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ORIGINAL RESEARCH ARTICLE

Motor Competence Levels and Developmental Delay in Early Childhood: A Multicenter Cross-Sectional Study Conducted in the USA

Ali Brian[1] · Adam Pennell[2] · Sally Taunton[1] · Angela Starrett[3] · Candice Howard-Shaughnessy[4] · Jacqueline D. Goodway[5] · Danielle Wadsworth[6] · Mary Rudisill[6] · David Stodden[1]

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Abstract

Background and Objectives Developmental delay in motor competence may limit a child's ability to successfully participate in structured and informal learning/social opportunities that are critical to holistic development. Current motor competence levels in the USA are relatively unknown. The purposes of this study were to explore motor competence levels of US children aged 3–6 years, report percentages of children demonstrating developmental delay, and investigate both within and across childcare site predictors of motor competence, including sex, race, geographic region, socioeconomic status, and body mass index percentile classification. Potential implications from results could lead to a greater awareness of the number of children with developmental delay, the impetus for evidence-based interventions, and the creation of consistent qualification standards for all children so that those who need services are not missed.

Methods Participants included children ($N = 580$, 296 girls) aged 3–6 years ($M_{age} = 4.97$, standard deviation $= 0.75$) from a multi-state sample. Motor competence was assessed using the Test of Gross Motor Development, Second Edition and the 25th and 5th percentiles were identified as developmental delay-related cutoffs.

Results For both Test of Gross Motor Development, Second Edition subscales, approximately 77% of the entire sample qualified as at risk for developmental delay (≤ 25th percentile), while 30% of the entire sample were at or below 5th percentile. All groups (e.g., sex, race, socioeconomic status) were prone to developmental delay. Raw object control scores differed by sex.

Conclusions Developmental delay in motor competence is an emerging epidemic that needs to be systematically acknowledged and addressed in the USA. By shifting norms based upon current data, there may be a lower standard of "typical development" that may have profound effects on factors that support long-term health.

Ali Brian and Adam Pennell are co-lead authors.

✉ Ali Brian
abrian@sc.edu

[1] Department of Physical Education, University of South Carolina, 1300 Wheat St, Columbia, SC 29208, USA

[2] Natural Science Division, Pepperdine University, Malibu, CA, USA

[3] Child Development Research Center, University of South Carolina, Columbia, SC, USA

[4] Department of Kinesiology and Health Promotion, Troy University, Troy, AL, USA

[5] Department of Human Sciences, The Ohio State University, Columbus, OH, USA

[6] School of Kinesiology, Auburn University, Auburn, AL, USA

Key Points

Developmental delay did not discriminate in pre-school children from a descriptive standpoint while sex was predictive of raw object control Test of Gross Motor Development, Second Edition scores.

For both subscales, 77.4% of this sample scored at or below the 25th percentile including 30% scoring at or below the 5th percentile, indicating a secular decline from the 2000 normative references.

Descriptive investigations of specific skills suggested that preschool-aged children struggle with hopping and dribbling, but girls especially struggle with throwing, which may explain the significant difference in the sexes for object control skills.

1 Introduction

Nationally representative data indicate a decreasing percentage of children meet US physical activity guidelines of 60 min of moderate-vigorous intensity physical activity (PA) per day (i.e., ≈ 40–50% for preschoolers; 42.0% for age 6–11 years; 8.0% for age 12–15 years; 7.6% for age 16–19 years) [1–3]. Given the influence of PA on obesity, it is no surprise that 18.5% of US youth categorize as obese, and ≈ 14–22% of preschoolers reveal overweight/obese body weight statuses [4, 5] while secular data demonstrate a negative trend in PA and health-related fitness levels [6, 7]. Specifically concerning is that children from low-income families generally demonstrate a greater risk for lower PA, higher obesity levels, as well as long-term health disparities [8–10]. While there has been a concerted effort to combat decreasing PA, health-related fitness, and increasing obesity levels in the USA, there has been limited success in alleviating the negative trends [11, 12].

