Evaluating Immediate Biomechanical Changes in Chronic Low Back Pain Patients Before and After Diagnostic Medial Branch Nerve Block

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INTRODUCTION: Chronic low back pain (cLBP) is a leading global cause of disability and is hallmarked by high symptom variability and treatment heterogeneity. Pain symptoms may improve naturally or after treatments such as pharmaceuticals, epidural injections, or nerve ablations, but objective biomechanical function may not immediately resolve alongside alleviation of symptoms with treatment. Approximately 30% of cLBP patients continue to display impairments in biomechanical function even after pain subsides which could leave patients susceptible to reinjury and at a higher risk for recurrent pain flares.[1] In this study, we are exploring the immediate effects of pain resolution from a diagnostic medial branch nerve block on biomechanical function to observe 1) how biomechanical function changes alongside changes in pain, and 2) whether there are factors indicating whether a patient will be an early biomechanical responder or not. Understanding the differences in recovery trajectories of cLBP patients could enable subgrouping/phenotyping patients leading to enhanced individualized treatment protocols in clinic.

METHODS: Chronic LBP patients (n=13) are recruited from the UCSF Orthopaedic Surgery Spine Center who are undergoing a medial branch nerve block. Biomechanical assessment and Patient-Reported Outcomes are collected prior to nerve block and within 1-3 hours following the nerve block. Three-dimensional skeletal tracking from video-based markerless motion capture (MMC) was used to assess spatiotemporal kinematics during gait and sit-to-stand (STS) performance. Paired t-tests were performed to assess the significance of changes in biomechanical metrics post nerve block. K-means clustering was used to elucidate patterns of biomechanical response among patients, and silhouette scores were used to find the optimal clustering parameter.

RESULTS SECTION: There were no statistical differences between females (n=8) and males (n=7) in age, weight, or BMI with an exception for height (163.2 ± 4.80; 174.8 ± 6.52 cm). Eleven patients responded to the medial branch block with at least a 20% improvement in pain scores and demonstrated significant improvements in several task-based kinematic metrics. On average, this pain responder group displayed a 0.90 ± 0.78 s decrease in average sit-to-stand transition time (p=0.03). Maximum trunk inclination angle to rise from the seated position was not significantly different following nerve block. During gait for the pain responders, average stride time decreased by 0.08 ± 0.08 s (p<0.01) and gait speed increased by 0.10 ± 0.06 m/s (p<0.01), but stride length and double support time remained unchanged. In all these metrics, the group of four patients who were pain non-responders showed no significant change post nerve block. K-means clustering was applied to the magnitudes of change observed in significantly improved metrics: sit-to-stand transition time, stride time, and gait speed. Among the pain responders, two strong clusters emerged (average silhouette score=0.73), which we classified as strong biomechanical responders (n=4) and moderate biomechanical responders (n=7). The strong responder cluster was characterized by larger decreases in sit-to-stand time (1.81 ± 0.21 s versus 0.30 ± 0.27 s) and stride time (0.10 ± 0.03 s versus 0.06 ± 0.10 s), as well as a larger increase in gait speed (0.14 ± 0.02 m/s versus 0.07 ± 0.06 m/s). This pattern extended to maximum sit-to-stand trunk inclination as well, with strong responders sitting more upright (decrease of 3.16 ± 3.17˚ versus 0.53 ± 4.90˚). Neither cluster exhibited a significant change in stride length or double support time post nerve block.

DISCUSSION: Time-based metrics significantly improved in responders to the medial branch nerve block. However, when exploring the underlying kinematics of each task, there was not a pattern amongst the responders that could explain the observed improvements in gait speed, stride time, and sit—to-stand transition time. K-means clustering was able to identify strong and moderate biomechanical responders within the overall pain responder cohort. Stratifying the biomechanical responders allowed for some clarity and differentiation in the variability of task kinematics, particularly in sit-to-stand trunk inclination. Strong responders displayed a greater degree of trunk inclination suggesting that, with the alleviation of pain from the medial branch nerve block, they could be more efficiently performing the task. Pain alleviation could allow for increased neuromuscular control and muscle recruitment of the lumbar spine and pelvic regions largely responsible for task performance. Many of the patients have had cLBP for five years or longer. Throughout the development of chronic pain, it's likely that individualized maladaptive movement patterns and compensatory strategies are adopted to maintain daily activity despite pain. These improvements in time-based metrics are likely a result of alleviated pain from the medial branch nerve block and changes in the mechanical metrics and maladaptive movement patterns to accomplish these tasks could require more time to start seeing similar improvements. Other biopsychosocial factors could also be mitigating the degree of improvement in these functional tests. Future studies in our group will explore the changes in movement quality between groups, include long-term follow-up, and consideration of muscle quality, fear avoidance, pain catastrophizing, and other related factors that could influence long-term recovery.

SIGNIFICANCE/CLINICAL RELEVANCE: Recovery is highly variable after a pain flare for cLBP patients, and our project aims to identify risk factors that influence trajectories. Understanding how biomechanics change in response to changes in pain could allow for better treatment selection and improved long-term outcomes for cLBP patients.

REFERENCES:
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IMAGES AND TABLES: