doi:10.14720/aas.2025.121.3.19609 Original research article / izvirni znanstveni članek

The effect of occupational therapy in an equine environment on sensory processing in children with autism spectrum disorder

Nika GOMBAČ [1], Lea ŠUC [2], Jaka ŽGAJNAR [3, 4]

Received Avgust 26, 2024; accepted July 24, 2025.
Delo je prispelo 26. avgusta 2024, sprejeto 24. julija 2025.

The effect of occupational therapy in an equine environment on sensory processing in children with autism spectrum disorder

Abstract: In children with autism spectrum disorder (ASD), sensory processing can be atypical, leading to significant challenges. Studies indicate that occupational therapy in an equine environment (OTEE) can effectively address these sensory processing issues of children with ASD.We conducted the study with 20 boys, aged 4 to 9, adhering to a structured treatment protocol. The findings demonstrated significant improvements in sensory processing among participants following ten OTEE sessions. Specifically, average scores showed a statistically significant impact at the 5% risk level in the categories of "vestibular", "touch", and "multisensory processing", "modulation related to body position and movement", "modulation of sensory input influencing emotional responses in children", "emotional and social responses", and "behavioral outcomes of sensory processing". Additionally, significant changes ($p < 0{,}05$) were observed in factors such as "inattention/distractibility", "sensory seeking", "emotionally reactive", and "poor registration". A statistically significant impact ($p < 0{,}01$) was evident in the "avoiding", "seeking", and "sensitivity" quadrants. Children participating in OTEE exhibited greater adaptability in sensory-rich environments, found increased enjoyment in these settings, and demonstrated improved tolerance for low-stimulation surroundings. They also responded more effectively to sensory stimuli and showed greater situational awareness.

Key words: horses, animal-assisted therapy, occupational therapy in an equine environment, children, autism spectrum disorders, sensory processing

Učinek delovne terapije s pomočjo konj na senzorično obdelavo pri otrocih z motnjo avtističnega spektra

Izvleček: Pri otrocih z motnjo avtističnega spektra (ASD) je lahko senzorna obdelava netipična, kar povzroča številne izzive. Raziskave kažejo, da lahko delovna terapija s pomočjo konj (OTEE) učinkovito zmanjšuje težave s senzorno obdelavo pri otrocih z ASD. Študijo smo izvedli z 20 dečki, starimi od 4 do 9 let, pri čemer smo sledili strukturiranemu protokolu zdravljenja. Rezultati so pokazali pomembna izboljšanja pri senzorni obdelavi med udeleženci po desetih OTEE terapijah. Natančneje, povprečne ocene so pokazale statistično značilen vpliv ($p < 0{,}05$) v naslednjih kategorijah: "vestibularna", "taktilna" in "večsenzorna" obdelava, "modulacija povezana s položajem telesa in gibanjem", "modulacija senzornih inputov, ki so pod vplivom čustvenih odgovorov", "čustveni in socialni odgovori" in "vedenje kot rezultat senzorne predelave". Poleg tega so se pokazale statistično značilne razlike ($p < 0{,}05$) pri dejavnikih "nepozornost/preusmerjanje pozornosti", "senzorno iskanje", "čustveno reagiranje" in "slaba registracija". Statistično značilna razlika ($p < 0{,}01$) se je pokazala pri kvadrantih "izogibanje", "iskanje" in "občutljivost". Otroci, vključeni v OTEE, so pokazali večjo prilagodljivost v senzorno bogatih okoljih, v takšnih okoljih so doživljali večje zadovoljstvo ter izkazovali boljšo toleranco do okolij z nizko senzorno stimulacijo. Na senzorične dražljaje so se odzivali učinkoviteje in izkazovali višjo stopnjo zaznavanja situacije.

Ključne besede: konji, terapija s pomočjo živali, delovna terapija s pomočjo konja, otroci, motnje avtističnega spektra, senzorična obdelava

1 Center of Physiotherapy Ljubljana, Slovenia
2 University rehabilitation institute Republic of Slovenia Soča, Slovenia
3 University of Ljubljana, Biotechnical Faculty, Department of Animal Science, Domžale, Slovenia
4 Corresponding author, e-mail: jaka.zgajnar@bf.uni-lj.si

1 INTRODUCTION

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition marked by difficulties in social interaction, communication and unusual or repetitive behaviors (American Psychiatric Association, 2013). A prominent behavioral phenotype in ASD is atypical sensory processing, which often manifests as heightened or reduced responsiveness to sensory stimuli (Mikkelsen, 2018). Study of Chang et al. (2012) suggests that behavioral challenges related to sensory inputs, such as auditory stimuli, correspond to physiological responses that are outside of the child's voluntary control. Studies have shown that over 90 % of individuals with ASD, both children and adults, exhibit atypical sensory processing, as assessed by questionnaires like the Sensory Profile (Watling et al., 2001; Dunn et al., 2002; Baird et al., 2006; Kern et al., 2007; Tomchek and Dunn, 2007; Crane et al., 2009; Wiggins et al., 2009; Peters et al., 2020). These sensory differences are thought to stem from disrupted processing of auditory, visual, vestibular, tactile, multisensory, or oral-sensory stimuli. The sensory processing pathway involves a complex chain, from the mechanical-to-electrical signal conversion in sensory receptors, transmission to subcortical and cortical regions, integration in the primary somatosensory cortex, and finally, the selection of appropriate emotional and behavioral responses at both conscious and subconscious levels (Mikkelsen et al., 2018; Thye et al., 2018; Pastor-Cerezuela et al., 2020).

These behavioral and emotional responses are considered appropriate when they align with the child's developmental stage, demonstrating fundamental emotional and social competencies such as emotional regulation, social inclusion, connection with others, affective interaction, appropriate responses to social stimuli, etc. Abnormal development at any one of these sensory processing pathways could result in abnormal sensory processing (Cvetek, 2014).

Sensory dysfunctions in ASD originate in the central nervous system and engage various brain structures (Mikkelsen, 2018; Thye et al., 2018). The underlying processes leading to brain dysfunction may also produce associated pathophysiological abnormalities. ASD is commonly linked to conditions such as seizure and epilepsy, neurotransmitter disorders, sleep disturbances, metabolic irregularities, and immune and gastrointestinal disorders. Conversely, some of these abnormalities may contribute to brain dysfunctions that manifest as ASD symptoms, indicating a bidirectional relationship between neurological and physiological factors (Frye and Rossignol 2016; Purpura et al., 2022).