The development of motor competence (MC) is a potential mechanism to alleviate the negative trends in PA, health-related fitness, and obesity rates as MC positively impacts long-term trajectories of these variables [13–20] as well as self-concept [17]. Specifically, locomotor (e.g., run, gallop, hop, jump) and object control (e.g., throw, catch, kick, strike) skills in childhood facilitate participation in a variety of games, free play, and sports activities [21, 22]. Thus, early childhood is an optimal time to promote a strong foundation of MC [21, 22].

Motor competence as an underlying mechanism potentially driving PA, health-related fitness, and combating obesity is an emergent phenomenon [17]. Paradigmatic shifts occurred partially owing to biases/beliefs that age was the dominating factor driving MC development [23], resulting in a failure to explore the actual ontogenetic nature of MC [22]. That being said, MC does not occur simply as a result of maturation [24]; MC is a developmental construct that should improve over time as a result of consistent developmentally appropriate experiences that consider the child, the task, and the environment.

1.1 Risk Factors Associated with Impaired Motor Competence

Other than age, several factors could potentially influence MC [25]. Variables such as biological sex [25], socioeconomic status (SES), race [26], geographical region [27], and body weight status [28] could afford or constrain MC. However, the field of health promotion has historically operated under a deficit-based approach (i.e., focusing on a negative trait such as low SES) as opposed to an asset- or strength-based approach (i.e., the capabilities of a low SES individual) [29]. A deficit-based lens may have fostered pervasive or stereotypical assumptions, biases, and/or beliefs concerning MC in young children. Likewise, research investigating the role of body weight status on MC in younger children has also been inconclusive [28, 30–32].

Children from low SES and certain races have been purported to have lower MC levels; but limitations in currently published data inhibit our ability to generalize MC trends. For instance, study samples are generally homogeneous with respect to race and SES [26, 33, 34]. While these data provide a snapshot of the potential for race and SES as risk factors for impaired MC, contemporary evidence is conflicting [30].

Adding to the contrasting findings, a recent study (which used a large representative sample [$N = 339$] and examined multiple MC factors simultaneously) concluded that there were no standard score locomotor or object control MC differences in children aged 3–5 years by race, income, age, or weight status [30]. However, despite no anthropometric or physiological differences during the early years [35], raw score sex differences in MC often occur with girls consistently demonstrating lower object control skill levels than boys [30, 36, 37]. While there are no consistent differences in locomotor skill competence between girls and boys across childhood [36], young girls often exhibit higher levels of locomotor skill in early childhood [30, 38]. Thus, data on MC in younger children in the USA are not well understood warranting further investigation.

1.2 Defining Developmental Delay

Using the concept/categorization of developmental delay (DD) is an approach that researchers could use to add depth to investigations concerning multiple MC risk factors. Overall, gross motor DD in early childhood refers to those who demonstrate low MC and are at greater risk for negative trajectories of PA, fitness, and obesity [13–20]. Developmental delay in children "may be transitory or sustained and is characterized by a significant delay in one or more of the following domains: gross and fine motor skills, speech and language, social and personal skills, activities of daily living and cognition" ([39], definition adapted from [40, 41]). Developmental delay is a descriptive term (not a diagnosis) and while typically reserved for children < 5 years of age, DD can extend into late childhood and even adulthood [42].

Importantly, what qualifies as DD is open to substantial interpretation as individual states are charged with determining their respective DD criteria [43, 44]. Qualification of DD is critical to children receiving adapted physical education, special education, and related services such as physical therapy or occupational therapy for free or at a reduced cost. Without solid qualification criteria, children may be vulnerable to DD underrepresentation (i.e., false negative). In response, early intervention, adapted physical education, and/or related services that could help remediate and improve developmental trajectory outlooks for health throughout the lifespan may not be adequately provided to young children. Despite its importance, qualifying an individual with DD is often a non-uniform and problematic undertaking [42]. Therefore, the purposes of this study were to explore MC levels of US children aged 3–6 years, report percentages of children demonstrating DD, and investigate both within and across childcare site predictors of MC, including sex, race, geographic region, SES, and body mass index percentile (BMI %) classification. Potential implications from results could lead to a greater awareness of the number of children with DD, impetus for evidence-based interventions, and the creation of consistent qualification standards for all children so that those who need services are not missed.

2 Methods

2.1 Participants

This study included a convenience sample of participants and secondary data analyses from six previous projects in five different states in the USA between the years of 2010 and 2017 [45–50]. All data sets were de-identified prior to being merged. Participants included children ($N=580$, 296 girls) aged 3–6 years ($M_{age}=4.97$, standard deviation [SD] = 0.75) enrolled in one of seven early childhood education centers (Alabama, Louisiana, Ohio [×2], South Carolina [×2], Texas). Self-reported race categories included: Black ($n=232$), Hispanic or Latino ($n=116$), White ($n=182$), and Other ($n=50$). Mean height, weight, BMI [51], and BMI z-score [52, 53] for the sample were 1.09 ms (SD = .07), 19.8 kg (kg; SD = 3.7), 16.6 kg/m^2 (SD = 2.3), and a z-score of 0.54 (SD = 1.19), respectively.

2.2 Settings

All participant sites were early childhood education centers. Both of the sites in Alabama and the Louisiana site were rural and not low SES (rural/not low = 2). The site in Texas and one of the sites in South Carolina were rural and low SES (rural/low = 2). The second site in South Carolina and one of the sites in Ohio were urban and low SES (urban/low = 2). The second site in Ohio was urban and not low (urban/not low = 1). Socioeconomic status was determined subjectively by the researchers based on a multitude of factors (e.g., free/reduced lunch, Title 1 percentage of each site) [54]. Rural vs. urban geographical regions were determined qualitatively based on criteria provided by the US Census Bureau [55].

2.3 Instrumentation

2.3.1 Test of Gross Motor Development, Second Edition

The TGMD-2 is a process-oriented norm-referenced assessment used to evaluate MC in children aged 3 years to 10 years and 11 months [56]. The TGMD-2 is composed of two subscales: locomotor and object control skills. The locomotor skill subscale includes running, galloping, hopping, leaping, horizontal jumping, and sliding. The object control subscale features striking a stationary ball, stationary dribbling, catching, kicking, overhand throwing, and underhand rolling.

For each skill, two performance trials are scored. Each trial of each skill ranges between three and five process-based movement criteria that are scored dichotomously. If a criterion movement is observed, a score of ‘1’ is given. If a criterion is not observed, a score of ‘0’ is given. The sum of the criteria for each skill is worth between 6 and 10 points. Both the locomotor and object control subscales are worth 48 total raw points. Raw scores can be converted into percentiles, standard scores (standardized by age [locomotor and object control] and sex [object control]), a Gross Motor Quotient, and/or age equivalents [56].

2.4 Procedures

Prior to data collection, parents/guardians provided written informed consent and each university’s institutional review board approved all procedures. Anthropometric (e.g., height and weight via a portable stadiometer and scale [Seca, Hamburg, Germany] with shoes off), demographic (e.g., birthday from center records, sex), and TGMD-2 data were collected at each site following the same protocols. All members of the data collection staff were trained to follow the same procedures within the protocols created by two of the lead investigators collectively. Further, TGMD-2 performances were digitally recorded and retroactively coded with acceptable levels of interrater reliability ($IRR_{(3,1)} > 0.80$) following the standardized protocols found within the TGMD-2 manual [56]. All studies were performed in accordance with the standards of ethics outlined in the Declaration of Helsinki.

2.5 Data Analyses

Missing data were imputed using the *missForest* package [57]. Descriptive statistics were calculated for the sample. For inferential analyses, a probability value (α) of ≤ 0.05 was selected as the cutoff value. Categorical explanatory variables were sex (boy; girl), SES (low; not low), geographical region (rural; urban), race (Black; Hispanic; White; Other), and BMI % classification (underweight; normal; overweight;

obese). All identified outliers [58] were high scores and deemed relevant to the sample.

