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ORIGINAL

The efficiency of artificial neural network (ANN) for diagnosis of obesity and hypertension

La eficacia de la red neuronal artificial (RNA) para el diagnóstico de la obesidad y la hipertensión

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Abstract

Aim & Background: Obesity and hypertension are health problems in any society. The aim of this study was to evaluate the sensitivity, specificity and accuracy of artificial neural network (ANN) for the diagnosis of obesity and hypertension. Material & ***Methods:*** For this study, demographic information about 500 students aged 7-18 years was recorded in the ANN program. The recorded demographic information consisted of 11 input variables and 3 output variables. Input variables included age, sex, weight, height, waist circumference, body mass index, waist-to-height ratio, abdominal obesity, physical activity, genetics, and unhealthy eating behaviors, while output variables included obesity, systolic blood pressure, and diastolic blood pressure. In this study, Levenberg-Marquardt and Conjugate Gradient algorithms were used to training the network.
Results: The results showed that the sensitivity, specificity and accuracy of ANN based on experimental data in the diagnosis of obesity were equal to 0.941, 1 and 0.990, respectively; for high systolic blood pressure were 0.800, 1 and 0.970 and for high diastolic blood pressure were 0.875, 1 and 0.980, respectively. In addition, it was found that the sensitivity, specificity and accuracy of ANN based on the obtained total data in the diagnosis of obesity were equal to 0.945, 0.997 and 0.992, respectively; for high systolic blood pressure were 0.857, 0.993 and 0.970, respectively and for high diastolic blood pressure were 0.810, 0.997 and 0.900, respectively.
Conclusion: Based on the results of the present study, it can be concluded that ANN designed to diagnose obesity, systolic and diastolic blood pressure has high accuracy, so the use of ANN to diagnose other similar diseases was suggested.

Keywords: Artificial Neural Network, Health, Obesity, Hypertension, Efficiency, Iran.

Resumen

Objetivo y antecedentes: La obesidad y la hipertensión son problemas de salud en cualquier sociedad. El objetivo de este estudio fue evaluar la sensibilidad, la especificidad y la precisión de la red neuronal artificial (RNA) para el diagnóstico de la obesidad y la hipertensión.
Material y métodos: Para este estudio, se registró la información demográfica de 500 estudiantes de entre 7 y 18 años en el programa RNA. La información demográfica registrada constaba de 11 variables de entrada y 3 de salida. Las variables de entrada incluían la edad, el sexo, el peso, la altura, el perímetro de la cintura, el índice de masa corporal, la relación cintura-estatura, la obesidad abdominal, la actividad física, la genética y los comportamientos alimentarios poco saludables, mientras que las variables de salida incluían la obesidad, la presión arterial sistólica y la presión arterial diastólica. En este estudio, se utilizaron los algoritmos de Levenberg-Marquardt y de Gradiente Conjugado para entrenar la red.
Resultados: Los resultados mostraron que la sensibilidad, la especificidad y la precisión de la RNA basada en datos experimentales en el diagnóstico de la obesidad fueron iguales a 0,941, 1 y 0,990, respectivamente; para la presión arterial sistólica alta fueron 0,800, 1 y 0,970 y para la presión arterial diastólica alta fueron 0,875, 1 y 0,980, respectivamente. Además, se comprobó que la sensibilidad, la especificidad y la precisión de la RNA basada en los datos totales obtenidos en el diagnóstico de la obesidad eran iguales a 0,945, 0,997 y 0,992, respectivamente; para la presión arterial sistólica alta eran 0,857, 0,993 y 0,970, respectivamente y para la presión arterial diastólica alta eran 0,810, 0,997 y 0,900, respectivamente.
Conclusiones: En base a los resultados del presente estudio, se puede concluir que la RNA diseñada para diagnosticar la obesidad y la presión arterial sistólica y diastólica tiene una alta precisión, por lo que se sugirió el uso de la RNA para diagnosticar otras enfermedades similares.

