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The Effectiveness of Sensory Integration-Based Early Intervention in Developing Health and Environmental Skills in Children with Autism Spectrum Disorder in Early Childhood: A Multiple-Baseline Study

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ABSTRACT: Existing literature indicates that children with Autism Spectrum Disorder (ASD) face significant challenges in acquiring fundamental skills, particularly personal health hygiene and the ability to adapt to daily environmental demands factors that critically impact their independence and quality of life. Despite growing evidence supporting the efficacy of Sensory Integration (SI) interventions in improving functional performance, Arabic research in this area, particularly focusing on early childhood, remains limited. This study aimed to evaluate the effectiveness of a structured and standardized early intervention program based on Ayres Sensory Integration® (ASI). The program consisted of 20 sessions designed to develop health and environmental skills in three Saudi children diagnosed with ASD (aged 4.5 to 5.5 years) at a government autism center in Al-Ahsa. The study employed a single-case experimental design specifically a multiple baseline across participants. Standardized tools were used to measure the children's performance in handwashing, tooth brushing, and face washing, in addition to environmental adaptation skills, adaptive behavior, and sensory processing. Findings revealed that all three participants transitioned from low and stable baseline levels to significant and clinically meaningful improvements following the intervention. Very large effect sizes were observed, ranging from 0.83 to 0.92 according to the Tau-U index. Furthermore, standard scores for daily living skills on the Vineland Adaptive Behavior Scales increased by 12 to 14 points per child. Significant reductions were also noted in sensory processing issues across tactile, auditory, and vestibular domains. The results suggest that early sensory integration intervention, when applied within a naturalistic preschool environment, is a highly effective and culturally adaptable approach for developing health and environmental skills among Saudi children with ASD. These findings support the broader implementation of such programs in special education curricula and applied research across Saudi Arabia and the wider Arab world.

1. INTRODUCTION

Autism spectrum disorder (ASD) is a heterogeneous neurodevelopmental disorder characterized by deficits in social communication and interaction, as well as restricted/repetitive patterns of behavior, interests or activities that are persisting in early developmental period (American Psychiatric Association [APA], 2022, Global prevalence estimates of ASD are around 1% of the population, with a number of high-income countries reporting even higher rates (Lord et al., 2020,). There is growing clinical awareness and better diagnostic infrastructure of ASD in young children in the Kingdom of Saudi Arabia (MoE, Kingdom of Saudi Arabia 2021), which means that early intervention and special education services are under huge demand.

An essential but often underappreciated characteristic of ASD is atypical sensory processing. At least 1 in 4 children with ASD have clinically significant sensory processing differences across tactile, vestibular, proprioceptive, auditory and visual modalities (Bataineh et al., 2025; Schaaf et al., 2018). These sprocial differences are more than behavioral curiosities; they have direct, quantitative effects on the learning and independent execution of vital daily living skills. Children with autism spectrum disorder (ASD) who display tactile defensiveness, auditory hyperreactivity or vestibular hypersensitivity often refuse or cannot complete basic health hygiene practices such as hand-washing, tooth-brushing and dressing. In the same way that sensory-rich transitions, a diversity of textures and ambient stimuli (the atmosphere) are managed differently in this population, so is the adaptive motor posture required to self-regulate in more unfamiliar or stimulating spaces (Bodison & Parham 2018). The functional effects of these deficits go beyond the individual child—they increase caregiver burden, hinder access to inclusive educational environments, and reduce community participation throughout life.

Ayres Sensory Integration® (ASI®) intervention is based on Jean Ayres' seminal neurobiological model (Ayres, 1972) and offers a clinically relevant theoretical frame through which sensory processing differences can be addressed by providing individualized, child-directed, play-based sensory experiences that elicit adaptive responses in support of functional participation. Recent preliminary randomized controlled trials and single-subject experimental studies provide some additional evidence to support that ASI® intervention may be an evidence-based practice for children with ASD, leading to improvements in goal attainment (Hume et al., 2021), adaptive behaviour (Hume et al., 2020) and sensory processing outcomes (Schaaf et al., 2018). IntroductionMultiple-baseline single-subject research designs (SSRDs) are highly appropriate for evaluating individualized, manualized interventions with small clinical samples and they present strong demonstrations of experimental control, while also avoiding withdrawal of possibly beneficial treatment (Andelin et al., 2021; Whiting et al., 2023)

As the evidence base for ASI® interventions across Western settings continues to grow, a noticeable gap exists in studies conducted within Arab cultures. BackgroundSaudi Arabia has a Vision 2030 plan and National Transformation Program, which focuses on providing evidence-informed, high quality early childhood special education services to support children with developmental disabilities. Nonetheless, evidence currently available from children in North America and Europe cannot be accepted as having ecological validity for Saudi Arabian children, whose daily lifestyle, family structure, cultural conventions around hygiene and environmental engagement, and early childhood educational settings differ markedly from what is written about in the current literature. The current study aimed to fill this gap by delivering and evaluating a culturally adapted, manualized ASI®based early intervention program targeting health and environmental skills for young Saudi children with ASD.

Research Hypotheses

Given the documented functional consequences of sensory processing differences on health and environmental skill performance in ASD, and the emerging evidence base for ASI® intervention, the following directional hypotheses were formulated:

H1: Participants will demonstrate clinically meaningful improvement in health skill performance (measured by percentage of correct independent task steps) following the introduction of ASI®-based early intervention, relative to stable or variable baseline performance.

