Characterizing Persistent Neurotological Deficits Following Blast Exposure

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INTRODUCTION

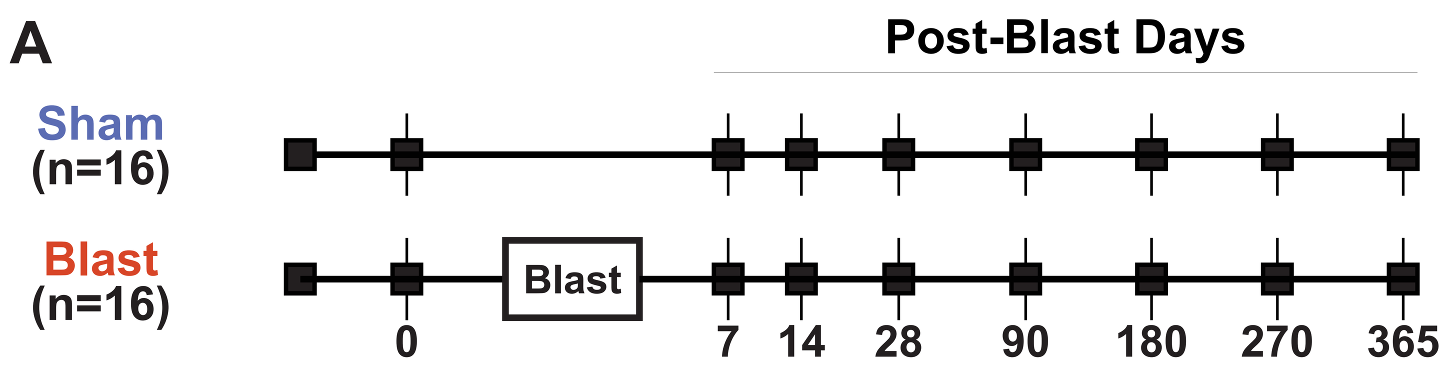
Blast injury is a common cause of persistent hearing and balance disorders in military personnel and civilians. However, the long-term effects of blast exposure on auditory and vestibular function remain poorly defined. Using a reproducible oxy-acetylene shock tube, we characterized blast-induced changes in auditory brainstem responses (ABR), cervical vestibular evoked myogenic potentials (cVEMP), and balance beam performance in male and female Brown Norway rats for up to one year post-injury.

METHODS

1

Model: Male and female Brown Norway rats (14 to 18 weeks).
Blast Protocol: 10 – 12 psi
Primary Outcomes: Balance Beam (n=3-4), ABRs and cVEMPs (n=8)

