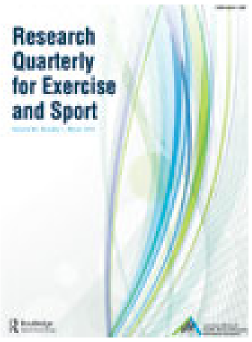

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Promoting Adapted Physical Activity Regardless of Language Ability in Young Children With Autism Spectrum Disorder

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ABSTRACT

Purpose: There is a relationship between motor and language skills in children with Autism Spectrum Disorder (ASD), but little work addresses the ramifications of this relationship for professionals who teach motor skills to this population. Within a motor skills intervention, this study probed the importance of language skills for motor intervention. We examined the relationship between motor and language skills at baseline, and then the relationship between baseline language skills and motor improvements resulting from the intervention. **Method**: Twenty children aged 4–6 years with ASD participated. Eleven children received 20 hr per week of motor intervention for 8 weeks. Nine children did not receive motor intervention. Language skills (Mullen Scales of Early Learning) and motor skills (Test of Gross Motor Development – 2) were assessed at baseline and post-intervention. Spearman correlations tested the associations between baseline language and baseline motor skills. This analysis was repeated in the intervention sample to test the association between baseline language level and response to intervention (motor skill changes from baseline to post-intervention). **Results**: Prior to intervention, locomotor skills are positively correlated ($p < .001$) with both receptive ($rs = 0.827$) and expressive ($rs = 0.722$) language skills. Similarly, object-control skills are positively correlated ($rs < .001$) with receptive ($rs = 0.779$) and expressive ($rs = 0.729$) language skills. However, those baseline language skills do not relate to motor change in the experimental group. **Conclusion**: These results suggest that motor programs may improve motor skills in children with ASD when language is supported, regardless of pre-program language ability.

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Autism; education; intervention; motor

Teaching children with Autism Spectrum Disorder (ASD) is an increasingly prominent need in the field of physical education; however, pre-requisite language abilities may lead to biased expectations of possible motor progress. ASD is a developmental disability affecting increasing numbers of children in the United States: estimates from 2014 suggested that 1 in 59 children is affected with ASD (Baio, 2018) but more recent studies based on parent report suggest numbers as high as 1 in 40 (Kogan et al., 2018). Since motor ability and language skills are correlated in children with ASD (Bhat et al., 2012; Leonard & Hill, 2014), some might assume that a certain amount of language ability is pre-requisite for meaningful motor skill improvement. This assumption could foster low expectations for children with lower language abilities, or perhaps even exclude participants without language ability from motor skill development activities. In published motor skill interventions for children with ASD, there is a lack of investigation regarding the influence of baseline language ability upon the motor improvement of participants.

There is, however, a rich legacy of research investigating both language and motor skills in children with ASD. Language delay and motor delay *on their own* are not cardinal features of ASD, but children with ASD do frequently show delays in both language and motor development. Children with ASD show lower scores on expressive, receptive, and phonological language assessments than typically developing peers (Garrido et al., 2017). Significant delays in motor development have also been noted in children with ASD (Ament et al., 2015; Fournier et al., 2010; Leonard et al., 2014; Liu & Breslin, 2013; Lloyd et al., 2013). In one study, 83% of children with ASD had motor composite scores at least one standard deviation below the population mean, whereas only 6% of children without ASD showed these low motor scores (Hilton et al., 2012). Thus, although neither is pathognomonic or included in the diagnostic description of ASD, it is clear that both language and motor skills are frequently delayed in children with ASD.

There is also a rich research history investigating a connection between language and motor development.

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This relationship in its simplest form is observed during typically developing infancy (Iverson, 2010). Rhythmical arm movements have been shown to increase before the start of the canonical babble, and decrease after this phase (Ejiri, 1998; Iverson & Fagan, 2004). This phenomenon has also been identified in infants at risk for ASD (Iverson & Wozniak, 2007). Typically, developing infants interact more with their caregivers once they can independently walk than they did before independent locomotion (Clearfield, 2011; Clearfield et al., 2008; Karasik et al., 2011; Kretch et al., 2014). Earlier acquisition of the skills of sitting and walking is associated with a better vocabulary (Libertus & Violi, 2016; Oudgenoeg-Paz et al., 2012; Walle & Campos, 2014). At 18 months of age, language and motor abilities are correlated, and interestingly, these motor and language abilities equally predict future language ability at 3 years (Wang et al., 2014). This connection between language and motor development remains relevant as typically developing children proceed into early childhood (Alcock & Krawczyk, 2010; Cheng et al., 2009; Merriman et al., 1995), and in children with other disabilities including cerebral palsy (Coleman et al., 2013).

