Doctoral dissertation in 2023 (abstract)

Potential Applications of Fingertip Pulse Wave Fluctuation
; Mental and Physical Health from Biometric Information

International Graduate School of Advanced Studies
J.F. Oberlin University

Eri Shibayama

Abstract

First part: Research Background and Purpose

Chapter1: Fluctuations in Biological Signals and Mental and Physical Health

It has been suggested that dynamic "fluctuation" is more important than static stability in maintaining a healthy state (Tsuda, Tahara & Iwanaga, 1992; Oyama-Higa, Miao, & Mizuno-Matsumoto, 2006). Chaos analysis, a nonlinear time series analysis, is used to quantify the fluctuations inherent in biological signals. The chaos attractor and LLE calculated by this analysis is an objective indicator that is deeply related to physical and mental health.

In contemporary Japan, early detection of depression and dementia is considered important. However, these diseases may progress without awareness, and objective data must be measured using scientific methods. Therefore, we focused on the analysis of fluctuations in biological signals that are related to physical and mental health, and among these biological signals, we focused on fingertip pulse wave. In addition to its important psychophysiological significance, fingertip pulse wave is an objective indicator that is noninvasive and causes little burden to the body and mind.

Chapter2: Purpose and Structure of this Study

It is inferred that the value calculated by analyzing the fluctuation of finger pulse wave can be applied as an objective index to grasp physical and mental health. However, at present, there is not enough research linking physical and mental health to fluctuations in biological signals, and for this reason, general use has not yet been made. Therefore, the purpose of this paper is to conduct basic research on the relationship between finger pulse wave fluctuations and physical and mental health.

Second Part: Potential Applications of Fluctuation Analysis of Fingertip Pulse Waves in Daily Life Situations

Chapter3: Study 1: Fluctuations of finger pulse wave fluctuations over a period of several months

LLE, which is a quantitative expression of fluctuation, did not vary significantly within individuals over a period of several months under certain similar environmental conditions. In addition, when some stimuli were given, the LLE of the fingertip pulse wave was reflected in the LLE, suggesting that the fluctuation was also somewhat large.

Chapter4: Study 2: Influence of individual personality traits and physical condition on fluctuations in fingertip pulse wave fluctuations over a period of several months.

In addition to the individual's characteristic personality and illness, the mood state and physical condition were recorded along with weekly finger pulse wave measurements to examine the association. However, due to the large number of absences during the experiment, it was not possible to determine the association solely from this study. However, based on the free response column, we believe that the results support previous studies on the possibility that physical and mental health is reflected in the fluctuation of the fingertip pulse wave.

Third Part: Potential Applications of Fluctuation Analysis of Fingertip Pulse Waves in Medical Situations

Chapter5: Study 3: Characteristics of Chaotic Attractor of Acceleration Pulse Wave in Patients with Mental Illness

We investigated whether the shape of the chaotic attractor of the acceleration pulse wave of the fingertip pulse wave differs in shape between patients with psychiatric disorders and normal subjects. The results revealed that the chaotic attractor of the acceleration pulse wave of the fingertip pulse wave of patients with psychiatric disorders was generally round, whereas the attractor of normal subjects was generally triangular in shape. This suggests that the chaotic attractors can be used to estimate mental and physical health status in medical and everyday situations, such as assisting in the diagnosis of mental disorders by objective indicators and in the early detection of mental disorders.

Chapter6: Study 3: Characteristics of Chaotic Attractor of Acceleration Pulse Wave in Patients with Mental Illness; Intersubjective evaluation using impression ratings

In this intersubjective study, participants who were not involved in this research were asked to rate the shape and size of the chaotic attractor of the acceleration pulse wave of the fingertip pulse wave without indicating the presence or absence of mental illness. The results showed that it was possible to determine the presence or absence of mental illness with a very high probability.

Fourth Part: Potential Applications of Fluctuation Analysis of Fingertip Pulse Waves in Intervention and Nursing Care Situations

Chapter7: Study 5: A Study of Recollective Intervention Using Fluctuation Analysis of Fingertip Pulse Waves

To determine whether chaos analysis of finger pulse wave could be utilized as an objective index of the effects of psychotherapy and other methods, we conducted a recall intervention

and measured fluctuations in finger pulse wave and psychological state to examine their relevance. The results showed that psychological state improved only during autobiographical memory recall, and at the same time, the mean value of LLE was significantly higher. We can infer that the increase in LLE due to the recall of autobiographical memories obtained in this experiment had a positive effect on cognitive functions.

Chapter8: Changes in finger pulse wave fluctuation by past recollection; Examination of the effect of recollection method according to the content of recollection

In this study, we investigated the effects of recalling pleasant memories, sad memories, and tomorrow's plans on the LLE of the fingertip pulse wave. The results showed that the finger pulse wave fluctuation tended to increase from pre- to post-experiment when pleasant childhood memories were recalled more than in other experiments, and that the finger pulse wave increased more temporarily when sad childhood memories were recalled, but then decreased again more frequently.

Fifth Part: Comprehensive Discussion

Chapter9: Synthesis of this paper, Chapter10: Summary of this paper

We believe that the basic research conducted in this paper has increased the applicability of fingertip pulse wave fluctuations in various situations and has shown images of further utilization. We believe it is necessary to continue basic research on the relationship between finger pulse wave fluctuations and mental and physical health in order to make practical use of the data.