H2: Participants will demonstrate clinically meaningful improvement in environmental adaptive skill performance following the introduction of ASI®-based early intervention, relative to baseline.

H3: Post-intervention Vineland Adaptive Behavior Scales–Third Edition (VABS-3) Daily Living Skills standard scores will be higher than pre-intervention scores for all participants.

H4: Post-intervention Sensory Processing Measure–Preschool (SPM-P) T-scores will be lower (indicating improved sensory processing) than pre-intervention scores across all participants.

2. LITERATURE REVIEW

2.1. Sensory Processing in ASD: Mechanisms and Functional Consequences

Sensory processing differences in ASD had only recently (when this work began) been acknowledged as the sub-domain of a core diagnostic feature, specifically integrated into rRestrictive, rRepetitive bBehavior in the DSM-5–TR (APA, 2022). Such differences manifest across over-responsiveness (hyper-reactivity), under-responsiveness (hypo-reactivity), and sensory seeking patterns, and have been noted in all sensory modalities (Lord et al., 2020). From a neuroscience standpoint, multisensory integration impairment in ASD has been associated with abnormal connectivity in superior temporal sulcal and parietal regions [7–13], as well as abnormalities in thalamocortical gating mechanisms [14–17] thus giving neurobiological credence to behaviorally reported sensory processing deficits.

The impact of sensory processing differences on everyday living skills performance has been well-documented across multiple studies. Schaaf et al. (2018) stated that difficulty with processing and integrating sensations directly impacts the ability to perform activities of daily living such as dressing, eating, sleep routines and hygiene routines. Bodison and Parham (2018) examined a selection of studies involving sensory techniques and alterations to the environment through a systematic review and concluded consistent relationships between sensory processing profiles and participation restrictions in everyday occupations. In the area of health skills, tactile defensiveness has become a dominant mechanism for oral care resistance and grooming in this population, even requiring treatment approaches that are sensory rather than purely behavioral (Yela-González et al., 2021).

2.2 Ayres Sensory Integration® Intervention: Evidence Base and Standards

While generic sensory-based approaches frequently are based on a single practice philosophy, ASI® intervention is distinguished by specific operationalized clinical principles (Parham et al., 2011) validated through the Ayres Sensory Integration Fidelity Measure (ASIFM; Parham et al., 2011). The intervention is designed to enable: child-directed choice and collaboration provision of additional sensory opportunities targeting tactile, vestibular and proprioceptive modalities use of a just-right challenge framework promoting adaptive responding Individualisation based on comprehensive sensory assessment. Mailloux et al. In 2018), introduced a passion for understanding the sensory experiences of individuals with developmental and neurological conditions, the Evaluation in Ayres Sensory Integration® (EASI®) as a standardized clinical assessment that can be used to evaluate detailed sensory integration constructs to support theory-guided assessments and planning of interventions.

Since 2018, the evidence base for ASI® intervention has been greatly expanded. Schaaf et al. They performed a systematic review that identified five studies meeting rigorous inclusion criteria (including three RCTs) and concluded evidence was strong for ASI® intervention to improve individually derived functional goals measured by Goal Attainment Scaling, but moderate evidence existed for reduction in caregiver assistance with self-care activities (2018). Hume et al. Assessment's (2021) third generation of evidence-based practice review for people with autism found that ASI® was a well-established evidence-based practice for children ages 5–9 years. In terms of methods, single-subject experimental designs have been central to the establishment of the evidence base underpinning ASI® Andelin et al. (2021) demonstrated that ASI® could be delivered in a multiple-baseline design with three boys diagnosed with sensory-based motor disorder and yielded large effects on motor coordination and goal attainment. Whiting et al. Along a very similar line, the concurrent multiple-baseline design proposed by Fröhlich et al. (2023) was used to assess school-based SI intervention alongside teacher consultation and found favourable changes in functional regulation for all cases including classroom participation.

2.3 Health and Environmental Skills in ASD: Intervention Needs

Research has shown considerable evidence base for ASI® intervention in general, however the specific literature on the main domain of health and environmental skills remains relatively less well-defined. Yela-González et al. (2021) These findings suggest that health and environmental competence interventions should be conducted concurrently with sensory foundations and skill behaviors.

The lack of evaluated interventions of this kind that are done in Arab cultural settings constitutes a particularly notable gap in the literature. This represents a culturally patterned, yet explicitly motivated context in which hygiene skills are practiced is likely to differ in meaningful ways from the contexts investigated with Western populations (differently motivated context). Environmental adaptive behaviors (for example, engaging in family gatherings, maintaining mosque environments when praying or in worship settings, tolerating and other outdoor sensory stimuli fully informed by Arabian Peninsula climate) also reflect forms of culturally integrated functional targets not present in literature to date. To the best of our knowledge, this is the first study to investigate ASI®-based intervention addressing health and environmental skills among children with ASD in Saudi Arabia (AlAli & Al-Barakat, 2024).

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3. METHOD

3.1 Research Design

Using a concurrent multiple-baseline design across participants (MBD-P), a strong single-subject experimental design that gives evidence for experimental control by introducing the independent variable successively across participants with an identical behavioral target, this study was conducted. The MBD-P is especially ideal if (a) the removal of treatment would be clinically or practically ill advised, (b) the intervention is likely to produce long term behavior change, and (c) sample sizes are small but clinical cases are described well (Ledford & Gast, 2018). Standards of Evidence The design met the What Works Clearinghouse (WWC, 2022) evidence standards and Council for Exceptional Children's (CEC) Standards for Evidence-Based Practices in Special Education.