The selection of a preferred treatment approach is guided by the specific set of symptoms present in each individual, as the manifestation of issues can vary significantly among children. The primary treatment goal is to enhance functional skills in core areas of deficit and reduce the impact of other associated challenges (Levy et al., 2009). The authors recommend educational and behavioral therapy (Levy and Hyman, 2008; Volkmar et al., 2014; Trzmiel et al., 2019), pharmacotherapy (Trzmiel et al., 2019), communication therapy (Levy and Hyman, 2008; Volkmar et al., 2014) and social skills support (Levy and Hyman, 2008). Authors promote also occupational and physical therapy (Levy and Hyman, 2008; Domínguez-Lucio et al., 2023) and other interventions such as psychosocial intervention and sensory oriented interventions (Volkmar et al., 2014). Complementary and alternative medical treatments, biologically based or non-biological treatment are the one that are also the most often applied in practice (Levy et al., 2009). One of the complementary forms of rehabilitation is also occupational therapy in an equine environment (OTEE) (Dingman, 2008; Peters et al., 2022).

OTEE is performed by occupational therapists, physical therapists or speech language pathologists whose goal is to engage an individual's sensory, neuromotor and cognitive system and achieve certain functional outcomes (Koca and Ataseven, 2016; Srinivasan et al., 2018). Interaction with horses is a pleasant experience and has numerous positive effects, including improving the quality of life and reducing restlessness or negative mood (Peters et al., 2020). Studies highlight the positive impacts of OTEE in ASD, including improvements in social functioning (Bass et al., 2009; Memishevikj and Hodzhikj, 2010; Van den Hout and Bragonje, 2010; Ward et al., 2013; Lanning et al., 2014; Chen et al., 2015; Borgi et al., 2016), communication (Memishevikj and Hodzhikj, 2010; Gabriels et al., 2012; Coffey, 2014; Holm et al., 2014; Anderson and Maints, 2016), reduction of unusual behaviour (Memishevikj and Hodzhikj, 2010; Kern et al., 2011; Gabriels et al., 2012; Ajzenman et al., 2013; Coffey, 2014; ; García-Gómez et al., 2014; Holm et al., 2014; Lanning et al., 2014; Anderson and Maints, 2016; Llambias et al., 2016) and other important areas such as sensory processing (Bass et al., 2009; Memishevikj and Hodzhikj, 2010; Van den Hout and Bragonje, 2010; Wuang et al., 2010; Kern et al., 2011; Ward et al., 2013; Coffey, 2014). As the literature indicates, abnormalities in auditory processing are present in the vast majority of individuals with ASD (Tomchek and Dunn, 2007; Bolton et al., 2012), as some authors states, 65 % of individuals with ASD have atypical processing of sound (Chang et al., 2012; Bishop et al., 2013). This is exactly the area that OTEE has been shown to have significant impact (Ward et al., 2013).

Also, in tactile processing, studies showed important impact, because there are always many different textures and surfaces to feel in contact with a horse (Ward et al., 2013; Coffey, 2014). All physical and sensory activities in the OTEE environment, both on the ground and while on the horse, provide rich tactile, vestibular, proprioceptive, and olfactory stimulation, which also contribute to improving behavioral regulation (Peters et al., 2020). Because of the diversity of sensory stimuli involved in contact with a horse, we incorporated guidelines from Chang et al. (2012) into our treatment protocol for children with ASD who demonstrate general sensory processing difficulties. In our experiment we included interventions to facilitate development of sensory modulation and self-regulation across multiple sensory systems. Therapies were always performed in the same way, within a predictable environment and routine. Anticipated changes in routine or environment were also planned, following Chang et al. (2012), which we incorporated into our study.

The aim of our study was to explore the relationship between OTEE and the sensory processing skills in children with ASD, focusing particularly on auditory, tactile and vestibular processing. We examined the effects of a stable, predictable environment and routine on children's sensory responsivness, looking at how these factors might influence sensory input processing, attention and emotional responses. Our study encompassed both individual analyses and group-level insights, with a sample of 20 preschool and school-aged boys. Building on literature that underscores OTEE's positive effects on children with ASD, our study sought to answer a primary question: what is the average progression in sensory processing outcomes observed among participants across individual OTEE sessions? To ensure consistency, each therapy session adhered strictly to a detailed treatment protocol, which is thoroughly outlined in the paper. This protocol facilitated uniformity in approach while allowing us to observe changes systematically, enabling an accurate assessment of sensory processing improvements over the course of the intervention.

2 MATERIAL AND METHODS

2.1 PROCEDURE

The practical part of the study took place at the Educational research centre for Horse breeding Krumperk (Gorjuša 19a, 1233 Dob pri Domžalah), which is a part of Biotechnical Faculty, University of Ljubljana. The experiment took place in an indoor riding arena, where only the children's parents were present, if they chose to be, and no other people were allowed during the sessions. This setup minimized external influences, such as presence of unfamiliar people, noise, and other potential disturbances, creating an environment conducive to accurately measuring the effects of the therapy.

2.2 THE COURSE OF THE EXPERIMENT

The study extended over a four-month period, with each participant completing ten individualised treatment sessions across ten weeks (one session treatment per week). Each session lasted 60 minutes, with a median time (the middle value in a sorted set of numbers, dividing the set into two equal halve) of 26.1 minutes dedicated to horseback riding and 22.4 minutes of ground-based activities. The remaining time was set aside for a closing phase. The exact time spent on the horse and on the ground varied among children due to differences in functioning, sensory processing, and overall well-being. Over successive sessions, the time spent on the ground activities typically decreased, allowing for relatively longer time on the horse. A comprehensive treatment protocol detailing the structure and activities planned for each session is included.

At the treatments three occupational therapists were present. One of the therapists led the horse by the hand, the other planned and carried out the treatment with the child and the third therapist recorded all in details and walked by the horse and assisted if necessary. A specially trained 15-year-old Lipizzaner horse was selected for the OTEE treatments. This horse was in a good state of health and showed stable behaviour.2.3 Treatment protocol

The treatments were structured following the American Framework of Practice – AOTA (2013), drawing on rehabilitation and cognitive perceptual models, incorporating a range of approaches tailored to individual needs.

The primary aim of the activities on the ground and on the horseback (without saddle) was to enhance children's responses to daily sensory experiences. Activities were designed through games personalized to each child's specific sensory challenges, abilities and needs, as assessed by the sensory profile prior to the first session, aligning with the treatment protocol. The activities during treatments escalated in different areas, depending on the individual participant.

Each OTEE session began with sensory-based activities on the ground, emphasing tactile processing. Children were introduced to the horse by initially attending to, touching and petting various parts of the horse, followed by grooming activities using a sequence of brushes (first a steel horse brush, then bristles brush) (see Figure 1). As sessions progressed, activities included saddling and horseback riding, beginning with exercises targeting vestibular and proprioceptive processing (see Figure 1). These activities gradually expanded to integrate additional sensory systems—such as auditory, tactile, and visual—using various objects like rings, cones, and cards to enrich the sensory experience. The final phase, or closure, took place on the ground, where children unsaddled the horse, tidying up used accessories and rewarding the horse. This phase also emphasized safety practices (*e.g.* avoiding the area behind the horse), improving their basic knowledge of the horses and to remind the children of their behavior (do not kick at the hooves, do not hit the horse, *etc.*). Each well done completed task was followed by a praise or a reward (verbal encouragement 'excellent', high-five).

