Biomechanical Analysis of Human Postural Control with an Aid of Auditory Stimuli

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1. INTRODUCTION & OBJECTIVE

Maintaining proper posture and balance is essential not only for injury prevention but also for optimizing performance and overall well-being in activities that include daily chores and complex movement patterns of dance and athletics. According to the World Health Organization (WHO) report from 2021, falls are the second leading cause of unintentional injury mortality worldwide, causing an estimated 684,000 deaths annually [1]. Yashima's et al. (2021) investigated the impact of auditory noise on static balance control and found that introducing a weak auditory noise can improve static balance in individuals with lower balance capabilities [2]. Additionally, audio biofeedback (ABF) was identified as a valuable tool, providing an extra sensory cue to help coordinate and enhance balance [3]. The objective of the present study is to explore how auditory stimuli (music) influence the mechanical principles governing human balance and posture. This study examined the influence of three auditory stimuli (Indian-type instrumental music - Veena, Flute, and Tabla) on 25 participants standing on a force platform. With each type of music, all participants underwent a mono-pedal stance with their eyes opened. The force platform used in this examination was SENSIX, which has an integrated device mounted onto a dedicated platform of length 600 mm, width 400 mm, and a vertical position of 2.4 mm concerning the top of the plate. This platform is used for data collection, with a sampling rate of 100 Hz. The raw analog data from the force plates were filtered using a low-pass digital Butterworth filter with a cut-off frequency of 20 Hz that was second-order with zero latency to eliminate measurement noise. Using these pre-processed forces and moments data along three perpendicular axes (Fx, Fy, and Fz; Tx, Ty, and Tz). Using time-series signal processing tools, linear time-series features (Statistical) such as Mean, Standard deviation, Kurtosis, Skewness, Variance, RMS and non-linear time-series features such as entropy (Sample, approximate, and Fuzzy), Higuchi Fractal Dimension, Katz Fractal Dimension, Lyapunov Exponent from Vertical Ground Reaction Force (VGRF – Fz) were extracted.

2. RESULTS & CONCLUSION

Three types of entropy feature were significantly ($p<0.05$) high without auditory stimuli when compared to with auditory stimuli (Veena, Flute, and Tabla). While listing to Tabla entropy was significantly ($p<0.05$) low compared to other instrumental music. Figure 1 shows that Katz Fractal Dimension time-series features were significantly ($p<0.05$) high for Tabla instruments.

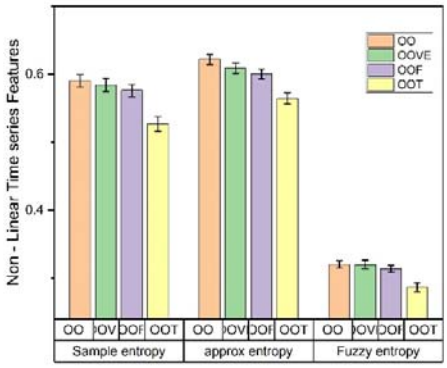

Figure 1. Means and standard errors of Non-linear Vertical ground reaction force (VGRF) time-series features during four experimental conditions.

Similarly, few statistical features show significant differences between (with and without music). Also, analysis of the pith and max frequency in three instrumental music with speech processing techniques. Results provide that the role of auditory stimuli (instrumental music) provides new insights in postural balance, and human mono pedal posture can be actively or spontaneously modulated by an external discrete auditory instrumental rhythm, which might be exploited for learning and rehabilitation. #

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Keywords: Posture; Balance; Standing; Auditory Stimuli; Instrumental Music, Biomechanics.#

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