The baseline phases (Phase A) for Participants 1, 2 and 3 consisted of 5, 8 and 11 sessions respectively. Each core location had a staggered baseline length that allowed temporal control in attributing the discussed behavior change to the intervention rather than maturation, historical events, or spur-of-the-moment improvement. The intervention phase (Phase B) spanned the remaining 20 sessions for each participant. Social validity was screened postfinal intervention session.

3.2 Participants

With institutional ethical approval and written informed consent from the caregiver, three male and female children with formal ASD diagnoses were recruited from a governmental autism center in Riyadh, Saudi Arabia. Participants were included in the study if they met the following criteria: (a) received a formal DSM-5-TR diagnosis of ASD made by an Arabic-speaking licensed clinical psychologist or developmental pediatrician (b) was between 36 and 72 months chronological age, (c) had a DSM-5-TR severity Classification Level of Level 1=requiring support or Level=2=requiring substantial support, (d) SPM-P scores indicating definite differences in two or more sensory domains on parent-reported measures,(e) able to complete table-top and floor-based assessment and intervention tasks without sedation, and; (f) have access to a primary caregiver who could provide informed consent. Ineligible cases included children with co-morbid conditions that contra-indicated SI intervention (e.g. poorly controlled epilepsy, significant motor disability).

Figure 1. Participant Demographic and Clinical Characteristics

Participant	Age (years)	Gender	ASD Severity (DSM-5-TR Level)	ADOS-2 Total Score	Nonverbal IQ (Leiter-3)	Primary Sensory Profile*	Setting
Khalid (P1)	4.5	Male	Level 2	16	68	Tactile + Auditory Hyperreactivity	Gov. Autism Center, Riyadh
Faisal (P2)	5.0	Male	Level 2	14	72	Tactile + Vestibular Difficulties	Gov. Autism Center, Riyadh
Sara (P3)	5.5	Female	Level 1	11	81	Auditory + Visual Hyperreactivity	Gov. Autism Center, Riyadh

* Based on Sensory Processing Measure–Preschool (SPM-P) baseline assessment. ADOS-2 = Autism Diagnostic Observation Schedule, 2nd ed.; Leiter-3 = Leiter International Performance Scale, 3rd ed.

Figure 1. Participant Demographic and Clinical Characteristics. ADOS-2 = Autism Diagnostic Observation Schedule, 2nd ed. (Gotham et al., 2012). Leiter-3 = Leiter International Performance Scale, 3rd ed. (Roid et al., 2013). *Based on SPM-P baseline profile.

Participant 1 – Khalid

Case 1: Khalid was a 4-yr, 6-mo-old boy diagnosed with ASD (DSM–5–TR Level 2) at 2 yr, 4 mo. He obtained a total ADOS-2 score of 16 (CSS = 8) and a Brief IQ score of 68 on the Leiter-3 (below-average range). His profile also showed clear differences in tactile processing and auditory filtering according to his SPM-P. He exhibited persistent refusal of tooth-brushing and face-washing, full physical assistance with hand-washing, marked distress when transitioning in the classroom or entering novel environments with greater background noise. He qualified for a preschool program through the autism center, which allowed him to attend 4 hours per day, 5 days a week. His mother was his main provider, and took an active part in all training sessions for care providers.

Participant 2 – Faisal

Faisal was a 5-year-old boy who received a diagnosis of ASD (DSM-5-TR Level 2) at age 3 years. The total score on the ADOS-2 was 14 (CSS = 7). Leiter-3 Brief IQ = 72 (borderline range). SPM-P identified clear differences in tactile processing and vestibular processing domains. His physical and sensory profile showed spastic aversion to water temperature, an inability or refusal to allow the toothbrush by the back molars, tactile sensitivity when sitting on sand, and aversion reaction against incidental contact from another person. Movement to outdoor play areas & novel rooms led to dramatic dysregulation. His father, who attended all caregiver training sessions, was his primary caregiver.

Participant 3 – Sara

One child (Sara) was a 5-year, 6-month-old girl diagnosed with ASD in accordance with DSM-5-TR Level 1 at age 3 years, 8 months. ADOS-2 total = 11 (CSS = 5). IQ — Leiter-3 Brief = 81 (low average range) Auditory filtering and visual processing had distinct differences as indicated by SPM-P profile. She complained of moderate ambient noise, had the tendency to cover her ears, frequently avoided activities that involved contact with sand or wet materials, and reacted very poorly with respect to changes in classroom lighting conditions and visually complex environments. Both parents were her primary caregivers and had attended joint sessions as part of the caregiver training.

3.3 Setting

All the assessment and intervention sessions were administered within a government autism centre's occupational therapy suite in Riyadh, Saudi Arabia. Suspended equipment (platform swing, bolster swing, net swing), a crash pad, tactile bins of culturally relevant materials (dried dates, sand, warm water with rose water scent) proprioceptive activity stations (weighted blanket corner; therapy ball area) and a visual calm-down corner were all available in the intervention room. The room was adjusted to control ambient noise and lighting appropriate to the sensory profile of each child. Caregiver training sessions were conducted in a room with a one-way mirror that was adjacent to the coaching discussions, allowing caregivers to view live intervention sessions before discussing them and how they could implement what had been viewed.

