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Assessing Health-Related Quality of Life Outcomes Through Sensory Modulation Profiles in Adults with Atypical Sensory Processing: A Cross-Sectional Study

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Research Article

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Abstract

Introduction: Atypical sensory modulation—manifesting as low registration, sensitivity, avoidance, or sensory seeking—can significantly affect adults' daily functioning and health-related quality of life (HRQoL). Despite growing interest in sensory diversity, its relationship with HRQoL remains insufficiently explored in adult populations.
Objectives: This study investigated the association between sensory modulation profiles and HRQoL outcomes in adults, with the aim of informing neurodiversity-affirming clinical approaches.
Methods: A cross-sectional study included 86 adults (aged 23–54), evenly divided into two groups based on typical vs. atypical sensory modulation profiles, assessed via the Adolescent/Adult Sensory Profile (AASP). HRQoL was measured using the SF-36. Statistical analyses included the Kolmogorov–Smirnov test, Mann–Whitney U test, and Pearson's correlation.
Results: Adults with atypical sensory modulation profiles reported significantly lower HRQoL across all eight SF-36 domains ($p < .001$), most notably in domains related to fatigue, pain, mental health, and social functioning. No significant associations were found between HRQoL outcomes and age or gender, suggesting sensory modulation profiles were the primary factor.
Conclusion: Sensory modulation differences are strongly associated with reduced HRQoL, independent of demographic factors. These findings underscore the importance of integrating sensory-informed, person-centered strategies in adult care to support well-being and promote environmental accommodation over pathologisation.

Keywords: Sensory Modulation Disorder, Sensory Integration Dysfunction, Sensory Processing Disorder, Health-Related Quality of Life, Health Status Indicators, Adults, SF-36 Questionnaire, Cross-Sectional Study

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1. Introduction

Sensory processing patterns shape how individuals interpret and respond to sensory stimuli from both the external and internal environment. While many people exhibit balanced responses, others experience heightened or diminished reactivity, affecting emotional regulation, daily functioning, and quality of life (Dunn, 1997; Schaaf & Mailloux, 2015). Contemporary approaches increasingly frame these differences as natural variations within the spectrum of neurodiversity, especially when individuals develop effective coping strategies (Davies et al., 2022; Bundy et al., 2022; Neal et al., 2023). A widely used framework for understanding sensory modulation is Dunn's Four-Quadrant Model, which categorises sensory processing patterns based on neurological thresholds (high vs. low) and behavioural responses (active vs. passive). This yields four distinct profiles: low registration, sensory seeking, sensory sensitivity, and sensory avoiding (Brown & Dunn, 2002; Salatino & Schmidt, 2023). Each profile reflects different ways of engaging with sensory input, from passive under-responsiveness to active efforts to manage overstimulation (Dunn, 1997; Brown & Dunn, 2002). While clinical frameworks such as Sensory Modulation Disorder (SMD) describe sensory responses that interfere with daily life, growing perspectives emphasise that distress often results from environmental mismatch rather than inherent pathology (Bar-Shalita et al., 2008; Bundy et al., 2022). Sensory integration refers to the neurophysiological process through which the brain organises input from visual, auditory, tactile, vestibular, proprioceptive, olfactory, and gustatory systems into adaptive behaviour (Ayres, 1979; Miller et al., 2007). When modulation is disrupted, individuals may present with sensory over-responsiveness (e.g., aversion to noise), under-responsiveness (e.g., missing verbal cues), or sensory-seeking behaviour (e.g., craving movement), all of which can impact participation and well-being (Bar-Shalita et al., 2019; Cermak et al., 2021). Neuroimaging studies support these experiences by showing altered activation in sensory cortices and disrupted connectivity with limbic regions, reflecting central sensitisation and reduced sensory gating (Gracely et al., 2002; Yamada et al., 2017; Inagaki et al., 2024). These changes are associated with emotional dysregulation, fatigue, and somatic symptoms (Rodrigues et al., 2021). Although historically underrecognised in adults, atypical sensory modulation has been linked to chronic stress, social withdrawal, and misdiagnosis in clinical settings (Wilbarger & Cook, 2011; Neal et al., 2023). Reframing these experiences through a sensory-informed lens supports more accurate interpretation and tailored support (Bundy et al., 2022; Salatino & Schmidt, 2023). Health-related quality of life (HRQoL) refers to individuals' perceived well-being across physical, psychological, and social domains (Ware & Sherbourne, 1992). Sensory modulation patterns may influence HRQoL by affecting energy regulation, social participation, and engagement in meaningful routines (Lane et al., 2010; Pfeiffer et al., 2005; Salatino & Schmidt, 2023). For example, individuals with sensory sensitivity may avoid overstimulating environments, leading to reduced opportunities for connection and decreased well-being (Rodrigues et al., 2021; Bundy et al., 2022). Despite growing awareness, few studies have systematically explored the relationship between adult sensory modulation profiles and HRQoL. Greater understanding of this link is essential for informing inclusive, person-centered approaches that promote meaningful participation and psychosocial resilience across diverse sensory needs.

