Research Article

Occupational Therapy Using Ayres Sensory Integration®: A Randomized Controlled Trial in Brazil

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Importance: Research conducted in the United States has found that occupational therapy using Ayres Sensory Integration® is an effective evidence-based intervention for children with autism spectrum disorder (ASD). Replication of this research in other cultures is needed.

Objective: To evaluate the outcomes of occupational therapy using Ayres Sensory Integration in a sample of Brazilian children with ASD.

Design: Prospective randomized controlled trial.

Setting: Occupational therapy clinic.

Participants: Seventeen children with ASD ages 5–8 yr ($n = 9$ in the intervention group, $n = 8$ in the usual-care control group) recruited from a local hospital via flyers and word-of-mouth. Completed pretreatment characterization and baseline measurement.

Interventions: The intervention group received occupational therapy using Ayres Sensory Integration, and the control group received usual therapeutic and educational services only.

Outcomes and Measures: We conducted a pre–post assessment of self-care and socialization using the Pediatric Evaluation of Disability Inventory and individualized goal ratings.

Results: Participants in the intervention group scored significantly higher on outcome measures of self-care ($p = .046$, $r_b = .57$), social function ($p = .036$, $r_b = .61$), and parent-identified goal attainment ($p < .001$, $r_b = .94$) compared with the control group.

Conclusions and Relevance: Occupational therapy using Ayres Sensory Integration was effective in enhancing self-care, socialization, and goal attainment for children with ASD in a Brazilian cohort.

What This Article Adds: This study contributes further support from outside the United States that occupational therapy using Ayres Sensory Integration is an effective evidence-based intervention to improve self-care, socialization, and parent-identified goal attainment in children with ASD.

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Autism spectrum disorder (ASD) is the most prevalent neurodevelopmental disorder of childhood. Global statistics on incidence vary, but the World Health Organization (2022) has reported the global incidence of ASD to be about 1.0%. Brazil ranks eighth highest in the world, reporting 27 cases per 10,000 children (Wee, 2017), or 1.5 to 2.0 million people in Brazil, about 1.0% of the population (United Nations Brazil, 2015).

Many children with ASD have challenges with independent daily living skills including feeding, dressing, bathing, sleeping, and transitioning (Bal et al., 2015; Smith et al., 2012). These challenges affect the child's function and independence and their family's ability to participate in work, leisure, and community activities (Schaaf et al., 2011; Williams et al., 2018). Lack of independence in daily living skills often results in poor long-term outcomes, including inability to live independently in adulthood (Smith et al., 2012). Thus, many families seek occupational therapy services to promote daily living skills and independence in children with ASD.

Mounting evidence indicates that many children with ASD also have sensory integration difficulties that compromise their occupational performance in daily living skills (Lane et al., 2010; Lloyd et al., 2013; Schaaf et al., 2011; Williams et al., 2018). Thus, occupational therapy using Ayres Sensory Integration® (ASI) is a frequently used and sought-after intervention (Green et al., 2006; Mandell et al., 2013). The ASI frame of reference posits that sensorimotor abilities provide a foundation for higher-level skills and behaviors, including daily living skills, socialization, and learning. ASI intervention is designed to address sensorimotor factors to improve function and participation in daily life activities (Parham & Mailloux, 2020; Schaaf & Mailloux, 2015). ASI is now included as an evidence-based intervention for children with ASD in the National Clearinghouse on Autism Evidence and Practice (Schoen et al., 2019; Steinbrenner et al., 2020).

Although occupational therapy using ASI is considered an evidence-based intervention in the United States, replication studies are needed to provide an evidence base in other countries and cultures. Thus, we examined the effectiveness of occupational therapy using ASI in a cohort of children with ASD in Brazil. We addressed the following research question: Do Brazilian children randomized to occupational therapy using ASI have better outcomes in self-care, socialization, and parent-identified goal attainment than children receiving usual care?

Method

In this prospective randomized controlled trial, we compared the pre- and postintervention scores of two matched groups of children with ASD: an intervention group who received occupational therapy using ASI and a usual-care control group. We received ethics approval from the Federal University of Paraná (UFPR; CAAE 11487413.5.0000.0102) and registered the study as a clinical trial with the university's research ethics committee.