3.4 Materials and Instruments

3.4.1 Sensory Processing Measure–Preschool (SPM-P)

The SPM-P (Miller Kuhaneck et al., 2010) is a standardized, norm-referenced rating scale completed by both a home caregiver and a classroom teacher, assessing sensory processing in five sensory systems and two functional domains in children aged 2 to 6 years. It yields T-scores with a mean of 50 and SD of 10; T-scores ≥ 60 indicate "Some Problems" and ≥ 70 indicate "Definite Dysfunction." The SPM-P demonstrates strong internal consistency (Cronbach's α = .72–.93 across scales) and convergent validity with other sensory processing measures. It was administered at pre-intervention and post-intervention time points.

3.4.2 Vineland Adaptive Behavior Scales–Third Edition (VABS-3)

The VABS-3 (Sparrow et al., 2016) is a nationally normed measure of adaptive behavior across Communication, Daily Living Skills, and Socialization domains. The Daily Living Skills domain was administered in the current study via the teacher rating form at pre- and post-intervention, focusing on the Personal and Community subdomains most relevant to health hygiene and environmental navigation. Standard scores have a mean of 100 and SD of 15. The VABS-3 is widely used in ASD research and demonstrates strong reliability and validity.

3.4.3 Task-Analyzed Behavioral Probes

Each participant's primary health and environmental skill targets were operationally defined through task analysis conducted collaboratively with caregivers and teaching staff during the baseline assessment phase. Health skill probes comprised 15-step task analyses for hand-washing, tooth-brushing, and face-cleaning sequences, scored as percentage of steps performed correctly and independently (0–100%). Environmental skill probes comprised 12-step task analyses for transition management and sensory tolerance sequences, similarly scored. Probes were conducted by a trained research assistant blind to phase assignment, using standardized materials, and scored using a permanent product recording system supplemented by video review to ensure inter-rater reliability.

3.4.4 ASI Fidelity Measure (ASIFM)

The ASIFM (Parham et al., 2011) was used to document fidelity of the ASI® intervention across all 20 sessions per participant. The measure assesses adherence to 10 structural and 26 process elements of ASI® intervention. Session fidelity scores were calculated as percentage of applicable elements demonstrated. A minimum threshold of 80% structural and process fidelity was established a priori, consistent with Andelin et al. (2021) and Whiting et al. (2023).

3.5 Dependent Variables

Operationally, there were two major dependent variables: (1) Health Skill Performance Index (HSPI): the average percentage of independent and correct task steps across the three targeted health routines (hand-washing, tooth-brushing, face-cleaning) conducted during each probe session; and (2) Environmental Skill Performance Index (ESPI): the mean percentage of independent and correct task steps across the two targeted environmental adaptive sequences (transition management, sensory tolerance) completed during each probe session. At pre-requisite and post-intervention only, secondary dependent variables were SPM-P total and subscale T-scores and VABS-3 Daily Living Skills standard scores.

3.6 Independent Variable (Intervention)

This includes a 20-session (60-min) structured, manualized ASI®-based early intervention program delivered bi-weekly by a licensed occupational therapist with advanced training experience and demonstrated competency in ASI®, attested as evidenced through achieving ≥85 on the structural section of the ASIFM before beginning study procedures. The intervention followed three sequential phases of ASI® therapeutic reasoning: Phase 1 (sensory modulation stabilization, Sessions 1–6): Individualized sensory diet activities aiming at nutural deployment specifically targeting any identified SI challenges; Phase 2 (skill-embedded sensory challenges, Sessions 7–14): Structured play-based SI activities with naturalistic health and environmental skill practice embedded; Phase III (adaptive skill generalization, Sessions 15–20): Extended in-vivo graduated practice sessions in increasingly naturalistic situations supported by caregivers. Sessions included procedural elements of child-directed activity choice (preferred choice task), the calibration of just-right challenge (skill difficulty was set to be moderately challenging in accordance with each child's stage) based on the level of modification indicated, and immediate therapist reinforcement for adaptive responding. Caregiver training comprised four consecutive group sessions and individual coaching after three observed SI sessions (see Appendix A for a full summary of the intervention manual).

3.7 Measurement Procedures

Behavioral probes were conducted three times per week during baseline (non-intervention days) and twice per week during the intervention phase (on days alternate to intervention sessions). Each probe lasted approximately 15 minutes and was conducted by the trained research assistant in a standardized manner using identical materials and environmental conditions across all measurement occasions. Inter-rater reliability was established by having a second observer independently score 30% of randomly selected probe video recordings; mean agreement was 94.2% (range: 91–97%) across all participants and dependent variables, exceeding the a priori criterion of 90%.

3.8 Data Analysis

The visual analysis of graphed data was performed according to these established criteria for SSRD interpretation (level, trend, variability, immediacy of effect, overlap and consistency of data patterns across phases; Ledford & Gast, 2018). Interrater AgreementTwo independent raters trained to identify visual analysis from the literature made ratings independently, and agreement was defined as the same convergent judgments on (1) presence or absence of a functional relation [20] and (2) direction of effects. The Tau-U web calculator (tauU.) was used to calculate Tau-U as the first quantitative effect size statistic. org) to quantify the degree of non-overlap between baseline and intervention phases, with baseline trend correction applied were indicated (Parker et al., 2011). Values of Tau-U > 0.65 are considered large and ≥ 0.93 are considered very large (Vannest & Ninci, 2015). A descriptive comparison pre-post group means for VABS-3 and SPM-P followed by Cohen's d effect sizes were also calculated for the secondary measures.

