# Transcutaneous Electrical Nerve Stimulation of Bladder20 Acupoint for mitigation of Nausea

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## Abstract

Transcutaneous Electrical Nerve stimulation (TENS) is an emerging stimulation for the treatment of Nausea. In this study, we combined computational and experimental approach to scrutinize the effectiveness of TENS on the Bladder20(BL20) acupoint. Using COMSOL Multiphysics, we evaluated the waveform, the effect of electrode angle and stimulation area. Thereafter, a TENS was applied to BL20 of twelve healthy men in an experiment for 30 minutes. Our analysis shows that the stimulation modulates sympathetic outflow and significantly reduces the firing frequency of sympathetic nerves of the BL20 acupoint. Moreover, we found that the excitation of the dorsal root ganglion (DRG) in BL20 was effective using biphasic stimulation at a π/2 rad electrode arrangement and on the amplitude range of 10 to 35mA.

## Background

Nausea is a discrete event of the motion sickness syndrome. A variety of treatments have been used to mitigate nausea. For example, acupressure treatment of Pericardium 6 (PC6), Bladder point (BL20), and kidney 21 (KID21) are an ancient form of healing that together brings about finger and hand pressure to stimulate the acupoints on the body (Noreen Iftikhar, 2019). Nonetheless, use of an acupressure failed to increase tolerance to Nausea. TENS has been reported as a safe, low cost, and easy-to-use neuromodulatory technique that involves non-invasive delivery of weak direct current. The sympathetic autonomic outflow and the central autonomic network underlying autonomic nervous system (ANS) response to nausea are an important determinant of overall nausea intensity and, ultimately, a potential therapeutic target for effective mitigation (Riccardo Barbieri, 2016). We developed experimental and computational methods to scrutinize the effectiveness of Bladder20(BL20) acupoint stimulation for mitigation of nausea. In response to TENS, the parameters for change in bio-signal and excitability of DRG are evaluated. First a precipitation of nausea was performed using a driving simulator to provoke the symptom of nausea and then a TENS was applied to the Bl20 acupoint. The Purpose of this study is to evaluate the optimum parameters and the suitability of the acupoint for mitigation of nausea.

## Methods

Computational Method: Figure.1 shows the dorsal root ganglion in the Bl20 acupoint. To evaluate the optimum parameters and effectiveness of TENS in the acupoint DRG of BL20 was parameterized to reproduce the action potential, activation function, and strength-duration relationships. Parameters like the waveform, pulse width, electrode location and arrangement were valuated using COMSOL Multiphysics.

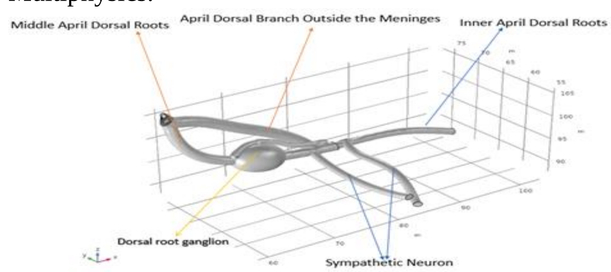



Figure. 1 Anatomical representation of the DRG, nerve roots, epidural tissue, and DRG lead in the FEA model.

**Experiment**: Figure.2 shows the stimulation target and arrangement in the Bl20 acupoint. Three experimental periods: a baseline period of 30 minutes during which resting physiological measures were recorded, followed by an exposure period of 30 minutes and a stimulation after precipitation of nausea. After the stimulation the heart rate, HRV, respiration rate and Skin temperature were measured for 5 minutes before and after stimulation using biosignalsplux Professional.