A



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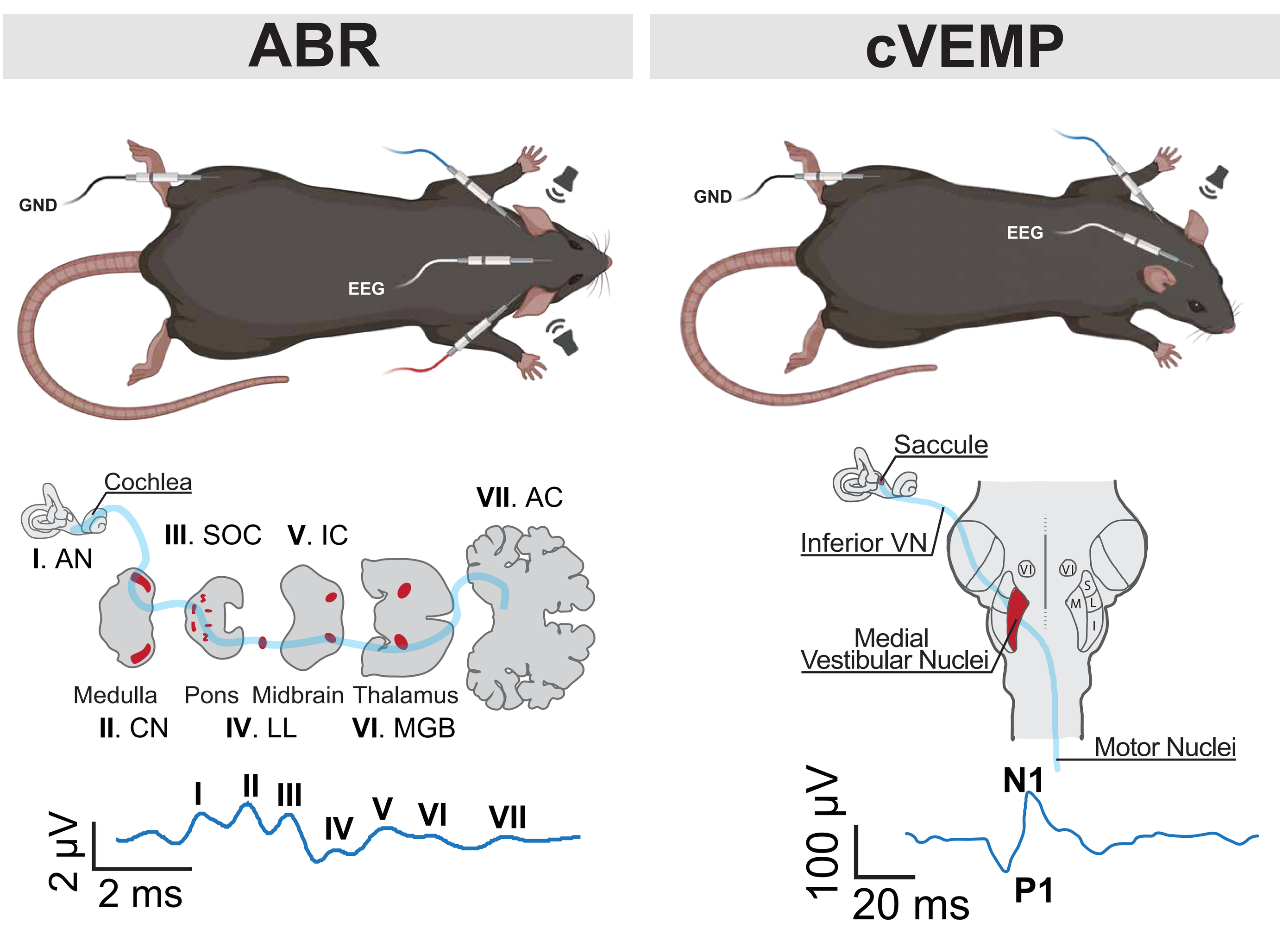