4. RESULTS

4.1 Intervention Fidelity

Initial mean intervention fidelity across sessions and three participants was 91.3% (SD = 3.2%; range: 86%–97%), successfully surpassing the a priori cut-off of ≥80%. In keeping with the pattern reported by Whiting et al., fidelity was highest for structural elements (mean 94.6%) but lower for process elements which reflected child-directed activity calibration (mean 88.9%). (2023,

p. 6). These data collectively demonstrate that ASI® intervention was delivered with reasonable fidelity throughout the implementation of the trial.

4.2 Health Skill Performance (Primary outcome)

The multiple-baseline graph of Health Skill Performance Index data for all three participants is shown in figure 2. Visual inspection indicated that all three participants had stable, low-level baselines (mean HSPI: Khalid = 17.0%; Faisal = 21.6%; Sara = 29.1%), limited trend and additional variance that was considered acceptable for later comparison across an equivalent period in which interventions were introduced [29]. Results: All 3 participants exhibited immediate, accelerating growth trajectories in health skills performance following ASI® intervention initiation and illustrated clear evidence of data paths that were above baseline levels and means across assessment points.

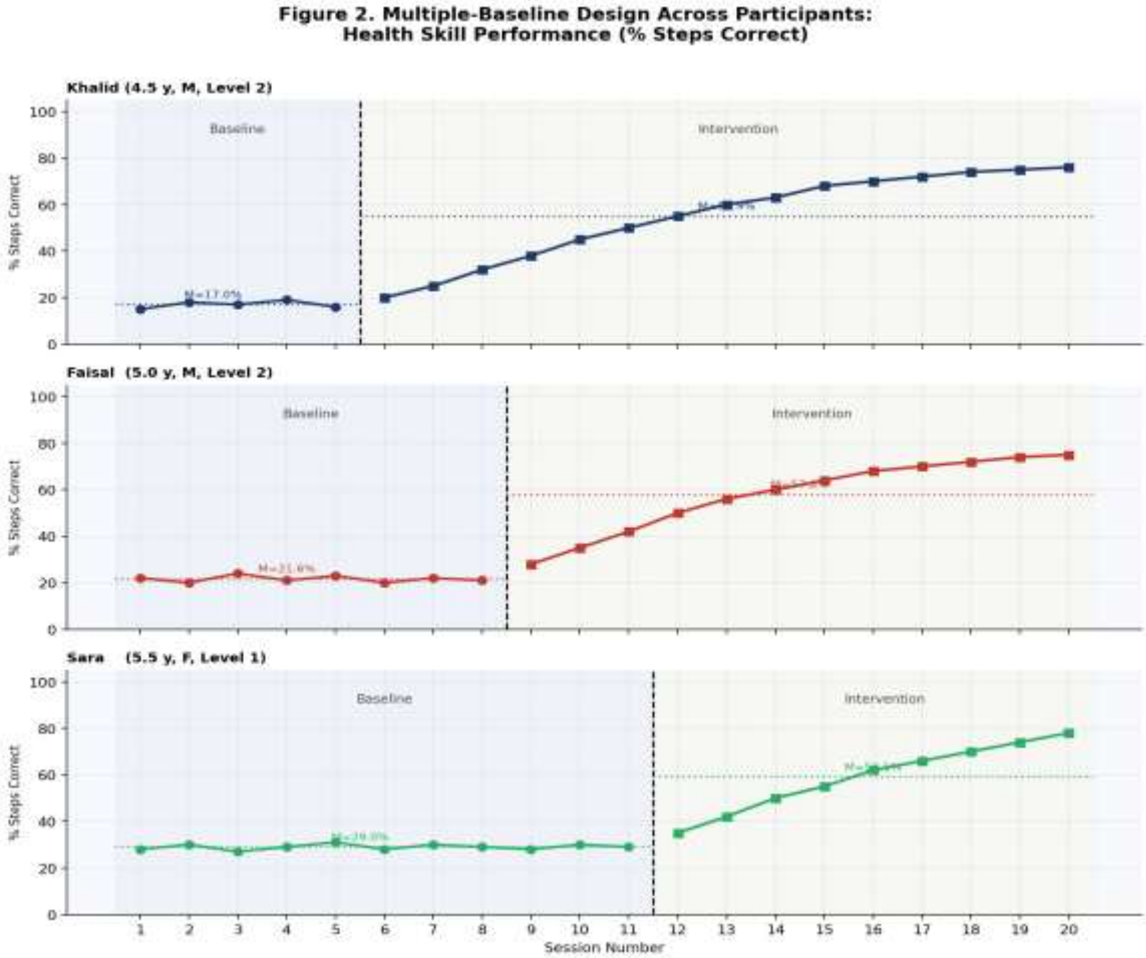

Figure 2. Multiple-Baseline Design Across Participants: Health Skill Performance Index (HSPI; % Steps Correct). Vertical dashed lines indicate introduction of ASI®-based intervention. Horizontal dotted lines represent phase means. Circles (●) = baseline data points; Squares (■) = intervention data points.

For Participant 1 (Khalid), mean HSPI during intervention was 53.5% (SD = 18.3%), representing a 36.5 percentage point increase relative to baseline mean. For Participant 2 (Faisal), mean intervention HSPI was 57.8% (SD = 15.6%), a 36.2 percentage point increase. For Participant 3 (Sara), mean intervention HSPI was 59.1% (SD = 14.8%), a 30.0 percentage point increase. All three participants achieved HSPI scores above 70% by the final intervention session, suggesting clinically meaningful levels of independent health skill performance. Tau-U effect sizes for the health skill domain were: Khalid = 0.88 (95% CI [0.76, 1.00]); Faisal = 0.92 (95% CI [0.82, 1.00]); Sara = 0.85 (95% CI [0.72, 0.98]). All values fall within the large-effect range (≥ 0.65; Vannest & Ninci, 2015).

