

# Photoplethysmogram Morphology in Stress: from Mental to Pain to Physical Activity-induced Stress

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**Introduction:** Stress is a fundamental aspect of modern society that has a significant impact on both personal and work life. The ability to indicate mechanisms through which stressors affect the body is crucial to determine between various stressors. This would allow the application of unsupervised stress monitoring during daily living. The aim of this study is to disclose morphological changes in photoplethysmogram (PPG) during mental stress, pain stress, and physical activity-induced stress to facilitate stress monitoring and diagnosis.

**Methods:** Three databases with PPG and electrocardiogram biosignals were used in this study, covering all three types of stress. Heart rate and six morphological PPG parameters were evaluated.

**Results:** The results revealed that mental and pain stress reduced the amplitude of PPG by 60-77%, while physical activity-induced stress, on the contrary, increased it by 17-44%. In terms of time-related PPG parameters, mental stress is more similar to physical activity-induced stress than pain stress. This is most visible in the time interval from systolic to diastolic peak.

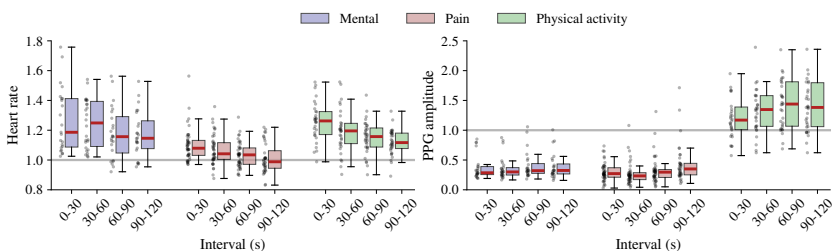


Fig. 1. Relative changes of heart rate and PPG amplitude during mental, pain, and physical activity-induced stress.

**Conclusion:** PPG morphology changes caused by mental and pain stress are related but distinctly different from those caused by physical activity stress. It can be concluded that different types of stress cause specific changes in the PPG morphology and have distinct effects on the cardiovascular system.