Participant Recruitment

We recruited study participants at the Neuropediatrics Center of the UFPR Clinic Hospital, a rehabilitation hospital in Curitiba, Brazil, serving children with developmental concerns. The inclusion criteria were as follows: (1) diagnosis of ASD, based on the diagnostic criteria of the *Diagnostic and Statistical Manual of Mental Disorders* (5th ed.; American Psychiatric Association, 2013), by a neurodevelopmental pediatrician at the Neuropediatrics Center; (2) age 5 yr, 0 mo to 8 yr, 11 mo at the time of enrollment (the Sensory Integration and Praxis Tests [SIPT; Ayres, 1989], one of the outcome measures, is validated for this age range); (3) evidence of sensory integration difficulties, defined as three or more subscale scores in the "definite difference" range on the Sensory Profile (SP; Dunn, 1999); (4) ability to complete at least 9 of the 17 SIPT tests (to provide adequate data for intervention planning); and (5) IQ in the 50th percentile or higher on the Portuguese version of Raven's Colored Progressive Matrices (CPM; Raven et al., 2009). Children were excluded if they had been born prematurely (≤36 wk gestation) or with low birth weight (≤2.5 kg), received medication for chronic seizures, or had a neurological or genetic disorder such as cerebral palsy or Down syndrome. Parents agreed to refrain from initiating any new treatments during the study period and to accompany their child to treatment if randomized to the intervention group.

Instruments

Four evaluators blinded to group assignment administered all tests to the children in Portuguese. The tests that were standardized in Brazil or translated to Portuguese are indicated in the description.

ASI posits that underlying sensorimotor functions support participation (Schaaf & Mailloux, 2015). Thus, a key principle of occupational therapy using ASI is that improving underlying sensorimotor function will result in more successful occupational performance. To evaluate the effectiveness of our intervention, we examined change in *proximal outcomes,* which are sensorimotor factors, and *distal outcomes,* which are related to occupational performance (Schaaf & Mailloux, 2015). Distal outcomes were our primary focus; however, we also measured change in proximal outcomes in exploratory analyses to see whether changes in sensorimotor factors improved occupational performance, as Ayres (2005) suggested.

Eligibility Screening Assessments

After determining potential participants' eligibility to participate on the basis of diagnosis, age, and birth history, the evaluators administered the SP, SIPT, and CPM to verify the remaining inclusion criteria.

We used the Portuguese version of the SP (Mattos et al., 2015). The SP is a caregiver-report questionnaire that measures caregivers' perceptions of their child's sensory responses to a variety of daily life events and experiences; the SP is validated for children ages 3–10 yr (Dunn, 1999). The SP comprises 125 items in 14 subscales (6 on sensory processing, 5 on sensory modulation, and 3 on emotional and behavioral responses). Parents score the frequency of behaviors on a 5-point Likert scale (1 = *always* to 5 = *never*). Final scores are used to classify the child's performance as *typical, probable difference,* or *definite difference*. Internal reliability (Cronbach's α) for the subscales ranges from .47 to .91, and construct validity is reported to be moderate (Dunn, 1999). Scores in the definite difference range on three or more subscales were required to be eligible for this study.

The SIPT is a set of 17 performance-based, norm-referenced tests that measure sensory perception,

praxis, balance, and bilateral coordination (Ayres, 1989). These tests require minimal verbal instructions; when participants needed instructions, the evaluator gave them in Portuguese. Interrater reliability for the 17 tests ranges from .94 to .99 and test–retest reliability from .33 to .94 (Ayres, 1989). Standard scores below –1.0 on any of the SIPT tests indicate performance below expectations compared with the normative group for the child's age. Standard scores greater than +1.0 generally indicate performance that is better than expected compared with age norms. Eligible participants completed at least 9 of the 17 SIPT tests, the minimum needed to plan appropriate intervention.

Raven's Colored Progressive Matrices (Raven et al., 2009) is a multiple-choice intelligence test of abstract reasoning that has been validated in Brazil (Flores-Mendoza et al., 2014). The test includes 36 items divided into three series of 12 items organized to assess the main cognitive processes in children up to the stage of concrete operations. Internal consistency ranges from .65 to .91, with a mean higher than .80 (Cotton et al., 2005). Results are presented as percentiles (1–99), with the average at the 50th percentile. Eligible participants scored in the 50th percentile or higher.

Distal Outcome Measures

The Pediatric Evaluation of Disability Inventory (PEDI; Haley et al., 1992) is a measure of children's functional skills administered in interviews with caregivers. We used two PEDI scales, the Functional Skills scale and the Caregiver Assistance scale, both of which are composed of three subscales: Self-Care (73 items), Mobility (59 items), and Social Function (65 items). The PEDI change score has been used as an outcome measure in other intervention studies for children with ASD (Schaaf et al., 2014, 2018). In this study, we used a Brazilian cultural adaptation of the PEDI, for which the six subscales have been shown to have excellent internal consistency ranging from .95 to .99 (Mancini, 2005).

Before randomization, the evaluators interviewed parents to identify three occupation-based goals for their child using goal attainment scaling (GAS; Kiresuk & Sherman, 1968; Ruble et al., 2012) and the interview process described by Mailloux et al. (2007). The evaluator and parent determined the child's current level of function on each goal using a 5-point scale from –2 to +2. The parent then indicated their expectation for each goal—that is, the level of performance they felt would represent meaningful progress toward the goal—using the same scale; the expected outcome was scored 0. Parents' concerns focused on areas of daily life such as play, dressing, bathing, feeding, school participation, organizational skills for participation in school, and sports participation.

As an exploratory distal outcome measure, we compared parents' preintervention expectations for goal attainment to their postintervention ratings of their child's performance. For each goal, we calculated a difference score—that is, the difference between the sum of the parent's expected goal attainment level for the three goals and the sum of the child's performance levels at postintervention for those goals.

Proximal Outcome Measures

We used two measures, the SIPT and the Sensory Processing Measure (SPM; Parham, Ecker, et al., 2007), to explore changes in sensorimotor factors postintervention.

Although the SIPT (Ayres, 1989) has been used as a characterization measure in studies of occupational therapy using ASI (Pfeiffer et al., 2011; Schaaf et al., 2014), its use as an outcome measure has not been reported. We used specific SIPT tests as exploratory outcome measures to provide data about changes in sensory integration. We chose the SIPT tests with test–retest reliability >.80 (Ayres, 1989): Standing and Walking Balance (r = .86), Design Copying (r = .93), Postural Praxis (r = .86), Bilateral Motor Coordination (r = .82), Motor Accuracy (r = .84), Oral Praxis (r = .90), and Sequencing Praxis (r = .84).

The SPM is a caregiver-report instrument that assesses sensory reactivity, praxis, and social participation in children ages 5–12 yr using a 4-point Likert scale (Parham, Ecker, et al., 2007). We compared pre- and postintervention SPM scores as an exploratory outcome measure of sensory functions. This measure provides a total sensory score that combines the responses on five sensory scales (tactile, auditory, visual, proprioception, and vestibular) with responses to questions on gustatory (taste) and olfactory (smell) functions, which are not included in the SP. Interrater reliability for the SPM is strong (.99 for the total score), and individual item interrater reliability ranges from .94 to .99 (Parham, Ecker, et al., 2007). To obtain data from the home and school, we used both the Home version (75 items) and the School version (62 items) in this study and obtained permission from the publisher for forward–back translation to Portuguese and review by one of the test authors.

Fidelity to Intervention

Fidelity assessment has become an essential element of intervention research and evidence-based practice (Bond & Drake, 2020). Measurement of fidelity is a way to ensure that the intervention is delivered in keeping with the principles and practices of the intervention being studied.

We used the Ayres Sensory Integration Fidelity Measure (ASIFM) to determine whether the intervention provided to the intervention group met the fidelity criteria for ASI (Parham, Cohn, et al., 2007; Parham et al., 2011). The ASIFM has strong validity; raters are able to distinguish ASI intervention from other approaches with an accuracy of 92%. The ASIFM consists of a structural elements section, which details the essential elements of ASI such as available equipment and interventionist training, and a process

elements section, which details the content of the intervention to ensure it follows the essential principles. According to the ASIFM authors, a score of ≥85 of 110 points on the structural elements and ≥80 of 100 points on the process elements is needed to ensure fidelity to ASI (May-Benson et al., 2014; Parham, Cohn, et al., 2007; Parham et al., 2011).

Procedures

The study team first screened potential participants to determine eligibility and ascertain willingness and ability to participate. The evaluators then conducted baseline SIPT, SP, and SPM assessments, to ensure that all participants demonstrated clear problems in sensory integration, and the GAS interview. Screening, baseline testing, parent interviews, and outcome measurement all took place at the Neuropediatrics Center of the UFPR Clinic Hospital or at the private therapy clinic where the intervention took place.

Participants were then randomly assigned to the intervention or control condition using the GraphPad Method 5 (GraphPad Software, San Diego, CA). A statistician who was not directly involved in the study conducted the randomization and analyses.

