8**, 149-152.
- Colley, R.C., Garrigué, D., Janssen, I., Craig, C.L., Clarke, J. and Tremblay, M.S. (2011) Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Statistics Canada, Health Reports* **22**, 5-23.
- Engel, A.C., Broderick, C.R., van Dooran, N., Hardy, L.L. and Parmenter, B.J. (2018) Exploring the relationship between fundamental motor skill interventions and physical activity levels in children: A systematic review and meta-analysis. *Sports Medicine* **48**, 1845-1857.
- Engelen, L., Bundy, A.C., Naughton, G., Simpson J.M., Bauman, A., Ragen, J., Baur, L., Wyver, S., Tranter, P., Niehues, A., Scjiller, W., Perry, G., Jessup, G. and van der Ploeg, H.P. (2013) Increasing physical activity in young primary school children—its child's play: a cluster randomised controlled trial. *Preventive Medicine* **56**, 319-325.
- Falk, B. and Dotan, R. (2006) Child-Adult Differences in the Recovery from High-Intensity Exercise. *Exercise and Sport Science Review* **34**, 107-112.
- Fisher, K.R., Hirsh-Pasek, K., Newcombe, N. and Golinkoff, R.M. (2013) Taking shape: Supporting preschoolers' acquisition of geometric knowledge through guided play. *Child Development* **84**, 1872-1878.
- Foulkes, J.D., Knowles, Z., Fairclough, S.J., Stratton, G., O'Dwyer, M., Ridgers, N.D. and Fowweather, L. (2017) Effect of a 6-week active play intervention on fundamental movement skill competence of