Figure 1: Some of the treatment activitis on the ground and on the horseback

OTEE sessions included routine activities. For encouragement we used cards and symbols (for example horse equipment, rider equipment, horse body parts, food for the horse, numbers, 'stop' and 'forward' symbols and activity schedule for non-verbal participants; see Figure 2). This has a positive effect on improving understanding, communication and behavior in children with ASD (Lauren Harrell, 2023).

2.3 SAMPLE OF PARTICIPANTS

The group of potential study participants was formed by contacting parents who were interested in participating in our study. The inclusion criteria for participants were male, aged between three and ten years, with verbal or non-verbal ability, with sensory processing problems, with a diagnosis of autism or Asperger's syndrome or in process of being diagnosed, with prior experience of learning to ride, therapeutic riding, or no previous contact with horses. Exclusion criteria included female participants, children over the age of 10, lack of interest in horses, and severe behavioural and sensory processing issues. From a study sample of 29 participants, 9 were excluded either due to disinterest for horses (n = 3), major problems with sensory processing (n = 3) or behaviour that was difficult to control on a horse (n = 3).

The final study sample consisted of 20 participants, aged between 4 and 9 years (Median = 7, SD = 1.9) with

Figure 2: Use of cards and symbols when saddling a horse and during horseback riding

a current clinical diagnosis of ASD (n = 17), Asperger's syndrome (n = 2) or in the process of being diagnosed with Asperger's syndrome (n = 1). Some of ASD population (70 % of study sample) had comorbid disorders, including attention deficit hyperactivity disorder – ADHD (15 %), developmental deficit (20 %), mental disorders (5 %), condition after feverish cramps (5 %), speech problems (15 %) and attention deficit disorder (10 %). More than half of the participants (n = 13) were verbal, with limited verbal ability, others (n = 7) were non-verbal. Contact with horses prior to the study was reported for 15 participants, only two of whom had contact in the context of equine assisted therapy.

2.4 SENSORY PROFILE

The sensory profile (SP) was evaluated before first (t1) and after final (t10) OTEE session. In such a manner we were able to compare how OTEE, effects on the sensory processing of children with ASD. The SP is a valid and reliable detailed questionnaire for parents/caregivers (Dunn,1999). It uses the five-point Likert scale (5 = never (5 % or less of the time), 4 = seldom (25 % of the time), 3 = occasionally (50 % of the time), 2 = frequently (75 % of the time), 1 = always (95 % or more of the time)) to rate 125 items evaluating children's responses to daily sensory experiences. Items are grouped into forteen categories (A. "auditory processing", B. "visual processing", C. "vestibular processing", D. "touch processing", E. "multisensory processing", F. "oral sensory processing", G. "sensory processing related to endurance/tone", H. "modulation related to body position and movement", I. "modulation of movement affecting activity level", J. "modulation of sensory input affecting emotional responses", K. "modulation of visual input affecting emotional responses and activity level", L. "emotional/social responses", M. "behavioral outcomes of sensory processing", N. "items indicating thresholds for response"), nine factors (1. "sensory seeking", 2. "emotionally reactive", 3. "low endurance/tone", 4. "oral sensory sensitivity", 5. "inattention/distractibility", 6. "poor registration", 7. "sensory sensitivity", 8. "sedentary", 9. "fine motor/perceptual") and four quadrants (1. "registration", 2. "seeking", 3. "sensitivity", 4. "avoiding") (Dunn, 1999).

Categories encompass all sensory systems, as well as the behavioral and emotional responses and modulations that reflect the integration of sensory inputs used in daily life. The factors describe children based on their

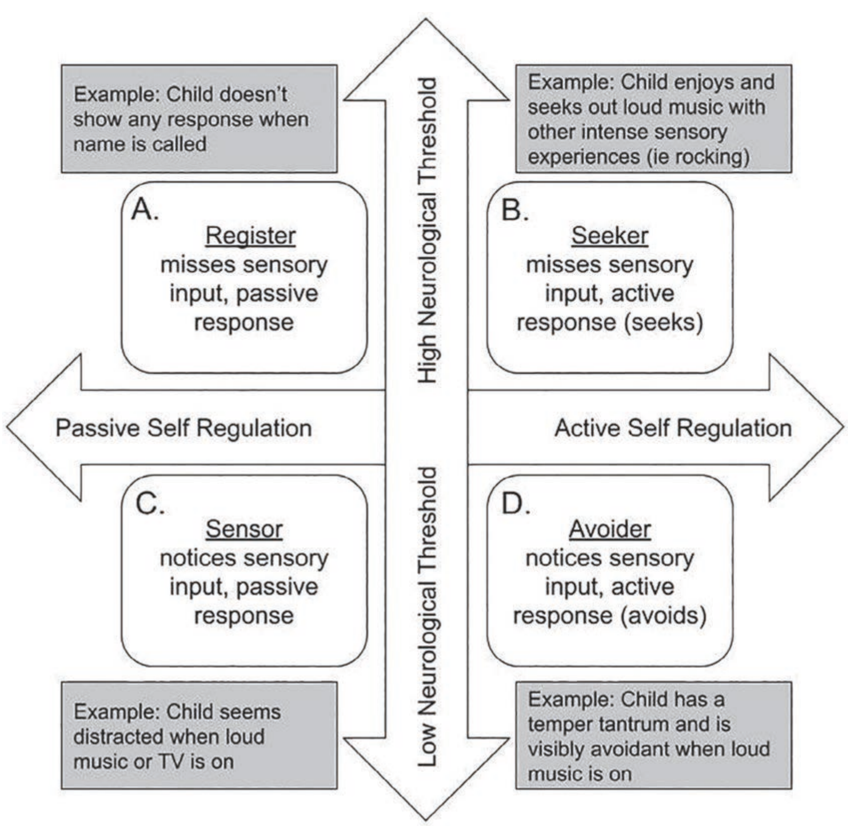

Figure 3: Quadrants in Sensory Profile (Butera et al., 2020)

responsiveness to sensory input (*e.g.*, overly responsive or underresponsive). Quadrants (Figure 3) describe four subtypes of sensory functioning (Register, Seeker, Sensor, and Avoider), which represent scores for sensory patterns and are defined by a combination of neurological thresholds and self-regulation. The registration pattern represents a high neurological threshold with a passive response, the seeking pattern represents a high neurological threshold with an active response, the sensitivity pattern reflects a low neurological threshold with a passive response and the avoiding pattern is associated with low neurological threshold and an active response (Dunn, 2006).

In presenting results from specific categories, factors, or quadrants, we employed a ranking system with five categories: "definite difference" (much more than others), "probable difference" (more than others), "typical performance" (similar to others), "probable difference" (less than others), and "definite difference" (much less than others). A "probable difference" signaled potential sensory processing issues, whereas a "definite difference" indicated established challenges in sensory processing. The sensory profile supplement (Dunn, 2006) was utilized to assess sensory processing abilities and performance patterns across these categories.