We verified the structural elements of fidelity to intervention (e.g., interventionist experience, equipment safety and variety, appropriateness of documentation) using a checklist before the study began to ensure that all required elements were in place. All intervention sessions were videotaped.

Interventions

Intervention Group: Occupational Therapy Using ASI

The intervention group received a manualized ASI-based occupational therapy intervention (Schaaf & Mailloux, 2015) delivered by a single occupational therapist, the first author (Claudia Omairi), who had more than 20 yr of experience and advanced training in ASI. The intervention took place in an occupational therapy clinic equipped with mats, swings, bolsters, and other equipment needed for the ASI approach and described in the ASI Fidelity measure. The intervention is based on the principles of ASI identified by Ayres (2005) and later detailed by others (Mailloux & Smith Roley, 2018; Parham, Cohn, et al., 2007; Parham & Mailloux, 2020; Parham et al., 2011; Schaaf et al., 2014). The active ingredients of ASI are individually tailored sensorimotor activities that are contextualized in play at the just-right challenge to facilitate adaptive behaviors for participation in tasks and activities (Schaaf & Mailloux, 2015).

We used the data-driven decision-making (DDDM) process for ASI (Schaaf & Mailloux, 2015) to ensure that the individualized activities targeted the sensorimotor factors that we hypothesized would influence the child's goal attainment. For example, we hypothesized that tactile overreactivity would interfere with a child's ability to participate in daily grooming routines (parent goal), so the interventionist used individually tailored sensorimotor activities such as active play that provided total body, deep touch, and proprioceptive sensations to decrease the child's tactile overreactivity and promote tolerance and integration of light touch sensation. The interventionist also integrated pretend play using actual grooming activities into treatment—for example, helping the child comb a doll's hair or play pretend hairdresser—to integrate sensorimotor experiences with functional goals for grooming.

Intervention activities took place in a large therapy room equipped with mats, a variety of swings, a climbing wall, carpeted barrels, large inner tubes, large balls, and foam blocks. This type of environment allows for active sensorimotor play that the child can direct with facilitation by the therapist to promote successful and adaptive participation in sensorimotor experiences. Participants received the intervention in 60-min sessions 3 times per wk for 10 wk, for a total of 30 hr.

Intervention and Control Groups: Usual Care

We defined *usual care* as each child's usual or customary educational and therapeutic services. Both groups continued with their usual care. We collected data on the type and amount of usual care during the study period; we found that the groups received similar amounts and types of services. Of the 9 participants in the intervention group, all continued their regular education program, and none received special education services. Five received no additional services; of the remainder, 4 received speech therapy for 60–120 min per wk, 3 received psychological counseling for 40–60 min per wk, and 1 received music therapy for 60 min per wk. Of the 8 participants in the control group, all continued their regular education program, and none received special education services. Four received no additional services; 4 received speech therapy for 60–120 min per wk and psychological counseling for 30–60 min per wk. Thus, usual care was similar for the intervention and control groups, and we did not consider any differences to be a major threat to internal validity.

Data Analysis

For quantitative variables, we calculated means, medians, minimum values, maximum values, and standard deviations. For categorical variables, we calculated frequencies and percentages and used Fisher's exact test for comparisons. We applied two-sample *t* tests for independent samples to compare the groups' mean change from pre- to postintervention; two-sample *t* tests are commonly applied to the analysis of continuous outcomes in a randomized trial. For data that were not normally distributed, we used nonparametric variables and made comparisons using the Mann–Whitney *U* test. We used nonparametric Wilcoxon tests to compare pre- and postintervention outcome measures. Effect size is presented as a rank biserial correlation (r_b) for

