

PREVENTIVE AND CURATIVE HEALTH PROFILING  
BASED ON AUGMENTED EVENT-RELATED  
POTENTIALS (ERP) AND MACHINE LEARNING

BY

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## ABSTRACT

There are two profiles regarding a healthy lifestyle, which are preventive and curative. Preventive people that avoid potential health problem or treat them early have lower medical costs compared to curative people. According to the report through the Ministry of Health in 2015, the Government of Malaysia has spent 98% of the total amount of RM 11870 million hospital expenditure for curative care. Existing techniques using self-assessment and reported test have been conducted to assess health lifestyle profile, but these techniques susceptible to produce a response bias that leads to misclassification. Another alternative method emerges based on the knowledge that the different individual profile is influenced by the perception formed by each individual, which comes from the human brain. EEG can measure brainwave activity. However, in its raw form, EEG is very difficult to assess the highly specific neural processes that are the focus of cognitive neuroscience. Thus, another method by averaging of the raw signal, Event-Related Potentials (ERPs) became the primary tool of the cognitive neuroscientist and make the technique ideal for studying perception and attention. This research captured the brain activities using electroencephalography (EEG) during receiving healthy and unhealthy food images which act as a stimulus associated with health. These EEG signals converted mathematically into the ERP signals and fed into the classification interface as input. This research aims to identify and classify individual profile, namely preventive and curative using ERP brain signals. In term of classification, the methodology used was the dynamic evolving Spiking Neural Network (deSSN) based in the Neucube architecture. The conclusions from the finding confirm a strong association of perceptions of food images and health profiles are clearly expressed. The results of the ERP analysis shown the mean amplitudes of P300 and LPP components in Parietal and Occipital lobe were higher for healthy foods in the preventive groups. Whereas within curative groups it has been shown the higher for unhealthy foods. These results are suspected to reflect their preferences in choosing food in their daily lifestyle. However, the classification results have shown that unhealthy food stimuli in LPP wave show superior results compared to data analysis in other conditions. Therefore, this study proven the proposed method to do profiling for preventive and curative by using ERP data work on Neucube framework. The classification with ERP data is believed to support the results of the self-assessment and build a more accurate and reliable profiling method. It is hoped that the research findings can lead people more towards a healthy lifestyle.

## خلاصة البحث

هناك نوعان من المظاهر المتعلقة بأسلوب الحياة الصحي، وهما وقائي وعلاجي. الأشخاص الوقائيون الذين يتجنبون المشكلة الصحية المحتملة أو يتعاملون مع المشكلة مبكراً لديهم تكاليف طبية منخفضة مقارنة بالأشخاص الذين يتلقون العلاج. وفقاً للتقرير الصادر عن وزارة الصحة في عام ٢٠١٥، أنفقت حكومة ماليزيا ٩٨٪ من إجمالي مبلغ ١١٨٧٠ مليون رينجيت ماليزي من نفقات المستشفى على الرعاية العلاجية. وقد أجريت التقنيات الحالية باستخدام التقييم الذاتي واختبار التقارير عنه لتقييم نمط الحياة الصحية، ولكن هذه التقنيات عرضة لإنتاج تحيز استجابة يؤدي إلى سوء التصنيف. هناك طريقة بديلة أخرى بناءً على معرفة أن الصورة الفردية المختلفة تتأثر بالإدراك الذي يشكله كل فرد، والذي يأتي من أن الدماغ البشري. تقنية EEG تستطيع قياس نشاط الدماغ ومع ذلك، من الصعب للغاية تقييم عمليات التخطيط الدماغية العصبية التي تعتبر محورياً لعلم الأعصاب الإدراكي. وهكذا، أصبحت طريقة الأحداث ذات الصلة (ERPs) هي الوسيلة الأساسية لعلم الأعصاب الإدراكي، وهذه التقنية مثالية لدراسة الإدراك والانتباه. هذا البحث يهدف إلى تحليل أنشطة الدماغ باستخدام تخطيط كهربية الدماغ (EEG) أثناء تلقي صور غذائية صحية وغير صحية والتي تعمل بمثابة محفز يرتبط بالصحة. يتم تحويل هذه الإشارات رياضياً إلى إشارات ERP تخطيط وجعلها كمدخل لعملية التصنيف. يهدف هذا البحث إلى تحديد وتصنيف الملف الشخصي لتحديد الوقائية والعلاجية باستخدام إشارات ERP من حيث التصنيف، كانت المنهجية المستخدمة هي الشبكة الديناميكية Spiking Neural المتطورة (deSSN) التي تعتمد على تصميم Neucube. تؤكد الاستنتاجات التي توصلت إليها وجود ارتباط قوي بين تصورات الصور الغذائية والتشكيلات الصحية بوضوح. أظهرت نتائج التحليل تخطيط أن السعات المتوسطة لمكونات P300 و LPP في الفص الجداري والسفلي كانت أعلى بالنسبة للأطعمة الصحية في المجموعات الوقائية. بينما ضمن المجموعات العلاجية، فقد ثبت أنه أعلى بالنسبة للأغذية غير الصحية. يشتهر في أن هذه النتائج تعكس تفضيلاتهم في اختيار الطعام في نمط حياتهم اليومي. ومع ذلك، فقد أظهرت نتائج التصنيف أن المحفزات الغذائية غير الصحية في موجة LPP تظهر نتائج متفوقة مقارنة بتحليل البيانات في الظروف الأخرى. لذلك، اقترحت هذه الدراسة طريقة للقيام بالتنميط للوقاية والعلاج باستخدام بيانات ERP في إطار Neucube. يعتقد أن التصنيف باستخدام بيانات ERP يدعم نتائج التقييم الذاتي ويجعل طريقة التصنيف أكثر دقة وموثوقة. ومن المأمول أن تؤدي نتائج البحث إلى توجيه الناس نحو نمط حياة صحي.