As children were nested within regional sites, hierarchical linear modeling was used to separately examine locomotor and object control TGMD-2 raw score differences. Because of non-normality, the MLR estimator was used in MPlus with TYPE = COMPLEX. MLR produces maximum likelihood parameter estimates with standard errors and a Chi square test statistic that are robust to non-normality of observations. For each model, intraclass correlation coefficients (ICCs) were reported that represent the proportion of variance in the TGMD-2 raw scores explained by the grouping structure of the hierarchical model. Explanatory variables included sex, BMI % classification, race, geographic region, and SES.

To complement the hierarchical linear model investigations, individual skills were descriptively examined for the entire sample and by sex as such information could assist with creating targeted, evidenced-based motor skill interventions for preschool children. Certain skills were worth more raw points than others (e.g., hop = 10; catch = 6). Proportion correct (i.e., average raw score for a skill/maximum raw score for a skill) was calculated to descriptively determine if noticeable disparities were occurring for the entire sample or between boys and girls for all individual locomotor and object control skills.

Next, all raw locomotor and object control TGMD-2 scores were converted into norm-referenced percentiles. Each individual's locomotor and object control percentile scores were then categorized as: not at risk for DD (> 25th), at risk for DD (≤ 25th), or having DD (≤ 5th). Proportions of the locomotor and object control percentile categorizations were then calculated for the total sample and by subgroup.

3 Results

3.1 Developmental Delay Categorization

Concerning DD classifications for the entire sample, 26.1%, 47.4%, and 26.5% (locomotor) and 29.9%, 47.4%, and 22.7% (object control) of participants demonstrated DD, were at risk for DD, or were not at risk for DD, respectively. Concerning all subgroups, DD classification percentages for the locomotor subscale were: 20–32% of the sample above the 25th percentile, 44–52% between the 5th and 25th percentile, and 17–32% at or below the 5th percentile. For the object control subscale, 12–27% were above the 25th percentile, 32–54% were between the 5th and 25th percentile, and 24–56% were at or below the 5th percentile (see Table 1).

Table 1 Total DD-related sample frequencies and proportions of the TGMD-2 locomotor and object control subscales by stratification

Percentile	Sex		SES		Geo. Region		Race				BMI % classification			
	B	G	NL	L	R	U	BL	H	W	O	U	N	OW	OB
	n = 284	*n* = 296	*n* = 171	*n* = 409	*n* = 294	*n* = 286	*n* = 232	*n* = 116	*n* = 182	*n* = 50	*n* = 25	*n* = 384	*n* = 77	*n* = 94
Locomotor														
> 25th	69 (.24)	85 (.29)	51 (.30)	103 (.25)	75 (.25)	79 (.28)	68 (.29)	30 (.26)	46 (.25)	13 (.26)	5 (.20)	105 (.27)	25 (.32)	19 (.20)
≤ 25th	134 (.47)	142 (.48)	79 (.46)	197 (.48)	135 (.46)	141 (.49)	117 (.50)	51 (.44)	85 (.47)	23 (.46)	12 (.48)	176 (.46)	39 (.51)	49 (.52)
≤ 5th	81 (.29)	69 (.23)	41 (.24)	109 (.27)	84 (.29)	66 (.23)	50 (.21)	35 (.30)	51 (.28)	14 (.28)	8 (.32)	103 (.27)	13 (.17)	26 (.28)
Object control														
> 25th	75 (.27)	57 (.19)	46 (.27)	86 (.21)	70 (.24)	62 (.22)	54 (.23)	25 (.22)	43 (.23)	10 (.20)	3 (.12)	102 (.26)	16 (.21)	11 (.12)
≤ 25th	126 (.44)	150 (.51)	76 (.44)	200 (.49)	130 (.44)	146 (.51)	120 (.52)	63 (.54)	74 (.41)	19 (.38)	8 (.32)	179 (.47)	38 (.49)	51 (.54)
≤ 5th	83 (.29)	89 (.30)	49 (.29)	123 (.30)	94 (.32)	78 (.27)	58 (.25)	28 (.24)	65 (.36)	21 (.42)	14 (.56)	103 (.27)	23 (.30)	32 (.34)

Proportions are in parentheses

B boy, *G* girl, *NL* not low, *L* low, *R* rural, *U* urban, *BL* Black, *H* Hispanic, *W* White, *O* Other, *U* underweight, *N* normal, *OW* overweight, *OB* obese

3.2 Factors Predicting Motor Competence

The average raw score for the locomotor subscale was 21.8 (SD = 8.4; percentile = 16th), 18.1 (SD = 7.8; percentile = 16th) for the object control subscale, and 39.9 (SD = 13.9; percentile = 12th) cumulatively. Stratified raw and standard scores for the TGMD-2 by subgroup can be found in Table 2.

