Does head trauma explain vestibular abnormalities in adults with substance use disorders?

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Introduction

Background: Substance use disorders (SUDs) affect more than 17% of people aged 12 years and older in the United States.[1-3] Beyond their well-documented neurological, hepatic, and cardiovascular consequences, SUDs may also impair vestibular function, resulting in oculomotor abnormalities, dizziness, and imbalance.[4-6] Despite this, vestibular dysfunction remains understudied in people with SUD, with prior studies limited by small samples, narrow vestibular test batteries, and a lack of control groups.[4,6] Head trauma and traumatic brain injury (TBI) are also disproportionately common among adults with SUD,[5,7,8] and head trauma is an established cause of vestibular dysfunction.[9,10] In our preliminary study (n = 80), several central vestibular and balance abnormalities remained more prevalent among adults with SUD after adjustment for head-trauma history.[5]

Research Question: Is SUD status or head-trauma history more strongly associated with subjective symptoms and objective vestibular abnormalities?

Study Goals:

1. Compare the prevalence of head-trauma, subjective vestibular symptoms, and objective vestibular abnormalities between adults with and without SUD.
2. Determine whether SUD status or head-trauma history is more strongly associated with subjective symptoms and objective vestibular abnormalities when both factors are considered together.

Hypotheses:

1. Adults with SUD would have a higher prevalence of head-trauma, subjective vestibular symptoms, and objective vestibular abnormalities than adults without SUD.
2. SUD status and head-trauma history would each be independently associated with subjective symptoms and objective vestibular abnormalities, with stronger associations for SUD status.

Methodology

Participants:

- **Study design:** Multisite prospective cross-sectional study from 2023-2025 as part of a larger study to examine the association between SUDs and hearing, vestibular, and balance outcomes.
- **Study sites:** Lincoln, Nebraska; Chicago, Illinois; and El Paso, Texas, using standardized equipment and protocols.
- **Study population:** 281 adults aged 18-59 years, including 179 adults with a history of SUD and 102 non-SUD controls.
- **Demographics:** Mean age: 39 years, SD: 11.76 range: 18-59 years; 79% non-white, 48% Female)
- **Testing conditions:** Participants provided informed consent, reported no substance use within 24 hours of testing, and passed a brief capacity screening to ensure they could complete the study procedures.
- **Exclusion criteria:** Adults who self-reported a prior diagnosis of hearing, vestibular, or seizure disorder; use of a hearing-device; or showed abnormal tympanometry suggestive of conductive dysfunction on day of testing.

Measures: A self-administered, tablet–based survey collected demographics and general health information, otologic and substance-use histories, head-trauma history, and symptoms.

- **Subjective measures:** weekly dizziness/imbalance, fear of falling, and falls.
- **Objective vestibular testing:** Bedside vestibular examination (ocular range of motion, smooth pursuit, near-point convergence, cross-cover testing, head-thrust testing, head-shake nystagmus testing, and dynamic visual acuity), Videonystagmography, oculomotor testing, lateral semicircular canal video head impulse testing, cervical and ocular vestibular evoked myogenic potentials, and static standing balance testing.

Study Variables and Outcomes:

- **Independent Variables:** SUD status and self-reported head-trauma history
- **Goal 1: Compare prevalence between adults with and without SUD.** Outcomes included self-reported head-trauma/TBI history, weekly dizziness/imbalance, fear of falling, falls, and at least one objective vestibular abnormality.
- **Goal 2: Determine whether SUD status or head-trauma history has the stronger association.** Both factors were considered together for weekly dizziness/imbalance and any objective vestibular abnormality, defined as at least one objective vestibular abnormality.

Statistical Analysis: For Goal 1, logistic regression compared head-trauma prevalence and vestibular outcomes between adults with and without SUD, adjusting for study site. Models adjusted for study site to account for site-related differences in baseline outcome rates and the unequal distribution of SUD and non-SUD participants across sites. For Goal 2, separate models for weekly dizziness/imbalance and any objective vestibular abnormality included SUD status, head-trauma history, and test site. Wald contrasts compared the SUD and head-trauma log-odds coefficients to test whether their adjusted associations differed in strength. Percentages reflect available responses or test results, and $p < 0.05$ significance was used.

