# Associations Among Daily Living Skills, Motor, and Sensory Difficulties in Autistic and Nonautistic Children

**Brittany G. Travers, Lucia Lee, Nicole Klans, Alexandra Engeldinger, Desiree Taylor, Karla Ausderau, Emily C. Skaletski, Joshua Brown**



**Importance:** Motor and sensory challenges are commonly reported among autistic individuals and have been linked to challenges with daily living skills (DLS). To best inform clinical intervention, greater specificity in how sensory and motor challenges relate to DLS is needed.

**Objective**: To evaluate the relationship between combined sensory and motor scores and DLS performance among autistic and nonautistic children and to explore associations between motor scores and performance on specific DLS items.

**Design:** Descriptive design.

**Setting:** University research lab.

**Participants:** Autistic children, nonautistic children with no family history of or diagnosis related to autism, and nonautistic children with a family history of or diagnosis related to autism (ages 6–10 yr; $N = 101$). All participants communicated verbally.

**Intervention:** None.

**Outcomes and Measures:** Parent-report measures of DLS and sensory features and standardized assessments of motor performance.

**Results:** Findings indicated a strong relationship between motor difficulties and all domains of DLS. At the item level, motor skills were associated with occupations of dressing, bathing, health management, cleaning up and organization, meal preparation and clean-up, education, and safety. Combined sensory and motor measures better predicted DLS than sensory or motor measures alone.

**Conclusions and Relevance:** Children with motor and sensory challenges are likely to experience challenges with a diversity of occupations, which is important given the prevalence of motor and sensory challenges among autistic children and among children with other neurodevelopmental conditions. Therapeutic interventions that account for or address these motor challenges and associated sensory features are likely to further enhance DLS.

**What This Article Adds:** A combination of motor challenges and sensory features better predict DLS than either motor or sensory challenges alone. In addition, motor challenges in children are most highly associated with DLS challenges in the domains of dressing, bathing, cleaning, education, safety, health, and meal preparation. Occupational therapists can use this information when considering how the results of sensory and motor assessment may guide clinical intervention in autistic and nonautistic children.

Travers, B. G., Lee, L., Klans, N., Engeldinger, A., Taylor, D., Ausderau, K., Skaletski, E. C., & Brown, J. (2022). Associations among daily living skills, motor, and sensory difficulties in autistic and nonautistic children. *American Journal of Occupational Therapy, 76,* 7602205020. https://doi.org/10.5014/ajot.2022.045955

Significant motor impairments are present among 25% to 51% of autistic children[1] (Fournier et al., 2010; Ming et al., 2007; Surgent et al., 2021). Motor-related performance skills combine with other client factors, body functions, and context to affect occupational participation (American Occupational Therapy Association [AOTA], 2020). Indeed, previous research highlights that motor

[1]On the basis of the majority preference of those in this diagnostic population, we use identity-first language (e.g., autistic) in this article (Kenny et al., 2016).

challenges are strongly associated with challenges in adaptive daily living skills (DLS) among very young autistic children (MacDonald et al., 2013); preschool-age autistic children (Jasmin et al., 2009); school-age autistic children (Alañiz et al., 2015); and in a longitudinal cohort of autistic children, adolescents, and adults (Travers et al., 2017). Challenges in DLS may be particularly important to address. DLS are predictive of quality of life (Bishop-Fitzpatrick et al., 2016; Hong et al., 2016) and sustained employment (Chan et al., 2018), and autistic children exhibit slower progression in and attainment of DLS than nonautistic peers with no known diagnoses and nonautistic peers with other neurodevelopmental diagnoses (Bal et al., 2015; Green & Carter, 2014; Jasmin et al., 2009).

However, the current literature has neither explored nor identified which specific DLS are most associated with motor challenges among autistic children or how motor and sensory challenges in combination may influence DLS, even though sensory features are well known to be associated with DLS among people with autism (Baker et al., 2008; Jasmin et al., 2009). In addition, the current literature has not explored these questions in a group with varying degrees of motor challenges. The latter is particularly important because motor challenges are not specific to autism but occur across a number of other neurodevelopmental conditions and may be one of the earliest indicators of autism risk among infant siblings of autistic children (Iverson et al., 2019). Motor skills have also been associated with DLS in children with cerebral palsy (CP), developmental coordination disorder (DCD), and attention deficit hyperactivity disorder (ADHD; Biscaldi et al., 2015; Summers et al., 2008; van Eck et al., 2010).

To better understand the nature of the connection between motor skills and DLS, the first objective of this study was to replicate previous findings supporting the relationship between motor scores and overall DLS performance among autistic and nonautistic children. On the basis of previous research, we hypothesized that motor scores from the Bruininks–Oseretsky Test of Motor Proficiency Second Edition (BOT–2) Short Form (Bruininks & Bruininks, 2005) would be highly associated with parent-reported DLS composite measures and subscales of the Vineland Adaptive Behavior Scales, Second Edition (VABS–II; Sparrow et al., 2005). The second objective was to extend previous findings to identify specific DLS challenges (based on VABS–II subscales and items) that are related to motor performance among autistic and nonautistic children. This objective aimed to reveal the specifics of the motor and DLS relationship to inform clinical intervention. Given the reported overlap in motor and sensory features, the third objective was to examine whether combining motor and sensory information would be a better predictor of DLS than sensory or motor features alone.