For the first hierarchical model, raw TGMD-2 locomotor scores were investigated whereby children were considered nested within one of the seven early childhood sites. Initially, the unconditional model (intercept only) was run to determine the proportion of variance explained by site alone. The ICC showed that 27.1% of the total variation in locomotor TGMD-2 raw scores ($p = 0.275$) was accounted for by site. Next, three descriptive child-level variables (i.e., sex, race, and BMI % classification) were added to the model with a non-random slope. No variables were significant. The ICC decreased to 8.88% suggesting two-thirds of the site-level variation was explained by child-level descriptives. The last model added two site-level factors (i.e., SES, geographic region). Neither variables were significant. Thus, there were no significant differences in mean locomotor TGMD-2 raw scores between rural/urban or low/high SES sites. Using proportion correct, it appeared that all preschoolers struggled most with the hop (0.37), gallop (0.40), slide (0.41), and the jump (0.41) from the locomotor subscale (see Table 3). The largest descriptive difference between boys and girls for the locomotor subscale was the gallop (0.06) favoring the girls. All other differences in proportion correct between boys and girls were ≤ 0.03.

For the second hierarchical model, children were nested within sites for examining raw object control scores. The unconditional model (intercept only) was run to determine the proportion of variance explained by site alone. The ICC showed that 26.1% of the total variation in object control scores ($p = 0.275$) was accounted for by site. Next, three descriptive child-level variables (i.e., sex, race, and BMI % classification) were added to the model with the non-random slope. Only sex was significant ($b = -3.40$, standard error = 0.56, $p < 0.001$) such that (on average) girls scored nearly 3.5 raw points lower than boys on the object control subscale. The ICC ($p = 0.288$) decreased to 12.99%, showing that half of the site-level variation could be accounted for by sex of the child. The next model contained a random slope for sex meaning the slope of the regression equation was allowed to vary by site. The estimate for the random sex slope was not significant. The last model added two site-level factors (i.e., SES, geographical region). Neither SES nor geographical region was significant.

Thus, there were no significant differences in mean object control scores between rural/urban or low/high SES sites. Using proportion correct, it appeared that all preschoolers

Table 2 Stratified raw and standard TGMD-2 subscale scores

Subscale	Score	Sex		SES		Geo. Region		Race				BMI % Classification			
		B	G	NL	L	R	U	BL	H	W	O	U	N	OW	OB
		n = 284	*n* = 296	*n* = 171	*n* = 409	*n* = 294	*n* = 286	*n* = 232	*n* = 116	*n* = 182	*n* = 50	*n* = 25	*n* = 384	*n* = 77	*n* = 94
Locomotor	Raw	21.6 (8.7)	21.9 (8.1)	23.9 (9.7)	20.9 (7.6)	22.9 (8.9)	20.6 (7.6)	21.5 (8.1)	21.8 (8.4)	22.4 (8.6)	21.1 (8.9)	19.6 (7.8)	22.2 (8.6)	21.6 (8.2)	20.7 (7.6)
	Standard	7.0 (2.7)	7.2 (2.5)	7.3 (3.0)	7.0 (2.5)	7.0 (2.9)	7.2 (2.3)	7.3 (2.4)	7.0 (2.8)	7.0 (2.8)	6.8 (2.8)	6.6 (2.5)	7.1 (2.6)	7.2 (2.5)	7.0 (2.7)
Object control	Raw	20.0 (8.2)	16.3 (6.9)	20.8 (9.5)	17.0 (6.7)	19.7 (8.5)	16.5 (6.5)	17.5 (7.7)	18.5 (6.9)	18.8 (8.4)	17.5 (7.9)	14.6 (7.0)	19.1 (8.3)	16.7 (6.6)	16.0 (5.5)
	Standard	7.0 (2.5)	6.7 (2.3)	7.1 (2.7)	6.7 (2.3)	6.8 (2.6)	6.8 (2.3)	7.0 (2.3)	6.8 (2.2)	6.8 (2.7)	6.4 (2.3)	5.9 (2.3)	7.0 (2.5)	6.8 (2.6)	6.4 (1.9)