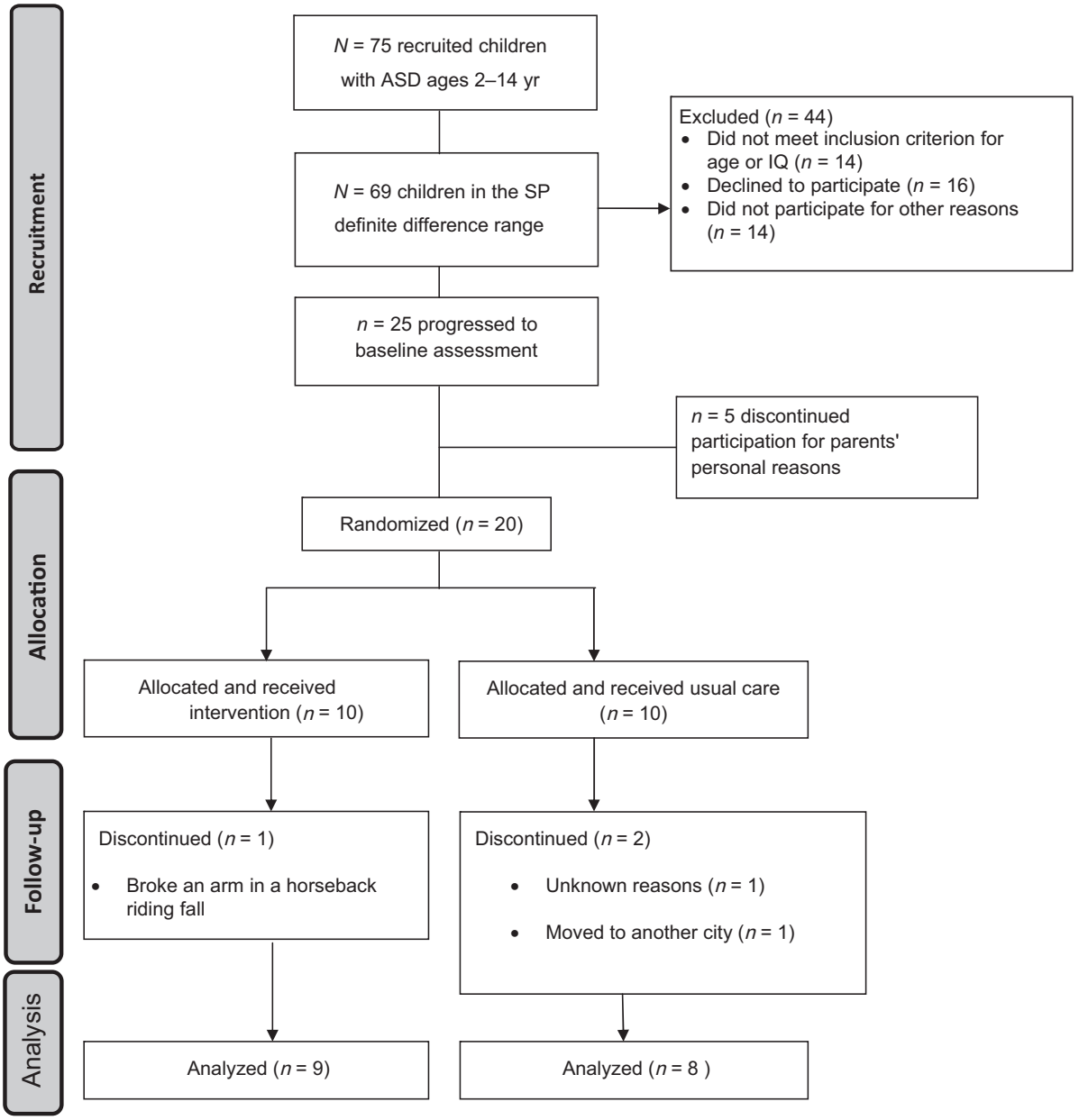
quantitative variables or an odds ratio (OR) for categorical variables (Li et al., 2017).

For the PEDI, we compared change scores for each subscale of the Functional Skills and Caregiver Assistance scales. For the parent-identified goals, we calculated a change score for each goal. For example, if a participant had a preintervention level of –2 and a postintervention level of +1 on a goal, the change score would be 3—the number of increments from –2 to +1. We summed the total change scores on all goals for each group to obtain a mean change score for each group. We also calculated a difference score representing the difference between parents' preintervention expected goal attainment levels and the children's performance levels at postintervention.

Results

We screened 75 potential participants, of whom 69 were eligible to participate on the basis of their SP score. Fourteen children did not meet the inclusion criterion for age or IQ, and the parents of 30 declined to participate (n = 16) or did not participate for other reasons (n = 14). Of the 25 children who progressed to baseline assessment, the parents of 5 decided not to continue with the study for personal reasons. Therefore, 20 participants were randomly assigned to the intervention and control groups (10 per group); 1 intervention participant and 2 control participants later dropped out for personal or unknown reasons. An overview of the flow of participants through the study is provided in Figure 1.

Figure 1. Flow of participants through the study.



Note. Flow diagram format adapted from the Consolidated Standards of Reporting Trials (Rennie, 2001). ASD = autism spectrum disorder; SP = Sensory Profile.

The final sample thus included 17 participants, 9 in the intervention group and 8 in the control group. Participants' demographic characteristics are shown in Table 1. The intervention and control groups were similar at baseline on age, gender, birth history, and parent characteristics.