The data obtained from the SP provides insights into the sensory sensitivities of each child, allowing for tailored adjustments to activities during each session to meet individual needs. Dunn (1994) notes that the information gathered from the SP is based on practical application, making it a valuable tool for monitoring progress over time.

2.5 STATISTICAL ANALYSIS

In our data analysis, we employed a combination of descriptive and inferential statistical methods to thoroughly examine sensory processing patterns and behavioral responses. All statistics analyses were conducted using the SPSS 27.0 software package (IBM Corporation, Chicago, IL, USA). To test the normality of the data distribution, we used the Shapiro-Wilk test. When the Shapiro-Wilk test indicated a statistically significant deviation from normality ($p < 0.05$) for sensory categories, factors or quadrants, we applied the Wilcoxon test—a non-parametric test suitable for evaluating paired samples differences, to assess changes between initial and final treatment sessions. When the distribution of an individual category, factor, or quadrant did not deviate significantly from normal ($p > 0.05$), we used a parametric t-test for dependent samples to test the difference between the initial (t1) and final (t10) data. Additionally, we used the chi-square test to examine statistically significant differences between categorical variables. This approach allowed us to rigorously analyze the data, ensuring that the statistical methods used were appropriate for the nature of the data and the research questions being addressed.

We aimed to identify commonly reported behavioral characteristics of sensory processing in the ASD group. The "common behavior" criterion was based on a previous study of children with autism (Kientz and Dunn, 1996) and was met if 80 % or more respondents rated a single behavioral item as occurring frequently or always.

3 RESULTS

The primary objective of this study is to demonstrate the efficacy of OTEE for children diagnosed with ASD. The initial part of the paper focuses on the average progression observed among participants between evaluations. In the final part, the statistically significant changes that occurred within the categories (A–N), factors (1–9), and quadrants (1–4) of sensory processing after the completion of OTEE are presented in individual subsections.

To evaluate the internal consistency of the sensory profile's categories, factors, and quadrants, Cronbach's alpha coefficients were calculated, resulting in values of 0.87 for categories, 0.72 for factors, and 0.85 for quadrants.

The sensory profile demonstrated progress in mean scores (in terms of the total score) between the first and final evaluation for all 14 categories (Table 1), nine factors (Table 2), and four quadrants (Table 3).

3.1 SENSORY PROFILE CATEGORIES

After ten treatments, the mean values showed significant improvements in performance in four areas: "auditory processing" (A), "visual vrocessing" (C), "tactile processing" (D), and "emotional/social responses" (K). For two of the sensory processing domains ("auditory processing" and "vestibular processing"), "existing problems" were upgraded to "potential problems." For the other two domains ("tactile processing" and "modulation of visual inputs influenced by emotional responses"), mean values indicating "possible problems" improved to mean values indicating "no more problems".

All categories of the sensory profile (A–N) showed a statistically significant deviation from the normal

Table 1: Results and one sample *t*-test result of the sensory profile categories for the whole group (N = 20)

Sensory profile categories (A–N)	Possible points	AVG	SD	MIN	MAX	*p*
Sensory processing						
A. Auditory processing						
Pre-treatment testing	40	24.95	6.45	14	37	0.092
Post-treatment testing		26.75	5.65	17	39	
B. Visual processing						
Pre-treatment testing	45	36.75	7.44	20	45	0.068
Post-treatment testing		38.15	6.41	22	45	
C. Vestibular processing						
Pre-treatment testing	55	43.25	5.45	32	52	0.005
Post-treatment testing		44.70	4.72	32	52	
D. Touch processing						
Pre-treatment testing	90	71.10	8.78	56	84	0.007
Post-treatment testing		73.50	7.30	60	84	
E. Multisensory processing						
Pre-treatment testing	35	21.15	4.25	13	28	0.025
Post-treatment testing		22.65	4.51	14	31	
F. Oral sensory processing						
Pre-treatment testing	60	41.80	8.81	26	57	0.130
Post-treatment testing		43.50	7.45	32	57	
Modulation						
G. Sensory processing related to endurance/tone						
Pre-treatment testing	45	34.80	6.03	23	45	0.666
Post-treatment testing		34.95	5.82	23	45	
H. Modulation related to body position and movement						
Pre-treatment testing	50	41.10	5.10	26	50	0.019
Post-treatment testing		42.50	4.28	32	50	
I. Modulation of movement affecting activity level						
Pre-treatment testing	35	25.10	5.00	13	33	0.057
Post-treatment testing		26.20	3.52	19	33	
J. Modulation of sensory input affecting emotional responses						
Pre-treatment testing	20	13.75	2.53	8	18	0.040
Post-treatment testing		14.20	2.46	9	19	
K. Modulation of visual input affecting emotional responses and activity level						
Pre-treatment testing	20	14.15	1.82	11	19	0.071
Post-treatment testing		14.60	1.98	11	19	
Behavior and emotional responses						
L. Emotional/social responses						
Pre-treatment testing	85	57.55	10.67	31	75	0.002
Post-treatment testing		61.05	10.32	32	77	
M. Behavioral outcomes of sensory processing						
Pre-treatment testing	30	17.70	3.80	10	25	0.032
Post-treatment testing		18.40	3.37	10	24	
N. Items indicating thresholds for response						
Pre-treatment testing	15	10.90	2.34	7	14	0.103
Post-treatment testing		11.45	1.72	7	14	

distribution ($p < 0.05$). Consequently, we used a non-parametric test for dependent samples (Wilcoxon test) to examine the differences between the initial (t1) and final (t10) evaluations.

The results confirm that a statistically significant difference between the initial (t1) and final (t10) assessments, at the 5% risk level ($p < 0.05$), occurred in seven sensory categories. In vestibular processing (C) ($p = 0.005$), which provides information about the body's position in space and informs us whether the body is stationary or in motion, including the speed and direction of movement, significant effects were observed. Similarly, significant effects were found in touch processing (D) ($p = 0.007$), which is responsible for transmitting information to the brain regarding the texture, shape, temperature, and other characteristics of objects and surfaces we touch. Significant effects were also noted in multisensory processing (E) ($p = 0.025$), which involves the integration of signals arriving almost simultaneously from different sensory modalities. The movement of the horse had a pronounced positive influence on modulation related to body position and movement (H) ($p = 0.019$). Additionally, contact with a horse positively affected modulation of sensory input influencing emotional responses in children (J) ($p = 0.040$), emotional/social responses (L) ($p = 0.002$), and behavioral outcomes of sensory processing (M) ($p = 0.032$) (Table 1).