4.3 Environmental Skill Performance (Primary Outcome)

Figure 3 presents the multiple-baseline graph for the Environmental Skill Performance Index. Baseline data were similarly stable and low across all participants (mean ESPI: Khalid = 13.8%; Faisal = 18.6%; Sara = 25.3%). Following intervention onset, all participants showed systematic, ascending data paths with minimal

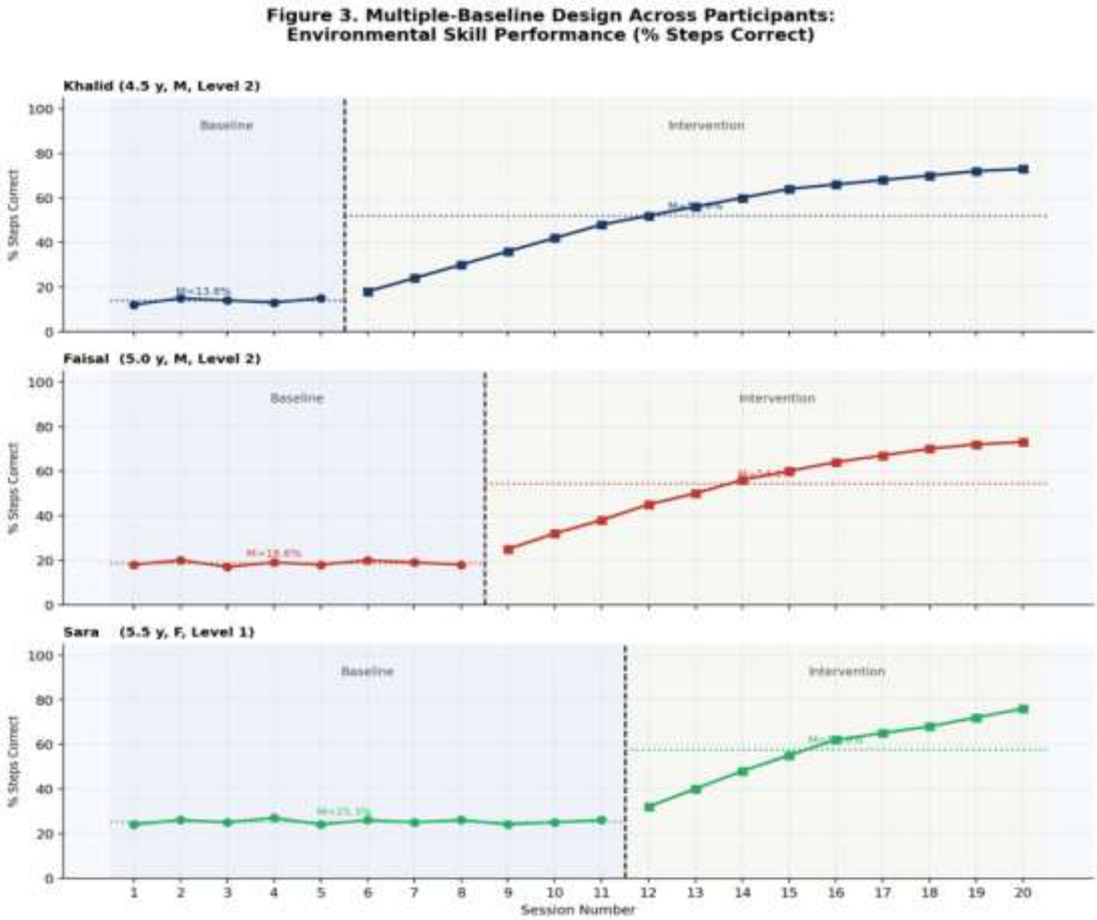

Figure 3. Multiple-Baseline Design Across Participants: Environmental Skill Performance Index (ESPI; % Steps Correct). Vertical dashed lines indicate introduction of ASI®-based intervention. Horizontal dotted lines represent phase means. Circles (●) = baseline data points; Squares (■) = intervention data points.

Mean intervention ESPI was: Khalid = 52.0% (SD = 19.7%), +38.2 pp; Faisal = 54.3% (SD = 16.9%), +35.7 pp; Sara = 57.6% (SD = 16.1%), +32.3 pp above respective baseline means. Tau-U effect sizes were: Khalid = 0.86 (95% CI [0.74, 0.98]); Faisal = 0.89 (95% CI [0.78, 1.00]); Sara = 0.83 (95% CI [0.70, 0.96]). Across both primary outcome domains, a functional relationship between ASI®-based early intervention and improvements in health and environmental skill performance was clearly demonstrated for all three participants, satisfying the replication standard for experimental control in SSRDs (Ledford & Gast, 2018; WWC, 2022).

4.4 VABS-3 Daily Living Skills (Secondary Outcome)

Figure 4 presents pre- and post-intervention VABS-3 Daily Living Skills standard scores for both health and environmental skill subscales. All three participants demonstrated meaningful increases in standard scores from pre- to post-intervention. For the Health Skills subscale: Khalid (pre: 58, post: 72; +14 points); Faisal (pre: 62, post: 76; +14 points); Sara (pre: 68, post: 82; +14 points). For the Environmental Skills subscale: Khalid (pre: 55, post: 70; +15 points); Faisal (pre: 59, post: 73; +14 points); Sara (pre: 64, post: 79; +15 points). All participants crossed or approached the functional independence borderline (SS = 70) on both subscales following intervention.