# Method

## Study Design

This study used a descriptive design that examined associations between parent-report measures of DLS and standardized assessments of motor performance. It was part of a larger research study that aimed to identify specific brain stem regions that are linked to sensorimotor and social communication features in autistic individuals and nonautistic individuals. All participants were enrolled in the larger study, although data collection for the larger study is ongoing. The nonautistic group had two subgroups: (1) children without a family history of autism or known neurodevelopmental diagnoses, whom we refer to as the *no dx or hx group,* and (2) children with a family history of autism or conditions genetically associated with autism (Carroll & Owen, 2009; Lionel et al., 2011), whom we refer to as the *intermediate phenotype group.* The latter group was included to represent children who are typically excluded from traditional autism research but who might represent an intermediate behavioral phenotype between autistic children and children with no known diagnoses.

## Participants

Participants were 101 children ages 6 yr, 0 mo, to 10 yr, 11 mo ($M$ = 8.7 yr, $SD$ = 1.5) in three groups: the autism group, the no dx or hx group, and the intermediate phenotype group. The children had a wide range of intellectual functioning, although they all communicated verbally at the time of testing (IQ range = 62–149, $M$ = 108.49, $SD$ = 15.49). To determine whether our sample size was sufficient, we performed a post hoc power analysis using G*Power (Version 3.1; Faul et al., 2007). With an $\alpha$ error probability of .05, this analysis demonstrated an estimated power of .99 for detecting a large effect and an estimated power of .94 for detecting a medium effect.

Participant group totals were as follows: For the autism group, $n$ = 37 children; for the no-dx-or-hx group, $n$ = 34; and for the intermediate phenotype group, $n$ = 30. The *intermediate phenotype group* was defined as children who had a diagnosis of ADHD; a first-degree relative diagnosed with autism spectrum disorder, bipolar disorder, major depressive disorder, or schizophrenia; or both. These conditions were chosen on the basis of evidence that there is substantial genetic overlap among them (Carroll & Owen, 2009; Lionel et al., 2011) and the fact that motor challenges have been reported in people with conditions such as ADHD (Biscaldi et al., 2015) and in first-degree relatives of autistic individuals (Mosconi et al., 2010; Wu et al., 2018). The first author (Brittany G. Travers) and a licensed clinical psychologist verified final group placement for all participants by means of the Autism Diagnosis Observation Scale–Second Edition (ADOS–2; Lord et al., 2012), the Social Communication Questionnaire (SCQ; Rutter et al., 2003), and the

Social Responsiveness Scale–Second Edition (SRS–2; Constantino & Gruber, 2012). All participants in the nonautistic group scored above a 35.5 on the BOT–2, suggesting they did not meet the threshold for DCD (Bruininks & Bruininks, 2005). In the autism group, the average IQ was 104.32 ($SD$ = 17.70); in the no-hx-or-dx group, 113.00 ($SD$ = 12.53); and in the intermediate phenotype group, 108.50 ($SD$ = 14.64). There was a nonsignificant trend for an IQ difference among the groups, $F(2, 98) = 2.88$, $p = .06$, but IQ was controlled for in all analyses.

Recruitment occurred through distribution of flyers to local businesses and community centers, Internet postings of the flyer, and letters to prospective participants in the Waisman Center's Intellectual and Developmental Disabilities and K–12 registries. Exclusion criteria included a diagnosis of tuberous sclerosis or fragile X syndrome or contraindications to MRI. Participants were also excluded from the larger study if they did not speak English or could not provide verbal assent to participate in the study.

## Measures

### Wechsler Abbreviated Scale of Intelligence, Second Edition

The Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI–II; Wechsler & Hsiao-pin, 2011) is both a reliable and a valid measure of intelligence. The test is designed for individuals ages 6 to 90 yr. Composite scores were calculated using the two-subscale score.

### Vineland Adaptive Behavior Scales, Second Edition

The VABS–II is a caregiver questionnaire that assesses the participant's personal and social skills (Sparrow et al., 2005). The VABS–II provides age-standardized scores for DLS, has test–retest reliability, and demonstrated strong internal consistency.

### Bruininks–Oseretsky Test of Motor Proficiency Second Edition, Short Form

The BOT–2 is a standardized, norm-referenced measure used to assess a person's motor performance (ages 4–21 yr). The BOT–2 Short Form is a screening tool that has demonstrated strong internal consistency reliability (.82–.87), test–retest reliability (.80–.87), and interrater reliability (.98). Recently, the BOT–2 Short Form demonstrated appropriate reliability and validity and high sensitivity for preschool-age children (Gharaei et al., 2019), suggesting that this measure is appropriate even for the youngest of the current cohort. Higher scores on the BOT–2 Short Form indicate more proficient motor skills. Short Form standard scores (normed for age and sex) were used in the data analysis.

### Sensory Experiences Questionnaire, Version 3.0

The Sensory Experiences Questionnaire, Version 3.0 (SEQ–3.0; Baranek, 2009) is a caregiver-report measure that characterizes sensory features among children ages 2 to 12 yr. Items measure the frequency of atypical sensory behaviors across four key sensory patterns: hyporesponsiveness, hyperresponsiveness, repetitions and seeking behaviors, and enhanced perception (Ausderau et al., 2016). Sensory features were evaluated using the SEQ–3.0's 97 quantitative items, which are scored on a 5-point Likert scale ranging from 1 (*never/almost never*) to 5 (*always/almost always*). Higher scores indicate more severe sensory symptoms. Follow-up analyses used the summed total for all four sensory patterns. All but 1 participant had a completed SEQ–3.0.

## Procedures

Parental consent and participant assent were obtained from an investigator at the beginning of the study, which consisted of one to three visits. All procedures were approved by the University of Wisconsin–Madison Institutional Review Board (No. 2016-0441) and were in accordance with the ethical standards of the committee as well as with the 1964 Helsinki Declaration and its later amendments. Parents completed caregiver forms, and participants completed behavioral and neuroimaging tasks.

