SLEEP AND HYPERAROUSAL IN AUTISM: A CALL FOR FEASIBLE AND ACCURATE MEASUREMENT

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Introduction

- Sleep problems and symptoms of psychological distress are common in autistic individuals.[1,2]
- Sleep problems and psychological distress are bi-directionally related, such that each exacerbates the other.
- Despite emerging evidence linking autonomic hyperarousal as a key driver for these co-occurring conditions[3], there are no standardised protocols for monitoring autonomic nervous system (ANS) activity in real-world settings.

Objective

- Drawing on recent work implicating common neurocircuitry underlying chronic hyperarousal and sleep disruption in autism, namely locus-coeruleus–norepinephrine (LC-NE) and thalamocortical network alterations, we explore the current state of sleep and ANS arousal monitoring in autistic individuals.

Results

- Current gold standard ANS arousal protocols are limited in their use in autistic individuals, due to their focus on parasympathetic indices (e.g., HRV-based) and underutilisation of sympathetic markers (e.g., skin blood flow; Table 1).
- PSG remains the gold standard for sleep assessment. However, this approach is not feasible for many autistic individuals and high costs prohibit treatment monitoring in clinical contexts.
- A single overnight recording from a wrist-, ear- or ankle-worn optical sensor yields five clinically meaningful metrics that together characterise both sleep quality and its underlying autonomic context (see Fig 1).

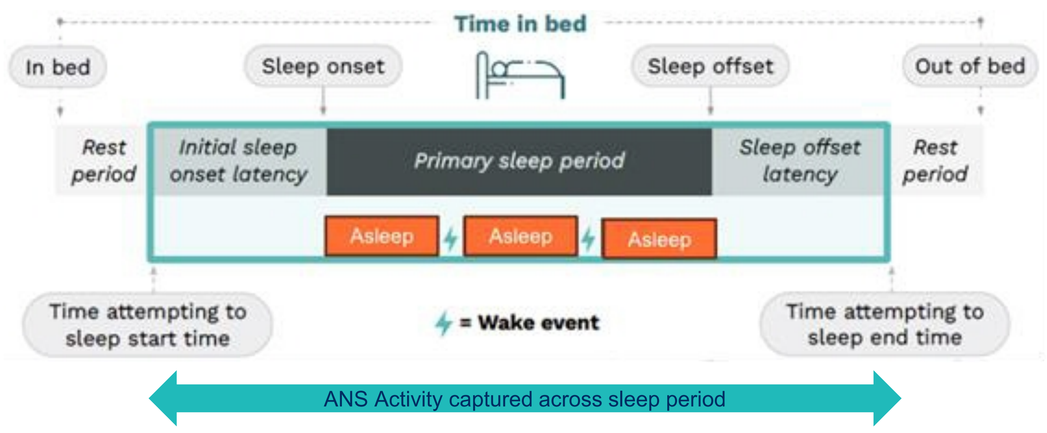

Figure 1. Key metrics that can be derived from a wearable optical sensor. Source: https://datacc.dimesociety.org/core-measures-sleep/

Table 1. ANS and Sleep assessment protocols

Sensing technology	Measuring Principle	Metrics
Electrocardiography (ECG)	Captures cardiac depolarisation patterns, reflecting cardiac autonomic modulation.	Heart Rate (HR); HR Variability (HRV) Root Mean Square of Successive Differences (RMSSD; beat-to-beat interval variability)
Photoplethysmography (PPG)	Detects pulsatile blood volume variations through light absorption changes	Pulse rate, pulse amplitude, PPG-derived HRV metrics, PPG-derived sympathetic arousal
Electrodermal Activity (EDA)	EDA provides direct assessment of sympathetic nervous system activity	Skin conductance level (SCL), skin conductance responses (SCR), response amplitude, frequency, recovery time
Skin temperature	Monitors temperature changes	Mean peripheral temperature, temperature variability, vasoconstriction patterns
Polysomnography (PSG)	Electrophysiological and physiological signals (neural, muscular, respiratory)	Sleep architecture (sleep timing; sleep onset latency [SoL], total sleep time [TST], wake after sleep onset [WASO], sleep efficiency [SE%], respiratory metrics, cardiovascular metrics (HR, HRV)
Actigraphy	Accelerometry records physical movement	Sleep timing, SoL, TST, WASO, SE%

Table 2. Clinical considerations for ANS and Sleep Monitoring

Clinical Use Case	Clinical Question	Recommended Modality	Key Metrics	Autism-Specific Considerations
Pre-assessment baseline	What is this client's baseline arousal and sleep state?	Nocturnal PPG (sympathetic arousal + HRV) + actigraphy	RMSSD, SE%, SoL	● Captures real-world patterns ● Avoids recall bias ● Sensory-friendly wearable supports compliance
Stress trigger identification	When and why is this client's autonomic system dysregulated?	Longitudinal nocturnal PPG + structured symptom diary	Nightly HRV variability, sleep timing	● Identifies hidden patterns clients may not be able to self-report ● Cross-referenced with daily events
Daytime stress regulation	Can this client up-regulate vagal tone during or between sessions?	HRV biofeedback (ECG or PPG)	Real-time HRV	● Evidence-based for anxiety reduction ● Sensitive to posture and movement ● Accessible and non-invasive (PPG)
Therapy progress monitoring	Is my intervention shifting autonomic balance over time?	Pre/post nocturnal PPG + validated psychometrics (e.g., WHO-5, ABAS-3)	Change in HRV Change in sleep metrics	● Avoids reliance on self-report ● Enables multi-provider communication ● Heterogeneous biometric response expected across individuals

Conclusions

- Pending validation, nocturnal photoplethysmography-derived sympathetic arousal combined with HRV may provide accessible proxy markers of LC-NE–mediated hyperarousal in autistic individuals that actigraphy alone cannot detect.
- Current wearable protocols predominantly capture parasympathetic indices and overlook sympathetic hyperarousal (the autonomic dimension most closely tied to emotional dysregulation and sleep disturbance in autism) leaving clinicians managing consequences rather than mechanisms.
- Feasibility studies co-designed with autistic individuals and validated against parasympathetic, sympathetic, and central LC-NE indices (e.g., pupillometry, PSG arousal profiling) are the immediate next step toward clinical translation

References: 1. Estes, A., et al. (2024). Sleep and Autism: Current Research, Clinical Assessment, and Treatment Strategies. Focus, 22(2), 162–169. 2. Recio P, et al. (2024). Autistic Sensory Traits and Psychological Distress: Mediating Role of Worry and Intolerance of Uncertainty. Brain Sci. 2024; 14(11):1088. 3. Bast, N., et al. (2025). Locus coeruleus tonic upregulation increases selectivity to inconspicuous auditory information in autistic compared to non-autistic individuals: A combined pupillometry and electroencephalography study. Mol Autism, 16(1), 41.