APPROVAL PAGE

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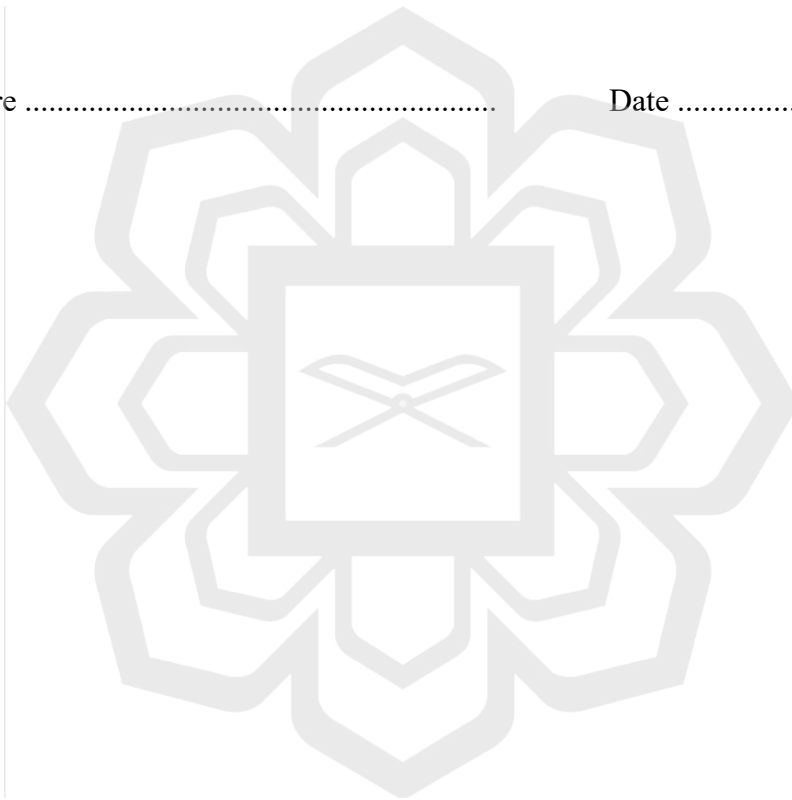
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## DECLARATION