## Data Analysis

Data analysis was completed using R Version 3.6.2 (R Core Team, 2019). We controlled for multiple comparisons by using omnibus testing, a tiered statistical approach in which a global statistical test (e.g., motor predicting all DLS) is performed. If this test was significant, we then ran follow-up statistical analyses to examine the nature of the relation (e.g., BOT–2 motor scores predicting scores on the DLS Personal, Domestic, and Community subscales). For all analyses, both linear and quadratic fits were assessed using the Akaike Information Criterion (AIC; Akaike, 1974). Independent variables were mean-centered to reduce multicollinearity. Our first omnibus test used a linear regression to examine the relationship between DLS standard scores and motor skills across our sample. A basic assumption of our study was that motor skills and DLS would be similarly associated across all groups (autism, intermediate phenotype, and no dx or hx). We tested this assumption by including group as a moderator in the model and found no significant interaction, $F(2, 93) = 0.14$, $p = .87$. This confirmed our assumption that there was a similar relation between motor skills and DLS across all three groups and allowed us to collapse across all groups in our analysis. To determine that these relations held in the autism group, we performed a follow-up analysis within just that group. Age was not included as a covariate because both motor and DLS scores were standardized for age. However, given the documented relationship between IQ and DLS (Liss et al., 2001), we controlled for IQ in all models. AIC was used to determine whether a linear or quadratic fit was most appropriate. The final omnibus model was as follows: DLS standard scores ~ intercept + BOT–2 standard scores + BOT–2 standard scores$^2$ + IQ.

Because the results of the first omnibus test were significant, we continued to the next level of analysis, in which we evaluated *v* scores on the three DLS subscales: Personal, Domestic, and Community (all age-normed). Again, IQ was controlled for in all models. Assumptions of this test were examined, and only one analysis (of the Domestic subscale) demonstrated a violation of the assumption of kurtosis. However, an adequate transformation was not found, so the results are reported below.

Because the results for all three subscales were significant, we moved on to the item-level analysis and performed multiple ordinal logistic regressions using the MASS package in R (Venables & Ripley, 2002) to model the relationships between scores on the BOT–2 Short Form and those on the VABS–II DLS items. Items on the VABS–II were rated as 0 (*never performed*), 1 (*sometimes or partly performed*), or 2 (*behavior is usually or habitually performed*). Alternative options included NA (*not applicable*) or NO (*no opportunity*). Only those VABS–II items that had at least 25% of responses in the 0, 1, and 2 category and at least five occurrences of a score of 0, 1, or 2 were included in the analysis, with the goal of having at least five cases at each level of the dependent variable for each statistical analysis. This limited our analyses to 51 of 109 items, but fewer than five responses at each level would not have allowed appropriate interpretation of the statistical findings. An $\alpha$ value of $p <$ .05 was used to determine the significance of these relationships. In addition to controlling for multiple comparisons through omnibus testing, we reported which analyses reached statistical significance with a false discovery rate correction (Benjamini & Hochberg, 1995). Consistent with previous models, we included IQ as a covariate. Because the items were not age normed, we also included age as a covariate. All items that reached significance were thematically coded.

Because sensory features and motor difficulties were recently found to be highly interrelated in this sample (Surgent et al., 2021), we performed follow-up analyses to address whether combining motor and sensory information would be an even better predictor of DLS than sensory or motor features alone. Specifically, we performed two separate stepwise regressions: (1) a stepwise regression that first took our model of quadratic BOT–2 scores predicting DLS and examined how much more variance was explained by adding the SEQ–3.0 total score to the model and (2) a stepwise regression looking at how sensory features predict DLS and examining how much more variance is added by the quadratic BOT–2 scores. The $R^2$ change and statistical comparison of the models determined the most robust predictors of DLS. All models controlled for IQ.

## Results

A significant relation between motor skills and DLS was observed (Table 1). This relation also held in the autism group, with motor skills significantly predicting DLS, $b = 0.98$, $SE = 0.37$, $t(35) = 2.61$, $p = .02$. The quadratic model (AIC = 842.82) was found to be a better fit than the linear model (AIC = 847.38) and is shown in Figure 1A. Figure 1B illustrates the nature of this quadratic relationship, such that there was a strong motor–DLS association for participants with a standard score of <45 (i.e., 31st percentile), $r(60) = .38$, $p = .002$, but no association for participants with a standard score of ≥45, $r(37) = .05$, $p = .76$.

This linear regression was then repeated at the next level, to assess the model fit for the DLS Personal, Domestic, and Community subscales. As illustrated in Figures 1C to 1E, the quadratic models outperformed linear models, and Table 1 shows that all DLS categories demonstrated a significant relation with motor performance.

To explore the relationship between motor scores and DLS performance on specific DLS items, ordinal logistic regressions were performed for the 51 VABS–II items individually. Table 2 shows the 24 items (47%) that reached statistical significance and their thematic codes.

To account for the possibility that sensory features (which are related to motor skills) may actually be driving the relationship between motor scores and DLS, we performed stepwise linear regressions to examine how strongly VABS–II standard scores were predicted by (1) motor skills alone, (2) sensory features alone, and (3) combined motor skills and sensory features. We found that the combined motor skills and sensory model explained 5.5% more variance in DLS than the motor-alone model, which was a significant increase ($F = 7.59$, $p = .007$). Similarly, we found that the combined motor skills and sensory model explained 4.5% more variance in DLS than the sensory-alone model, which was also a significant increase ($F = 3.12$, $p = .049$). Moreover, motor skills continued to be a significant predictor of DLS even after accounting for sensory features (Table 3).

