

# Gaming Beyond the Novelty Effect of Immersive Virtual Reality for Physical Rehabilitation

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*Abstract*-Immersive virtual reality (**iVR**) head-mounted display (**HMD**) systems paired with serious exercise games can positively augment physical rehabilitation process from both engagement and analytics perspectives. This article presents a serious game for iVR HMD-based long-term upper-extremity exercise. We demonstrate the capabilities of our game through a case study with five users recovering from upper-extremity injuries. We examine how our program maintains engagement and motivation over eight weeks, where users completed biweekly prescribed movements framed as protecting a virtual butterfly. We assess user experiences through a mixture of biomarkers from brainwave, heart rate, and galvanic skin response recorded at runtime, as well as motion capture and behavioral game data. Our results suggest that the iVR game was an effective medium in inducing high compliance, physical performance, and biometric changes even with increasing difficulty beyond the novelty effect period. We conclude with

disorder [14], various phobias [4], [15], schizophrenia [16], and others. The detachment from reality and immersion in a virtual world can reduce discomfort, even as far as minimizing pain when compared to clinical analgesic treatments [17]. Strong immersive stimuli through a **VR** system together with the ability to combine presence and emotion in a virtual world is key to influencing user behavior [13]. However, quantifying this success is often difficult due to system constraints and a lack of computational power [18].

Similarly to **iVR**, research in biometric sensing has seen explosive growth over the past decade. We argue that biofeedback may serve as a versatile tool to quantify the success of an iVR-based physical therapy experience. Brain-computer inter-