MEASURING NOCICEPTION IN KNEE OSTEOARTHRITIS USING PHYSIOLOGICAL AND MOVEMENT RESPONSES: A PROOF-OF-CONCEPT STUDY

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Background

Current tools to measure pain are broadly subjective impressions of the impact of the nociceptive impulse felt by the patient (Figure 1, Hawker et al., 2011). A direct measure of nociception may offer a more objective indicator. Specifically, movement-induced physiological responses to nociception may offer a useful way to monitor knee OA (Chen et al., 2021; Suokas et al., 2012).

In this proof-of-concept study, we evaluated whether integrated biomechanical and physiological sensor datasets could display linked and quantifiable information to a nociceptive stimulus.

Method

Following ethical approval, we applied a quantified thermal pain stimulus (Figure 3) to a volunteer during stationary standing and treadmill walking in a gait lab setting (Figure 5). An inertial measurement unit (IMU, Figure 7) and an electromyography (EMG, Figure 8) lower body marker set were tested and integrated with ground reaction force (GRF, Figure 9) data collection. Galvanic skin response (GSR) electrodes (Figure 2) and skin thermal sensors were manually timestamp linked to the integrated system.

Results

The integrated EMG, GRF and IMU data show fluctuations within 0.5 seconds of each other when a thermal pain trigger is applied at several time points during a stationary standing test (Figures 6-9).

Manually timestamped physiology measures displayed increased values during testing for skin conductivity (up to 5 µSiemens, 37% compared to baseline, Figure 4), representing electrical conductivity of the skin and directly relates to sweat gland production, and skin temperature (up to 0.3˚C, 1% compared to baseline).

Discussion

This proof-of-concept study suggests that physiological data mimics biomechanical data in response to a known pain stimuli.

While this protocol requires further evaluation as to the measurement parameters, the association of the physiological output to the known pain stimulus suggests the potential development of wearable nociceptive sensors that can measure disease progression and treatment effectiveness.

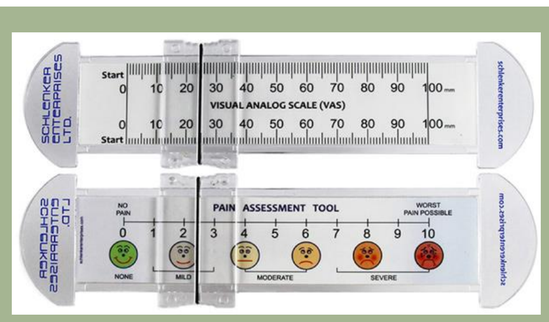

Figure 1. Visual Analogue Scale (between 0-10) for scoring patient self-reported pain.

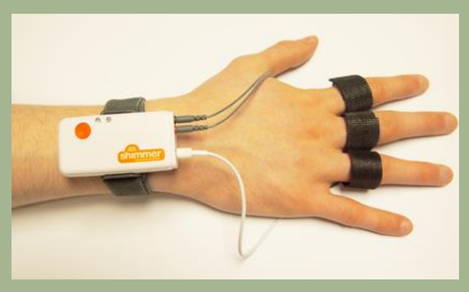

Figure 2. GSR unit with electrodes for skin conductance and skin temperature measurements and photoplethysmography sensor for heart rate recordings.

Figure 3. Thermode control panel and trigger to apply quantified thermal pain stimulus.

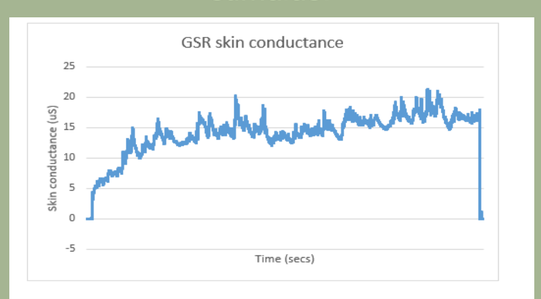

Figure 4. GSR skin conductance result showing electrical conductivity measure of the skin during full testing session for stationary standing test.

Figure 5. Participant with IMU, EMG and GSR sensors attached and thermode stimulus applied during treadmill walking test.