## Discussion

Our study replicates previous findings (Alañiz et al., 2015; Jasmin et al., 2009; MacDonald et al., 2013; Travers et al., 2017) of a positive relationship between motor difficulties and DLS, indicating that children with decreased motor abilities demonstrate reduced DLS performance. These findings extend previous research by demonstrating that this association is consistent across the DLS Personal, Domestic, and Community subscales, even after controlling for important variables such as age and IQ. Therefore, motor challenges among children appear to be consistently linked to DLS across different domains. Perhaps one of the most intriguing findings was the quadratic

**Table 1. Regression Statistics for Multiple Regression Results**

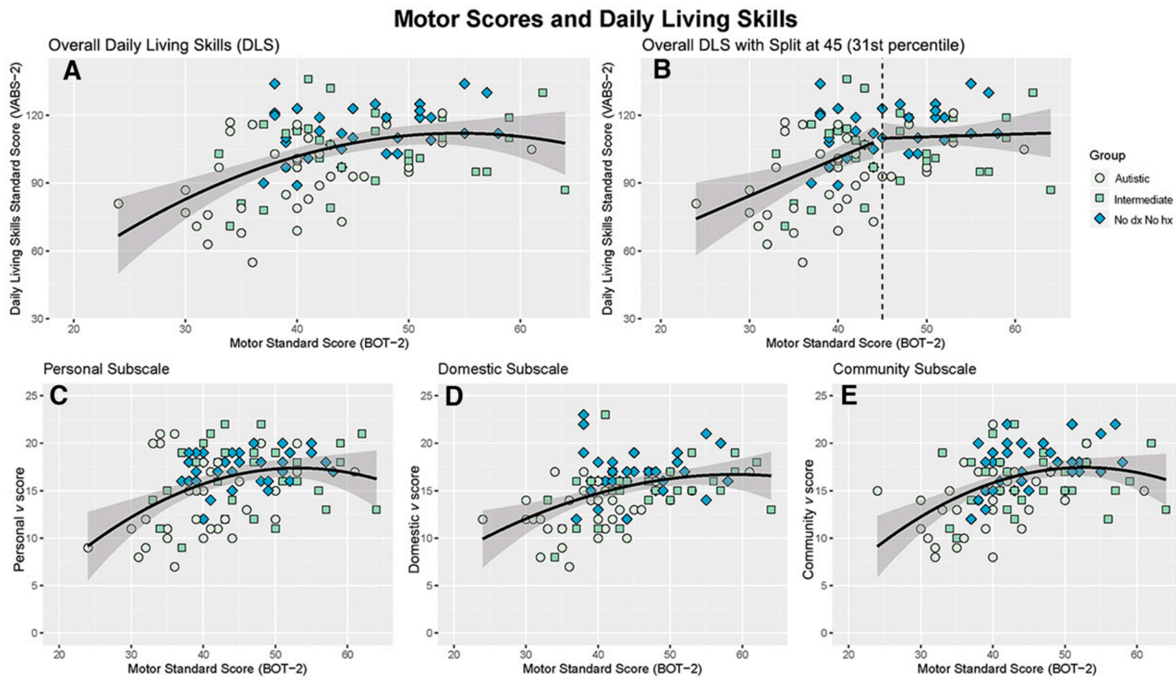
| Predictor Variable and Statistics | VABS–II Daily Living Composite and Subscales | | | |
|---|---|---|---|---|
| | Daily Living Skills Standard Scores | Personal Subscale *v* Scores | Domestic Subscale *v* Scores | Community Subscale *v* Scores |
| Intercept | | | | |
| *b* | 105.77 | 16.45 | 15.38 | 16.41 |
| *SE* | 1.93 | 0.42 | 0.35 | 0.36 |
| *p* | <.001 | <.001 | <.001 | <.001 |
| Motor | | | | |
| *b* | 0.88 | 0.16 | 0.16 | 0.12 |
| *SE* | 0.22 | 0.05 | 0.04 | 0.04 |
| *p* | <.001 | .001 | <.001 | .004 |
| Motor$^2$ | | | | |
| *b* | −0.038 | −0.008 | −0.005 | −0.007 |
| *SE* | 0.020 | 0.004 | 0.004 | 0.004 |
| *p* | .05 | .05 | .17 | .08 |
| IQ | | | | |
| *b* | 0.20 | 0.02 | 0.01 | 0.07 |
| *SE* | 0.11 | 0.02 | 0.02 | 0.02 |
| *p* | .08 | .32 | .63 | .001 |
| Full model | | | | |
| $F(3, 97)$ | 10.79 | 6.80 | 7.30 | 12.33 |
| *p* | <.001 | <.001 | <.001 | <.001 |
| Adjusted $R^2$ | .227 | .148 | .159 | .253 |

*Note. b* = unstandardized β. VABS–II = Vineland Adaptive Behavior Scales, Second Edition.

relationship between motor skills and DLS. Specifically, if a child scored higher than a standard score of 45 (31st percentile) on the BOT–2 Short Form, their motor skills were not related to DLS, which suggests that there is a threshold at which motor performance is no longer able to predict DLS functioning. Although future research is required, this novel finding may suggest that only a certain level of motor skills is required to successfully engage in DLS. This finding has implications for practitioners who are assessing motor skills; a screening score below the 31st percentile on the BOT–2 Short Form can alert them to further investigate the child's full profile of motor skills and engagement in DLS. Although eligibility requirements vary by funding source, many eligibility thresholds for direct occupational therapy intervention are well below the 31st percentile. On the basis of the associated functional limitations, these findings suggest that scores at or below the 31st percentile (equivalent to 0.5 standard deviations below the mean) should warrant consideration of eligibility for occupational therapy.