Table 1. Baseline Participant Characteristics

Characteristic	Intervention Group (n = 9)	Control Group (n = 8)	p[a]	U[b]	Effect Size[c]
Age, yr			.815	33.0	.08
M (*SD*)	6.5 (0.9)	6.6 (0.6)			
Mdn (range)	6.7 (5.0–7.8)	6.7 (5.8–7.3)			
Gender, *n* (%)			1.00		.50
Male	7 (77.8)	7 (87.5)			
Female	2 (22.2)	1 (12.5)			
Grade level at school, *n* (%)			1.00		.67
Kindergarten	6 (66.7)	6 (75.0)			
1 or 2	3 (33.3)	2 (25.0)			
Sensory Profile scores			.888	34.0	.06
M (*SD*)	6.9 (2.9)	7.6 (4.2)			
Mdn (range)	6.2 (3–12)	7.5 (3–14)			
IQ, percentile			.743	32.5	.10
M (*SD*)	79.2 (15.6)	75.5 (18.2)			
Mdn (range)	80 (50–99)	75 (50–99)			
Therapies part of usual care, *n* (%)			1.00		
0	5 (55.6)	4 (50.0)			
≥1	4 (44.4)	4 (50.0)			
Birth weight, g			.888	34.5	.04
M (*SD*)	3,051 (353)	3,184 (661)			
Mdn (range)	2,980 (2,550–3,600)	2,925 (2,570–4,075)			
Gestational age, wk			.815	33.0	.08
M (*SD*)	38.6 (1.9)	38.9 (1.9)			
Mdn (range)	38 (37–43)	38 (37–42)			
Mother's age, yr			.236	23.0	.36
M (*SD*)	30.7 (4.6)	33.9 (5.2)			
Mdn (range)	32.3 (23–38)	34.5 (27–44)			
Father's age, yr			.681	27.5	.13
M (*SD*)	32.9 (5.5)	33.4 (3.0)			
Mdn (range)	32 (26–44)	33 (30–37)			
Mother's education, *n* (%)			.294		.21
Less than high school graduate	1 (11.1)	3 (37.5)			
High school graduate or above	8 (88.9)	5 (62.5)			
Father's education, *n* (%)[d]			.550		.31
Less than high school graduate	1 (11.1)	2 (28.6)			
High school graduate or above	8 (88.9)	5 (71.4)			
Marital status of parents, *n* (%)			.620		.42
Married or stable union	5 (55.6)	6 (75.0)			
Single or separated	4 (44.4)	2 (25.0)			

[a]Fisher's exact test. [b]Nonparametric Mann–Whitney *U* test. [c]Rank biserial correlation for quantitative variables or odds ratio for categorical variables. [d]A data point was missing for one father in the control group.

Fidelity to Intervention

Two independent occupational therapists not associated with the study who had received ASIFM training viewed and rated 25 treatment session videos selected at random (about 10% of total intervention sessions). For the 25 treatment sessions, one fidelity rater gave a mean total score of 97.5 (SD = 4.3) and the other a mean total score of 93.9 (SD = 6.3). The raters' combined average score for the segments was 95.7, and they rated 100% of the video segments as meeting the criterion score of 80 needed to verify that the intervention showed fidelity to the manualized ASI intervention.

Distal Outcomes

We compared change scores for the intervention and control groups for the two distal outcome measures, the PEDI and GAS.

The intervention group showed significantly greater improvement compared with the control group on the PEDI Functional Skills Self-Care subscale (U = 15.5, p = .046, r_b = .57) and Caregiver Assistance Social Function subscale (U = 14.0, p = .036, r_b = .61). In addition, the intervention group showed greater improvement on the Functional Skills Mobility subscale (U = 30.0, p = .606, r_b = .17) and Social Function subscale (U = 27.0, p = .423, r_b = .25), but these differences were not statistically significant. PEDI results are displayed in Table 2.

Mean change scores for the scaled goals were significantly greater for the intervention group compared with the control group (U = 1.5, p < .001, r_b = .94; see Table 2). In addition to evaluating the mean change scores, as an exploratory analysis we compared the groups' mean difference scores between the parent's expected performance level and the child's postintervention performance level for the three goals. Median difference scores were –1.0 for the intervention group and –5.0 for the control group (U = 2.0, p < .001, r_b = .94), showing that the intervention group's goal attainment was closer to their parents' expectations than the control group's goal attainment.