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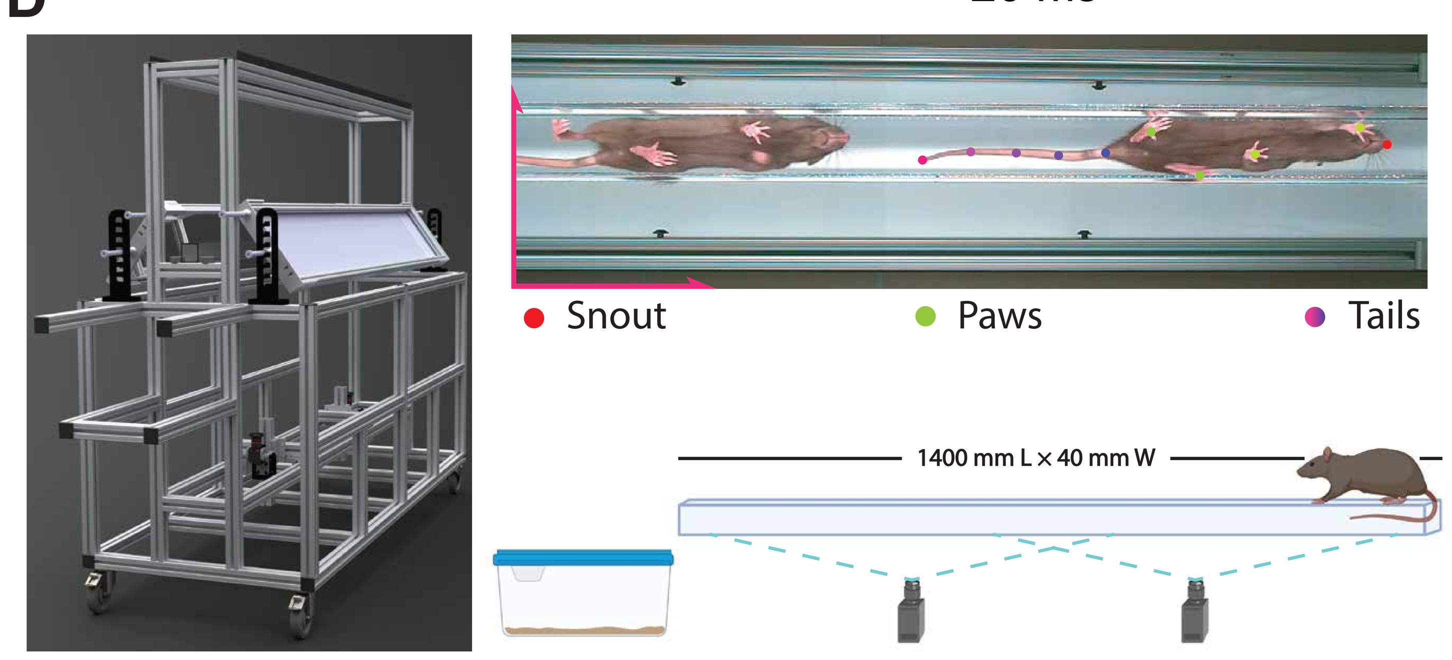