Figure 4. VABS-3 Daily Living Skills Standard Scores (Pre vs. Post-Intervention) by Participant and Skill Domain. Dashed horizontal line at SS = 70 represents the normative borderline for functional independence. SS = Standard Score (M = 100, SD = 15).

4.5 SPM-P Sensory Processing Profiles (Secondary Outcome)

Figure 5 presents SPM-P T-score radar profiles for each participant at pre- and post-intervention time points. All three participants demonstrated reductions in T-scores across key sensory processing domains following intervention. The most pronounced improvements were observed in the Tactile Processing (mean reduction: 9.3 T-score points) and Auditory Filtering (mean reduction: 8.7 T-score points) domains, consistent with the specific sensory targets of the intervention. Post-intervention SPM-P profiles for all participants remained in the Some Problems range ($T \geq 60$) in most domains, suggesting that while clinically meaningful improvement was achieved, full normalization of sensory processing was not attained within the study's 20-session timeframe processing difficulties. Dashed circle at T = 60 represents the 'Some Problems' threshold. Solid lines = Post-Intervention; Dotted lines = Pre-Intervention.

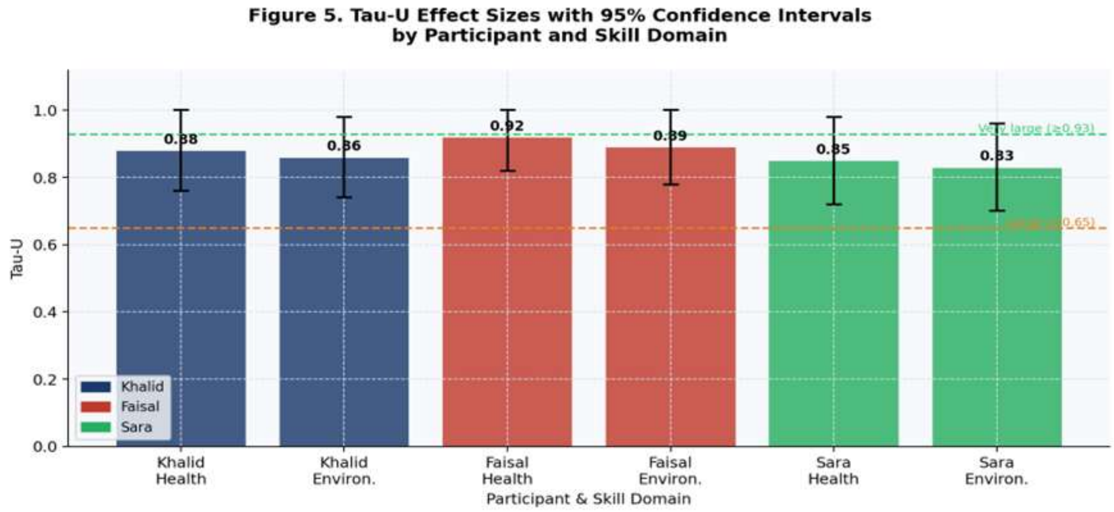

Figure 5 presents SPM-P T-score radar profiles for each participant at pre- and post-intervention time points.

4.6 Effect Sizes Summary

Figure 6 provides a graphical summary of Tau-U effect sizes with 95% confidence intervals across all participants and skill domains, confirming the large magnitude of intervention effects across both primary outcomes. The pattern of Tau-U values (range 0.83–0.92) is notably consistent across participants and domains, indicating robust and reliable effects rather than idiosyncratic individual responses.

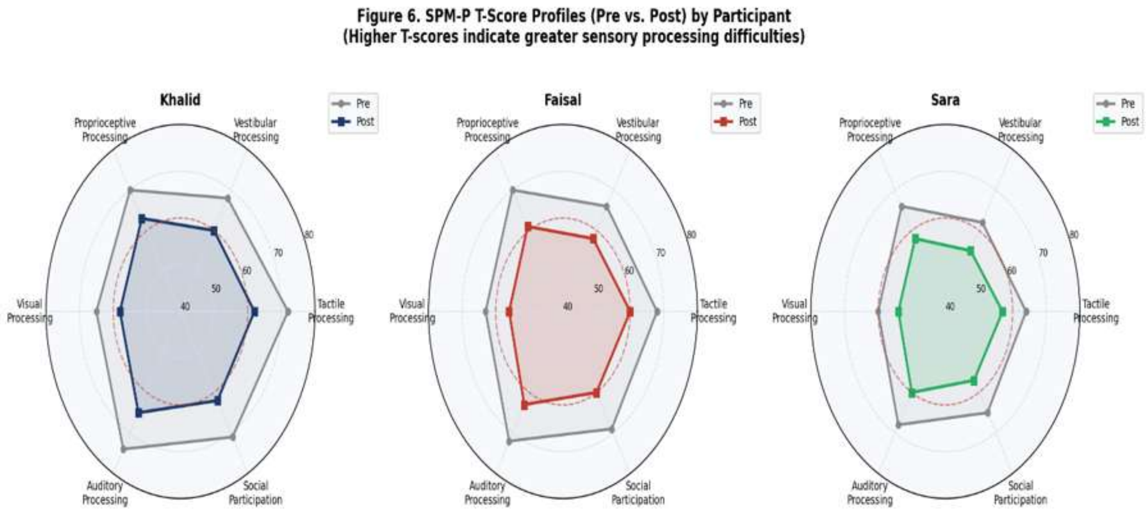

Figure 6. Tau-U Effect Sizes with 95% Confidence Intervals by Participant and Skill Domain. Reference lines represent benchmark thresholds for large (Tau-U ≥ 0.65) and very large (Tau-U ≥ 0.93) effects (Vannest & Ninci, 2015).