Palabras clave: Red Neural Artificial, Salud, Obesidad, Hipertensión, Eficiencia, Irán.

Introduction

Obesity is a major public health problem, not only in developed countries but also in developing countries such as Iran, and has many medical and psychological consequences for children and adolescents[1]. Obesity is now so prevalent in the world's population that it is replacing nutrition and infectious diseases as the most important cause of disease. In particular, obesity is associated with diseases such as diabetes, heart disease, certain forms of cancer and sleep-disordered breathing and is determined by a body mass index higher than 30 kg/m^2 [2].

According to the World Health Organization, overweight and obesity are the abnormal accumulation of fat in the body that harms human health. In children and adolescents, the Body Mass Index (BMI) is used to measure overweight and obesity[3]. The BMI of each person is defined as the division of weight per kilogram by height squared in meters. Obesity lasts from childhood to adulthood and is significantly associated with increased blood pressure in adulthood. In addition, the level of blood pressure in childhood is the best predictor of blood pressure in adulthood[4-6]. Circulation throughout the body is done by the pressure created in the blood vessels of the body. Blood pressure is mostly related to heart rate and flexibility in the walls of the arteries. There are two types of blood pressure, such as systolic and diastolic. Systolic is the highest blood pressure and diastolic is the lowest blood pressure[7]. Despite the great variety in blood pressure, the general population in children and adolescents is called diastolic pressure of 80 mmHg or higher and systolic pressure of 120 mmHg or higher, hypertension[8].

High blood pressure is an important risk factor for heart and kidney failure. Since the most common sign and symptom in patients with high blood pressure is asymptomatic in them, its prevention can lead to the prevention of complications. There is a direct correlation between mean systolic and diastolic blood pressure and BMI; In other words, body mass index is an important predictor of hypertension[9,10]. In a similar study in Puerto Rican adolescents, a statistically significant relationship was observed between mean systolic and diastolic blood pressure and obesity[11]. Also, the study of the relationship between BMI, waist size, waist-to-height ratio and hypertension among Lithuanian adolescents aged 12-15 years, shows that BMI parameters and waist circumference are more strongly associated with hypertension and then the parameter Waist-to-height size more accurately predict hypertension[12]. Another study showed that waist size could be an important factor in predicting hypertension in Chinese children and adolescents aged 7-17 years. Also, BMI along with waist size had a greater effect on predicting blood pressure in children and adolescents[13].

Obtaining an estimate of the prevalence of obesity among children is necessary in order to assess the need for preventive measures and identify high-risk groups. Despite the global prevalence of obesity, there are limited reports from developing countries on the prevalence of obesity among children. In addition, in some studies, abdominal obesity and obesity and the combined effect of both factors in increasing blood pressure have been identified[14-16]. A study of Greek adolescents aged 6-18 years showed that overweight and obesity can be controlled by modifying behavior and following the Mediterranean lifestyle, which includes the Mediterranean diet, physical activity and active lifestyle[17].

Recently, many researches have used artificial intelligence tools, especially artificial neural network (ANN), to diagnose and predict diseases in the medical field. The high capacity of ANN, which is inspired by biological computing networks, has led to their rapid expansion. Recently, some attempts to predict the percentage of excess body fat in adults with the approach of artificial neural networks have been reported[18-20]. The aim of this study was to evaluate the sensitivity, specificity and accuracy of ANN for the diagnosis of obesity and hypertension in students aged 7-18 years.

Material & Methods

This study is a descriptive-analytical study that is predicted by artificial neural network (ANN). In this study, ANN predicts and evaluates the status of obesity and hypertension in children and adolescents based on input variables. The statistical population of this study was 500 students aged 7-18 years. The researcher-made questionnaire[21] related to the objectives of the present study was completed by a specialist physician and researchers.