Table 2: One sample *t*-test and paired samples *t*-test result of the sensory profile factors for the whole group (N = 20)

Sensory Profile Factors (1–9)	Possible points	AVG	SD	MIN	MAX	p
1. Sensory Seeking						
Pre-treatment testing	85	59.15	9.40	44	76	0.002
Post-treatment testing		62.10	8.17	51	77	
2. Emotionally Reactive						
Pre-treatment testing	80	50.45	10.32	25	71	0.003
Post-treatment testing		53.60	10.39	25	70	
3. Low Endurance/Tone						
Pre-treatment testing	45	34.80	6.03	23	45	0.666
Post-treatment testing		34.95	5.82	23	45	
4. Oral Sensory Sensitivity						
Pre-treatment testing	45	30.50	7.92	17	43	0.262
Post-treatment testing		31.55	7.43	18	43	
5. Inattention/Distractibility						
Pre-treatment testing	35	20.20	5.18	12	27	0.021
Post-treatment testing		22.15	4.41	14	32	
6. Poor Registration						
Pre-treatment testing	40	30.65	4.20	22	38	0.013
Post-treatment testing		31.55	4.09	24	39	
7. Sensory Sensitivity						
Pre-treatment testing	20	16.85	2.95	11	20	0.034
Post-treatment testing		17.40	2.42	11	20	
8. Sedentary						
Pre-treatment testing	20	15.15	4.27	4	20	0.397
Post-treatment testing		15.50	3.34	8	20	
9. Fine motor/perceptual						
Pre-treatment testing	15	10.10	2.17	6	13	0.124
Post-treatment testing		10.45	1.94	6	13	

Note. H_a $\mu \neq 0$; p shows the results of a one sample *t*-test and paired samples *t*-test (Factor 5)

3.2 SENSORY PROFILE FACTORS

On average, the greatest improvement in sensory processing factors (1–9) (Table 2) was achieved in "emotional responsiveness" (2), while the least improvement was observed in "low endurance/tone" (3). The smallest differences between children occurred in both evaluations in the factor "poor registration" (6). Conversely, the greatest differences between boys appeared in the factor "sedentary activity" (8) during the initial assessment and in "oral sensory sensitivity" (4) during the final assessment.

After ten treatments, the average values show a significant progression to a better category only in the factor "inattention/ distractibility" (5), indicating a shift from "existing problems" to the presence of only "possible problems" in sensory processing.

For all factors except one, the Shapiro-Wilk test indicated a statistically significant deviation from normal distribution ($p < 0.05$).

3.3 SENSORY PROFILE QUADRANTS

Participants achieved the greatest average progress in the quadrant "seeking" (2) and the smallest in the quadrant "registration" (1) (Table 3). The smallest differences within the group of children, both at the initial and final assessments, were observed in the "avoiding" (4) quadrant. The greatest variability within the group was detected in the "seeking" quadrant during the initial assessment and in the "registration" (1) quadrant during the final assessment.

The maximum possible score was not achieved in any of the sensory processing quadrants.

Significant improvements after ten treatments were observed in two quadrants: "seeking" (2) and "avoiding" (4). In the "seeking" (2) quadrant, only "possible problems" were shown after ten treatments, while in the "avoiding" (4) quadrant, the effectiveness of OTEE was demonstrated by the "absence of problems" in this sensory processing quadrant.

Three quadrants (registration, seeking, and sensitivity) show a statistically significant deviation from the normal distribution ($p < 0.05$). In contrast, in the avoiding quadrant, the distribution does not deviate statistically significantly from normal ($p = 0.067$; $p > 0.05$).

However, in the area of registration, there is no statistically significant difference in the analysed population ($p = 0.06$; $p > 0.05$). The chi-square test revealed statistically significant differences between categories in all four quadrants at the risk level of 1% before and after OTEE treatment ($p < 0.01$).

3.4 CATEGORIES PERFORMANCE CLASSIFICATIONS

Notable progress from "definite difference" (much more than others) to "probable difference" (more than others) was observed in two categories - "auditory processing" (A) and "vestibular processing" (C) - as well as in the factor "inattention/distractibility" (5) and the quadrant "seeking" (2). Additionally, progress from "probable difference" (more than others) to "typical performance" (similar to others) was observed in two categories "touch processing" (D) and "modulation of

Table 3: One sample *t*-test and paired samples *t*-test result of the sensory profile quadrants for the whole group (N = 20)

Sensory profile quadrants (1–4)	Possible points	AVG	SD	MIN	MAX	*p*
1. Registration						
Pre-treatment testing	75	55.10	8.11	41	70	0.063
Post-treatment testing		56.25	8.14	41	72	
2. Seeking						
Pre-treatment testing	130	89.55	14.08	65	118	0.006
Post-treatment testing		93.95	11.80	80	118	
3. Sensitivity						
Pre-treatment testing	100	74.25	9.76	55	93	<.001
Post-treatment testing		77.70	8.09	62	96	
4. Avoiding						
Pre-treatment testing	145	111.40	13.07	84	136	0.002
Post-treatment testing		115.55	11.20	96	139	

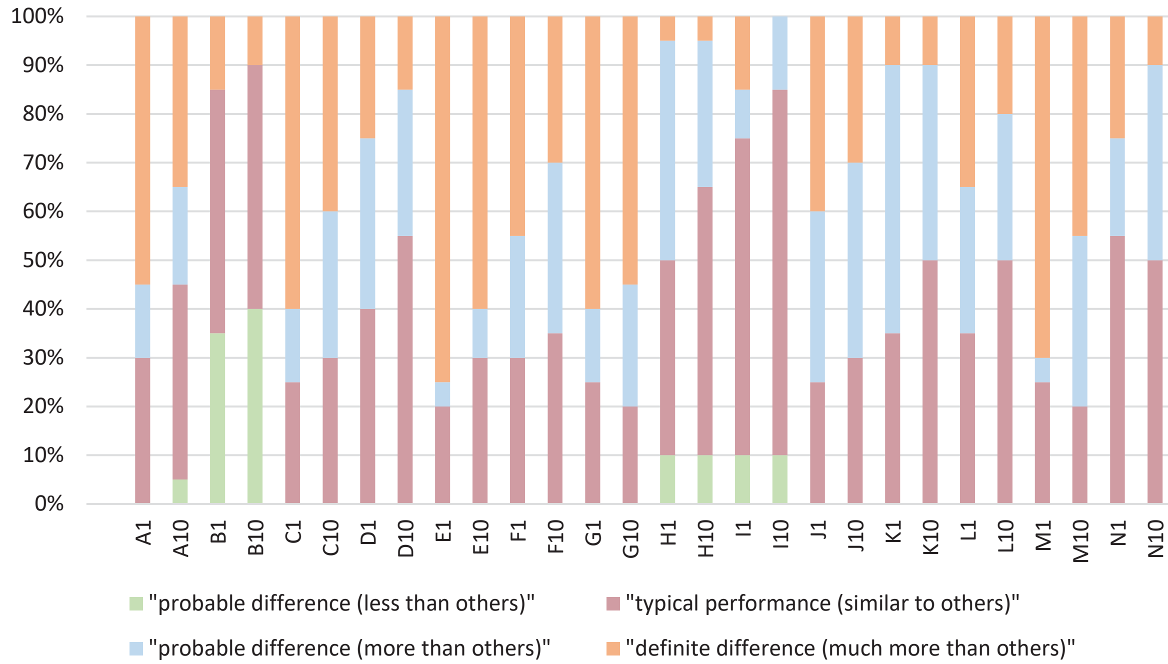

Figure 4: Frequency of sensory profile categories performance classifications within group of children with ASD (N = 20)

visual input affecting emotional responses and activity level" (K) —and in the quadrant "avoiding" (4), as shown in Figure 4. This indicates that the average distribution within typical performance improved across most categories between the initial and final assessments. Simultaneously, the proportion of cases showing a "definite difference" (much more than others) either decreased or remained unchanged, while the proportion showing a "probable difference" (more than others) either increased or remained unchanged (Figure 4).