The neurobiological underpinnings of this relationship are also worthy of consideration. In motor learning, it has been observed that the content of verbal statements can alter the response time of motor transfer of objects (Glenberg et al., 2008). In a functional magnetic resonance imaging study, the activation of language and right-handed motor areas of the brain were correlated when performing finger movements and a verb generation language task (Loring et al., 2000). Similarly, in a motor control study, the kinematics of reaching and grasping were altered based on the meanings of words read during the tasks (Gentilucci et al., 2000). Thus, many different disciplines support the assertion that the language and motor areas of the brain influence one another in practice.

In research specific to ASD, there appears to be a relationship between language and motor skills, but the directionality and significance of such a relationship are debated. In an early case study, a child with autism made more vocalizations when motorically quiet, and moved the most immediately prior to vocalizations, indicating that increased motor response often precedes the amount of vocal response (Bram et al., 1977). Another study found that relationships between both fine and gross motor skills and both expressive and receptive language abilities were stronger in children with ASD than in a group representing the general population (Dyck et al., 2006). In addition, there is much evidence suggesting that motor behavior in infancy can predict later language ability (Bedford et al., 2016; LeBarton & Iverson, 2013; Leonard et al., 2015), suggesting that early motor behaviors could prove just as useful for diagnosis of ASD as early language skills (Baranek, 1999). A recent review highlights the important bidirectional connections between physical activity and social functioning in children with ASD (Reinders et al., 2019). Thus, it appears that there is a rich legacy of research in ASD indicating a relationship between language and motor skills, but the time-specificity and importance of this relationship are debated.

In the motor intervention context, the relationship between language and motor skills is uninvestigated, as are the ramifications of such a relationship for intervention response. For example, no motor interventions for children with ASD (to our knowledge) have measured language neither as an independent variable nor as an outcome measure. Interestingly, some motor skill interventions have yielded benefits in *social* skills (Sowa & Meulenbroek, 2012). A 12-week therapeutic horseback riding program primarily focused on motor skill development provided benefits not only in motor skills but also in social responsiveness and motivation for school-aged children with ASD (Bass et al., 2009). Children in this program also showed improvements in sensory-seeking behavior (Bass et al., 2009). Social skill scores improved after a 12 week in-school fundamental movement skills (FMS—basic motor abilities that provide the foundation for more specific athletic abilities) intervention for children with ASD-like characteristics aged 3–7 (Bremer & Lloyd, 2016). In other cases, no changes in social skills arose after physical activity interventions (Bremer et al., 2015; Pan, 2010). These discriminant results might speak to the diverse content and curriculum present in each motor intervention, and how such programming interacts with the social domain. None of these studies included a discussion of language benefits. A significant body of research investigates the relationship between motor and language skills in children with ASD, but very little work addresses the importance of language ability within motor interventions, which would be the setting most relevant to physical education.

The purpose of this study was to examine these questions of language and motor skill ability and motor response to intervention within the motor intervention context. A secondary data analysis of a motor intervention for children with ASD (Ketcheson et al., 2017) was performed for the current study. Language as an outcome variable was not collected in this study, but baseline language ability was available. Thus, the purposes of this study were to assess:

Aim 1. The baseline relationship between language and motor skills, Aim 2. The relationship between baseline language skills and motor improvement in the intervention.

Considering the literature, we hypothesize that baseline language and motor skills will be related to one another in this sample (Bedford et al., 2016; Wang et al., 2014). In addition, we hypothesize that baseline language ability will not correlate with motor response to intervention; children will benefit similarly to motor instruction regardless of baseline language ability (Hilton et al., 2012; Hsu et al., 2004; MacDonald et al., 2013, 2014; Sipes et al., 2011).

