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Using non-invasive assessment methods to predict the risk of metabolic syndrome

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ABSTRACT

This study aimed to develop non-invasive assessment indicators for predicting the risk of metabolic syndrome. A cross-sectional study design with 154 convenient subjects recruited from the family clinics was used for this study. Physical assessment sheet, lifestyle profile, the heart rate variability assessment and standard blood sample tests were used to measure variables. The subjects were categorized into four groups based on the number of factors meeting the criteria for metabolic syndrome. After excluding invasive blood tests, the results of multivariate logistic regression identified non-invasive assessment (blood pressure, body mass index and very lower frequency of heart rate variability) were the significantly predictors of the risks of metabolic syndrome. When invasive blood test cannot be performed, community health care providers can use the non-invasive physical assessments to predict the risk of early-stage metabolic syndrome, consequently enabling them to implement related health education and interventions.

1. Introduction

Cardiovascular diseases and diabetes cause serious health problems for people in modern society. Metabolic syndrome (MS) is a significant indicator in determining type 2 diabetes and cardiovascular disease (Grundy, Hansen, Smith, Cleeman, & Kahn, 2004; Eckel, Grundy, & Zimmet, 2005). However, diagnosis of MS relies on blood sample assessment that in turn requires invasive tests seldom performable in a community setting. Thus, a non-invasive physical assessment method capable of predicting the risk of metabolic syndrome is needed to benefit community dwellers, especially those in rural and remote communities. Numerous studies have confirmed that unhealthy lifestyles are the primary cause of MS (Grundy et al., 2004), and heart rate variability (HRV) is a key predictive indicator for potential cardiovascular disease (Vinik, Maser, Mitchell, & Freeman, 2003). Therefore, the major purpose of this study was to evaluate the effectiveness of a non-invasive method incorporating HRV assessment, a health-promoting lifestyle scale, and a simple physical assessment in predicting MS risk. The invasive blood test was conducted subsequently to verify the effectiveness of the proposed non-invasive method, which can be expected to provide health care providers with a convenient approach for early screening of metabolic syndromes in community dwellers.

Metabolic syndrome refers to the overall physical complications generated by dysfunctional body functions and metabolic overloading (Opie, 2007). This syndrome can be regarded as a collection of risk factors that subsequently result in diabetes and cardiovascular disease (Hwang, Bai, & Chen, 2006). High rates of MS were found worldwide (Zimmet, Magliano, Matsuzawa, Alberti, & Shaw, 2005), and men were more likely than women to have MS (Brunero, Lamont, & Fairbrother, 2009).

According to the definition modified based on the Expert Panel on Detection and Evaluation of Treatment of High Blood Cholesterol in Adults (2001) and announced by the Ministry of Health and Welfare, (2012), a patient with 3 or more of the following 5 risk factors is very likely to have metabolic syndrome: (1) waist circumference (≧90 cm for men and ≧80 cm for women); (2) fasting glucose (≧100 mg/dl); (3) blood pressure (BP; ≧130/85 mmHg); (4) high-density lipoprotein (HDL; <40 mg/dl for men and <50 mg/dl for women); and (5) triglyceride (TC; (≧150 mg/dl). For such a patient, invasive blood test is the definitive method for verifying metabolic syndromes. Nevertheless, for most community health care providers, invasive blood test can seldom be conducted because of inconvenience in drawing blood and taking care of blood sample. A simplified non-invasive assessment method is needed to help predict the risks of metabolic syndrome in community dwellers and to facilitate subsequent disease prevention in a more convenient and efficient manner.

HRV as a non-invasive assessment method is associated with metabolic syndrome. The human heart beats, even under a stable physiological state, may still present a specific degree of change or variance (McMillan, 2002; Jao, Lin, Sheng, Chen, & Ho, 2009) known as HRV. In

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normal conditions, the sympathetic and parasympathetic nerves produce mutual constraints to achieve equilibrium (Vinik et al., 2003; Stein et al., 2007). Metabolic syndrome has been found to occur primarily due to insulin resistance (Moran et al., 2004; Kartal & Inci, 2011) and invades the autonomic nervous system, hindering normal heart rate regulation and causes abnormal cardiovascular functions (Task Force of the European Society of Cardiology and the North American Society of Pacing & Electrophysiology, 1996; Hwang & Huang, 2007).

Unhealthy lifestyles have also been cited as a primary cause of MS (Grundy et al., 2004; Hwang et al., 2006), and also associated with increased MS prevalence is higher body mass index (BMI) caused by inactive lifestyles and poor dietary choices (WHO, 2003). Except for HRV, obesity, sedentary work, improper diet, and other environmental factors have been identified as the main causes of metabolic syndrome (Grundy et al., 2004). All these suggest that a crucial correlation exists among metabolic risk indicators, HRV test, and lifestyle behaviors. The study was accordingly conducted based on the hypothesis that the proposed non-invasive method (composed of HRV, lifestyle, and simple physical assessments) helps predict the risk of metabolic syndrome.