4 DISCUSSION AND CONCLUSIONS

The results of this study suggest that OTEE can be an effective intervention for children with ASD and may have an effect on sensory functioning.

The study demonstrated significant changes in mean scores and among participants who underwent the OTEE program. After ten treatments, significant improvements in average values towards better performance were observed in four areas (A, C, D, and K) out of 14. In "Auditory" (A) and "Vestibular processing" (C), "Existing problems" improved to "Potential problems". Similarly, after ten treatments, only "Possible problems" were present in the factor "Inattention/Distractibility" (5) and in the quadrant "Seeking" (2) In the areas of "Touch processing" (D) and "Modulation of visual input affecting emotional responses and activity level" (K), as well as in the "Avoiding" (4) quadrant, the effectiveness of OTEE was evident, with an absence of problems in the group of examinees. The results from the initial and final assessments confirmed that OTEE has a statistically significant impact at the 5% risk level in seven categories and four factors and statistically significant impact at the 1% risk level in the areas of "avoiding" ($p = 0.002$; $p < 0.01$), "seeking" ($p = 0.006$; $p < 0.01$), and "sensitivity" ($p < 0.001$; $p < 0.01$). This suggests that, following OTEE, children are less burdened by sensory-rich environments, find greater enjoyment in such settings, have fewer difficulties tolerating low-stimulation environments, respond more easily to sensory stimuli, and demonstrate heightened awareness of their surroundings. These results are in line with previous research showing that the outcomes of OTEE for children with ASD demonstrate significant improvement in the areas of sensory processing (Bass et al., 2009; Memishevikj and Hodzhikj, 2010; Van den Hout and Bragonje, 2010; Wuang et al., 2010; Kern et al., 2011), especially in the field of touch processing (Ward et al., 2013; Coffey, 2014) and auditory processing (Ward et al., 2013). Visual, auditory and somatosensory cortices have reciprocal pathways with the cerebellum (Zhua et al., 2006). Because it is linked with motor learning skills, motor control and social engagement, Bass et al. (2009) assumed it is possible that OTEE is linked to cerebellar functioning. Silkwood-Sherer et al. (2012) claimed that the respond to a variety of somatosensory, vestibular, and visual stimuli enables the child's simultaneous forward movement on the horse.

Our study found that OTEE had a statistically significant effect on children's responsiveness to sensory input. One key outcome was the observed improvemnet in "inattention", where statistically significant changes were noted. Similar positive outcomes in attentional focus were reported in previous research by Bass et al. (2009) and Lanning et al. (2014), with Chen et al. (2015) noticing increased engagement with the horse, suggesting that interaction with the animal may influence brain activation, particularly in the frontal regions responsible for attentional processes.

In our study, statistically significant difference in neurological thresholds for responses was found between the initial (t1) and final (t10) evaluations. While one of the previous studies reported progress in the registration and sensitivity quadrants (Ward et al., 2013), our study showed statistically significant differences at the 1% risk level in three quadrants: "avoiding", "seeking", and "sensitivity". Additionally, the average scores for the "seeking" and "avoiding" quadrants also improved. After treatments children had only possible problems with "Seeking" and no more problems with "avoiding". The statistically significant improvement in sensory seeking observed in our study is consistent with the statistically significant treatment effects reported by Bass et al. (2009).

At the behavioral level, only one item—"looks away from task to notice all actions in the room"—was initially marked as "common behavior", meeting the threshold of 80 % or more of participants. Notably, OTEE had a significant impact on this behavior, which involves multisensory processing with a low neurological threshold. Improvements in behavior can be attributed to the multisensory experience of being near a horse and the simultaneous improvement in attention. Findings from our study also demonstrated a positive reduction in challenging behavior traits and difficulty in children's responses to daily sensory experiences. After treatments, fewer participants exhibited certain behaviors as "always" or "frequently," and more participants responded without any problems in sensory processing. Schmitz Olin et al. (2017) reported that some behaviors may occur as a tendency to induce sensory stimulation. According to Marco et al. (2011), atypical behavioral responses to sensory information are common in individuals on the autism spectrum.

Our findings suggest that OTEE may be a promising therapeutic option for children with ASD, particularly in enhancing sensory processing, modulating sensory inputs, and supporting positive behavioral and emotional responses. By improving children's responsiveness to sensory input and helping align their sensory processing with neurological thresholds, OTEE demonstrates notable therapeutic potential. Although our results are promising, further longitudinal studies with larger sample sizes are required to strengthen and generalize these findings.

An area that requires further investigation is the role of the horse itself. Only one horse was used in this study, so it would be beneficial to explore how different horses might influence therapeutic outcomes. Additionally, it is important to consider the impact of therapy sessions on the horse's well-being and behavior. Future studies focusing on both the therapeutic effects on children and the influence on the participating horses are encouraged. Given the strong indications of positive outcomes, broader integration of OTEE in ASD rehabilitation is recommended.

5 REFERENCES

Ajzenman, H. F., Standeven, J. W., & Shurtleff, T. L. (2013). Effect of hippotherapy on motor control, adaptive behaviors, and participation in children with autism spectrum disorder: A pilot study. *The American Journal of Occupational Therapy*, *67*(6), 653–663. https://doi.org/10.5014/ajot.2013.008383

American Psychiatric Association, D. S. M. T. F., & American Psychiatric Association, D. S. (2013). *Diagnostic and statistical manual of mental disorders: DSM-5* (Vol. 5, No. 5). Washington, DC: American psychiatric association. https://doi.org/10.1176/appi.books.9780890425596

Anderson, S., & Meints, K. (2016). Brief Report: The Effects of Equine-Assisted Activities on the Social Functioning in Children and Adolescents with Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders*, *46*(10), 3344–3352. https://doi.org/10.1007/s10803-016-2869-3

American Occupational Therapy Association (2013). Occupational therapy practice framework: Domain And Process, 3rd ed. Draft for External Review.