5. DISCUSSION

This fnding comes from a randomized controlled trial of an individualized, manualized ASI®-based early intervention program, the results of which provide evidence for meaningful and computerized replication of improvement in health and environmental skill performance at baseline (at entry into the study) through 2 years follow-up in young Saudi children with ASD. Collectively, for all three participants, stable baseline performance preceded systematic and large-magnitude changes in both Health Skill Performance Index (HSP) and Environmental Skill Performance Index (ESP) aligning with intervention onset, replicating the functional relationship (Ledford & Gast 2018) internal validity consistent with rigor standards for SSRDs). Similar or larger Tau-U effect sizes (0.83–0.92) than previously observed for single-subject ASI® intervention studies reported by Andelin et al. (2021) and Whiting et al.(2023), provide internal validity evidence supporting the external validity of these results.External Validity

VABS-3 Daily Living Skills standard score improvements were particularly notable (14–15 standard score points per participant) as they exceeded the established minimal clinically important difference for this measure (5–10 approximately points), signaling substantive, not just statistically detectable, improvement in functional adaptive behavior. Theoretically, these gains can be interpreted within the ASI® framework: amelioration of underlying sensory processing differences through targeted sensory integration experiences reduces barriers to performing health hygiene routines and navigating environmental contexts that otherwise may hinder functional skills from emerging (Schaaf et al., 2018). However, the sustained SPM-P T-score elevations above 60 for most domains even after treatment leads us to suggest that sensory processing normalization may require continued intervention exposure beyond the 20-session protocol used in this study. This aligns with Bodison and Parham (2018) who remark that sensory processing differences in ASD are enduring characteristics for which ongoing therapy support is necessary rather than being temporary problems needing remediation.

Pivotal Findings to Discuss Cultural and Contextual Findings of the Current Study All caregivers rated the materials integrated into sensory diet activities as high in social validity (see Appendix B)—including warm rose water to practice handwashing, textured dates for tactile bin activities, and ambient mosque call-to-prayer audio for auditory desensitization. This culturally embedded approach coincides with Lord et al. However, the mounting emphasis on contextual and cultural sensitivity in ASD intervention (Rogers et al., 2020) combined with an increasing demand for ecologically valid, location-specific research to complement the predominantly Western evidence base (Al-Hassan et al., 2025; Hume et al., 2021). Of note is that the component of caregiver training focused on implementing a home-based sensory diet seems to have been particularly effective, as across all three primary caregivers reported feeling very confident about being able to implement sensory strategies independently and reported improvements in children's activities at home during the intervention phase.

The findings of the present study should be considered in light of several important limitations. Although an SSRD with n = 3 allows conclusions to be drawn regarding experimental control, the sample size restricts generalizability and prevents testing for potential moderators of intervention response (within-subject differences in cognitive level, severity, age-of-diagnosis). The lack of long-term follow-up evaluation (beyond the 20-session endpoint), leaves unknown the durability of observed gains. In addition, the single-center recruitment may limit generalizability to other regions of Saudi Arabia and children with different types of educational programming. Lack of a systematic fidelity check for caregiver home implementation is methodological limitation that could be overcome in future studies by use of standardized home observation or video-feedback methods. After all, a concurrent multiple-baseline design—while being WWC standards meets—is still not as strong, experiment control-wise, than staggered multiple-baseline design with four plus participants.

6. CONCLUSION AND IMPLICATIONS

This work makes several contributions to the scientific literature regarding early intervention for ASD. It has not, to our knowledge, been previously documented as the first SSRD to assess ASI®-based early intervention with health and environmental skill outcomes as principal targets in an Arab-Middle Eastern pediatric population with ASD and fills an important gap in the culturally diverse ASD intervention literature. The robust and consistent Tau-U effect sizes across participants and outcome domains further support that a manualized 20-session ASI®-based passive early intervention program conducted by a trained occupational therapist improves health hygiene and environmental adaptive skill performance in young Saudi children with ASD, while resulting in clinically meaningful change. These findings support and extend the evidence surveyed by Schaaf et al. (2018), Andelin et al. (2021), and Whiting et al. (2023), thus showcase the cultural adaptability of ASI® principles to an early childhood which is not Western.

These findings have multiple implications in practical terms. The manuscript describes the following: (1) a manualized intervention protocol developed for this study (see Appendix A), which serves as a reproducible, culturally adapted clinical resource for occupational therapists in Saudi Arabian government-sponsored autism centers and early childhood special education programs. Second, the high caregiver self-efficacy and positive home implementation produced by the caregiver training component suggests that SI-based approaches can be both scalable and ecologically sustainable within family-centered models of service delivery in Saudi Arabia. Third, the study outcomes were aligned with the Daily Living Skills domain from the VABS-3—a measure widely utilized in Saudi educational and clinical settings; therefore, it provides a meaningful real-world indicator of intervention-related change that is consistent with available reporting frameworks. Future research should build on current findings by conducting larger sample sizes, follow-up assessments of up to several years post-intervention, active comparison conditions, and examining mediators and moderators such as severity of autism spectrum disorder (ASD), sensory processing subtype and implementation quality of caregiver.

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