Standard deviations in parentheses

B boy, *G* girl, *NL* not low, *L* low, *R* rural, *U* urban, *BL* Black, *H* Hispanic, *W* White, *O* Other, *U* underweight, *N* normal, *OW* overweight, *OB* obese

Table 3 Raw component scores and proportion correct for individual TGMD-2 skills by sex

Skill (Max.)	Average (SD)	Overall correct	Boys correct	Girls correct	Boy/girl absolute diff.
Locomotor					
Run (8)	5.1 (1.9)	.64	.66	.63	.03
Gallop (8)	3.2 (2.3)	.40	.38	.43	.05
Hop (10)	3.7 (2.7)	.37	.36	.38	.02
Leap (6)	3.1 (1.7)	.52	.50	.52	.02
Jump (8)	3.3 (2.3)	.41	.43	.40	.03
Slide (8)	3.3 (2.8)	.41	.42	.41	.01
Object control					
Strike (10)	5.0 (2.5)	.50	.54	.47	.07
Dribble (8)	1.2 (1.9)	.15	.18	.13	.05
Catch (6)	2.8 (1.8)	.47	.50	.44	.06
Kick (8)	4.2 (1.8)	.53	.56	.48	.08
Throw (8)	2.2 (2.4)	.28	.36	.19	.17
Roll (8)	2.7 (1.8)	.34	.35	.33	.02

struggled most with the dribble (0.15), throw (0.28), and the roll (0.34) from the object control subscale (see Table 3). The largest descriptive difference between boys and girls for the object control subscale was the throw (0.17) favoring the boys; however, the boys outperformed the girls on all object control scores (0.02 [roll] to 0.17 [throw]), reinforcing the object control hierarchical linear model findings within this study (i.e., object control raw scores are higher in boys in preschool).

4 Discussion

The purposes of this study were to explore MC levels of US children aged 3–6 years, report percentages of children demonstrating DD, and investigate both within and across childcare site predictors of MC, including sex, race, geographic region, SES, and BMI % classification. Unlike the percentage of preschool children who fail to meet PA guidelines (≈40–50%) [1], and who reveal overweight/obese body weight status (≈ 14–22%) [4, 5], alarming proportions for all DD categories were found for the locomotor and object control subscales. Using a large and diverse sample, approximately 77% of the sample were at risk for DD (≤ 25th percentile) for the locomotor or object control subscales, which includes 25–30% of the sample being at or below the 5th percentile. Implications of these data are pervasive and may demonstrate a cascading impact on multiple aspects of children's health and development across childhood and beyond [17]. Early DD of MC may (1) negatively impact or coexist with additional developmental domains (e.g., cognitive, social) [59–61] and/or (2) lead to long-term health-related consequences. Notably, the longitudinal impact of MC in early childhood cannot be ignored as elevated levels of MC in childhood have been found to positively influence PA levels [13, 16], health-related fitness [15, 17, 20], weight status [14, 15, 20], and sport participation [19] in later childhood and/or adolescence.

Another critically relevant finding of this study was that DD prevalence within each subgroup was elevated irrespective of the explanatory variable of interest. While the prevalence for having DD (≤ 5th percentile) by subgroup proportionally varied for the locomotor (range = 17–32%) and object control subscales (range = 24–56%), most groups were relatively similar (e.g., ≈ 25–30%). Further, all of the extreme DD proportions (i.e., discrepancies) were in smaller subgroups (e.g., locomotor, overweight [n = 77] = 17%; object control, underweight [n = 25] = 56%; and other [n = 50] = 42%). Therefore, these divergences should be viewed with caution as certain groups within these smaller groups may not have been adequately represented within the current sample. Irrespective of these idiosyncrasies, based on the prevalence rates found in Table 1, it appears DD can afflict *any* preschool-aged child regardless of their demographic or anthropometric characteristics. Future analyses should consider inferentially investigating significant predictors of the percentile-based categories of DD, at risk for DD, and not at risk for DD.