Proximal Outcomes

We examined mean change scores for specific SIPT tests as an exploratory proximal outcome using nonparametric Wilcoxon tests. The intervention group showed significantly greater mean change on the following SIPT tests and subtests: Postural Praxis (T = 4.2, p = .028, r_b = .82), Motor Accuracy–Solid Black Line (T = 2.5, p = .028, r_b = .86), Motor Accuracy–Medium Broken Line (T = 0.0, p = .028, r_b = 1.00), Design Copying–Accuracy (T = 2.5, p = .018, r_b = .89), and Design Copying–Approach (T = 3.5, p = .024, r_b = .84). There were no significant differences between groups in mean change scores for the other SIPT tests.

To explore changes in SPM scores, we compared the groups' mean change in total sensory score on the Home and School versions. We selected the total score because some individual sensory scales include a small number of items. A decrease in T scores indicates improvement (i.e., reduction in sensory-related problems). The intervention group showed a decrease in SPM total sensory scale T scores on both the Home and School versions. On the Home form, the intervention group's mean change score was –5.4, whereas the control group's mean change score was +0.05 (U = 1.0, p < .001, r_b = .90), indicating a slight increase in problems. On the School form, the intervention group showed a significantly better mean change score of –6.1, whereas the control group showed a nonsignificant mean change score of –0.1 (U = 0, p = .001, r_b = 1.00).

Discussion

In this study, children with ASD who received occupational therapy using ASI showed greater gains

Table 2. Comparison of Change Scores for the Pediatric Evaluation of Disability Inventory and Goal Attainment Scaling

Variable	Intervention Group (n = 9)		Control Group (n = 8)		p[a]	U[b]	r_b[c]
	M (SD)	Mdn (Range)	M (SD)	Mdn (Range)			
Pediatric Evaluation of Disability Inventory							
Functional Skills							
Self-Care	6.3 (2.3)	7 (3 to 9)	3.5 (2.7)	3 (0 to 7)	.046	15.5	.57
Mobility	2.4 (2.9)	2 (−2 to 8)	1.5 (2.4)	1 (−2 to 5)	.606	30.0	.17
Social Function	10.9 (4.3)	12.0 (5 to 18)	6.3 (9.0)	4.5 (−3 to 18)	.423	27.0	.25
Caregiver Assistance							
Self-Care	7.1 (4.5)	8 (0 to 12)	3.6 (3.9)	3 (0 to 11)	.093	18.5	.49
Mobility	2.8 (3.0)	2 (0 to 8)	1.5 (1.3)	2 (0 to 3)	.541	29.0	.19
Social Function	3.2 (4.7)	1.0 (−4 to 12)	−2.9 (4.7)	−1.5 (−10 to 1)	.036	14.0	.61
Goal Attainment Scaling							
Difference score[c]		7 (3 to 9)		1 (1 to 4)	<.001	1.5	.94

[a]Fisher's exact test. [b]Nonparametric Mann–Whitney U test. [c]Rank biserial correlation.

in self-care, socialization, and parent-identified goal attainment compared with children in the usual-care group. These findings extend to a Brazilian sample the evidence supporting occupational therapy using ASI for children with ASD.

Our study has relevance for children with ASD and their families in several ways. First, it provides evidence supporting an intervention that addresses challenges with sensory integration, an important aspect of ASD. As noted, sensory integration challenges affect children's participation in daily living skills and other activities and tasks. Children's difficulties in these areas also influence their parents' ability to participate in work and leisure activities (Schaaf et al., 2011; Williams et al., 2018). Thus, improvements in sensory integration can not only help children participate in activities and tasks more successfully but also assist families in completing tasks and participating in chosen activities.

Second, our results show that occupational therapy using ASI led to improvements in daily living skills, including self-care skills as measured by the PEDI. Daily living skills are important predictors of later success in independent living (Green & Carter, 2014; Kilincaslan et al., 2019). We followed the ASI protocol in (1) creating hypotheses based on baseline assessment data about how the child's sensory integration challenges would affect their daily living skills and then (2) targeting intervention activities to address these skills, with DDDM guiding this process. Thus, this study provides preliminary evidence that ASI-based occupational therapy can improve independence in self-care, potentially extending to later life; this premise will need to be studied longitudinally.