2. Aim of the article

This study investigates the relationship between sensory modulation patterns and health-related quality of life (HRQoL) in adults. Drawing on Dunn's model, it explores how low registration, sensory seeking, sensitivity, and avoidance—measured via the Adolescent/Adult Sensory Profile (AASP)—relate to perceived HRQoL across physical, emotional, pain-related, and social domains using the SF-36. We hypothesise that individuals with pronounced sensory modulation differences will report significantly lower HRQoL scores than those with typical sensory profiles. By examining this link, the study aims to advance understanding of adult sensory diversity and inform person-centered strategies, underscoring the relevance of sensory neurodiversity in healthcare.

3. Material and methods

This cross-sectional quantitative study explored how sensory modulation patterns influence health-related quality of life (HRQoL) in adults. A total of 86 participants aged 23–54 were evenly divided into two groups. The ASP group (n = 43; 18 males, 25 females; mean age = 31.4) included adults with atypical sensory modulation profiles, as determined by scores on the Adolescent/Adult Sensory Profile (AASP). Participants were classified into this group if they had at least one quadrant score more than 1 standard deviation above or below the normative mean, consistent with atypical sensory modulation. The control group (n = 43; 14 males, 29 females; mean age = 34.1) consisted of individuals whose quadrant scores fell within the normative range (±1 SD) and who reported no sensory-related difficulties. Participants were recruited between June and September 2024. Inclusion criteria were age 18–60 and the ability to independently complete self-report questionnaires. Exclusion criteria included diagnosed neurological or psychiatric conditions and cognitive impairments that could affect data reliability. Sensory profiles were assessed using the AASP, which categorises sensory modulation tendencies into four

quadrants—low registration, sensory seeking, sensitivity, and avoidance—based on Dunn's Four-Quadrant Model (Brown & Dunn, 2002). Scores falling outside the normative range were classified as atypical. HRQoL was measured using the 36-Item Short Form Health Survey (SF-36), assessing eight domains and producing composite Physical and Mental Component Summary scores. Statistical analyses were performed using IBM SPSS Statistics 27.0. Data normality was assessed with the Kolmogorov–Smirnov test. Between-group differences were analysed using the Mann–Whitney U test, and Pearson's correlations were calculated to examine associations with age and gender. Statistical significance was set at $p \leq 0.05$. All procedures adhered to the General Data Protection Regulation (GDPR) and the principles of the Declaration of Helsinki. Participation was fully anonymous and voluntary, with informed electronic consent obtained. As the study involved only anonymous self-report questionnaires and no collection of identifiable or sensitive health information, formal ethical approval was not required under national research ethics guidelines.

4. Results

Results are presented in three parts: (1) internal consistency of the SF-36, (2) descriptive statistics, and (3) between-group comparisons. Internal consistency of the SF-36 subscales and total score was evaluated using Cronbach's alpha coefficients. As presented in Table 1, alpha values ranged from .792 to .860 across all subscales, indicating strong internal reliability within this sample.

Table 1: Internal consistency of SF-36 subscales and total score (Cronbach's alpha values)

	Cronbach's alpha
General health	0.849
Physical functioning	0.803
Emotional role limitations	0.832
Physical role limitations	0.840
Energy/Fatigue	0.805
Mental health	0.860
Social functioning	0.792
Pain	0.823
Total SF-36 score	0.842

Note: *α = Cronbach's alpha; higher values indicate stronger internal consistency.*

Descriptive statistics for all eight SF-36 subscales and the total score are presented in Table 2. Scores ranged from 0 to 100. Both groups reported the highest mean scores in Physical Role Limitations and the lowest in General Health. Standard deviations indicated moderate variability within each group.

