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DEVELOPMENT, VALIDATION AND USABILITY EVALUATION OF MOBILE APPLICATION TO MONITOR REAL-TIME EXERCISE HEART RATE ZONE

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ABSTRACT

Conventional heart rate (HR) monitor device and mobile application have been developed with numerical digital displays, and such display is not practical under most exercising condition. This work describes the development of smartphone application called Chromozone designed to monitor exercise HR in real-time using the color-coding system. Chromozone development goals include to: (1) enables real-time communication of HR signal from Bluetooth-enabled HR transmitter to Chromozone application, (2) determine individual HR zone based on maximum HR, age, gender, and selected exercise zone, and (3) to display accurate color-coded which correspond to individual optimal HR zone range in real-time, and this development objective was successfully met. Validation and usability assessment of the developed application were performed in conventional HR monitor users. Chromozone was compared against clinically accepted, laboratory-grade electrocardiogram, and was found to generate excellent criterion-concurrent validity (r = 0.994, p < 0.001) in Spearman rho correlation-coefficient test for absolute agreement, and acceptable bias of 1.96 bpm and narrow limits of agreement (3.07 to -3.51) in Bland Altman test for relative agreement. Similarly, relative (intraclass correlation coefficient test: 0.998, p < 0.001) and absolute (within-subject coefficient of variation: 1.95 ± 1.4 %) reliability test of HR dataset from repeated exercise trials using Chromozone application shows an excellent consistency. Additionally, this study also showed that usability level of Chromozone application is within the satisfactory level, although it is necessary to consider several critical feedbacks from the participants for future version update. The outcome of this work provides a strong support for Chromozone application as a valid, reliable, and effective exercise HR monitoring tool. The application could potentially help athlete, active individual as well as the clinical population to monitor and regulate their exercise training regime in a more effective manner.

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CHAPTER ONE
INTRODUCTION

1.1 Research Background

The heart is the hub of most circulatory functions at rest and during exercise. The heart rate (HR) is defined as the number of heart beats per minute. HR is measured by the number of contractions of the ventricles located in the heart's lower chambers. HR is regulated by the sympathetic and parasympathetic nervous system's synchronization. HR is adjusted based on physical activity to supply the need for oxygen and the removal of metabolic by-products from the body. Different factors can alter the magnitude of HR responses. Sudden HR changes could also be response to emotions such as excitement, trauma, anxiety, satisfaction, disappointment (Zhu et al., 2019). HR level could also be dramatically altered by specific medication, drug, or dietary consumption. For instance, the use of beta blockers or thyroid medication could result in sudden decrease and increase of HR, respectively. The HR response can also be slightly change based on the body position (e.g., lying, sitting, or standing) (Schneider et al., 2018).

HR is among the most frequently examined physiological parameters in humans and is crucial in understanding an individual's health. Monitoring the heart rate is now more common among consumers. Various exercises equipment and mobile technology are becoming more capable of accurately and reliably measure HR. Several methods used to measure HR include manual pulse rate assessment, photoplethysmography (PPG), Short-range Heart Rate Telemetry and ECG. To measure the pulse rate, numerous pulse points exist in the human body. The most important of these are the carotid, brachial, radial, femoral, posterior tibial, and dorsal arteries. The pulse is a pressure wave that travels through the arterial wall (Zhu et al., 2019). PPG is an uncomplicated, non-invasive and inexpensive optical measurement method that physiologically measures of the HR and other basic cardiovascular indices such as oxygen content in arterial blood and blood flow (Schneider et al., 2018).

The HR monitors in the market for conventional sports mostly use the short-range HR telemetry method usually in a form of chest HR transmitter, to detect