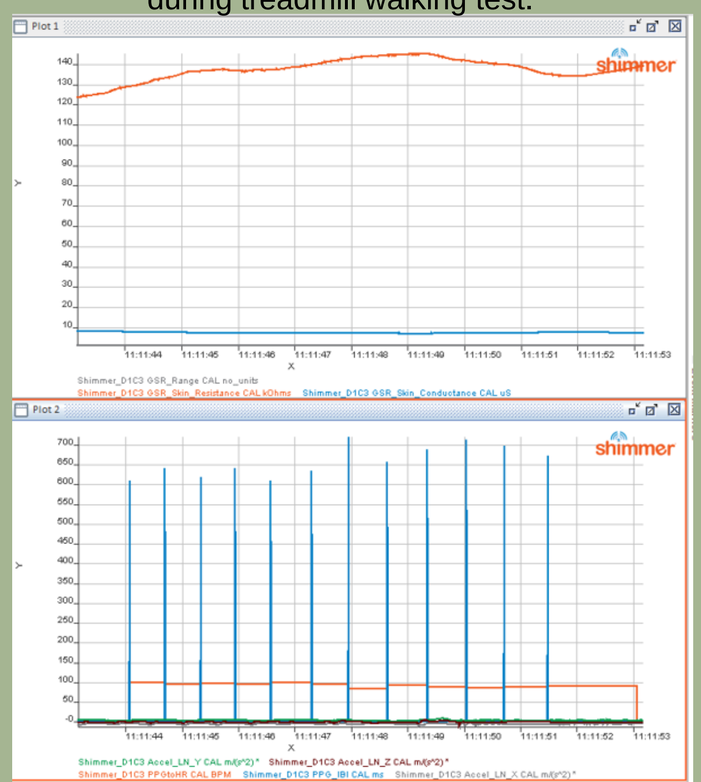

Figure 6. Plot 1: Skin resistance and conductance live recording (inversely proportional). Plot 2: photoplethysmography live recording. Both show live recording snapshot during stationary standing test.

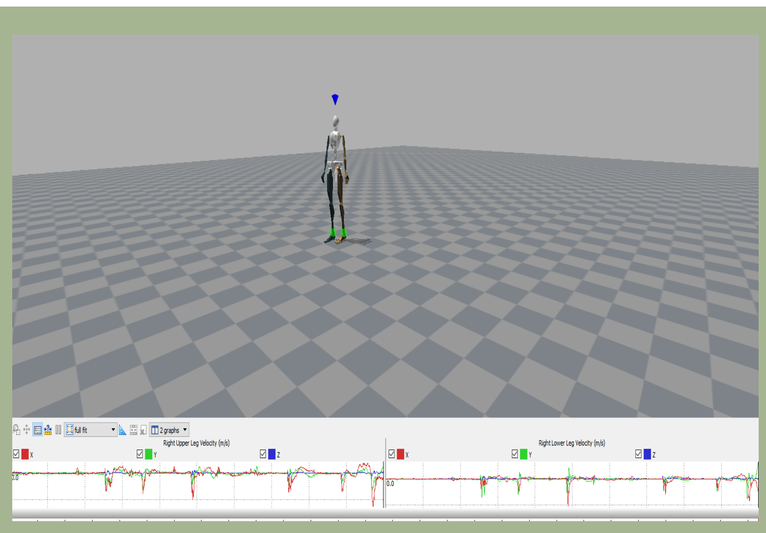

Figure 7. IMU kinematics with sensor constructed avatar during live recording of stationary standing test.

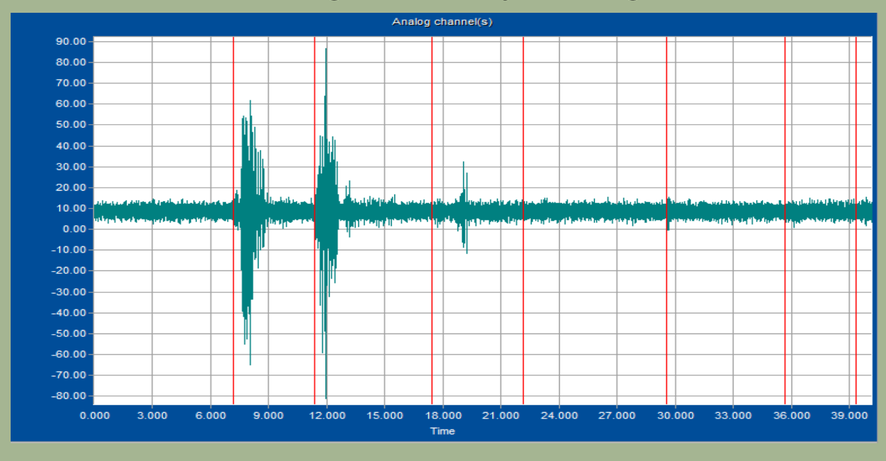

Figure 8. EMG recording of right leg quadricep (rectus femoris) muscle during stationary standing test with red line event markers representing thermal pain trigger.

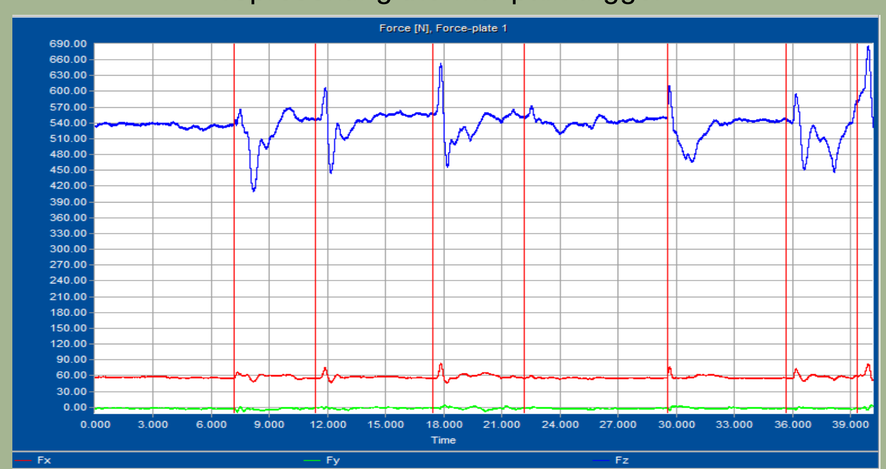

Figure 9. Force recording of right leg during stationary standing test with red line event marker representing thermal pain trigger.

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