Table 2: *Mean HRQoL scores and standard deviations for each SF-36 domain in typical vs. atypical sensory profile groups*

Subscale	Group	n	Mean	SD
General health	Group 1 (ASP)	43	46.10	8.50
	Group 2 (Control)	43	62.60	9.30
Physical functioning	Group 1 (ASP)	43	61.40	8.50
	Group 2 (Control)	43	69.90	8.50
Emotional role limitations	Group 1 (ASP)	43	55.90	38.50
	Group 2 (Control)	43	93.70	23.30
Physical role limitations	Group 1 (ASP)	43	70.30	36.70
	Group 2 (Control)	43	94.60	14.60
Energy/Fatigue	Group 1 (ASP)	43	34.90	9.30
	Group 2 (Control)	43	64.90	9.10
Mental health	Group 1 (ASP)	43	49.10	8.60
	Group 2 (Control)	43	72.30	5.30
Social functioning	Group 1 (ASP)	43	60.50	10.80
	Group 2 (Control)	43	86.80	7.80
Pain	Group 1 (ASP)	43	59.90	15.60
	Group 2 (Control)	43	83.90	13.00
Total SF-36 score	Group 1 (ASP)	43	54.80	6.20
	Group 2 (Control)	43	75.20	4.30

Note: *ASP = Atypical Sensory Processing; n = sample size.*

Mann–Whitney U tests showed statistically significant differences ($p < .001$) between groups on all SF-36 subscales (Table 3).

The ASP group reported consistently lower HRQoL, especially in Energy/Fatigue, Mental Health, Social Functioning, and Pain.

Table 3: Mann–Whitney U Test Results Comparing HRQoL Scores Across SF-36 Domains Between Groups

Subscale	Group	n	Mean Rank	*p*
General health	Group 1 (ASP)	43	22.50	< .001
	Group 2 (Control)	43	52.50	
Physical functioning	Group 1 (ASP)	43	28.10	< .001
	Group 2 (Control)	43	46.90	
Emotional role limitations	Group 1 (ASP)	43	27.70	< .001
	Group 2 (Control)	43	47.30	
Physical role limitations	Group 1 (ASP)	43	30.30	< .001
	Group 2 (Control)	43	44.70	
Energy/Fatigue	Group 1 (ASP)	43	19.80	< .001
	Group 2 (Control)	43	55.20	
Mental health	Group 1 (ASP)	43	19.20	< .001
	Group 2 (Control)	43	55.80	
Social functioning	Group 1 (ASP)	43	20.10	< .001
	Group 2 (Control)	43	55.00	
Pain	Group 1 (ASP)	43	23.30	< .001
	Group 2 (Control)	43	51.70	
Total SF-36 score	Group 1 (ASP)	43	19.00	< .001
	Group 2 (Control)	43	56.00	

Note: *ASP = Atypical Sensory Processing; n = sample size; p values are two-tailed.*

No significant correlations were found between HRQoL outcomes (total or subscale scores) and demographic variables such as age or gender. These findings indicate that the observed group differences in quality-of-life scores are primarily associated with sensory modulation patterns rather than demographic characteristics.

5. Discussion

5.1 Interpretation of findings

This study confirms that adults with atypical sensory modulation profiles report significantly lower HRQoL across all SF-36 domains. These results align with previous findings linking sensory modulation differences to reduced physical, emotional, and social well-being (Davies et al., 2022; Salatino & Schmidt, 2023). The most substantial group differences emerged in domains related to fatigue, mental health, pain, and social participation, consistent with evidence on how mismatches between environmental demands and individual sensory patterns contribute to emotional distress and reduced coping capacity (Bar-Shalita et al., 2019; Neal et al., 2023).

Participants with atypical sensory profiles often reported experiences such as overstimulation in social situations, persistent low energy, or difficulty filtering environmental stimuli. These experiences may help explain the reduced HRQoL observed in domains such as fatigue, pain, and mental health.

Importantly, these findings support emerging views that sensory modulation differences reflect neurodiversity rather than dysfunction. Lower HRQoL may arise not from sensory traits themselves but from environments that fail to accommodate them (Bundy et al., 2022; Salatino & Schmidt, 2023). These findings align with research showing that both hyper- and hypo-responsiveness can contribute to mental health vulnerabilities. While hyper-responsiveness often relates to heightened anxiety and sensory overload, hypo-responsiveness has been associated with diminished emotional awareness, alexithymia, and depressive symptoms. A recent meta-analysis identified atypical sensory profiles as significant predictors of psychiatric risk, underscoring the importance of recognising sensory modulation patterns in psychological assessment (Engel-Yeger & Dunn, 2011; van den Boogert et al., 2022).

