Prediction of Body Mass Index: A comparative study of Multiple Linear Regression, ANN and ANFIS models

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Abstract

A report by the National Cholesterol Education Program’s Adult Treatment Panel III recognized metabolic syndrome as a multiplex risk factor for cardiovascular hearth disease (CHD) as well as type 2 diabetes; therefore, it is important to give these factors further clinical attention. Early diagnosis and prediction of disease, particularly the diseases related to metabolic syndrome, are increasing dramatically. On the other hand, most patients with metabolic syndrome are obese or overweight. In this regard, an accurate BMI estimation model based on metabolic syndrome components and risk factors provides facilities to control these modifiable components through various lifestyle changes. Thus, this study investigates if the people who have metabolic syndrome components and risk factors are expected to be obese. The central issue is selecting the appropriate model from a potentially large class of candidate models. Multiple Linear Regression (MLR) and two soft computing techniques, namely: Artificial Neural Networks (ANN) and Adaptive Neuro-Fuzzy Inference System (ANFIS) by considering Metabolic Syndrome components as input variables, were chosen and applied in this study. ANFIS is a particular form of ANN with a hybrid intelligent system. ANFIS benefits from the ANN’s superior learning algorithms and Fuzzy Inference Systems’ excellent estimation functions. Obviously, all three developed models are capable of predicting BMI value. The performance of these three estimation models (MLR, ANN and ANFIS) were compared based on RMSE, MAPE and $R^2$. Consequently, the results indicate that the ANFIS model is more feasible than the other two models in predicting BMI.

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1. Introduction

Body Mass Index is a simple measurement that uses a weight-to-height ratio and is used to classify adults who are underweight, overweight or obese. BMI is calculated as the person’s weight in kilograms divided by the square of their height in meters (kg/m²) (Hiza, Pratt, Mardis, & Anand, 2001; WHO, 2013). As the BMI increases, particularly in cases where the BMI exceeds 30, the health risks also rise accordingly (Hiza, Pratt, Mardis, & Anand, 2001). In general, public health guidelines define a BMI between 18.5 and 24.9 kg/m² to be normal, between 25.0 and 29.9 kg/m² is considered overweight and ≥ 30.0 kg/m² is obese (National Heart, 1998; Hiza, Pratt, Mardis, & Anand, 2001). Globally, obesity has become a significant threat for many countries. In fact, the prevalence of obesity is growing in both developed and developing countries (Ng, et al., 2014). A higher BMI is determined to be frequently associated with the increased risk of cardiovascular heart disease (CHD), type 2 diabetes and certain types of cancers (Field, et al., 2001). A report by the National Cholesterol Education Program’s Adult Treatment Panel III (NCEP ATP III) (Williams, 2002) recognized metabolic syndrome as a multiplex risk factor for CHD as well as type 2 diabetes; therefore, it is important to give these factors further clinical attention (Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004; Sancar &Tinazli, 2016). According to the NCEP ATP III definition, metabolic syndrome is present if three or more of the following five components are met: waist circumference over 102 cm (men) or 88 cm (women) blood pressure over 130/85 mmHg; fasting triglyceride (TG) level over 150 mg/dl; fasting high-density lipoprotein (HDL) cholesterol level less than 40 mg/dl (men) or 50 mg/dl (women); and fasting blood sugar over 100 mg/dl. Furthermore, most of the patients with metabolic syndrome are obese or overweight. In order to provide more effective guidance for public health authorities, it is important to understand the complex systems of inter correlated influences on BMI (Yu, Liu, Alhamzawi, Becker, & Lord, 2016).

The aim of this study is to investigate if the people who have metabolic syndrome components and risk factors are expected to be obese. Therefore, the objective is to establish a biologically reasonable model to predict BMI with metabolic syndrome components and associated risk factors. Since the risk of contracting metabolic syndrome can be reduced by controlling these modifiable components and risk factors through various lifestyle changes (smoking cessation, healthy nutrition, physical exercise, etc.), thus, obesity can be prevented. This is because, as stated previously, it is expected that people with metabolic syndrome are obese. In this study, MLR, ANN and ANFIS estimation models were applied and compared to identify a reasonable model in order to predict BMI. Literature reviews revealed that recent research into finding a feasible BMI estimation model based on the metabolic syndrome components, soft computing techniques and regression modelling have not been considered. Considering the current lack of this new perspective, the present study has shown the importance of the biologically acceptable model.

2. Materials and Methods

Pearson correlation coefficient (r) was used to prepare the input (independent, predictor or explanatory) variables; Multiple Linear Regression (MLR), Artificial Neural Network (ANN) and Adaptive-Neuro Fuzzy Inference Systems (ANFIS) structures and implementations are all discussed in this section. Fig. 1 shows the block diagram of the current study.
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