CONCLUSION

Blast exposure produced persistent auditory and vestibular dysfunction characterized by long-term elevations in ABR and cVEMP thresholds and reductions in suprathreshold response amplitudes that remained detectable up to one year post-injury. In contrast, balance beam assessments revealed only modest and transient changes in locomotor performance, despite evidence of altered gait patterns during the early post-blast period. These findings suggest that sensory deficits persist long after blast exposure and may precede or exceed measurable impairments in gross motor function.

RESULTS

2 Post-Blast Longitudinal Auditory Brainstem Response Changes

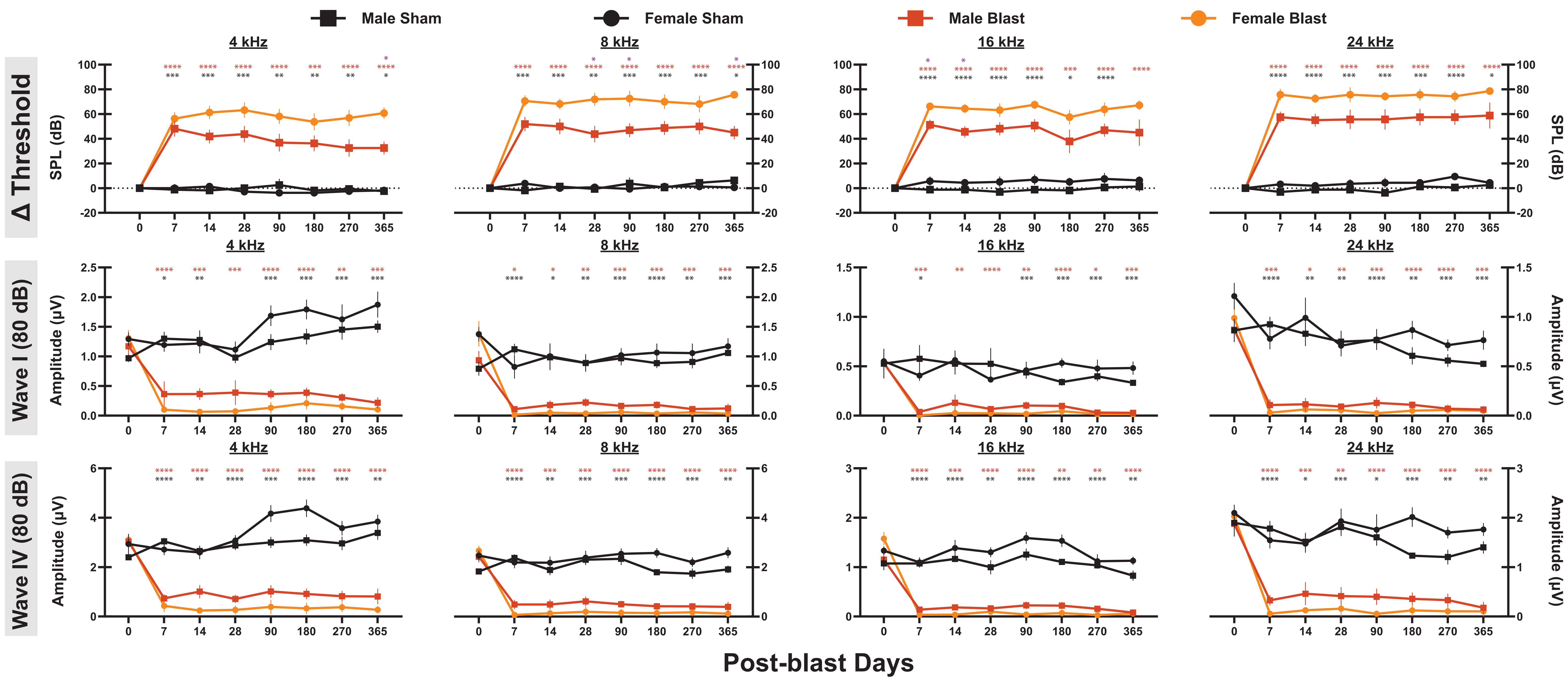

Figure 2. Longitudinal auditory brainstem response (ABR) thresholds and wave amplitudes following blast exposure. ABR threshold shifts (top row), wave I amplitudes at 80 dB SPL (middle row), and wave IV amplitudes at 80 dB SPL (bottom row) evoked by 4, 8, 16, and 24 kHz pure-tone stimuli were measured in sham and blast rats from baseline (D0) through 365 days post-blast (D365). Data are presented as mean ± SEM (n = 8 per group). Blast exposure produced persistent threshold elevations and sustained reductions in wave I and wave IV amplitudes relative to sham controls, indicating long-term auditory dysfunction affecting both peripheral and central auditory pathways. Black asterisks indicate comparisons between Male Sham and Male Blast groups; red asterisks indicate comparisons between Female Sham and Female Blast groups; purple asterisks indicate comparisons between Male Blast and Female Blast groups. Statistical analyses were performed using a mixed-effects model (REML) with Holm–Šídák's multiple-comparisons test. Significance levels are denoted as *p < 0.05, **p < 0.01, ***p < 0.001, and ****p < 0.0001.