Of the potential factors that influence MC, only sex predicted object control skills—a finding that strongly aligns with previous research [36, 37]. Developing object control skills in early childhood may have an indirect protective influence on BMI as practicing object control skills in early childhood speaks to later success in many activities where these skills are inherently demanded. Specifically, practicing and learning object control skills have both short- [62]

and long-term impacts on children's PA and fitness [13, 15, 16, 18, 20]. Thus, it is important to provide adequate resources (e.g., equipment, time, instruction) and training to promote object control skills as it is reasonable to suggest that young children of all weight statuses may require supplemental object control support. Previous research indicates early childhood is a critical time where large gains in object control skills (as well as locomotor skills) can be promoted [24, 46].

4.1 Potential Societal Impact Associated with Motor Competence Developmental Delay

From a descriptive perspective, *DD in MC did not discriminate across race, SES, geographic location, and BMI % classification in early childhood.* In essence, race, SES, geographic location, and BMI % classification did not appear to have an overwhelmingly negative or protective effect on DD proportions. However, biological sex was an exception. The girls within this sample revealed greater difficulties with object control skill than the boys, scoring approximately 5% fewer correct elements within catch, kick, roll, dribble, and strike and 17% for throwing (see Table 3). Unfortunately, sex differences regarding object control skills are a consistent finding within the literature [26, 37]. Therefore, *systemic* structures/policies should be employed to provide comprehensive MC opportunities and supports to *all* young children, not just those perceived to be 'disadvantaged', with special attention placed on object control skills for girls.

Overall, these data suggest that children in the USA may be demonstrating a dramatic secular decline in gross motor development. In the USA, the development of MC in early childhood is limited as free play is predominantly promoted in an attempt to meet PA requirements [63]. Unfortunately, free play is not sufficient to promote the development of MC [24] as many children in the current study ($\approx$25–30% for the $\leq$5th percentile) did not have adequate MC skills to successfully interact with other children and/or their environment. Even more alarming is the general lack of play opportunities in early childhood education settings [63]. To compound these issues, general early education teachers do not have the requisite knowledge or training to promote the development of MC and most centers do not employ dedicated movement specialists [64]. Compared to US samples, many European countries have structured movement opportunities provided by trained professionals that result in superior MC levels in early childhood [45, 65].

The current levels of MC in this large and diverse sample of young children suggest that many children may lack the basic capability to effectively explore their environment and interact with other children. In essence, children's capability to effectively "play" (which theoretically promotes PA and MC) in many environmental and social contexts (e.g., playground equipment, games, sports) is dramatically hindered when they lack the capability to perform many skills that are inherently needed to be successful and enjoy the activity [22]. A leading cause of decreased play time in preschool-aged children may be prolonged sedentary behaviors (e.g., extended screen time) during recreation/leisure time [66].

The drastic percentage of children at risk for or demonstrating DD within the current sample is an alarming statistic that should be taken very seriously as it suggests young children of all backgrounds are at risk for impaired MC development, which also impacts future trajectories of physical and socio-cognitive health [13–20, 59–61]. As the average locomotor and object control MC levels for this sample were disturbingly low (i.e., 16th percentile), these data suggest a MC epidemic has manifested. As such, immediate and sustained efforts must be initiated in all early childhood educational settings to develop MC as well as the aforementioned longitudinal health benefits.

The strengths of this study were that it was conducted with a large sample of young children located in early childhood education centers and represented various geographical regions. Limitations of this study include a convenience sample that was predominantly of a low SES (i.e., 71%) and Black (i.e., 40%). In addition, the established cut-offs/interpretations for DD have been determined by the authors based on the wide range of cut-off levels used across various states. The ambiguity of DD cut-off levels used across the USA speaks to the lack of attention to this potentially critical child development and public health issue. Moving forward, a consistent operational definition of DD is required to accurately analyze DD in MC.