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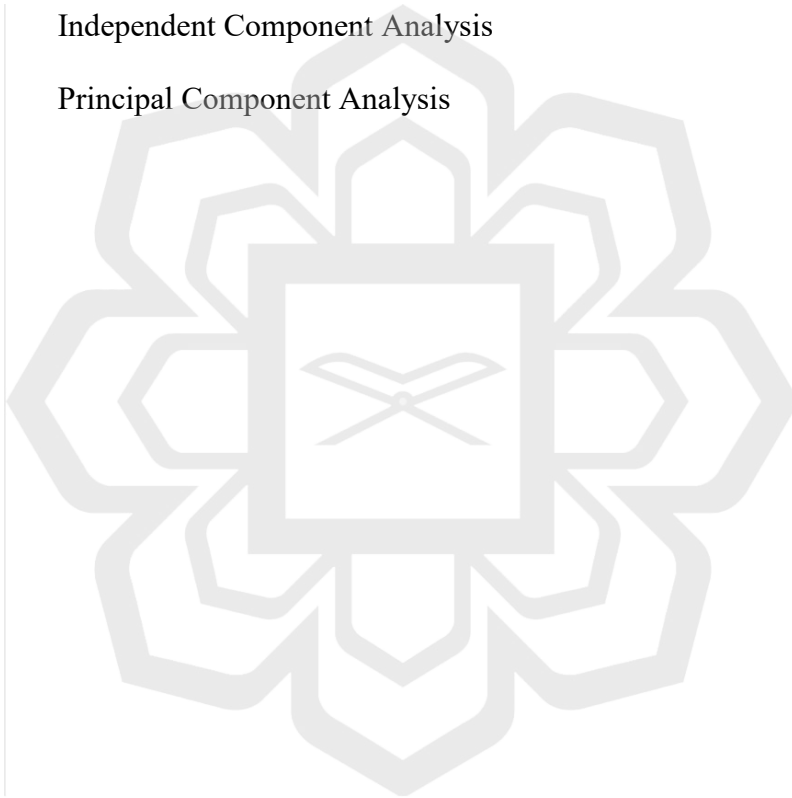
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## LIST OF ABBREVIATIONS

EEG	Electroencephalography
ERP	Event-related potential
DeSNN	Dynamic evolving Spiking Neural Network
HPLP-II	Health Promotion Lifestyle
ECoS	Evolving Connectionist Systems
ICA	Independent Component Analysis
PCA	Principal Component Analysis



# CHAPTER ONE

## INTRODUCTION

### 1.1 BACKGROUND OF THE STUDY

Healthy lifestyle behavior is defined as all activities which approved and applied by individuals with the aim of being healthy, maintaining health, and preventing disease (Çelebi, Gündoğdu, & Kızılkaya, 2017). Healthy lifestyle behavior is very important to prevent and manage chronic conditions, improve health, and ultimately reduce health care costs (Melnyk, Amaya, Szalacha, & Hoying, 2016). This study classifies a person's profile towards health into 2 types, namely preventive and curative profiling. The preventive profile is the people who adopt a healthy lifestyle by avoiding any potential health problems or immediately get the treatment before even feeling pain. Whereas curative profile is people who are reluctant to apply a healthy lifestyle which causes them only doing treatment or visit a doctor after the pathology process has begun.

According to the report of the Ministry of Health, the Malaysian Government has spent 98% of the total RM 14,519 million of hospital expenses for curative care in 2015 (Malaysia National Health Accounts (MNHA), 2017). Instead of that, preventive profiling benefits Malaysia by producing lower medical costs as compared to curative is expected to provide benefits for the community in promoting well-being, reducing preventable diseases, and reducing overall health care spending (Lim, Kueh, Arifin, & Ng, 2016).

In many studies, individual behavior toward a healthy lifestyle was assessed in a self-report namely Health Promotion Lifestyle Profile-II (HPLP-II). Six dimensions of lifestyles that improve health are measured by Spiritual Growth, Interpersonal Relations, Nutrition, Physical Activity, Health Responsibility, and Stress Management

(Walker, Sechrist, & Pender, 1987). Literature has conducted a study for validation of HPLP-II and concluded that the health promotion behavior scale proved to have a valid measurement model and a reliable construct among undergraduate students in Malaysia (Lim et al., 2016).

Nutrition or healthy eating was identified as one of the key factors influencing healthy lifestyle behaviors in Malaysia (CC et al., 2016). The Global Nutrition Report states that Malaysia has experienced an increment of diabetes, overweight and obese in recent years (Khambalia & Seen, 2010; “Nutrition Month Malaysia – April 2019,” 2019). The obesity rate in Malaysia is recorded as the highest level particularly in Southeast Asia (Pell et al., 2016). Thus, this study highlights the importance of the nutritional dimension in order to take further attention in assessing a healthy lifestyle.

