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Neuropathic Pain Features and Temporal Summation as Predictors of Exercise-Specific Movement-Evoked Pain in Knee Osteoarthritis: Preliminary Findings from the ROADMAP Pilot Study

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Movement-evoked pain (MEP) limits exercise in knee osteoarthritis (OA). Standard questionnaires (PDQ, WOMAC, GCPS) quantify symptom burden but poorly predict which tasks provoke pain. Integrating these measures with quantitative sensory testing (QST), particularly temporal summation (TS), may identify modalities more likely to elicit MEP. Forty-five adults with symptomatic OA were enrolled in a cross-sectional pilot; 19 complete cases formed the primary analytic sample. Participants completed questionnaires, QST at the hand and patella, and functional testing (6MWT, functional carry, leg press, chair-stand, arm-curl, hand grip, compound lift). TS was calculated as the difference in reported pain between a single punctate stimulus and series of 10 stimuli at 1-Hz (300g von Frey). Complete-case analyses were supplemented with modality-specific models (6MWT $n=25$; carry $n=37$; leg press $n=36$). Statistical methods included QST tercile contrasts, Spearman correlations, and HC3-robust regressions with QST and PDQ plus the relevant performance covariate. Multiple-imputation models ($m=20$) evaluated robustness. Higher QST was associated with greater RPE during carry (median 7.0 vs 4.0, $p=0.031$) and 6MWT (9.0 vs 7.0, $p=0.008$). PDQ correlated with carry pain ($\rho=0.46$, $p=0.047$) and trended with leg-press pain ($\rho=0.45$, $p=0.053$). In regressions, carry RPE was driven by time ($p=0.002$), with QST remaining positive ($R^2=0.37$). Modality-specific patterns were consistent. In multiple-imputation models, leg-press pain was predicted by QST ($\beta=+0.24$, $p=0.012$) and load ($p<0.001$), while WOMAC and GCPS were weak predictors. Integrating QST with neuropathic features identifies modality-specific vulnerability to MEP, providing a phenotype-based rationale to steer patients toward better-tolerated exercises, and guide individualized exercise prescription in OA.

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Virtual Reality Induced Awe in Chronic Low Back Pain: A Mixed-Methods Pilot Study

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Virtual reality (VR) applications are supported in managing acute pain, but effectiveness in chronic pain is limited. Current models emphasize necessity of examining discrete effects of VR across multiple dimensions of pain, particularly its emotional impact. Awe is a highly relevant yet largely unexplored emotion in chronic pain, as it involves cognitive processes—appraisals of vastness, feelings of connectedness, and accommodation of new ideas—which may influence the psychological processes shaping pain perception. This preliminary study utilized a mixed methods approach to evaluate the effects of inducing awe in a virtual environment among individuals with chronic low back pain (CLBP). Participants ($n=10$) with CLBP viewed 360-degree virtual nature scenes depicting mountain ascension, combined with music previously validated to elicit awe. Participants completed self-report measures before and after the VR session documenting pain intensity and emotional experiences. Following the post-session survey, a semi-structured qualitative interview was conducted. Thematic analysis identified themes consistent with awe ($n=9$), reduced pain-related cognitive intrusions ($n=7$), and presence of nostalgia and emotional recall ($n=5$). These findings converged with repeated-measures ANOVA results suggesting increased positive affect, decreased negative affect, and a significant decline in pain following the VR session. Responses on the Awe Experiences Scale were consistent with robust awe experiences, including heightened perceptions of vastness and connection to a greater whole. Results support the feasibility of inducing awe among individuals with pain via virtual immersion, with overall positive affective impact and reduction in frequency of self- and pain-related thoughts.

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Can Functional Data Analysis Elucidate Neuromuscular Changes from Mindfulness-Based Pain Intervention?

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Lumbosacral radicular pain (LRP), often referred to as sciatica, has a lifetime prevalence of up to 40%. Prior research shows psychological programs, including mindfulness-based interventions, are efficacious for symptom management in patients with chronic pain. We conducted a randomized controlled trial to evaluate the impact of virtually delivered Mindfulness-Oriented Recovery Enhancement (MORE) on pain and surface electromyography(sEMG) of the tibialis anterior (TA) and gastrocnemius-soleus (GS). Bilateral sEMG was collected during overground walking at baseline ($n=71$) and follow-up ($n=23$). Functional Data Analysis (FDA) was applied to 30 seconds of continuous, rectified sEMG waveforms to identify variations in three principal components of muscle activation: amplitude, timing, and shape. Using linear mixed models, we identified a significant pain*group*time interaction indicating improvement in TA muscle activation ($F[1,166.73]=7.74$, $p=0.006$) and reduced variability ($F[1,169.76]=8.78$, $p=0.003$) versus controls. TA and GS activation amplitudes were strongly correlated at baseline and follow-up ($r=0.60$ and $r=0.715$; $p\leq0.001$ for both), with GS activation inversely related to TA waveform complexity ($r=-0.671$; $p\leq0.001$), suggesting altered neuromuscular coordination in LRP. FDA plots revealed post-intervention painful extremities more closely resembled pain-free extremities with corresponding decreases in overactivation, waveform irregularity, and improved timing consistency. Our findings suggest the MORE intervention resulted in more efficient, less chaotic, and more pain-free muscle recruitment patterns consistent with improved neuromotor control and reduced pain-related compensations. By treating sEMG as a continuous waveform rather than discrete points, FDA elucidates clinically meaningful insights from subtle neuromuscular adaptations associated with pain. Funding: NMSA, NUNM.

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