Method

The current investigation is a secondary data analysis of a motor skill intervention for children with ASD aged 4–6 years. Please refer to the original study for greater detail regarding methodology and motor skill outcomes (Ketcheson et al., 2017). This study was approved by the institutional review board.

Participants

Twenty children with ASD aged 4–6 years (experimental group n = 11; control group n = 9) were recruited through local "early on" support groups and programs that provide early intervention services for children with disabilities. Participants met inclusion criteria in the original motor skill intervention study if they were between 4 and 6 years of age at study entry, resided within 50 miles of the intervention site, and met ASD cut off criteria for ASD on the Autism Diagnostic Observation Schedule (ADOS-2) (Lord et al., 2001, p. 2). If families indicated their child would be participating in extracurricular PA throughout the summer months, they were excluded from study participation. Families completed a questionnaire regarding summer services and participants in both groups were enrolled in a variety of services including occupational therapy and social skills training.

Intervention

The experimental group participated in the 8-week-long program that consisted of 20 hours a week of instruction on motor skills. Every participant worked in a 1:1 ratio where coaches provided direct individualized instruction to their assigned participant. The control group was instructed to participate in their regularly scheduled activities throughout the summer months. In terms of the intervention's reliance on language for instruction: the approach was individualized for each participant within the least restrictive environment for each learner. Results of baseline language assessments allowed staff to cater to current abilities in expressive and receptive language. Coaches used this data to deliver instruction. For example, for the non-verbal participants, a visual demonstration was presented, followed by series of keywords and an opportunity for child to respond, then prompting least invasive to most invasive. If a child did not understand following the delivery of these instructional cues, full physical prompting was supported. Instructional strategies from Classroom Pivotal Response Therapy (see Ketcheson et al., 2017 for full description of intervention) further supported learning, including multiple forms of representation to deliver instruction, maintenance of a 50/50 ratio of easy and difficult tasks, and shared control in decision-making. To reinforce direct and contingent reinforcement were utilized to reinforce attempts.

Procedures

All pre-and post-measures took place in 1 day where children were evaluated in quiet classrooms. Precautions to minimize distractions in each environment were taken including the removal of chairs, tables, and desks. A total of two parental questionnaires and three assessments were administered. With regard to questionnaires, first, families completed informed consent, next parents were asked to complete a questionnaire regarding extracurricular participation. Following questionnaires, a series of three assessments were administered. First, the Mullen Scales of Early Learning (MSEL) (Mullen, 1995) was used as our measurement of expressive and receptive language. Next, to evaluate motor skills, children were administered the Test of Gross Motor Development – 2 (TGMD-2) (Ulrich, 2000). Finally, an ADOS-2 was administered to confirm ASD diagnoses and the calibrated severity score (CSS) was used as a measurement of symptom severity.

Measures

Mullen Scales of Early Learning

The MSEL is a standardized measure of cognitive functioning appropriate for children birth to 5 years of age, subtests include non-verbal problem solving or visual reception, fine motor, receptive language, and expressive language. The age equivalent scores on the expressive and receptive language subtests were included in the analysis, and the visual reception T-score was included as a measure of nonverbal intelligence quotient (IQ) (Akshoomoff, 2006; Bedford et al., 2016; MacDonald et al., 2014). Visual reception standard scores have typical means of 50 with standard deviation of 10 (Mullen, 1995), and when this sample is compared to this average, current study participants showed rather lower IQ (sample mean and SD = 42.00 ± 11.96). Most children did not reach the ceiling of this assessment and it was therefore appropriate for the language levels represented in the intervention. In young children with and without autism, there is a limitation in the ability to tease language out of a cognitive assessment. This assessment is considered a better presentation of "IQ" in young children with Autism, who may have deficits in language, because of its non-verbal problem-solving items (Luyster & Lord, 2009). For this reason, this is the best measure of overall intelligence in this sample.