However, the self-reports of health-related behaviors are widely known of being vulnerable generating various errors in consequence of cognitive factors involved in formulating responses of interviews or answering questions to structured assessment instruments (Hébert, 2016; M. L. Wu, Whittmore, & Jung, 2016). Response to that, other alternatives have emerged after identifying the behavior differences that are influenced by perceptions of each individual which derived from the human brain (Güntekin & Başar, 2014). An event-related potential (ERP) is one method for measuring brain activity during cognitive processing. ERPs are averages of raw EEG signals that can provide insight into cognitive processes which can be an ideal technique for studying human perception and attention (Carbine, Rodeback, et al., 2018; Woodman, 2010).

In the past few years, several studies have analysed brain wave activity regarding the differences in their cognitive factors in relation to the food. A study (Carbine, Rodeback, et al., 2018) was devoted to reviewing several ERP studies involving

cognition related to food in order to investigate ERP components associated with eating habits. Recently, ERP studies have used artificial intelligence (AI) techniques that have proven to be useful for classification problems based on brain data with high accuracy (Armanfard, Komeili, Reilly, Mah, & Connolly, 2016; Jiang, Zeng, Tong, Zhang, & Yan, 2016; Khan, Sung, & Kang, 2019; D. Wu, Lance, & Lawhern, 2014). Evolving spiking neural network (eSNN) is an artificial intelligence technique specifically designed to deal with spatio-temporal brain data (STBD), such as EEG (Nikola Kasabov, 2012).

The purpose of this research is to identify and classify individual profile which consisted of preventive and curative lifestyle by using ERP signals. This study focuses on nutritional factors that are known to be one of the major problems currently in Malaysia. For classification, a method to be used is the eSNN that developed from the Evolving Connectionist Systems (ECoS) paradigm.

## **1.2 STATEMENT OF THE PROBLEM**

Techniques for assessing health profile are scarce. Existing techniques for analyzing personalities are based on self-assessment or reported tests, and existing instruments are easily contaminated and falsified. This is influenced by many factors, for instance the lack of respondents' understanding of the questions asked or because of a bias factor called social desires. Social-desire bias is a condition where the respondent attempting to impress and wants to look good on the results even if the questionnaire is anonymous (Crandall & Crandall, 1965; Mortel, 2008; Rosenman, Tennekoon, & Hill, 2011). Therefore, inaccurate and uncertainty results from self-assessment in assessing individual health lifestyle are the issues raised in this study. The existence of another alternative is required to provide more accurate results in assessing the health profile.

## ١, ٣ RESEARCH OBJECTIVES

The study aimed to achieve the following objectives:

١. To understand and analyze the relationship between food stimuli and health profile by using ERP.
٢. To design a suitable protocol to differentiate the healthy profile.
٣. To use computational intelligence method in classifying the health profile.

## ١, ٤ RESEARCH QUESTIONS

1. What is the relationship between food stimuli and health profile by using ERP?
2. What is the suitable protocol designed to differentiate the healthy profile?
3. How the computational intelligence method can be applied in profiling the health profile?

## ١, ٥ RESEARCH HYPOTHESES

This research study is working on the cognitive process by the individual brain based on the 5 following hypotheses:

- H1 Each individual has different brain responses on viewing the food images which can reflect their preference or dietary habit.
- H2 Healthy and unhealthy food images will provoke individual attention and perception.
- H3 Event-related potential (ERP) can quantify health profile (preventive or curative).
- H4 Dynamic evolving Spiking Neural Networks has the ability to understand and classify the individual's profile in regards to health.
- H5 By identifying health lifestyle profile (preventive and curative), health awareness can be increased.

## **١,٦ SIGNIFICANCE OF THE STUDY**

This study is intended to contribute to several aspects including human life, country, computer science, and psychology fields in increasing awareness of the importance of healthy lifestyles.

### **١,٦,١ Contribution to human life**

Awareness of healthy lifestyles, for the most part eating patterns is crucial in the current condition of society. Determining whether a person's profile is preventive and curative can help generate consciousness in a person with reference to health care. This emphasis can induce a major positive impact on human life. Then for further treatment in the future it can be continued with the method of character building for curative people to realize the existence of mistakes in their lifestyle that can have an influence on their lives from this point forward. Meanwhile, preventive people are directed to keep on to manage their stability in response to health care.