Baird, G., Simonoff, E., Pickles, A., Chandler, S., Loucas, T., Meldrum, D., & Charman, T. (2006). Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *Lancet*, *368*(9531), 210–215. https://doi.org/10.1016/S0140-6736(06)69041-7

Bass, M. M., Duchowny, C. A., & Llabre, M. M. (2009). The effect of therapeutic horseback riding on social functioning in children with autism. *Journal of Autism and Developmental Disorders*, 39, 1261–1267. https://doi.org/10.1007/s10803-009-0734-3

Bishop, S. L., Hus, V., Duncan, A., Huerta, M., Gotham, K., Pickles, A., ... Lord, C. (2013). Subcategories of restricted and repetitive behaviors in children with autism spectrum disorders. *Journal of Autism and Developmental Dis-*

orders, *43*(6), 1287–1297. https://doi.org/10.1007/s10803-012-1671-0

Bolton, P. F., Golding, J., Emond, A., & Steer, C. D. (2012). Autism spectrum disorder and autistic traits in the Avon Longitudinal Study of Parents and Children: precursors and early signs. *Journal of the American Academy of Child & Adolescent Psychiatry*, *51*(3), 249–260. https://doi.org/10.1016/j.jaac.2011.12.009

Borgi, M., Loliva, D., Cerino, S., Chiarotti, F., Venerosi, A. Bramini, M., ... Cirulli F. (2016). Effectiveness of a standardized equine-assisted therapy program for children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 46, 1–9. https://doi.org/10.1007/s10803-015-2530-6

Butera, C., Ring, P., Sideris, J., Jayashankar, A., Kilroy, E., Harrison, L., ... Aziz-Zadeh, L. (2020). Impact of sensory processing on school performance outcomes in high functioning individuals with autism spectrum disorder. *Mind, Brain, and Education*, *14*(3), 243–254. https://doi.org/10.1111/mbe.12242

Chang, M. C., Parham, L. D., Blanche, E. I., Schell, A., Chou, C. P., Dawson, M., & Clark, F. (2012). Autonomic and behavioral responses of children with autism to auditory stimuli. *The American Journal of Occupational Therapy*, *66*(5), 567–576. https://doi.org/10.5014/ajot.2012.004242

Coffey, E. (2014). *The effect of equine assisted therapy on the social functioning of children with autism.* Dublin: Dublin Business School.

Chen, C. C., Crews, D., Mundt, S., & Ringenbach S. D. R. (2015). Effects of equine interaction on EEG asymmetry in children with autism spectrum disorder: A pilot study. *International Journal of Developmental Disabilities*, *61*(1), 56–59. https://doi.org/10.1179/2047387714Y.0000000044

Crane, L., Goddard, L., & Pring, L. (2009). Sensory processing in adults with autism spectrum disorders. *Autism*, *13*(3), 215–228. https://doi.org/10.1177/1362361309103794

Cvetek, M. (2014). *Živeti s čustvi : čustva, čustveno procesiranje in vseživljenjski čustveni razvoj*. Ljubljana: Teološka fakulteta.

Dingman, A. (2008). Hoof prints: Equine therapy for autistic children. *Encounter*, *21*(4), 11–13.

Domínguez-Lucio, S., Compañ-Gabucio, L. M., Torres-Collado, L., & de la Hera, M. G. (2023). Occupational therapy interventions using new technologies in children and adolescents with autism spectrum disorder: a scoping review. *Journal of Autism and Developmental Disorders*, *53*(1), 332–358. https://doi.org/10.1007/s10803-022-05431-3

Dunn, W. (1994). Performance of typical children on the sensory profile: An Item Analysis. *The American Journal of Occupational Therapy*, *48*(11), 967–974. https://doi.org/10.5014/ajot.48.11.967

Dunn, W. (1999). *Sensory profile. User´s manual.* San Antonio: The Psychological Corporation.

Dunn, W., Myles, B. S., & Orr, S. (2002). Sensory processing issues associated with Asperger syndrome: a preliminary investigation. *The American Journal of Occupational Therapy*, *56*(1), 97–102. https://doi.org/10.5014/ajot.56.1.97

Dunn, W. (2006). *Sensory profile Supplement. User's manual.* San Antonio: The Psychological Corporation.

Frye, R. E., & Rossignol, D. A. (2016). Identification and treatment of pathophysiological comorbidities of autism Spectrum disorder to achieve optimal outcomes. *Clinical medicine insights: Pediatrics*, 10, 43–56. https://doi.org/10.4137/CMPed.S38337

Gabriels, R. L., Agnew, J. A., Holt, K. D., Shoffner, A., Zhaoxing, P., Ruzzano, S., ... Mesibov, G. (2012). Pilot study measuring the effects of therapeutic horseback riding on school-age children and adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders*, *6*(2), 578–588. https://doi.org/10.1016/j.rasd.2011.09.007

García-Gómez, A., Risco, M. L., Rubio, J. C., Guerrero, E., & GarcíaPeña, I. M. (2014). Effects of a program of adapted therapeutic horse-riding in a group of autism spectrum disorder children. *Electronic Journal of Research in Educational Psychology*, *12*(1), 107–128. https://doi.org/10.14204/ejrep.32.13115

Holm, M. B., Baird, J. M., Kim, Y. J., Rajora, K. B., D'Silva, D., Podolinsky, L., ... Minshew, N. (2014). Therapeutic horseback riding outcomes of parent-identified goals for children with autism spectrum disorder: an ABA' multiple case design examining dosing and generalization to the home and community. *Journal of Autism and Developmental Disorders*, *44*(4), 937–947. https://doi.org/10.1007/s10803-013-1949-x

Kern, J. K., Trivedi, M. H., Grannemann, B. D., Garver, C. R., Johnson, D. G., Andrews, A. A., ... Schroeder, J. L. (2007). Sensory correlations in autism. *Autism*, *11*(2), 123–134. https://doi.org/10.1177/1362361307075702

Kern, J. K., Fletcher, C. L., Garver, C. R., Mehta, J. A., Grannemann, B. D., Knox, K. R., ... Trivedi, M. H. (2011). Prospective trial of equine assisted activities in autism spectrum disorder. *Alternative Therapies in Health and Medicine, 17*(3), 14–20.

Kientz, M. A., & Dunn, W. (1997). A comparison of the performance of children with and without autism on the Sensory Profile. *The American Journal of Occupational Therapy*, 51, 530–537. https://doi.org/10.5014/ajot.51.7.530

Koca, T. T., & Ataseven, H. (2016). What is hippotherapy? The indications and effectiveness of hippotherapy. *Northern Clinics Of Istanbul*, *2*(3), 247–252. https://doi.org/10.14744/nci.2016.71601

Lanning, B. A., Matyastik Baier, M. E., Ivey-Hatz, J., Krenek, N., & Tubbs, J. D. (2014). Effects of equine assisted activities on autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 44, 1897–1907. https://doi.org/10.1007/s10803-014-2062-5

Lauren Harrell, L. R. T. (2023). *Comparing the effectiveness of social skills development interventions with therapeutic horseback riding in children with autism: An alternating treatment design (*Master's Theses). East Carolina University. 75 p.