- pre-school children: A cluster randomized control trial. *Perceptual and Motor Skills* **24**, 393-412.
- Gallahue, D.L., Ozmun, J.C., and Goodway, J.D. (2011) *Understanding Motor Development: Infants, Children, Adolescents, Adults*. 7th edition. New York: McGraw-Hill.
- Goodway, J.D. and Branta, C.F. (2003) Influence of a motor skill intervention on fundamental motor skill development of disadvantaged preschool children. *Research Quarterly for Exercise & Sport* **74**, 36-47.
- Gordon, E.S., Tucker, P., Burke, S.M. and Carron, A.V. (2013) Effectiveness of physical activity interventions for preschoolers: A meta-analysis. *Research Quarterly for Exercise & Sport* **84**, 287-294.
- Hardy, L.L., O'Hara, B.J., Roger, K., St. George, A. and Bauman, A. (2014) Contribution of organized and nonorganized activity to children's motor skills and fitness. *Journal of School Health* **84**, 690-696.
- Iivonen, S. and Saakslahki, A.K. (2014) Preschool children's fundamental motor skills: a review of significant determinants. *Early Child Development and Care* **184**, 1107-1126.
- Johnstone, A., Hughes, A.R., Janssen, X. and Reilly, J.J. (2017) Pragmatic evaluation of the GO2Play active play intervention on physical activity and fundamental movement skills in children. *Preventive Medicine Reports* **7**, 58-63.
- Johnstone, A., Hughes, A.R., Martin, A. and Reilly, J.J. (2018) Utilising active play interventions to promote physical activity and improve fundamental motor skills in children: A systematic review and meta-analysis. *BMC Public Health* **18**, 789-80.
- Lambrick, D., Westrupp, N., Kaufmann, S., Stoner, L. and Faulkner, J. (2016) The effectiveness of a high-intensity game intervention on improving indices of health in young children. *Journal of Sport Sciences* **34**, 190-198.
- Landy, J.M. and Landy, M.J. (1993) Ready to use P.E. activities for grades 5-6. Parker Publishing Company, West Nyack, N.Y.
- Lee, J., Tao Zhang, T., Chu, T. L., Gu, X. and Zhu, P. (2020) Effects of a Fundamental Motor Skill-Based Afterschool Program on Children's Physical and Cognitive Health Outcomes. *International Journal of Environmental Research and Public Health* **17**, 733-749.
- Logan, S.W., Robinson, L.E., Wilson, A.E., and Lucas, W.A. (2011) Getting the fundamentals of movement: A meta-analysis of the effects of motor skill interventions in children. *Child: Care, Health and Development* **38**, 205-215.
- Lubans, D.R., Morgan, P.J., Cliff, D.P., Barnett, L.M. and Okely, A.D. (2010) Fundamental movement skills in children and adolescents: Review of associated health benefits. *Sports Medicine* **40**, 1019-1035.
- Moghaddaszadeh, A., Ahmadi, Y. and Belcastro, A.N. (2016) Children and adolescent physical activity participation and enjoyment during active play. *Journal of Sports Medicine and Physical Fitness* **57**, 1375-1381.
- Moghaddaszadeh, A., Jamnik, V., and Belcastro, A.N. (2018) Characteristics of children's physical activity during active play. *Journal of Sports Medicine and Physical Fitness* **58**, 369-376.
- Pyle, A. and Danniels, E. A. (2016) Continuum of play-based learning: The role of the teacher in play-based pedagogy and the fear of hijacking play. *Early Education and Development* **28**, 274-289.
- Stodden, D., Goodway, J.D., Langendorfer, S., Robertson, M.A., Rudisill, M.E., Garcia, C. and Garcia, L. (2008) A Developmental Perspective on the Role of Motor Skill Competence in Physical Activity: An Emergent Relationship. *Quest* **60**, 290-306.
- Tortella, P., Haga, M., Loras, H., Sigmundsson, H. and Fumagalli, G. (2016) Motor skill development in Italian pre-school children induced by structured activities in a specific playground. *Plos One* **11**, e0160244.
- Truelove, S., Vanderloo L. M. and Tucker P. (2017) Defining and measuring active play among young children: a systematic review. *Journal of Physical Activity & Health* **14**, 155-66.
- Ulrich, D. (2000) *Test of Gross Motor Development*. 2nd edition. Austin: Examiner's Manual. Pro-Ed, Inc.
- West, S.T. and Shores, K.A. (2008) A comparison of four recreation facilitation styles and physical activity outcomes in elementary school children. *Journal of Park and Recreation Administration* **26**, 115-133.
- Zask, A., Barnett, L.M., Rose, L., Brooks, L.R., Molyneux, M. Hughes D. and Salmons, J. (2012) Three-year follow-up of an early childhood intervention: Is movement skill sustained? *International Journal of Behavioral Nutrition and Physical Activity* **9**, 1-9.

Key points

- Using multiple accelerometer placements (waist, wrist and ankle) during motor skill intervention programs are effective in quantified varying amounts of lower body versus upper body movement patterns, which are useful in designing children's motor skill programs.
- Children's active play in community-based settings can elicit self-paced energy expenditures of >170 kcal/hour and intensity levels between 40-60% MVPA.
- During early childhood the energy expenditure and moderate-vigorous nature of physical activity drives improvements fundamental motor skill proficiency.

AUTHOR BIOGRAPHY



Asal MOGHADDASZADEH

Employment

PhD student, York University, Toronto, Canada

Degree

MSc

Research interests

Children's health and fitness through guided active play, childhood developmental changes for motor skills with cardiovascular and muscle function, children's vascular responses to self-paced physical activity

E-mail: asalnz@yorku.ca



Angelo N. BELCASTRO

Employment

Professor of Exercise Physiology and Biochemistry at York University, Toronto, Canada

Degree

PhD

Research interests

Children's exercise physiology, children's cardiovascular and muscular responses to active play, exercise and sport, community-based physical activity

E-mail: anbelcas@yorku.ca

✉ Angelo N. Belcastro

Pediatric Exercise Sciences Laboratory, School of Kinesiology and Health Science, and Muscle Health Research Centre, Faculty of Health, York University, Toronto, Ontario, Canada