The questionnaire included various information such as age, gender, weight, height, waist circumference, body mass index (BMI), and waist to height ratio, abdominal obesity, physical activity, genetics, unhealthy eating behaviors, obesity, systolic blood pressure and diastolic blood pressure. Unhealthy eating behaviors include the daily consumption of fast food, cakes, cookies, chips, puffs, sugary drinks and soft drinks by children and adolescents, which can lead to obesity and high blood pressure. Unhealthy eating behaviors are scaled at three levels: low, medium and high[22,23]. Specifications for 11 input variables (including: age, sex, weight, height, waist circumference, abdominal obesity, BMI, waist-to-height ratio, physical activity, genetics, and unhealthy eating behaviors) and three output variables (including: obesity, systolic blood pressure and diastolic blood pressure) are shown in **table I**.

Table I: Specifications of input and output variables in the present study.

Variable name (symbol)	Variable type (Input / Output)	Mean	Minimum	Maximum
Age (I-1)	Input	12.59	7.05	19
Gender (I-2)	Input	0.52	0	1
Weight (I-3)	Input	42.06	15.7	103.2
Height (I-4)	Input	148.2	102	195
Waist size (I-5)	Input	68.5	27.5	111.5
Abdominal obesity(I-6)	Input	0.2	0	1
Body mass index (BMI) (I-7)	Input	18.7	10.45	44.65
Waist to height ratio (I-8)	Input	0.47	0.2	0.76
Physical activity (I-9)	Input	3.06	0	6.5
Genetics (I-10)	Input	2.09	1	4
Unhealthy eating behaviors (I-11)	Input	0.89	0	2.5
Obesity (I-12)	Output	0.11	0	1.1
Systolic blood pressure (I-13)	Output	100.57	61	153
Diastolic blood pressure (I-14)	Output	65.1	35	95

Finally, using the ANN toolbox in Matlab software, the entered data was analyzed. About 80% of the available data, ie 400 students, were used for education and the remaining 20% of the data, ie 100 people, were used for ANN testing. Finally, using Sigmolide tangent stimulus warping and two scaled conjugate gradient algorithms and Lunberg Marquardt, network training was performed and then the results were compared with each other. To determine the network with the best structure, trial and error method was used and networks with different number of neurons were trained.

Results

The results of the network with scaled conjugate gradient algorithm (SCGA) and Levenberg-Marquart algorithm (LMA) for output variables including obesity, systolic blood pressure, and diastolic pressure are presented. Regarding the output variable of obesity, comparison of network results showed that these variables with SCGA and LMA had 17 and 15 hidden neurons, respectively. While these values were 18 and 15 for systolic blood pressure output and 17 and 17 neurons for diastolic blood pressure, respectively. The accuracy values of the two algorithms (SCGA and LMA) for the designed network with the three output variables examined in **table III** are presented. In addition, the sensitivity, specificity and accuracy of the selected neural network are obtained based on the turbulence matrix of the experimental data and the whole data set for obesity outcomes, high systolic blood pressure, and high diastolic blood pressure, which were shown in **tables IV** and **V**. The results showed that the sensitivity, specificity and accuracy of ANN based on experimental data in the diagnosis of obesity were equal to 0.941, 1 and 0.990, respectively; for high systolic blood pressure were 0.800, 1 and 0.970 and for high diastolic blood pressure were 0.875, 1 and 0.980, respectively (**Table IV**). In addition, it was found that the sensitivity, specificity and accuracy of ANN based on the obtained total data in the diagnosis of obesity were equal to 0.945, 0.997 and 0.992, respectively; for high systolic blood pressure were 0.857, 0.993 and 0.970, respectively and for high diastolic blood pressure were 0.810, 0.997 and 0.900, respectively (**Table V**).

Table II: Network results by SCG and LMA algorithms for output variables.

Variable name	Algorithm type	Number of hidden layer neurons	Regression	Mean Squared Error	Gradient
Obesity	SCGA LMA	17 15	0.98123 0.99435	0.006148 0.000962	0.0038214 0.0031865
Systolic blood pressure	SCGA LMA	18 15	0.87721 0.92521	0.007804 0.0069324	0.013254 0.013952
Diastolic blood pressure	SCGA LMA	17 17	0.90234 0.92346	0.019251 0.019332	0.008449 0.007825

Table III: Designed network accuracy with two algorithms for obesity, systolic blood pressure and diastolic blood pressure.