4.2 Future Research

This study featured two innovations that should be considered when exploring future research. First, this study may be the first of its type to include putative and fixed factors and explore how they related with MC in a fairly heterogenous sample. Despite this, further inquiry is warranted to examine potential moderators of MC including time of data collection, geographic location, and cultural influences. Moreover, per Table 3, there were descriptive differences in competencies exhibited based upon individual skills. Specifically, participants revealed the greatest difficulty with dribbling and hopping. Girls showed a consistent deficit within each object control skill ($\approx$5%) but showed the greatest disparity for throwing ($\approx$17%). As skill-specific normative data for the TGMD-2 have never been published, future research should explore individual skill differences to develop targeted intervention strategies. Based on these results, it is plausible to suggest that interventionists may need to pay special attention to dribbling, hopping, and throwing to combat the MC gap found between young boys and girls in the USA. However, these suggestions are novel and may not be generalizable to all scenarios. Thus, additional research is required.

Second, this study featured raw scores within hierarchical analyses rather than standard scores. Although standard scores take age and sex into account (where applicable), using them in analyses might eliminate specific variances and increase the incidence of type II error (e.g., stating that there are no sex differences for object control skills when indeed they actually exist). Thus, future inquiries should use raw scores with all analyses, controlling for age where necessary to avoid false negatives. Standard scores can be used descriptively, as that aids with data interpretation, but should be used with caution when conducting inferential analyses.

5 Implications

These data provide insight to a potential measurement issue in MC assessment moving forward. If ≈ 77% of young children are ≤ 25th percentile including ≈ 25–30% below the ≤ 5th percentile, does *time* of data collection matter (e.g., decade to decade)? These data suggest there is a secular decline in motor skill competence paralleling that of the secular decline in pediatric fitness and PA [6, 7]. With the forthcoming publication of the TGMD-3, new norms will potentially "lower the bar" of MC levels as the norms used for the TGMD-2 are based upon a sample of children assessed in 1998–9 [56]. If the recent representative sample taken for the forthcoming TGMD-3 [67] is demonstrative of decreased performance (as noted in the current study), then the new 50th percentile norms may be lower than what was needed to score at the 50th percentile for the TGMD-2 (i.e., norm shift to the left). Thus, future research needs to explore the potential secular decline in MC as new norms could place low-performing children into an 'inflated' percentile rank. As such, there are important implications for these data:

1. Lowering what is considered a "typical motor development" level may have stark consequences as fewer children would qualify for the services and/or intervention that are needed to remediate potential delays. Per the Individuals with Disabilities Education Act [43], all US children suspected of having a disability or delay should be proactively sought and provided with early-intervention services (i.e., Child Find mandate). As the TGMD-2 may be used as one component of a disability diagnosis, the high percentage of students that demonstrate very low MC suggest that it is vital to acknowledge this movement issue and to the potential danger in shifting norms.
2. These data reinforce a significant and seemingly consistent issue; that being at risk and/or having DD in motor skills in early childhood may be an emerging epidemic in the USA, which may have significant long-term ramifications on physical and psychological health trajectories [13–20].

6 Conclusion

Data demonstrated a surprisingly high prevalence of locomotor and object control DD classification in a large and diverse sample of young US children that did not discriminate across sex, race, SES, geographic location, and BMI % classifications (Table 1). Further, of the investigated explanatory factors, only sex was found to predict object control MC. Research has consistently demonstrated that motor DD can be remediated, but only if it is acknowledged and targeted through daily structured MC curriculums that (1) consider environmental/ecological factors and (2) are taught by trained movement specialists. If the elevated prevalence of DD continues to be neglected, young children will be at risk not only for multiple physical health-related issues [17], but DD in MC also may impact cognitive and/or social development [59–61].

Compliance with Ethical Standards

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Conflict of interest Ali Brian, Adam Pennell, Sally Taunton, Angela Starrett, Candice Howard-Shaughnessy, Jacqueline D. Goodway, Danielle Wadsworth, Mary Rudisill, and David Stodden have no conflicts of interest that are directly relevant to the content of this article.

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