Test of Gross Motor Development – 2

The TGMD-2 was administered to assess motor skill competence. The TGMD-2 is a standardized valid and reliable evaluation for children ages 3–11, included within their norms are a representative number of children with developmental disabilities. It consists of 12 culturally relevant motor skills that are classified within 2 subtests, locomotor skills (e.g. run, hop, gallop) and object control skills (e.g.: kick, dribble, throw). Raw scores from the TGMD-2 were used in the analysis as raw scores are more sensitive in detecting intervention response (Robinson & Goodway, 2009). The TGMD-2 provides three raw scores: locomotor, object control, and total. The total raw score is the sum of the locomotor (movement of the body through space with no equipment) and object control (the use of implements common in sports) subscales. The TGMD-2 was the outcome used to measure response to motor intervention in the previous work (Ketcheson et al., 2017). As documented in this same previous work, the motor intervention was successful in improving the TGMD-2 scores of the experimental group compared to those in the control group. For the current study, we used TGMD-2 scores in two ways:

Aim 1. To examine the baseline relationship between language and motor skills, baseline TGMD-2 locomotor and object control raw scores were used in correlations with baseline language measures.

Aim 2. To examine the relationship between baseline language skills and motor improvement in the intervention, calculated change scores for the experimental group only were used. The change scores were calculated as the difference in raw score from baseline to post-intervention. Change scores for both locomotor raw score and object control raw scores were used. These change scores were used in correlations with baseline language measures. The ADOS-2 was administered to confirm a previous diagnosis of ASD. The assessment consists of several semi-structured tasks meant to elicit both social and communication responses with the aim of providing a measure of ASD symptom severity (Gotham et al., 2009). Participants were administered one of four Modules, with appropriate tasks based on expressive language ability. CSS were derived from the ADOS-2 in order to calculate ASD symptom severity (Shumway et al., 2012).

Statistical analysis

Before beginning any parametric tests, normality was assessed using the Jarque–Bera and Shapiro–Wilk tests for normality (Öztuna et al., 2006). The variables checked were baseline MSEL expressive language (age equivalent score), baseline MSEL receptive language (age equivalent score), baseline TGMD-2 locomotor (raw score), baseline TGMD-2 object control (raw score), TGMD-2 locomotor change score of the experimental group, and TGMD-2 object control change score of the experimental group. The normality of ADOS-2 CSS and MSEL cognitive T-score was also checked, in order to use parametric t-tests to check equivalence of groups at baseline (see below). Baseline TGMD-2 locomotor raw score, TGMD-2 locomotor change score of the experimental group, TGMD-2 object control change score of the experimental group, and MSEL cognitive T-score were normally distributed according to both tests of normality. Baseline MSEL expressive language (age equivalent score), baseline MSEL receptive language (age equivalent score), and baseline TGMD-2 object control raw score, and ADOS-2 CSS were non-normal according to both tests of normality. Nonparametric tests were chosen henceforth for those variables without normal distributions.

To check whether the control and experimental groups were generally equivalent at baseline, tests comparing the means of MSEL cognitive T-score, baseline TGMD-2 locomotor, baseline TGMD-2 object control, and ADOS-2 CSS scores by group were checked. Independent samples t-tests could be done for MSEL cognitive T-score and baseline TGMD-2 locomotor raw score. Both MSEL cognitive T-score and baseline TGMD-2 locomotor raw scores were not significantly different between groups. MSEL cognitive T-score did not meet the assumption of homogeneity of variances, so the adjusted t-test values were used. Mann–Whitney U-tests were used to compare the control and experimental group in baseline TGMD-2 object control raw score and ADOS-2 CSS. Both of these variables were not significantly different by group at baseline.

Descriptive characteristics of the sample (means, standard deviations, percentages of total sample) were calculated.

Aim 1. To assess the relationship between baseline motor and language scores, Spearman correlations were run, due to the non-normal distribution of both MSEL language scores and baseline TGMD-2 object control raw score. Four correlations at baseline were run: MSEL expressive language age equivalent score and receptive language age equivalent score each with both TGMD-2 locomotor raw score and object control raw score. The CSS was not used to covary because doing so would partially covary for language, which is a major construct of interest in this study. Next, confidence intervals were calculated at 95% for each correlation coefficient using a Fischer-Z transformation method typically used for Pearson correlations (Snedecor & Cochran, 1980); Altman and Gardner argue it can be applied to Spearman correlations as well, due to the similar distributions of the two (Altman & Gardner, 2000).