Our findings also show that children in the intervention group made gains in socialization, consistent with findings by Schaaf et al. (2014). Given that socialization is a primary area of concern in children with ASD, interventions to improve this area of functioning are needed. Although our intervention did not involve direct practice of social skills, the children nevertheless showed improvement in these skills. One possible explanation is that body sensory awareness (proprioception) is foundational to successful interactions with others, as Ayres (2005) suggested. Notably, this is the third randomized controlled trial to show significant improvements in socialization after occupational therapy using ASI (Pfeiffer et al., 2011; Schaaf et al., 2014).

One feature of this study is that it shows that occupational therapy using ASI, which is designed to target proximal or sensorimotor factors, can also improve distal or occupation-based outcomes. Again, this finding supports Ayres's (2005) original thinking. Ayres theorized that sensory integrative functions provide an important foundation for successful occupational performance. Schaaf and Mailloux (2015) explicated this premise by providing a method of measuring proximal and distal outcomes; in the DDDM process, the proximal factors, gleaned from assessment data, are linked to the proposed distal outcomes via hypothesis generation. Although it not possible to evaluate whether improvements in self-care, socialization, and goal attainment are a direct result of changes in the proximal factors, our exploratory analyses suggest that this may be the case. Thus, this study supports ASI tenets and links change in proximal sensorimotor factors to improvement in distal occupation-based outcomes.

Individualization of goals together with objective, quantitative measurement of goal attainment provide a useful strategy for measuring outcomes in children with ASD, given the heterogeneity of their symptoms and outcomes (Ruble et al., 2012). The intervention participants showed greater change in goal attainment than the control participants, with a moderate effect size. These results are consistent with those of other studies with children with ASD (Abdel Karim & Mohammed, 2015; Pfeiffer et al., 2011; Schaaf et al., 2011) and support the use of GAS as an outcome measure for interventions with children with ASD.

In addition to improvement in goal attainment, the intervention group showed greater attainment of goals in relation to parental expectations than the control group. This exploratory analysis captured parent satisfaction with goal attainment, an important aspect of intervention effectiveness (Moll et al., 2018). In addition, by the 3rd or 4th wk of intervention, parents of intervention group participants began providing unsolicited reports of improvements in their child's ability to complete daily routines or participate in tasks more independently. For example, one parent reported that their child had been unable to enter a busy bakery shop because of "overstimulation" and that after the intervention, they were able to enter the shop. Another parent mentioned that their child was able to wear clothing such as jeans that the child previously considered irritating. These anecdotal findings provide rich information about the effects of occupational therapy using ASI on everyday family life.

Limitations and Future Directions

This study has several limitations. Although the evaluators were blinded to group assignment, the parents were not. Thus, it is possible that some bias may have influenced parent-reported outcome measures. In addition, the sample sizes were small for each group, but the reasonably large effect sizes speak to the strength of the results. Ideally, future studies will include larger samples and performance-based outcome measures to complement parent-reported outcomes.

The eligibility criteria for the study included only the sensory symptoms assessed by the SP. The SP does not measure sensory integration directly but rather measures one aspect of sensory integration—sensory reactivity (i.e., hypo- and hyperreactivity)—and its impact on behavior based on caregivers' impressions. All children in both groups demonstrated signs of sensory

integration problems on the SIPT, a performance-based measure of sensory integration, but SIPT scores were not used as an inclusion criterion. Future studies should consider using comprehensive performance-based measures of sensory integration, such as the SIPT, as specific inclusion criteria to provide performance-based data on sensory integration abilities.

Not all the measures used in this study were standardized in Brazil, so it is possible that the data are skewed based on culture and language differences. Studies are underway to standardize measures of sensory integration in the Portuguese language and in Brazil (Mailloux & Smith Roley, 2018). It will be important to replicate this study when these versions become available.

Finally, our exploratory analyses included measures that have not been extensively used as outcome measures. Thus, definitive conclusions cannot be drawn about the differences found in these analyses.

Implications for Occupational Therapy Practice

This study has the following implications for occupational therapy practice:

- Occupational therapy using ASI can be provided with fidelity in a country (Brazil) outside the United States.
- The child's attainment of parent-identified goals can be a useful outcome measure for occupational therapy using ASI.
- Given that occupational therapy is a highly rated and sought-after intervention by parents of children with ASD, this study adds to the evidence for ASI as a useful intervention.
- Occupational therapy interventions targeting sensorimotor factors can help support participation in daily tasks and activities by children with ASD.

Conclusion

This study provides additional support for occupational therapy using ASI as an evidence-based intervention to improve self-care skills, socialization, and goal attainment in children with ASD. Further replication studies are needed to validate this intervention in a variety of cultures and languages.

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