We also examined which DLS items were driving the relation between motor skills and DLS and found that approximately half of the items were robustly predicted by motor performance (even after accounting for age and IQ). A thematic analysis of these items found that motor challenges were most related to occupations of dressing (i.e., buttoning large or small buttons), bathing and showering (i.e., bathing and drying oneself, washing and drying one's hair), education (e.g., calendar and coin skills), health management (i.e., caring for cuts, using a thermometer), cleaning and organization (e.g., putting away possessions; sweeping, mopping, vacuuming; using household products; cleaning rooms), meal preparation and clean-up (e.g., clearing table and breakable items, using simple appliances and a microwave, washing dishes, preparing basic foods), and safety (i.e., looking both ways before crossing the street, obeying curfews). Of these items, the strongest relationship was that between motor skills and cleaning and organization. Although there are widely varying sociocultural norms, children in this age range (6–10 yr) often participate in household chores (Hofferth & Sandberg, 2001), many of which center around cleaning and organization. Speculatively, increased attention to cleaning and organization skills with this age group, and corresponding caregiver expectations, may be why the relations between motor skills and this domain were so apparent. However, this will need to be directly tested in future research using DLS measures that address caregiver expectations in addition to DLS performance. The present findings

**Figure 1. BOT–2 motor standard scores prediction of DLS, using VABS–II overall DLS standard scores (A and B) and Personal (C), Domestic (D), and Community (E) subscale *v* scores.**




*Note.* The quadratic fit was found to outperform a linear fit in all of the analyses. The nature of the quadratic fit is further illustrated in (B) by splitting the regression lines at a standard motor score of 45. Autistic = group with an autism diagnosis; BOT–2 = Bruininks–Oseretsky Test of Motor Proficiency–Second Edition; DLS = daily living skills; Intermediate = intermediate phenotype group; no dx no hx = group without a known diagnosis of or family history of autism or known neurodevelopmental diagnoses; VABS–II = Vineland Adaptive Behavior Scales, Second Edition; *v* score = scaled score with $M = 15$ ($SD = 3$).

underscore the importance of assessing underlying motor skills and demonstrate that specific DLS tasks in the domains of cleaning and organization, bathing and dressing, meal preparation and clean-up, health management, education, and safety appear to be driving the observed motor–DLS relationship.

We also examined sensory features to determine whether what we are measuring in terms of motor skills may be just a proxy for sensory features or whether combining motor and sensory information would be an even better predictor of DLS. The results suggest that a combination of motor and sensory assessments predict a child's DLS performance better than either sensory or motor assessments alone. This finding underscores the need to assess both motor and sensory domains in occupational therapy practice and their influence on participation.

## Limitations and Future Directions

Successful DLS are multifaceted. Although the present findings reiterate the associations among motor skills, sensory features, and DLS, future research that additionally includes measurements of executive functioning and attention may contribute to a more comprehensive description of the strengths and areas of difficulty contributing to DLS.

Moreover, this study focused on autistic children, children without a neurodevelopmental diagnosis or autism-relevant family history, and children who may have an intermediate behavioral phenotype. A limitation is not being able to examine differences within the intermediate group (because of sample size) and the absence of additional populations such as children with CP, DCD, or Down syndrome. Future research specifically including these populations and studying the relationship among motor difficulties, sensory features, and DLS needs to be conducted to understand the overall relationship among these factors. Another limitation is that we examined only the DLS items on which at least five individuals fell into each score level of the VABS–II (0, 1, or 2). This limited the number of items that we were able to examine, but future research with larger sample sizes will be able to further elucidate specific items that are associated with motor challenges. In addition, the BOT–2 Short Form is a summary and screening measure of motor skills. Specific analyses of fine motor and gross motor skills with the full BOT–2 (or a similar motor assessment) would provide a more nuanced and comprehensive perspective of how motor challenges relate to DLS.

## Implications for Occupational Therapy Practice

This study has the following implications for occupational therapy practice:

Table 2. **Ordinal Logistic Regression Model of BOT–2 Short Form Predicting VABS–II DLS Item Scores**