3 Post-Blast Longitudinal Cervical Vestibular Evoked Myogenic Potential Changes

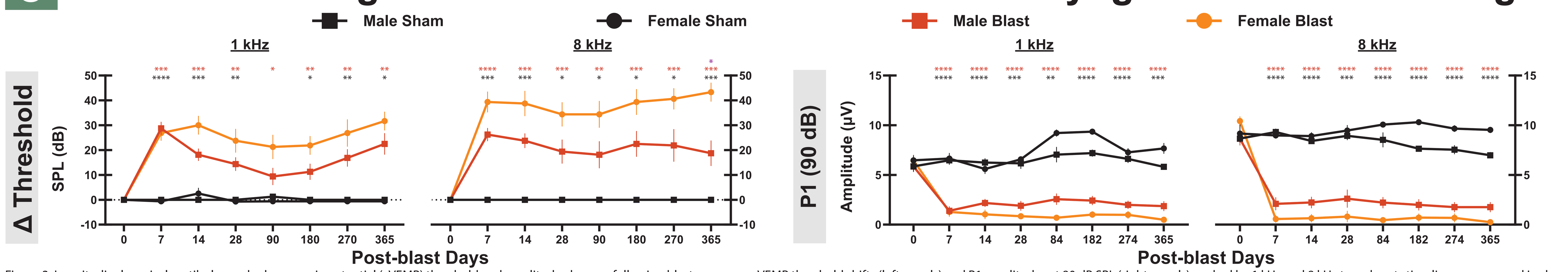

Figure 3. Longitudinal cervical vestibular evoked myogenic potential (cVEMP) threshold and amplitude changes following blast exposure. cVEMP threshold shifts (left panels) and P1 amplitudes at 80 dB SPL (right panels) evoked by 1 kHz and 8 kHz tone-burst stimuli were measured in sham and blast rats from baseline (D0) through 365 days post-blast (D365). Thresholds are presented as shifts from baseline values (Δ Threshold, dB). Data are presented as mean ± SEM (n = 8 per group). Blast exposure produced persistent elevations in cVEMP thresholds and sustained reductions in P1 amplitudes relative to sham controls, indicating long-term vestibular dysfunction. Male blast animals exhibited partial recovery of cVEMP function over time, whereas female blast animals demonstrated larger and more persistent deficits, particularly at 8 kHz stimulation. Black asterisks indicate comparisons between Male Sham and Male Blast groups; red asterisks indicate comparisons between Female Sham and Female Blast groups; purple asterisks indicate comparisons between Male Blast and Female Blast groups. Statistical analyses were performed using a mixed-effects model with Holm–Šídák's multiple-comparisons test. Significance levels are denoted as *p < 0.05, **p < 0.01, ***p < 0.001, and ****p < 0.0001.

4 Longitudinal Balance Beam Performance and Gait Adaptations Following Blast Exposure

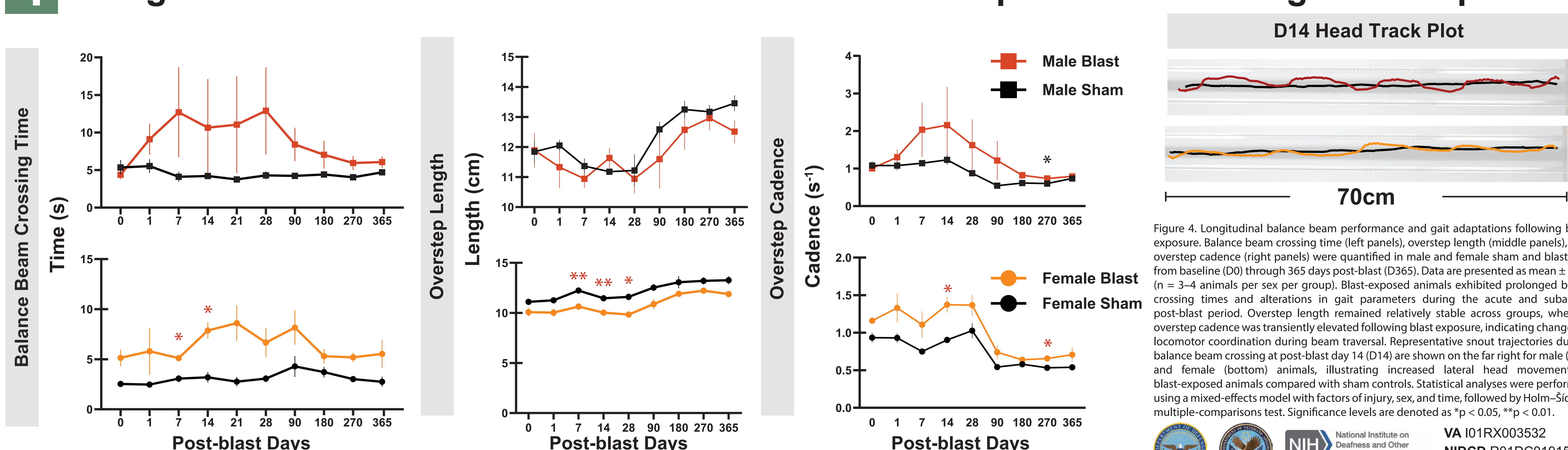

Figure 4. Longitudinal balance beam performance and gait adaptations following blast exposure. Balance beam crossing time (left panels), overstep length (middle panels), and overstep cadence (right panels) were quantified in male and female sham and blast rats from baseline (D0) through 365 days post-blast (D365). Data are presented as mean ± SEM (n = 3–4 animals per sex per group). Blast-exposed animals exhibited prolonged beam crossing times and alterations in gait parameters during the acute and subacute post-blast period. Overstep length remained relatively stable across groups, whereas overstep cadence was transiently elevated following blast exposure, indicating changes in locomotor coordination during beam traversal. Representative snout trajectories during balance beam crossing at post-blast day 14 (D14) are shown on the far right for male (top) and female (bottom) animals, illustrating increased lateral head movement in blast-exposed animals compared with sham controls. Statistical analyses were performed using a mixed-effects model with factors of injury, sex, and time, followed by Holm–Šídák's multiple-comparisons test. Significance levels are denoted as *p < 0.05, **p < 0.01.

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VA I01RX003532
NIDCD R01DC019158
DOD HT9425-23-1-0709