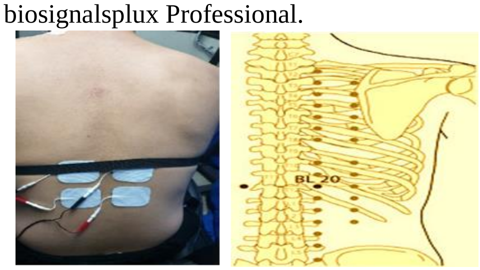
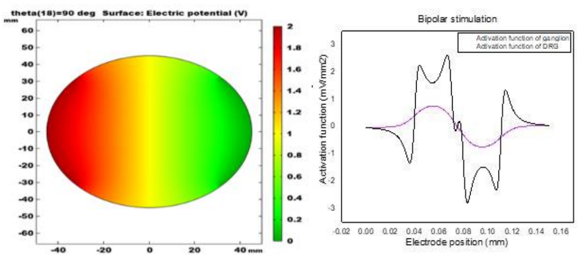



Figure 2. The location of the BL20 acupoint and the electrode positioning with the thoracic vertebrae 11 of an exoskeleton.

## Results and Discussion

Computational Stimulation results: Inward current density was used from the normal current density, for the fact that, the optimum stimulation was obtained at a perpendicular electrode tissue arrangement, and a maximum uniform electric field area of 4000mm2 for θ0 ≈ π/2. In the stimulation both conductance and permittivity were considered. The initiation for the generation of the electric potential depended on the shape and width of the stimulation pulse. The maximum action potential was obtained at a 405µs when an interphase of width of 1500µs was used. Biphasic stimulation with a pulse width of 405µs and interphase of 1500µs was non-invasive and safe, which can initiate the DRG optimally. Figure.3a demonstrates the optimal value of electrode angle θ0 that maximizes the area in which the electric field magnitude within ±10% of its value. It shows that the excitation of the tissue depends on the angle of electrode with a maximum electric potential response at a theta of π/2 rad. Figure.3b shows the Activation function of the ganglia at a with a pulse width of 250 to 500 µsec and an interphase time of 105µsec whereby the threshold potential was 15mA. Which is non-invasive, safe and effective to initiate the DRG.

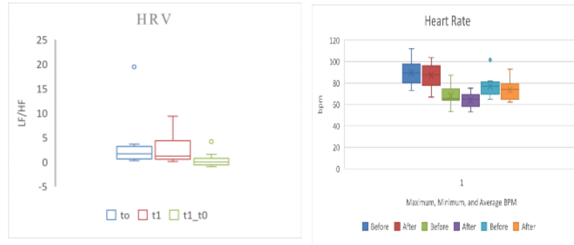



(a) (b)

Figure.3 (a) COMSOL-generated voltage distribution acupoint for an electrode angle theta (i.e. θ0) of 90◦. (b) Activation function of the ganglia in the bipolar, steady state stimulation at different electrode positions.

### Experimental results

The relations among subjective ratings of heart rate, motion sickness, and heart rate variability were examined by calculating the mean of each measure, for each subject during precipitation, and after stimulations. Not all subjects reported every rating of sickness during precipitation. Thus, an unbalanced analysis of variance was utilized to test for variations in heart rate variability and heart rate for each subject. Individual disparities in heart rate variability and heart rate were controlled by treating the subjects as a random effect in the unbalanced analysis of variance. The increase in heart rate was observed after precipitation of nausea, whereby the minimum value 87.21bpm was obtained, which shows the increase of the heart rate after precipitation with a P<0.05 for subject 8 in the experiment. After the biphasic bipolar stimulation, the heart rate value decreased to 75.19 bpm and the heart rate decreased significantly (Figure.4 (b)). The heart rate variability decreased with the biphasic bipolar stimulation of the acupuncture point, but it is not consistent and significant (Figure.4 (a)). The decrease heart rate with the excitation of the dorsal root ganglion was observed after the biphasic bipolar stimulation. Thus, the biphasic bipolar stimulation of the BL20 mitigate nausea effectively.




(a) (b)

Figure.4 (a) Heart rate after precipitation of nausea, and after TENS (Maximum beat per minute, Minimum beat per minute and average beat per minute respectively) with a P-value<0.05; (b) the heart rate variability after precipitation (to), after stimulation (t1) and the mean (t1_to) of BL20, p<0.05

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