| VABS–II Daily Living Skill Items | Value | *SE* | *t* | *p* | Thematic Coding |
|---|---|---|---|---|---|
| Personal items | | | | | |
| 26. Buttons large buttons in front, in correct buttonholes | .14 | .05 | 2.48 | .013 | D |
| 28. Buttons small buttons in front, in correct buttonholes | .11 | .04 | 2.57 | .010 | D |
| 32. Bathes or showers and dries self | .09 | .03 | 2.81 | .005[a] | B |
| 34. Washes and dries hair (with towel or hair dryer) | .09 | .03 | 2.53 | .011 | B |
| 35. Cares for minor cuts (for example, cleans wounds, puts on bandages, etc.) | .08 | .03 | 2.52 | .012 | H |
| 37. Uses thermometer to take own or another's temperature | .08 | .03 | 2.86 | .004[a] | H |
| Domestic items | | | | | |
| 5. Puts away personal possessions (for example, toys, books, magazines, etc.) | .06 | .03 | 2.11 | .035 | C |
| 7. Clears breakable items from own place at table | .12 | .04 | 2.90 | .004[a] | M |
| 9. Uses simple appliances (for example, a toaster, can opener, bottle opener, etc.) | .06 | .03 | 2.14 | .032 | M |
| 10. Uses microwave oven for heating, baking, or cooking (that is, sets time and power setting, etc.) | .07 | .03 | 1.96 | .049 | M |
| 13. Washes dishes by hand, or loads, and uses dishwasher | .09 | .03 | 3.06 | .002[a] | M |
| 14. Sweeps, mops, or vacuums floors thoroughly | .09 | .03 | 2.92 | .003[a] | C |
| 15. Clears table completely (for example, scrapes and stacks dishes, throws away disposable items, etc.) | .08 | .03 | 2.84 | .004[a] | M |
| 16. Uses household products correctly (for example, laundry detergent, furniture polish, glass cleaner, etc.) | .09 | .03 | 3.09 | .002[a] | C |
| 17. Prepares basic foods that do not need mixing but require cooking (for example, rice, soup, vegetables, etc.) | .06 | .03 | 2.10 | .036 | M |
| 18. Cleans one or more rooms other than own bedroom | .08 | .03 | 2.68 | .007[a] | C |
| Community items | | | | | |
| 12. Identifies penny, nickel, dime, and quarter by name when asked; does not need to know the value of coins | .09 | .04 | 2.08 | .038 | E |
| 13. Looks both ways when crossing streets or roads | .07 | .03 | 2.00 | .045 | S |
| 14. Says current day or the week when asked | .08 | .04 | 2.22 | .026 | E |
| 15. Demonstrates understanding of right to personal privacy for self and others (for example, while using restroom or changing clothes, etc.) | .08 | .03 | 2.31 | .021 | CM |
| 18. States value of penny (1 cent), nickel (5 cents), dime (10 cents), and quarter (25 cents) | .08 | .04 | 2.08 | .038 | E |
| 21. Points to current or other date on calendar when asked | .10 | .04 | 2.69 | .007[a] | E |
| 28. Obeys curfew parent or caregiver sets | .07 | .03 | 2.45 | .014 | S |
| 29. Watches or listens to programs for information (for example, weather report, news, educational, program, etc.) | .07 | .03 | 2.19 | .028 | E |

*Note.* B = bathing and showering; BOT–2 = Bruininks–Oseretsky Test of Motor Proficiency–Second Edition; C = cleaning and organization; CM = communication management; D = dressing; DLS = daily living skills; E = education; H = health management and maintenance; M = meal preparation and clean-up; S = safety; VABS–II = Vineland Adaptive Behavior Scales, Second Edition.
[a]Meets significance threshold for false discovery rate multiple comparison correction.

- Motor challenges are related to decreased DLS performance, particularly among children who score below the 31st percentile on the BOT–2 Short Form, a screening tool for motor difficulties. This has implications for intervention eligibility requirements, suggesting that children who screen at or below the 31st percentile in motor skills require further evaluation and may be eligible for occupational therapy services.
- Children with motor challenges may demonstrate difficulty with specific areas of

**Table 3. Regression Results for the Motor and Sensory Model That Was Found to Be More Predictive of Daily Living Skill Standard Scores Than Either Motor or Sensory Scores Alone**

| Predictor Variable and Statistics | Daily Living Skill Standard Scores |
|---|---|
| Intercept | |
| *b* | 105.01 |
| *SE* | 1.90 |
| *p* | <.001 |
| Motor | |
| *b* | 0.59 |
| *SE* | 0.24 |
| *p* | .02 |
| Motor$^2$ | |
| *b* | −0.03 |
| *SE* | 0.02 |
| *p* | .16 |
| Sensory | |
| *b* | −8.91 |
| *SE* | 3.23 |
| *p* | .007 |
| IQ | |
| *b* | 0.18 |
| *SE* | 0.11 |
| *p* | .10 |
| Full model | |
| $F(4, 95)$ | 10.69 |
| *P* | <.001 |
| Adjusted $R^2$ | .281 |

*Note.* $b$ = unstandardized β.

occupation: dressing, bathing, health management, cleaning up and organization, meal preparation and clean-up, education, and safety. These particular areas of DLS may be more challenging for children with motor difficulties and can be targeted in occupational therapy if deemed important by the child and family.

- Information from both motor and sensory assessments will better predict potential DLS challenges than either motor or sensory assessments alone. Therefore, whenever possible, both motor and sensory assessments should be integrated into evaluations.

## Conclusion

This study confirms the role that motor challenges play in daily living tasks and the importance of concurrently considering sensory features. Surprisingly, our data suggest that motor–DLS relationships exist in children who screen at or below the 31st percentile of motor skills, which is a broader definition of *motor challenges* than is typically used. The findings also demonstrate that these motor challenges are most related to occupations in the domains of bathing, health management, cleaning up and organization, meal preparation and clean-up, and education. These findings are important given the prevalence of motor and sensory challenges among autistic children and children with other neurodevelopmental conditions. Given the associations among DLS, quality of life, and employment in autism (Bishop-Fitzpatrick et al., 2016; Chan et al., 2018; Hong et al., 2016), it is important for therapeutic interventions to address motor challenges and sensory symptoms that are associated with DLS among children.

## Acknowledgments

This research was performed while the authors were a part of the Occupational Therapy Program, Department of Kinesiology, University of Wisconsin–Madison, and it was supported by the Hartwell Foundation's Individual Biomedical Award (to Brittany G. Travers), the Eunice Kennedy Shriver National Institute of Child Health and Human Development (P30 HD003352, U54 HD090256, and P50 HD105353 to the Waisman Center and R01 HD094715 to Brittany G. Travers and Karla Ausderau). The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institute of Child Health and Human Development or the National Institutes of Health. We sincerely thank all the families who spent their time participating in this study. We thank Hayley Crain for her time and expertise and all the team members of Motor and Brain Development Lab for their incredible work on this project.