Aim 2. In the experimental group only, four Spearman correlations were run: baseline MSEL expressive language age equivalent score and baseline receptive language age equivalent score with both TGMD-2 locomotor change score and TGMD-2 object control change score. Again, the nonparametric tests were chosen due to the non-normal distribution of both MSEL language scores. This set of correlations was to elucidate the relationships between baseline language ability and response to motor intervention. The CSS was not used as a covariate because doing so would partially control for language, one of our main constructs of interest. Again, confidence intervals at 95% were calculated for each correlation using the same method as in Aim 1. This study did not collect post language scores and our control group received no intervention; therefore, the analysis for Aim 2 was run with the experimental group only.

Results

Independent samples t-tests for MSEL cognitive T-score and baseline TGMD-2 locomotor raw score showed no significant differences between groups. Mann–Whitney U-tests of baseline TGMD-2 object control raw score and ADOS-2 CSS by group showed no significant differences at baseline. The finding of equivalence of groups at baseline is replicated in the larger motor intervention work (Ketcheson et al., 2017). Descriptive characteristics of the sample are presented in Table 1.

Table 1. Descriptive information, language, and motor characteristics of the sample.

	Total				Experimental				Control						
	N	%	Mean	SD	*N*	%	Mean	SD	*N*	%	Mean	SD	d	Power	*n*
Gender															
Male	15	75.0			9	81.8			3	66.7					
Female	5	25.0			2	18.2			6	33.3					
Race															
Caucasian	16	80.0			9	81.8			7	77.8					
African American	2	10.0			2	18.2			0	0					
Hispanic	1	5.0			0	0			1	11.1					
Other	1	5.0			0	0			1	11.1					
Some high school	1	5.0			2	18.2			0	0					
High school	1	5.0			1	9.1			1	11.1					
Some college	2	10.0			0	0			0	0					
Associate	2	10.0			3	27.3			0	11.1					
Bachelor	8	40.0			1	9.1			5	55.6					
Post Bachelor	6	30.0			4	36.4			2	22.2					
Age (months)			59.600	8.469			60.545	9.554			58.444	7.316	.25	.08	542
CSS			6.400	1.273			6.27	1.009			6.5556	1.590	.21	.07	718
MSEL scores															
Visual reception T-score			42.000	11.956			45.636	8.394			37.556	14.527	.68	.29	74
Expressive language age equivalent			48.700	19.134			57.818	10.787			37.556	21.680	1.18	.68	26
Receptive language age equivalent			49.700	19.090			57.818	11.241			39.778	22.499	1.01	.54	36
TGMD-2															
Baseline															
Total raw score			29.250	17.091			32.455	9.438			25.333	23.473	.39	.13	
Locomotor raw score			15.500	9.665			17.818	6.911			12.667	12.073	.52	.19	
Object control raw score			13.750	8.650			14.636	5.201			12.667	11.895	.21	.07	
Post-intervention															
Total raw score			51.350	25.779			67.545	11.510			31.556	24.724	1.86	.97	
Locomotor raw score			24.950	12.551			34.636	7.659			16.333	13.181	1.70	.93	
Object control raw score			24.950	12.551			32.909	6.01			15.222	12.132	1.84	.96	

SES = Socio-economic Status; CSS = Calibrated Severity Score on ADOS-2; MSEL = Mullen Scales of Early Learning; TGMD-2 = Test of Gross Motor Development – 2; d = Cohen's d effect size.

Aim 1: At baseline language competencies positively relate to motor competencies

In all participants at baseline, locomotor raw scores on the TGMD-2 were significantly related to MSEL receptive (r_s = 0.827, *p* < .001, 95%CI: *[0.606, 0.929]*) and expressive (r_s = *0.722, p < .001*, 95%CI: [*0.411, 0.883]*) language scores. For object control skills, raw scores on the TGMD-2 were significantly related to MSEL receptive (r_s = *0.779, p < .001*, 95%CI: *[0.514, 0.908]*) and expressive (r_s = *0.729, p < .001*, 95%CI: [*0.423, 0.886]*) language scores. These correlation coefficients all fall above r_s = 0.5, and therefore are considered large effects (Cohen, 1988). These results are represented graphically in Figure 1.