Results

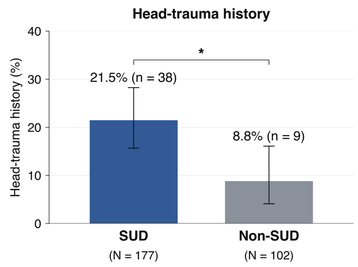


Figure 1. Self-reported head-trauma history. Adults with SUD had greater odds of reporting head trauma than adults without SUD after adjustment for study site (aOR, 2.91; 95% CI, 1.33–6.38; p = .008). Among 279 participants with available head-trauma data, 139 had SUD without head trauma, 38 had both SUD and head trauma, 93 had neither, and 9 had head trauma without SUD.

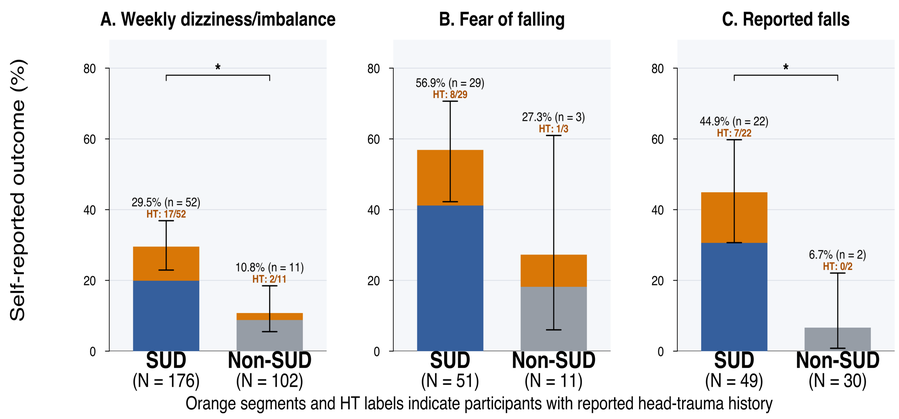


Figure 2. Self-reported vestibular and falls-related outcomes. After adjustment for study site, SUD was associated with greater odds of **A.** weekly dizziness/imbalance (aOR, 3.76; 95% CI, 1.84–7.71; p < .001) and **C.** reported falls (aOR, 11.35; 95% CI, 2.32–55.66; p = .003). **B.** The fear-of-falling comparison was not statistically significant (aOR, 3.26; 95% CI, 0.75–14.08; p = .114).

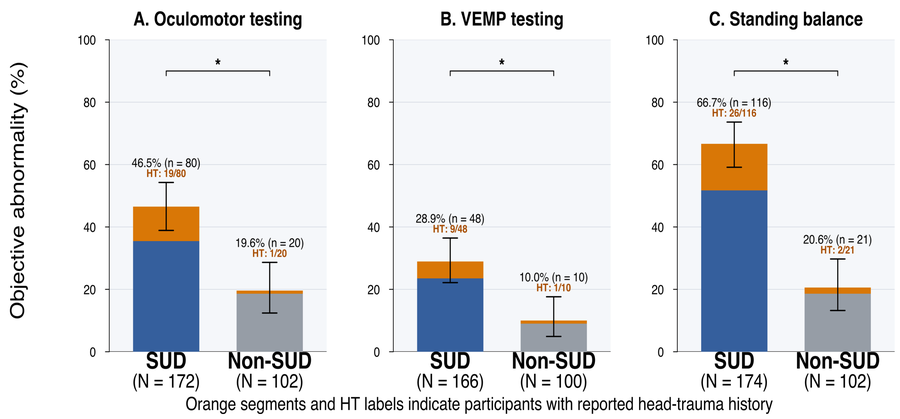


Figure 3. Objective vestibular-testing abnormalities. After adjustment for study site, adults with SUD had greater odds of **A.** an oculomotor abnormality (aOR, 4.45; 95% CI, 2.44–8.11), **B.** at least one absent cVEMP or oVEMP response (aOR, 4.23; 95% CI, 1.98–9.02), and **C.** failure of at least one standing-balance condition (aOR, 9.23; 95% CI, 4.95–17.20; all p < .001).