### **١,٦,٢ Contribution to government**

It is clear that curative people produce greater medical costs compared to preventive people. Understanding the profile of responding to lifestyle is expected to increase awareness of health care. This certainly has an impact on reducing the costs of the government because in reality the handling of severe diseases mostly affects curative people. Most serious illnesses are caused by the absence of early prevention and the lack of concern for one's health. After making a significant impact on the government and country, if it is responded to massively and seriously it will achieve a wider and stronger impact.

### **١,٦,٣ Contribution to psychology, neuroscience, and computer science field**

In studying and understanding personalities or profiles, it cannot be denied that the psychology field has a main role in it. Some protocols are built with the understanding

and knowledge of psychology to determine a person's profile related to a healthy lifestyle. HPLP II is one of the instruments that has been commonly used and moreover has been validated in Malaysian society. So this research will become a reference in the use of HPLP II questionnaires to assess a person's lifestyle, especially on nutritional factors. This assessment is also ultimately associated with the neuroscience field so that knowledge is extended between the two.

Neuroscience acts in taking EEG data obtained from the human brain. The understanding that human perceptions and attention are generated from the brain forms the fundamental of this research. Stimuli or protocols designed to trigger differences in brain activity in preventive and curative people can be a reference for future research. In short, the same experimental protocol can also be used in different subjects or condition because it has been tested in this study.

Lastly, as the main objective in this study to demonstrate the computational model in analysing EEG brain signal data. Signals processing includes signal filtering, conversion to ERP signals is done by computerized computational. In terms of data analysis, besides doing statistical analysis to see the significance of the data, a classification model was also applied with the evolving spiking neural network technique. Then the accuracy of the results generated by this model can be a benchmark of success or failure of this method in studying and understanding the data provided.

#### **\\, \\ LIMITATIONS OF THE STUDY**

The research sample is limited to 22 undergraduate students at the International Islamic University Malaysia by asking them to fill in the HPLP-II questionnaire distributed from August to September 2019. In the assessment of the questionnaire, a focus was taken on nutritional factors.

## **1.1 DEFINITIONS OF TERMS**

### **Electroencephalography**

Electroencephalography (EEG) is one of the most well-known psychophysiological methods that have the ability to produce recordings that reflect the electrical activity that occurs in the brain (Chambayil & Rajesh Singla, 2010; Garcés Correa, Orosco, Diez, & Laciari, 2015).

### **Event-related potentials**

Event-related potentials (ERPs) measure the electrical potential induced by the brain by extracting the average value of the spontaneous electroencephalogram when associated with a specific sensory, cognitive, or motor event (Lopez-calderon & Luck, 2014).

### **Preventive**

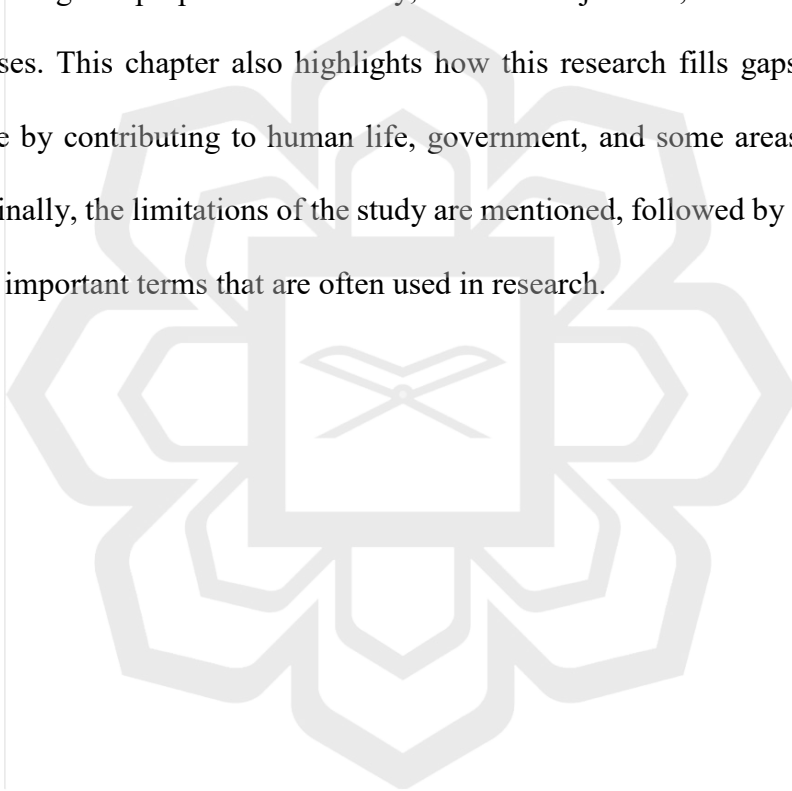
The preventive profile is the people who adopt a healthy lifestyle by avoiding any potential health problems or immediately get the treatment before even feeling pain. For instance, maintaining a dietary decision, regular check-ups, regular exercise, and other actions that intend to avoid disease. This research defines the preventive as the person who obtains the high score on nutrition factor from HPLP-II questionnaire.

