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Detection of high density lipoprotein cholesterol using feed forward artificial neural network.

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Abstract

The high-density lipoprotein-cholesterol (HDL) is well known as the "good cholesterol", since it removes harmful "bad cholesterol" out of blood. Low HDL levels increase the risk for cardiovascular diseases. This paper presents a solution for detection of low HDL level by using artificial neural network (ANN). The big dataset with 1517 persons is used for ANN training, validation and testing. Our solution achieves positive predictive value PPV=0.6782 and negative predictive value NPV=0.7066, which means that it is suitable both for positive and negative low HDL level detection.

Keywords: Artificial neural networks, Big data, Low HDL cholesterol level, Metabolic syndrome.

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Introduction

There are numerous proofs that dyslipidemia has major role in development of cardiovascular disease [1]. The high-density lipoprotein-cholesterol (HDL) is known as the "good cholesterol", because it transports "bad cholesterol" away from the arteries and back to the liver. High HDL level will reduce risk of cardiovascular diseases, particularly heart attack and stroke. The HDL levels [2,3]:

- HDL<1.29 mmol/l for women,
- HDL<1.03 mmol/l for men, increase the risk for cardiovascular diseases. In this paper we will present a solution for detection of low HDL level by using artificial neural network (ANN). The ANN inputs are: gender (GEN), age (AGE), body mass index (BMI), systolic blood pressure (SBP) and diastolic blood pressure (DBP). The ANN output is low HDL level diagnosis (Low HDL) in true/false form. This solution provides an easy-obtained, non-invasive and low-cost diagnosis of low HDL level. The paper is structured as follows. The second section presents measurements and dataset characteristics. Description of ANN solution is in the third section, while the obtained results are in the fourth section.

Measurements

The group of 1517 volunteers (725 men and 792 women, aged 18 to 76) was inquired in accordance with at the Department of Endocrinology, Diabetes and Metabolic Disorders of the Clinical Centre Chennai. Table 1 presents dataset characteristics.

Table 1. *Dataset characteristics.*

	MM.	Mean	Std.	Max.
AGE	18	43.44	10.8	76
BMI	16.6	29.65	6.95	64.6
WHIR	0.36	0.56	0.1	1.01
SBP	90	130.99	18.46	200
DBP	50	84.81	12.56	130
HDL	0.46	1.17	0.29	2.43

Body mass index (BMI) is calculated as the ration:

$BMI\ (kg/m^2)=BM\ (\text{kg})/(BH\ (m))^2$

Where *BM* is body mass measured using balanced beam scale with the precision of 0.1 kg and *BH* is body height measured using Harpenden anthropometer with the precision of 0.1 cm. Waist-to-height ratio (*WHtR*) is calculated as the ratio:

$WHtR=WC\ (m)/BH\ (m)$

Where *WC* is waist circumference measured using flexible tape with precision 0.1 cm, at the level of middle distance between the lowest point on the costal arch and the highest point on the iliac crest. By the standard procedure, in the morning hours, after 10-15 minutes of rest, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using sphygmomanometer. The values SBP ≥ 140 mmHg and DBP ≥ 90 mmHg are considered as high according to recommendations of European Society of Hypertension and American Heart Association [4-6].

Levels of cholesterol were determined by the standard enzyme procedure. The values of HDL cholesterol were determined by precipitation procedure with sodium-phospho-wolframate.

Feed Forward Network-Artificial Neural Network

Artificial neural network (ANN) is a model of artificial intelligence that simulates a network of biological neurons. It takes previously solved examples i.e., known data, learn complex relationships between inputs and outputs and become able to predict the output from a given input, i.e., unknown data. ANN is suitable for analysing, modeling and making sense of complex clinical data and can be very useful for medical diagnosis [7]. In numerous clinical areas, ANN has proven to be a better predictive tool than classical statistical methods (e.g. prediction of the heart attack, easy and low-cost identification of metabolic syndrome, primary estimation of the cardiometabolic risk, determination of WHtR limit for predicting hyperglycemia) [8-10].

The ANN input vectors have following structure:

$X(i)=(GEN(i), AGE(i), BMI(i), WHtR(i), SBP(i), DBP(i))$, while the output values are:

$Y(i)=Low\ HDL(i)$,

where i=1,2, ... 1517.

Coefficient *Low HDL* has value true or false depending on whether the considered person has or has not low HDL level. In order to perform ANN training, validation and testing, we randomly divide the dataset (1517 persons) with the proportion 80:10:10. In the MATLAB (Neural Network Toolbox), various feed-forward architectures with one hidden layer and 1-20 hidden neurons were trained by using: *trainlm* as a network training function, *tansig* neural function in hidden layers, *purelin* neural function in output layer and training parameters: $min\_grad=10^{-10}$, $mu=10^{-3}$, $mu\_dec=0.1$, $mu\_inc=10$ and $mu\_max=1010$.

Results

The whole procedure for each ANN architecture was repeated 100 times and the average positive predictive value PPV and negative predictive value NPV, and their standard deviations were calculated for testing sets. By definition, PPV and NPV are rations

$PPV=NTP/NTP+NFP$

$NPV=NTN/NTN+NFN$

- where *NTP*, *NFP*, *NTN* and *NFN* number of true positives, number of false positives, number of true negatives and number of false negatives are respectively:

The obtained results are given in the Table 2 and optimal ANN architecture is selected based on the maximal average PPV and NPV on the testing set.

From Table 2 it follows that the maximal PPV=0.6782 is achieved by the ANN architecture with HN=19. The maximal NPV=0.7066 is achieved by the ANN architecture with HN=9, and it leads to the conclusion that our ANN solution is suitable both for positive and negative prediction of *Low HDL*.

Table 2. *Average PPV and NPV, and their standard deviations on the testing set.*

HN	PPlicean	PPVstel	ATmean	NPVsld
1	0.6745	0.1018	0.6609	0.2027
2	0.6767	0.0907	0.677	0.1777
3	0.6727	0.0773	0.6913	0.1489
4	0.667	0.0719	0.7003	0.1318
5	0.6661	0.0669	0.7037	0.1201
6	0.6659	0.0633	0.7052	0.1114
7	0.666	0.0628	0.7063	0.1045
8	0.667	0.06	0.7064	0.0993
9	0.6688	0.0585	0.7066	0.095
10	0.6706	0.058	0.705	0.0935
11	0.6717	0.0565	0.7031	0.0907
12	0.6731	0.0556	0.7009	0.0889
13	0.6734	0.0544	0.7002	0.0863
14	0.6742	0.0534	0.7001	0.0843
15	0.6758	0.0531	0.6982	0.083
16	0.6767	0.0523	0.6971	0.0813
17	0.6766	0.0514	0.6966	0.0801
18	0.6776	0.0508	0.696	0.0789
19	0.6782	0.0503	0.6954	0.0777
20	0.6779	0.0498	0.6939	0.0768

Conclusion

In this paper, we have presented ANN detection of the low HDL level that includes solely non-invasive, low-cost and easily-obtained diagnostic methods. ANN inputs are: gender, age, body mass index, waist-to-height ratio, systolic and diastolic blood pressures, while ANN output is coefficient *Low HDL* in the true/false form. This solution provide that low HDL level can be detected in everyday clinical practice.

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