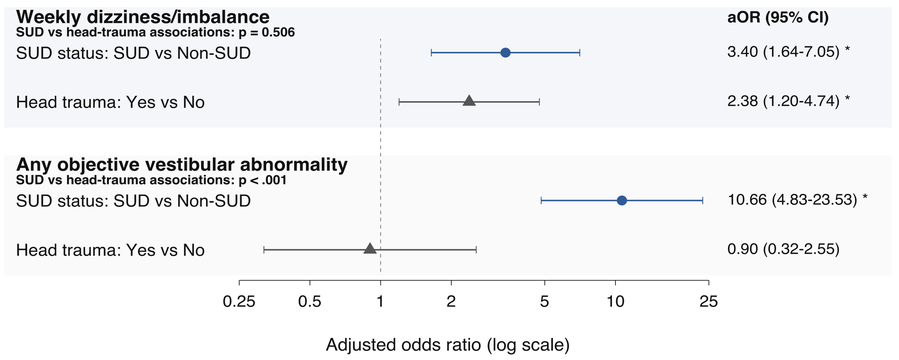


Figure 4. Independent associations of SUD status and head-trauma history with vestibular outcomes. Separate models for each outcome included SUD status, head-trauma history, and study site. SUD versus non-SUD comparisons included participants with and without head-trauma history. Head-trauma versus no-head-trauma comparisons included participants with and without SUD. Each association was adjusted for the other factor and study site. For weekly dizziness/imbalance (N = 278), both SUD status (aOR, 3.40; 95% CI, 1.64–7.05; p < .001) and head-trauma history (aOR, 2.38; 95% CI, 1.20–4.74; p = .013) were independently associated with greater odds of the outcome. Their adjusted associations did not differ significantly in strength (p = .506). For any objective vestibular abnormality (N = 275), SUD status was independently associated with greater odds (aOR, 10.66; 95% CI, 4.83–23.53; p < .001), whereas head-trauma history was not (aOR, 0.90; 95% CI, 0.32–2.55; p = .846). The association with objective abnormalities was significantly stronger for SUD status than for head-trauma history (p < .001). Among participants with available objective outcome data, abnormalities were identified in 164 of 174 adults with SUD (94.3%) and 63 of 101 adults without SUD (62.4%).

Discussion

Consistency with Existing Literature:

- The greater prevalence of head trauma in adults with SUD aligns with prior reports of frequent TBI in substance-use populations.[7,8] The association between SUD and objective vestibular abnormalities after accounting for head trauma that was seen in this study is consistent with our preliminary findings.[5]

Key Findings and Implications:

- **Respondents with SUD reported more dizziness/imbalance and falls.** These findings support assessing symptoms and fall history alongside objective testing. The fear-of-falling comparison remained inconclusive.
- **Both SUD and head-trauma history were independently associated with weekly dizziness/imbalance.** Our hypothesis of a stronger SUD association with subjective symptoms was not supported; therefore, we reject this component of our hypothesis. Both histories warrant consideration when evaluating self-reported vestibular symptoms.
- **SUD had a stronger adjusted association with objective vestibular abnormalities than head-trauma history.** Our hypothesis of a stronger SUD association with objective abnormalities was supported; therefore, we accept this component of our hypothesis. This suggests that reported head trauma alone does not explain the association observed with SUD.

Limitations:

- Statistical analysis: The present analyses estimate associations and cannot establish causation.
- Recall bias: Head-trauma history was self-reported and was not independently verified, potentially leading to misclassification.
- Incomplete data: Missing questionnaire and test results may affect estimates. All SUD respondents to the falls question reported weekly dizziness/imbalance, whereas some non-SUD respondents did not. This difference may bias the falls comparison.

Conclusions

Conclusions:

- **SUD history warrants consideration alongside head-trauma history during vestibular evaluation.** Otolaryngologists should assess dizziness, imbalance, and fall history in adults with SUD, recognizing that vestibular abnormalities may occur even without reported head trauma.
- **Consider objective vestibular testing in adults with SUD who report active dizziness or imbalance, particularly when symptoms coexist with a history of head trauma.** Persistent symptoms, falls, or abnormal bedside findings can guide the need for further testing and selection of an appropriate test battery.
- **Use clinically relevant findings to guide care that addresses balance, mobility, and safety.** Identified vestibular or balance deficits can inform targeted management, including vestibular rehabilitation and individualized fall-prevention strategies when appropriate.

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Figure notes: Percentages reflect available questionnaire responses or test results. In Figures 1–3, *n* indicates participants with the outcome and *N* indicates participants with available data; error bars show exact binomial 95% confidence intervals. Asterisks indicate p < .05 for site-adjusted SUD versus non-SUD comparisons. In Figure 4, points and horizontal bars show adjusted odds ratios and Wald 95% confidence intervals, the dashed line marks an aOR of 1, and asterisks indicate p < .05. All statistical tests were two-sided.

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