2. Method

2.1. Research design and subjects

A cross-sectional research design with convenient sampling was used for this study. Adults aged between 20 and 65 years, with no impaired cognition, and having a health examination in the family clinic of a medical center were recruited as the research subjects and requested to sign a written consent to participate in the study. Patients were excluded if they were hospitalized, diagnosed with diabetes or hypertension, taking medication for hypertension or diabetes, or experienced a surgery within the past year. Several physiological test (i.e., waist circumference and blood pressure) and blood test items (i.e., fasting blood sugar and high-density lipoprotein levels) were measured, and the blood test results were extracted 1 week later from patients' medical reports.

Based on five major criteria for metabolic syndrome (waist circumference, fasting glucose, BP, HDL and TC), the research subjects were categorized into the following 4 groups: the general healthy group (G0) with subjects meeting none of the 5 metabolic syndrome criteria, study group 1 (G1) with subjects meeting 1 MS criterion, study group 2 (G2) with subjects meeting 2 MS criteria, and the patient group (G3) with subjects diagnosed with metabolic syndrome.

2.2. Study measures

The research tools comprised a demographic questionnaire, a simple physical assessment, a health promotion lifestyle profile-short form (HPLP-S), and an HRV testing instrument.

2.2.1. Demographic questionnaire

The demographic questionnaire has 6 items. They are age, gender, education level, marital status, smoking and drinking habits.

2.2.2. Simple physical assessment

The physical assessment focuses on the following eight items: systolic blood pressure (SBP), diastolic blood pressure (DBP), body fat, height and weight for BMI, neck circumference, waist circumference, and hip circumference.

2.2.3. Health promotion lifestyle profile-short form (HPLP-S)

The HPLP-S (Wei & Lu, 2005) has 24 items with a 4-point Likert scale. The scores range between 24 and 96 with a higher score indicating better performance in terms of health-promoting lifestyle performance. The HPLP-S comprises 6 subscales, including self-actualization, interpersonal support, stress management, health responsibility, nutrition, and exercise. The internal consistency of the scale ranged from .63 to .97, with an average of .90. Factor analysis results indicated that the 6 conceptual structural models were consistent with the data (GFI = .90, AGFI = .87, NFI = .94, NNFI = .96, SRMR = .055) (Wei & Lu, 2005).

2.2.4. HRV test

HRV was measured using the NeXus-10 tablet manufactured by Mind Media, a small 10-channel wireless biofeedback instrument with Bluetooth capability. The primary function of this tool is to measure the HRV of subjects during a state of rest. The HRV frequency can be divided into high frequency (HF, which measures parasympathetic activity), lower frequency (LF, which measures the regulation between the sympathetic and parasympathetic nervous systems) and very lower frequency (VLF, which measures neuroendocrine and thermoregulatory functions). Subsequently, LF is divided by HF to obtain the LF/HF ratio (the suggested standard for adults is 1.5 to 2.0 ms^2) (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

Prior to the research, the biofeedback instrument was returned to its manufacturing factory for calibration and maintenance to ensure instrument functionality and accuracy. The analytical software employed in the study was BioTrace$^+$, which is also developed by Mind Media. This software can synchronously and continuously monitor and record ECG signals in 5 min intervals to obtain HRV-related data. The effectiveness of the biofeedback instrument and analytical software has been confirmed in numerous previous studies (Jadidi, Castrillon, & Svensson, 2008; Lourenção, Battistella, de Brito, Tsukimoto, & Miyazaki, 2008). The instrument is palm-sized and compact, and the process from startup to finger attachment can be completed in 5 min.

2.2.5. Metabolic indicator blood testing

Adopted as a criterion for placing the research subjects in proper groups of MS risk, the metabolic indicator blood test as an invasive physical assessment included fasting glucose test and HDL test performed in the lab of a medical center to measure blood sugar and HDL levels. The test and physical inspection results were then examined to determine the baseline for grouping.

2.3. Research procedures and theoretical considerations

This study was approved by the institutional review board of the medical center from where the research subjects were recruited. Potential subjects were invited to participate in the study following researcher/physician coordination. Prior to inclusion, the objectives and procedures of the present study were explained to the subjects with a written consent. Appropriate time and place were allocated to the subjects to conduct the various tests. To maintain the autonomy and privacy of the subjects, the questionnaires were completed anonymously, and the subjects were free to withdraw from the study at any time.

The research subjects were first required to receive a metabolic indicator blood test, and the 8-item simple physical assessment was conducted before the subjects proceeded to complete the demographic questionnaire and the HPLP-S survey. Finally, the subjects were instructed to sit in a relaxed position for 5 to 10 min, in which they were provided clear instructions about the ensuing HRV test. This helped reduce potential anxiety that might occur because of the lack of understanding about the HRV instruments and procedures. During the HRV test, the subjects were instructed to sit on a chair with the HRV wireless sensor attached to the index finger of their non-dominant hand for 5 minutes.

2.4. Statistical analysis

A descriptive analysis was used to examine the demographic data and research variables. The research subjects were categorized into