



THE DEVELOPMENT OF ABERRANT BLADDER REFLEXES THAT DRIVE HIND LIMB LOCOMOTOR ACTIVITY FOLLOWING COMPLETE SUPRASACRAL SPINAL CORD INJURY



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Introduction

Many rats with chronic suprasacral spinal cord injury (SCI) demonstrate hind limb locomotor activity (HLLA) in response to external crede or high pressure contractions during cystometry. We propose that this aberrant, pressure-driven bladder reflex pathway may be harnessed to facilitate walking in SCI patients. As a first step in exploring this possibility, we examined the relationship between intravesical pressure (IVP) and HLLA in chronic suprasacral SCI rats.

Material and Methods

- Female rats (4 weeks post-SCI at T9-10, n = 16) were anesthetized with isoflurane and fitted with transvesical catheters and right quadriceps EMG electrodes to monitor bladder and hind limb locomotor activities, respectively.
- Animals were mounted in Ballman restraint cages to which they had been previously acclimated.
- The catheter was connected to a pressure transducer, an infusion pump, and a saline-filled reservoir mounted on a metered vertical pole (pressure clamp).
- After 30 minutes of recovery from anesthesia, the bladder was filled at 0.1 ml/min with saline to verify bladder-to-bladder reflex activity for 30 minutes. IVP was then increased in an interrupted stepwise fashion from 0–120 cmH₂O at 10 cmH₂O increments. Each step consisted of five minutes: three minutes at the new pressure followed by two minutes at 0 cmH₂O. IVP and the number of HLLA events (as defined by rhythmic EMG discharges of 3–10 cycles/event) were recorded for each pressure step. This process was repeated for two more trials for each rat to assess the durability of the reflex.
- Data were analyzed using ANOVA with repeated measures both within and across pressure escalation trials. P < 0.05 was considered significant.

Results

ANOVA revealed that locomotor events increased with increasing intravesical pressure and decreased with the number of escalation trials (P < 0.0001 for both effects). The increase in the number of locomotor events with increasing intravesical pressure appeared to plateau at ~50-60 cmH₂O (P < 0.05 for all). The average of the maximal number of locomotor events for each animal decreased steadily from ~3.0, 2.5 and 1.75 over 3 trials.

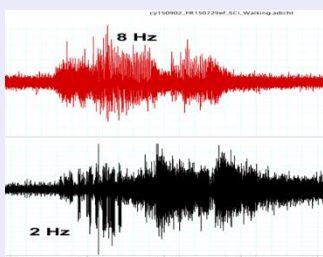
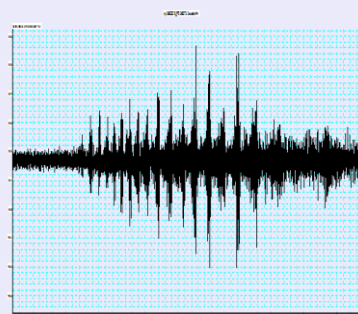
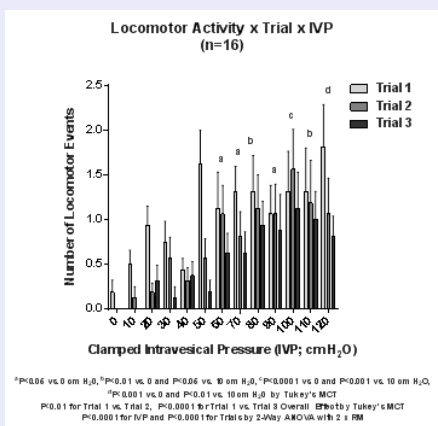


Illustration of the differences in timing and nature of the phasic motor generators that result in voiding external urethral sphincter EMG activity (top, red trace, 8-10 Hz) and quadriceps locomotor activity (bottom, black trace, 2 Hz).



Expanded Quadriceps EMG trace during a locomotor event in a rat during a bladder contraction in the control period.



Bladder Afferents in Series and Parallel

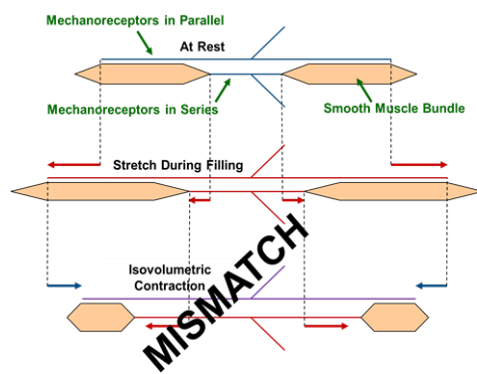


Illustration of afferent activity associated with rest, stretch and contraction. Filling results in stretch of both afferents in series and parallel, while contraction results in a reduction of tension in afferents in parallel but an increase in those in series, providing a mismatch signal that drives the bladder-to-hind limb locomotor aberrant reflex in chronic SCI rats.

Conclusions

There is a positive relationship between IVP and HLLA that suggests the emergence of an aberrant bladder-to-hind limb locomotor reflex pathway following SCI that is likely tied to contractile activity rather than baseline pressure. This suggests a reflex driven by a system of afferents in series and parallel. It may be possible to harness this reflex pathway independently of the state of the bladder to facilitate walking in SCI patients.