5.2 Neurobiological underpinnings

Neuroimaging studies have shown atypical activation in sensory and limbic areas, including reduced sensory gating and heightened emotional reactivity (Gracely et al., 2002; Inagaki et al., 2024). Dysregulation in systems such as the amygdala and

reticular activating system has also been associated with sensory hypersensitivity and fatigue (Sallee & March, 2001; Lane et al., 2002), highlighting the neurobiological relevance of sensory modulation patterns.

5.3 Interoception, exteroception, and broader sensory context

Although this study focused on exteroceptive processing, interoceptive disruption may contribute to reduced emotional awareness, alexithymia, and chronic fatigue in adults with sensory hypo-responsiveness (Seth et al., 2011; van den Boogert et al., 2022). Conversely, heightened interoception may amplify anxiety and pain in hyper-responsive individuals (Engel-Yeger & Dunn, 2011). Dunn's Four-Quadrant Model clarifies these patterns by linking behavioural responses (active/passive) to neurological thresholds (high/low), offering a framework to understand the distinct pathways through which sensory profiles influence well-being (Dunn, 1997; Brown & Dunn, 2002).

5.4 Clinical implications

Incorporating sensory modulation assessments into adult care—via tools like the AASP and SF-36—can support early recognition of sensory-related challenges. Tailored interventions (e.g., occupational therapy, mindfulness) may improve both sensory regulation and emotional health. Increased awareness among clinicians may also prevent misdiagnosis and enable neurodiversity-affirming support strategies (Schaaf & Mailloux, 2015; Neal et al., 2023).

5.5 Limitations

Limitations include the single-national sample, reliance on self-report, and a cross-sectional design. Future studies should adopt longitudinal and mixed-method approaches, integrate physiological data, and include more diverse populations to deepen understanding of how sensory modulation interacts with broader health determinants.

5.6 Future directions

Future studies should adopt longitudinal designs to examine how sensory modulation profiles evolve over time and interact with psychosocial and neurobiological factors.

The inclusion of objective physiological measures (e.g., EEG, heart rate variability) alongside self-report tools may yield deeper insight into sensory functioning. Interoception should also be explored, particularly its relationship with emotional regulation and fatigue.

Dunn's Four-Quadrant Model could serve as a framework for distinguishing risk profiles and guiding personalised interventions.

Future research should ensure clearer criteria for identifying atypical patterns and include culturally diverse samples to enhance external validity and promote neurodiversity-affirming approaches in adult care.

6. Conclusion

This study demonstrates that adults with atypical sensory modulation profiles—characterised by low registration, sensitivity, avoidance, or seeking—report significantly lower health-related quality of life (HRQoL) across all SF-36 domains. These consistent group differences across physical, emotional, social, and pain-related aspects support the primary hypothesis and highlight the pervasive impact of sensory diversity on adult well-being.

Crucially, these associations were independent of age and gender, underscoring that sensory modulation contributes uniquely to quality-of-life outcomes.

This reinforces the importance of shifting from deficit-based labels toward a neurodiversity-affirming perspective that values individual sensory patterns and prioritises environmental adaptation over pathologisation.

These findings are consistent with emerging neurobiological research indicating altered sensory-limbic connectivity, reduced gating, and heightened arousal and fatigue in individuals with atypical modulation.

When combined with evidence on interoception's role in emotion regulation and fatigue, this supports a sensory–neurofunctional framework for understanding adult health.

From a clinical standpoint, our results support the combined use of the Adolescent/Adult Sensory Profile and HRQoL instruments in adult assessments. They advocate for tailored, sensory-informed interventions—such as occupational therapy, mindfulness practices, and cognitive-behavioral strategies—that target both sensory and emotional domains.

Greater awareness among clinicians can reduce misdiagnosis and promote more accurate, person-centered care.

Limitations include the cross-sectional design, reliance on self-report, and a single-national sample, which may affect generalisability. Although validated tools were used, the study did not capture the full range of interoceptive or multisensory experiences.

Future research should adopt longitudinal and mixed-method approaches, incorporate physiological indicators (e.g., EEG, heart rate variability), and include culturally diverse populations.

This would enhance the ecological validity of findings and support more inclusive intervention development.

In summary, this study contributes to the growing understanding of sensory modulation as a critical determinant of adult quality of life.

Integrating sensory awareness into rehabilitation and healthcare can foster more equitable, holistic, and individualised models of support.

Conflict of interests

Authors declare no conflict of interests.

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