Aim 2: Baseline language competencies do not relate to motor intervention response

For participants in the experimental group, neither MSEL receptive (r_s = 0.094, *p* = .783, 95%CI: [−0.536–0.657]) nor expressive (r_s = 0.200, *p* = .554, 95%CI: [−0.454, 0.714]) language scores correlated with TGMD-2 locomotor raw score changes from baseline to post-intervention. Neither MSEL receptive (r_s = 0.177, *p* = .603, 95%CI: [−0.473, 0.702]) nor expressive (r_s = 0.321, *p* = .336, 95%CI: [−0.345, 0.772]) language scores correlated with TGMD-2 object control raw score changes from baseline to post-intervention. The results of these correlations are represented in scatterplots in Figure 2.

Discussion

The movement delays of young children with ASD are well documented and include a delay in acquisition of early motor milestones (Bhat et al., 2012; Flanagan et al., 2012) poor gross motor skills (Lloyd et al., 2013) and difficulties with motor coordination (Fournier et al., 2010). Links between the motor domain and several other domains of development have been investigated (Hilton et al., 2012; Hsu et al., 2004; MacDonald et al., 2013, 2014; Sipes et al., 2011). Additionally, research supports that gross motor abilities predict later expressive and receptive language development (Bedford et al., 2016; Wang et al., 2014). While there is significant evidence to support the implementation of motor skill interventions (Case & Yun, 2019; Colombo-Dougovito & Block, 2019; Healy et al., 2018) the current study filled a gap in the literature by examining the association of language and motor skills at baseline in a motor skill intervention, and then the extent to which language at baseline was associated with motor outcomes, when language needs are supported. Outcomes suggest that tailoring instruction based on individual needs may

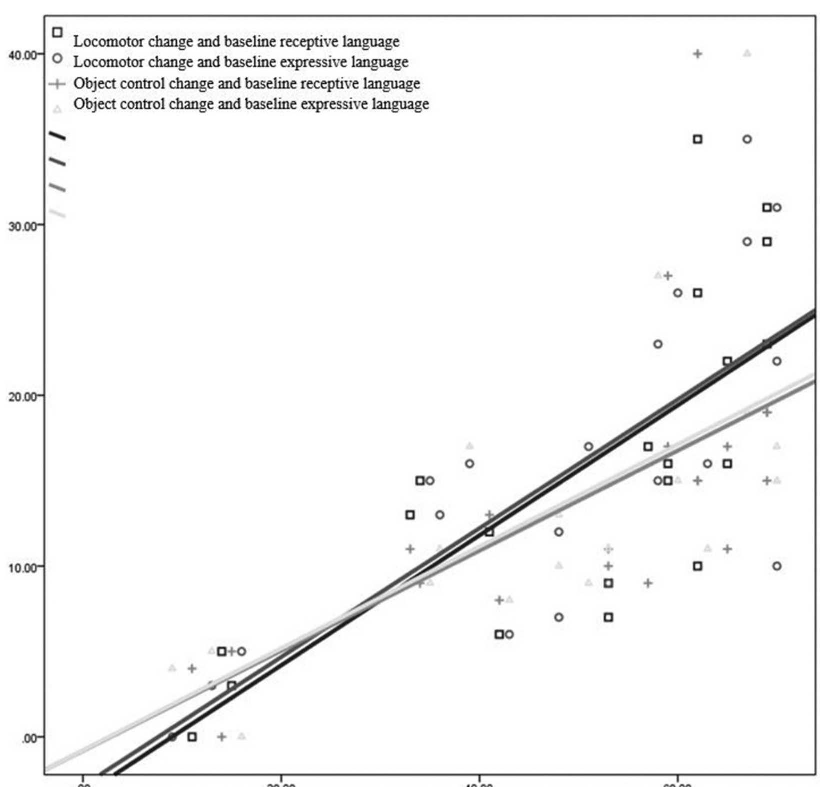

Figure 1. Baseline language competencies positively relate to baseline motor competencies.