## References

Akaike, H. (1974). A new look at the statistical model identification. *IEEE Transactions on Automatic Control, 19,* 716–723. https://doi.org/10.1109/TAC.1974.1100705

Alañiz, M. L., Galit, E., Necesito, C. I., & Rosario, E. R. (2015). Hand strength, handwriting, and functional skills in children with autism. *American Journal of Occupational Therapy, 69,* 6904220030. https://doi.org/10.5014/ajot.2015.016022

American Occupational Therapy Association. (2020). Occupational therapy practice framework: Domain and process (4th ed.). *American Journal of Occupational Therapy, 74*(Suppl. 2), 7412410010. https://doi.org/10.5014/ajot.2020.74S2001

Ausderau, K. K., Sideris, J., Little, L. M., Furlong, M., Bulluck, J. C., & Baranek, G. T. (2016). Sensory subtypes and associated outcomes in children with autism spectrum disorders. *Autism Research, 9,* 1316–1327. https://doi.org/10.1002/aur.1626

Baker, A. E., Lane, A., Angley, M. T., & Young, R. L. (2008). The relationship between sensory processing patterns and behavioural responsiveness in autistic disorder: A pilot study. *Journal of Autism and Developmental Disorders, 38,* 867–875. https://doi.org/10.1007/s10803-007-0459-0

Bal, V. H., Kim, S. H., Cheong, D., & Lord, C. (2015). Daily living skills in individuals with autism spectrum disorder from 2 to 21 years of age. *Autism, 19,* 774–784. https://doi.org/10.1177/1362361315575840

Baranek, G. T. (2009). *Sensory Experiences Questionnaire Version 3.0.* Unpublished manuscript.

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological), 57,* 289–300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Biscaldi, M., Rauh, R., Müller, C., Irion, L., Saville, C. W., Schulz, E., & Klein, C. (2015). Identification of neuromotor deficits common to autism spectrum disorder and attention deficit/hyperactivity disorder, and imitation deficits specific to autism spectrum disorder. *European Child and Adolescent Psychiatry, 24,* 1497–1507. https://doi.org/10.1007/s00787-015-0753-x

Bishop-Fitzpatrick, L., Hong, J., Smith, L. E., Makuch, R. A., Greenberg, J. S., & Mailick, M. R. (2016). Characterizing objective quality of life and normative outcomes in adults with autism spectrum disorder: An exploratory latent class analysis. *Journal of Autism and Developmental Disorders, 46,* 2707–2719. https://doi.org/10.1007/s10803-016-2816-3

Bruininks, R. H., & Bruininks, B. B. (2005). *Bruininks–Oseretsky Test of Motor Proficiency* (2nd ed.). Pearson Assessment.

Carroll, L. S., & Owen, M. J. (2009). Genetic overlap between autism, schizophrenia and bipolar disorder. *Genome Medicine, 1,* 102. https://doi.org/10.1186/gm102

Chan, W., Smith, L. E., Hong, J., Greenberg, J. S., Lounds Taylor, J., & Mailick, M. R. (2018). Factors associated with sustained community employment among adults with autism and co-occurring intellectual disability. *Autism, 22,* 794–803. https://doi.org/10.1177/1362361317703760

Constantino, J. N., & Gruber, C. P. (2012). *The Social Responsiveness Scale manual* (2nd ed.). Western Psychological Services.

Faul, F., Erdfelder, E., Lang, A.-G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39,* 175–191. https://doi.org/10.3758/BF03193146

Fournier, K. A., Hass, C. J., Naik, S. K., Lodha, N., & Cauraugh, J. H. (2010). Motor coordination in autism spectrum disorders: A synthesis and meta-analysis. *Journal of Autism and Developmental Disorders, 40,* 1227–1240. https://doi.org/10.1007/s10803-010-0981-3

Gharaei, E., Shojaei, M., & Daneshfar, A. (2019). The validity and reliability of the Bruininks–Oseretsky Test of Motor Proficiency, 2nd Edition Brief Form, in preschool children. *Annals of Applied Sport Science, 7*(2), 3–12. https://doi.org/10.29252/aassjournal.7.2.3

Green, S. A., & Carter, A. S. (2014). Predictors and course of daily living skills development in toddlers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 44,* 256–263. https://doi.org/10.1007/s10803-011-1275-0

Hofferth, S. L., & Sandberg, J. F. (2001). How American children spend their time. *Journal of Marriage and Family, 63,* 295–308. https://doi.org/10.1111/j.1741-3737.2001.00295.x

Hong, J., Bishop-Fitzpatrick, L., Smith, L. E., Greenberg, J. S., & Mailick, M. R. (2016). Factors associated with subjective quality of life of adults with autism spectrum disorder: Self-report versus maternal reports. *Journal of Autism and Developmental Disorders, 46,* 1368–1378. https://doi.org/10.1007/s10803-015-2678-0

Iverson, J. M., Shic, F., Wall, C. A., Chawarska, K., Curtin, S., Estes, A., . . . Young, G. S. (2019). Early motor abilities in infants at heightened versus low risk for ASD: A Baby Siblings Research Consortium (BSRC) study. *Journal of Abnormal Psychology, 128,* 69–80. https://doi.org/10.1037/abn0000390

Jasmin, E., Couture, M., McKinley, P., Reid, G., Fombonne, E., & Gisel, E. (2009). Sensori-motor and daily living skills of preschool children with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 39,* 231–241. https://doi.org/10.1007/s10803-008-0617-z