### **Curative**

The curative profile is people who are reluctant to apply a healthy lifestyle which causes them only doing treatment or visit a doctor after the pathology process has begun. This research defines the curative as the person who obtains the low score on nutrition factor from HPLP-II questionnaire.

## ١, ٩ CHAPTER SUMMARY

This chapter has presented and discussed the background of this research. This explains that unawareness and insensitivity to lifestyle have a negative impact on many parties including the government. Whereas self-assessment of health behaviour frequently leads to misclassification. In addition, the statement of the problem was criticized, because this study was designed to find other alternatives to profiling life patterns and it was intended that a computational model would be able to classify it. This is followed by presenting the purpose of the study, research objectives, research questions, and hypotheses. This chapter also highlights how this research fills gaps in the research literature by contributing to human life, government, and some areas of the research study. Finally, the limitations of the study are mentioned, followed by a brief definition of some important terms that are often used in research.



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **۲, ۱ INTRODUCTION**

Health behavior has been known to be characterized by human perception and attention to the importance of lifestyle. Since this study aims to identify and classify individual profiles regarding healthy lifestyles, therefore to design this research study further literature review is required.

Furthermore, this review will emphasize the understanding and importance of health behavior and what instruments are generally used to measure it, which will also highlight the importance of nutritional factors. This section also discusses the understanding of the event-related potential and its computational models. Then followed by the extent of ERP research related to the perception of lifestyle, especially eating patterns. The last discussion falls on the classification technique used in this research which is evolving spiking neural networks (eSNN). This section describes the findings of previous literature on the application of classification techniques to eSNN when dealing with brain data models

#### **۲, ۲ HEALTHY LIFESTYLE BEHAVIOR**

In broad terms, David Gochman (1982) defines health-related behavior as personal characteristics such as perceptions, motives, values, beliefs, expectations, and other cognitive aspects as well as with behavioral patterns related to health care, health recovery, and health improvement. Healthy lifestyle behavior is an approach in which people act or controls their behavior in order to apply a manner of living concept for maintaining health, protection and prevention of diseases (Çelebi et al., 2017; Van

Ryckeghem et al., 2014). In other definition, lifestyle in the context of health consists of individual actions and personal activities within daily life pattern that significantly affects health status (Pender NJ., 2011). Healthy lifestyle behavior (HLB) consists of methods or all approaches that can be applied to stay healthy and prevent diseases to achieve the quality of life, protect the state of well-being and maintain well-being at a high level (Babaoglu, Cevizci, & Ozdenk, 2014; Cheng, Weiss, & Siegel, 2016).

The constitution of World Health Organization states that being healthy is a fundamental right of every human being and creating awareness to all people on advantages of medical, psychological and linked knowledge which is necessary to the fullest achievement of health (World Health Organization, 2014). Health is the product of many aspects such as genetic predisposition, behavior, environment, residential community, government policies, prevention systems, and clinical care underwent by someone. According to data of WHO, diseases that emerge because lifestyle causes 40-50% of deaths in developing countries and 70-80% of deaths in developed countries (Babaoglu et al., 2014).

Healthy lifestyle patterns which are including of maintaining high-quality food, strong physicality, healthy weigh and free of smoking have been associated with a 66% lower risk of cardiovascular disease (Loef & Walach, 2012; Schwarzer, 2008). While unhealthy lifestyles potentially affect the emergence of many diseases such as metabolic disease, joint and bone problems, cardiovascular disease, hypertension, overweight and even disabilities or death (Babaoglu et al., 2014; Farhud, 2015). Moreover, unhealthy lifestyles also take part in causing chronic diseases as the main challenges of health to the population of the twenty-first century like diabetes, cancer, stroke, hypertension, and coronary artery disease (Higgins, Silverman, Sigmon, & Naito, 2012). In addition, the data show that disease risk from unhealthy lifestyles results in higher health care