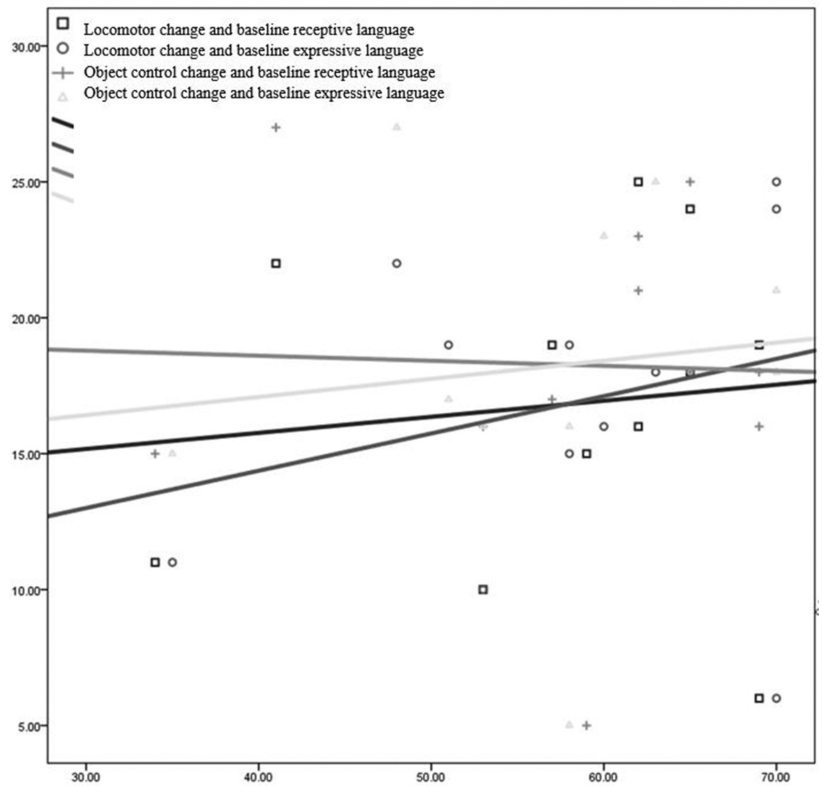

Figure 2. Baseline language competencies do not relate to motor intervention response.

pivotal for increasing motor outcomes in children with ASD. To our knowledge, this is a novel finding and adds to the limited but growing interest in this field of study. However, authors caution generalizable nature of these findings given low power and small the sample size. Future research should consider a priori investigation of this research, with the inclusion of the control group in both pre and post measures or replication of similar research question in a larger sample. Future findings could potentially challenge biases that might be present when forming expectations regarding the potential physical education progress of children with varying levels of language ability.

Recently, motor delays are becoming accepted as a common feature of ASD and tailored interventions targeting multiple developmental domains are being developed (Bremer et al., 2015; Bremer & Lloyd, 2016; Felzer-Kim & Hauck, 2020; Ketcheson et al., 2017). Similarly, APE seeks to improve the motor skills of children with ASD. Our results suggest that using language levels to individualize motor interventions and APE is attractive but potentially unnecessary. While authors caution generalizing current study results due to low power, initial findings should generate future dialogue about language skills and the potential benefit that can emerge as a result of tailored motor skill intervention. It is also interesting to consider the teaching style present; recent results from an Applied Behavior Analysis fundamental movement skills program show that even in an environment using highly standardized language and prompts across all participants, motor improvements can be made (Felzer-Kim, 2018). In addition, it appears that even in motor skill interventions of very different hourly doses, motor improvement can also be made (Case & Yun, 2019).