Levy, S. E., & Hyman, S. L. (2008). Complementary and alternative medicine treatments for children with autism spectrum disorders. *Child and Adolescent Psychiatric Clinics of North America*, *24*(1), 117–143. https://doi.org/10.1016/j.chc.2014.09.004

Levy, S. E., Mandell, D. S., & Schultz, R. T. (2009). Autism. *Lancet*, *374*(9701), 1627–1638. https://doi.org/10.1016/S0140-6736(09)61376-3

Llambias, C., Magill-Evans, J., Smith, V., & Warren, S. (2016). Equine-assisted occupational therapy: Increasing engagement for children with autism spectrum disorder. *The American Journal of Occupational Therapy*, *70*(6), 1–9. https://doi.org/10.5014/ajot.2016.020701

Marco, E. J., Hinkley, L. B., Hill, S. S., & Nagarajan, S. S. (2011). Sensory processing in autism: a review of neurophysiologic findings. *The Journal of Pediatric Research*, *69*(5), 48R–54R.https://doi.org/10.1203/PDR.0b013e3182130c54

Memishevikj, H., & Hodzhikj, S. (2010). The effects of equine assisted therapy in improving the psychosocial functioning of children with autism. *Journal of Special Education and Rehabilitation, 11*(3–4), 57–67.

Mikkelsen, M., Wodka, E. L., Mostofsky, S. H., & Puts, N. A. J. (2018). Autism spectrum disorder in the scope of tactile processing. *Developmental Cognitive Neuroscience,* 29, 140–150. https://doi.org/10.1016/j.dcn.2016.12.005

Pastor-Cerezuela, G., Fernández-Andrés, M. I., Sanz-Cervera, P., & Marín-Suelves, D. (2020). The impact of sensory processing on executive and cognitive functions in children with autism spectrum disorder in the school context. *Research in developmental disabilities*, *96*, 103540. https://doi.org/10.1016/j.ridd.2019.103540

Peters, B. C., Wood, W., Hepburn, S., & Bundy, A. (2020). Pilot study: Occupational therapy in an equine environment for youth with autism. *OTJR: occupation, participation and health*, *40*(3), 190–202. https://doi.org/10.1177/1539449220912723

Peters, B. C., Wood, W., Hepburn, S., & Moody, E. J. (2022). Preliminary efficacy of occupational therapy in an equine environment for youth with autism spectrum disorder. *Journal of autism and developmental disorders*, 1–15. https://doi.org/10.1007/s10803-021-05278-0

Purpura, G., Cerroni, F., Carotenuto, M., Nacinovich, R., & Tagliabue, L. (2022). Behavioural differences in sensorimotor profiles: a comparison of preschool-aged children with sensory processing disorder and autism spectrum disorders. *Children*, *9*(3), 408. https://doi.org/10.3390/children9030408

Schmitz Olin, S., McFadden, B. A., Golem, D. L., Pellegrino, J. K., Walker, A. J., Sanders, D. J., & Shawn, M. A. (2017). The Effects of Exercise Dose on Stereotypical Behavior in Children with Autism. *Medicine & Science Sports & Exercise*, *49*(5), 983–990. https://doi.org/10.1249/MSS.0000000000001197

Silkwood-Sherer, D. J., Killian, C. B., Long, T. M., & Martin, K. S. (2012). Hippotherapy—an intervention to habilitate balance deficits in children with movement disorders: a clinical trial. *Physical Therapy*, *92*(5), 707–717. https://doi.org/10.2522/ptj.20110081

Srinivasan, S. M., Cavagnino, D. T., & Bhat, A. N. (2018). Effects of Equine Therapy on Individuals with Autism Spectrum Disorder: A Systematic Review. *Review Journal of Autism and Developmental Disorders*, *5*(2), 156–175. https://doi.org/10.1007/s40489-018-0130-z

Thye, M. D., Bednarz, H. M., Herringshaw, A. J., Sartin, E. B., & Kana, R. K. (2018). The impact of atypical sensory processing on social impairments in autism spectrum disorder. *Developmental Cognitive Neuroscience*, 29, 151–167. https://doi.org/10.1016/j.dcn.2017.04.010

Tomchek, S. D., & Dunn, W. (2007). Sensory processing in children with and without autism: a comparative study using the short sensory profile. *The American Journal of Occupational Therapy*, *61*(2), 190–200. https://doi.org/10.5014/ajot.61.2.190

Trzmiel, T., Purandare, B., Michalak, M., Zasadzka, E., & Pawlaczyk, M. (2019). Equine assisted activities and therapies in children with autism spectrum disorder: A systematic review and a meta-analysis. *Complementary Therapies in Medicine*, 42, 104–113. https://doi.org/10.1016/j.ctim.2018.11.004

Van den Hout, C. M. A., & Bragonje, S. (2010). *The effect of equine assisted therapy in children with autism spectrum disorders*. Texas: Faculty of Human Movement Sciences.

Volkmar, F., Siegel, M., Woodbury-Smith, M., King, B., McCracken, J., State, M. (2014). Practice parameter for the assessment and treatment of children and adolescents with autism spectrum disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *53*(2), 237–257. https://doi.org/10.1016/j.jaac.2013.10.013

Ward, S.C., Whalon, K., Rusnak, K., Wendell, K., & Paschall, N. (2013). The association between therapeutic horseback riding and the social communication and sensory reactions of children with autism. *Journal of Autism and Developmental Disorders*, 43, 2190–2198. https://doi.org/10.1007/s10803-013-1773-3

Watling, R. L., Deitz, J., & White, O. (2001). Comparison of Sensory Profile scores of young children with and without autism spectrum disorders. *The American Journal of Occupational Therapy*, *55*(4), 416–423. https://doi.org/10.5014/ajot.55.4.416

Wiggins, L. D., Robins, D. L., Bakeman, R., & Adamson, L. B. (2009). Brief report: sensory abnormalities as distinguishing symptoms of autism spectrum disorders in young children. *Journal of Autism and Developmental Disorders, 39*(7), 1087–1091. https://doi.org/10.1007/s10803-009-0711-x

Wuang, Y. P., Wang, C. C., Huang, M. H., & Su, C. Y. (2010). The effectiveness of simulated developmental horse-riding program in children with autism. *Adapted Physical Activity Quarterly*, 27, 113–126. https://doi.org/10.1123/apaq.27.2.113

Zhua, J. N., Yunge, W. H., Chowe, B. K., Chand, Y. S., & Wanga, J. J. (2006). The cerebellar hypothalamic circuits: Potential pathways underlying cerebellar involvement in somatic visceral integration. *Brain Research Reviews*, *52*(1), 93–106. https://doi.org/10.1016/j.brainresrev.2006.01.003