Kenny, L., Hattersley, C., Molins, B., Buckley, C., Povey, C., & Pellicano, E. (2016). Which terms should be used to describe autism? Perspectives from the UK autism community. *Autism, 20,* 442–462. https://doi.org/10.1177/1362361315588200

Lionel, A. C., Crosbie, J., Barbosa, N., Goodale, T., Thiruvahindrapuram, B., Rickaby, J., . . . Scherer, S. W. (2011). Rare copy number variation discovery and cross-disorder comparisons identify risk genes for ADHD. *Science Translational Medicine, 3,* 95ra75. https://doi.org/10.1126/scitranslmed.3002464

Liss, M., Harel, B., Fein, D., Allen, D., Dunn, M., Feinstein, C., . . . Rapin, I. (2001). Predictors and correlates of adaptive functioning in children with developmental disorders. *Journal of Autism and Developmental Disorders, 31,* 219–230. https://doi.org/10.1023/A:1010707417274

Lord, C., Rutter, M., DiLavore, P., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism Diagnostic Observation Schedule* (2nd ed.). Western Psychological Corporation.

MacDonald, M., Lord, C., & Ulrich, D. (2013). The relationship of motor skills and adaptive behavior skills in young children with autism spectrum disorders. *Research in Autism Spectrum Disorders, 7,* 1383–1390. https://doi.org/10.1016/j.rasd.2013.07.020

Ming, X., Brimacombe, M., & Wagner, G. C. (2007). Prevalence of motor impairment in autism spectrum disorders. *Brain and Development, 29,* 565–570. https://doi.org/10.1016/j.braindev.2007.03.002

Mosconi, M. W., Kay, M., D'Cruz, A.-M., Guter, S., Kapur, K., Macmillan, C., . . . Sweeney, J. A. (2010). Neurobehavioral abnormalities in first-degree relatives of individuals with autism. *Archives of General Psychiatry, 67,* 830–840. https://doi.org/10.1001/archgenpsychiatry.2010.87

R Core Team. (2019). *R: A language and environment for statistical computing.* R Foundation for Statistical Computing. https://www.R-project.org/

Rutter, M., Bailey, A., & Lord, C. (2003). *The Social Communication Questionnaire manual.* Western Psychological Services.

Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland Adaptive Behavior Scales* (2nd ed.). Pearson Clinical Assessment.

Summers, J., Larkin, D., & Dewey, D. (2008). Activities of daily living in children with developmental coordination disorder: Dressing, personal hygiene, and eating skills. *Human Movement Science, 27,* 215–229. https://doi.org/10.1016/j.humov.2008.02.002

Surgent, O. J., Walczak, M., Zarzycki, O., Ausderau, K., & Travers, B. G. (2021). IQ and sensory symptom severity best predict motor ability in children with and without autism spectrum disorder. *Journal of Autism and Developmental Disorders, 51,* 243–254. https://doi.org/10.1007/s10803-020-04536-x

Travers, B. G., Bigler, E. D., Duffield, T. C., Prigge, M. D. B., Froehlich, A. L., Lange, N., . . . Lainhart, J. E. (2017). Longitudinal development of manual motor ability in autism spectrum disorder from childhood to mid-adulthood relates to adaptive daily living skills. *Developmental Science, 20,* e12401. https://doi.org/10.1111/desc.12401

van Eck, M., Dallmeijer, A. J., van Lith, I. S., Voorman, J. M., & Becher, J. (2010). Manual ability and its relationship with daily activities in adolescents with cerebral palsy. *Journal of Rehabilitation Medicine, 42,* 493–498. https://doi.org/10.2340/16501977-0543

Venables, W. N., & Ripley, B. D. (2002). *Modern applied statistics with S.* Springer. https://doi.org/10.1007/978-0-387-21706-2

Wechsler, D., & Hsiao-pin, C. (2011). *WASI–II: Wechsler Abbreviated Scale of Intelligence.* Pearson.

Wu, D., José, J. V., Nurnberger, J. I., & Torres, E. B. (2018). A biomarker characterizing neurodevelopment with applications in autism. *Scientific Reports, 8,* 614. https://doi.org/10.1038/s41598-017-18902-w

**Brittany G. Travers, PhD,** is Associate Professor, Occupational Therapy Program, Department of Kinesiology, and Investigator, Waisman Center, University of Wisconsin–Madison; btravers@wisc.edu

**Lucia Lee, MOT, OTR/L,** is Occupational Therapist, Froedtert Hospital, Milwaukee, WI.

**Nicole Klans, MOT, OTR/L,** is Occupational Therapist, Children's Minnesota, Minneapolis.

**Alexandra Engeldinger, MOT, OTR/L,** is Occupational Therapist, Aspire Therapy and Development Services, Madison, WI.

**Desiree Taylor, MOT, OTR/L,** is Doctoral Student, Occupational Therapy Program, Department of Kinesiology, University of Wisconsin–Madison, and Occupational Therapist, Aspire Therapy & Development Services, Madison, WI.

**Karla Ausderau, PhD, OTR/L,** is Associate Professor, Occupational Therapy Program, Department of Kinesiology, and Investigator, Waisman Center, University of Wisconsin–Madison.

**Emily C. Skaletski, MOT, OTR/L,** is PhD Student, Occupational Therapy Program, Department of Kinesiology, and Member, Motor and Brain Development Lab, Waisman Center, University of Wisconsin–Madison.

**Joshua Brown, OTD, OTR/L,** is Clinical Assistant Professor, Occupational Therapy Program, Department of Kinesiology, University of Wisconsin–Madison.