ASD is a developmental disability affecting increasing numbers of children in the United States: estimates from 2014 suggested that 1 in 59 children is affected with ASD (Baio, 2018) but more recent studies based on parent report suggest numbers as high as 1 in 40 (Kogan et al., 2018). Previous reports examining the trajectory of language outcomes in young children with ASD relative to the motor domain, examine changes without the consideration of intervention. In one such study, age, language, and motor abilities were found to be correlated and actually predicted language at 3 years of age (Wang et al., 2014). Next, previous research reported that gross motor abilities predict language outcomes in early and late childhood (Bedford et al., 2016). Reports such as these link language and motor abilities in their current states and throughout developmental time. From an intervention perspective, such reports could stimulate recruitment of participants with lower motor function in interventions designed to increase language function. The current study potentially opens up the dialogue to challenge this perspective by providing support that motor and language ability may be similarly linked; however, they do not predict responsiveness to motor skill instruction. However, given low power in the analysis, authors cautioned how these study results should be interpreted. Along with previous empirical support suggesting a motor and language link, outcomes underscore the importance of early motor interventions regardless of proficiency in expressive or receptive language.

Delays in early infant motor milestones may be among the first behavioral manifestations of an eventual ASD diagnosis (Bhat et al., 2012). The current study, as well as others, reports a link between language and motor skills in young children. Collectively, there is great value in promoting early and intensive motor interventions to address these delays, even before the onset of expressive or receptive language or identification of a delay. Early intervention, even before onset of language competency, could help reduce movement delays.

Next, given the pervasive nature of ASD, it is critical to examine the cascading relationship between developmental domains, including language, social, and motor outcomes. Specifically, to more comprehensively understand the relationship between motor and language domains, future research should focus on the longitudinal tracking of skills during early developmental periods. This knowledge may assist researchers in more appropriately tailoring interventions to simultaneously impact language and motor outcomes during sensitive periods of development. While the purpose of this study was to examine the role that language plays in motor intervention outcomes, emerging research suggests that beyond the core delays and deficits of children with ASD, there are additional health disparities which this population may also experience. In fact, children with ASD (aged 2–5) are 2–4 times more likely to be overweight or obese than their neurotypical peers, and weight status shares a relationship with motor proficiency (Broder-Fingert et al., 2014). This is of concern as motor proficiency may relate to weight status, and certainly relates to physical activity engagement (Williams et al., 2008). There is also ample research to contest that weight trajectories track into adolescence and adulthood. When taken together, a better understanding of the directionality that language plays in the context of the motor domain is needed. This may simultaneously address the need to include movement in the prescription of early intervention and fill the need for services that address language and health outcomes.

Limitations

The present study is a secondary data analysis of a previously published motor intervention. The original intervention was not designed to investigate relationships between language and motor skills, in fact, it measured motor outcomes as a primary objective and MSEL as a measure of language and cognition. Future motor skill intervention research should build cross-domain questions into their objectives, considering language and social variables both at baseline and from baseline to post-intervention. The present study is underpowered to detect a lack of relationship between baseline language scores and motor intervention response. Specifically, to examine Aim 2, authors acknowledge a significant lack of power, limiting the conclusions and generalizability of study results. Next, the lack of post-intervention motor scores also prevented the inclusion of the control group in Aim 2 analysis. It should be acknowledged that the interventionists delivering this motor intervention provided instruction that was tailored to the language abilities of each participant. In order to replicate the findings of the present study, language-supportive instruction is necessary. Language is likely essential while gaining motor skills in a motor intervention, and it is not the intention of the authors to suggest otherwise. Instead, the findings of the current study suggest that *baseline* language skills do not relate to the *amount* of motor progress *when individual language is supported* throughout the intervention. Authors finally caution against extensive generalization of these findings given small the sample size.

Conclusion

While expressive and receptive language delays are characteristic of children with ASD (American Psychological Association, 2013), over the past several years, the motor delays in this population have garnered increased attention. Findings from this study demonstrate that regardless of baseline language skills using a dedicated intervention that accounts for these needs could be beneficial. However, authors again caution conclusions in this study based on current findings, given the lack of power and low sample size.

Within the broader context of intervention research for pre-schooled age children with ASD, findings from this study could stimulate further investigation in the relationship between movement and the established "core deficits" of ASD. Careful methodological considerations in intervention research are needed in order to adequately examine the changing rates of development across multiple domains in young children with ASD.

What does this article add?

Current study outcomes suggest that tailoring instruction based on individual language needs may be important for increasing motor outcomes in children with ASD. This knowledge could be used as support for future research in early motor intervention prescriptions, including early intervention and adapted physical education, for all children with ASD who have motor delays.

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