

# Evaluating the Effectiveness of Immersive Technologies, Virtual Reality and Augmented Reality, to Increase Pain Threshold During Ice Immersion

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Samuel Rodriguez, MD, Principal Investigator  
Stanford University  
Stanford, California 94305

## Statistical Analysis Plan

### *Outcomes*

The primary outcome was Virtual Reality (VR)'s effect on pain tolerance. The first secondary outcome was VR's effect on perceived pain intensity. Our final secondary outcome was to investigate the effects of VR on modulating sympathetic response in the presence of painful stimuli. We made no changes to trial outcomes after the trial commenced.

### *Measures*

We assessed pain tolerance by measuring the duration that participants kept their hand immersed within the ice bath (in seconds). Given that the cold pressor test produces an uncomfortable experience, we considered longer duration within the ice bath to represent increased pain tolerance.

Our first secondary outcome, VR's effect on perceived pain intensity, was assessed by collecting pain scores from participants every 30 seconds while their hands were immersed. We measured pain scores on a 0-10 scale, where 0 represented no pain and 10 represented the most excruciating pain imaginable.<sup>1</sup>

Our final secondary outcome, the effects of VR on modulating sympathetic response in the presence of painful stimuli, was assessed by analyzing SCR (in microsiemens) per 30 second interval. We refer to each of these 30 second intervals as a separate epoch. Skin conductance is expected to increase with increasing sympathetic nervous system activity, as sympathetic activity increases sweat secretion to increase skin conductance.

### *Sample Size*

We considered a hazard ratio of 0.6 to be clinically significant given that it would indicate an approximate 30% improvement in pain tolerance. Assuming an alpha of 0.05 and power of 80%, sample sizes of 30 people in the VR group and 59 people in the control group were needed to be adequately powered to an estimated hazard ratio of 0.6.

### *Randomization*

We randomized participants to their first ice immersion intervention (VR or no VR) and hand use (dominant or non-dominant) using an electronic random number generator with a 1:1 allocation.<sup>2</sup> Participants then crossed over for their second ice immersion

### *Statistical Methods*

To analyze the effectiveness of VR on pain tolerance, we analyzed the survival time using a Cox mixed-effect model with trials nested in subject and fit using the `coxme` package using R software. We controlled for dominant hand treatment assignment, dominant hand order, and gender.

To analyze our secondary outcomes, we used linear mixed effects models with outcomes nested in subject using the `lme4` package in R. We controlled for dominant hand treatment assignment, dominant hand order, and gender when analyzing pain perception. The variables in the physiologic model were SCRD change over time and the SCRD change between groups, defined as those with and without VR.

## References

[1] Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Anderson JA. Studies with pain rating scales. *Ann Rheum Dis.* 1978;37(4):378-81.

[2] Suresh K. An overview of randomization techniques: An unbiased assessment of outcome in clinical research. *J Hum Reprod Sci.* 2011;4(1):8-11.