Algorithm type	Output variables		
	Obesity	Systolic blood pressure	Diastolic blood pressure
SCGA LMA	0.9916 0.9948	0.9564 0.9821	0.9445 0.9674

Table IV: Designed network accuracy with two algorithms for obesity, systolic blood pressure and diastolic blood pressure.

ANN prediction	Control (Healthy)	Disease
Disease (Obesity)	0	16
Control (Healthy)	83	1
Disease (Systolic blood pressure)	0	12
Control (Healthy)	85	3
Disease (Obesity)	0	14
Control (Healthy)	84	2

Table V: Designed network accuracy with two algorithms for obesity, systolic blood pressure and diastolic blood pressure.

ANN prediction	Control (Healthy)	Disease
Disease (Obesity)	1	52
Control (Healthy)	444	3
Disease (Systolic blood pressure)	3	70
Control (Healthy)	415	12
Disease (Obesity)	1	81
Control (Healthy)	399	19

Discussion

Obesity and high blood pressure are the common health problems in Iranian adolescents. In addition, in recent years, the use of ANN in medical sciences with the aim of promoting health, has greatly expanded[24-28]. The main purpose of this study was to evaluate the sensitivity, specificity and accuracy by ANN for the diagnosis of obesity and hypertension in students aged 7-18 years.

Various studies have shown that the input parameters used in the design of this network have the greatest impact on the prediction of hypertension and obesity in children and adolescents. Askary Kachoosangy et al. (2015) reported that there was significant association between increased BMI and hypertension. Maintaining normal weight and BMI is recommended as a priority to prevent high blood pressure[29]. Also the results of the study of Yuan et al. (2017) showed that BMI and waist circumference variables are directly related to blood pressure in Chinese adolescents, although according to the results of this study, BMI variable is better than waist circumference variable to diagnose pediatric hypertension[30]. Based on the findings of the study Khaji et al. (2016) which was performed on fifth grade elementary school children in Tehran, it was found that the prevalence of overweight and obesity in them is about 10% and 6%, respectively. In addition, the results of that study showed that different weight groups have significant differences in terms of blood pressure, which indicates that blood pressure has a significant relationship with weight[31].

Many previous studies have demonstrated the effective function of the Multi-Layer Perceptron (MLP) neural network in diagnosing and predicting diseases such as obesity and hypertension. In the study of Huang et al. (2010), which evaluated the effectiveness of ANN application and logistic regression model on residents over 35 years of age in rural China, found that ANN more accurately assesses the risk of hypertension[32]. In a study by Samant and Rao (2010) that evaluated the ability of ANN designed with the Lunberg-Marquardt algorithm to predict the probability of hypertension in a community of healthy and sick people (with a history of hypertension) in India, the maximum accuracy of ANN designed in that study was 92.85%[33]. A study by Ture et al. (2005) were performed to compare classification methods (three types of decision trees, four statistical algorithms and two neural networks) to predict the risk of hypertension. The results of that study showed that the MLP and Radial Basic Function (RBF) neural networks had the best performance among the mentioned classification methods with 89.29% and 86.36% accuracy, respectively[34]. Duran et al. (2019) used ANN with four input variables including age, height, weight and waist circumference to diagnose and predict obesity in children, which achieved an accuracy of 92%[35], while in the present study with 11 input variable with 95% accuracy, ANN was designed to diagnose and predict obesity and hypertension in children and adolescents. This shows that more effective factors are used in determining obesity and hypertension, with much more accurate diagnosis and prediction. Considering that in the present study, 11 effective variables in obesity and hypertension were used, the number of quantitative variables was used in the previous research; therefore, the results of the present study had a higher accuracy.

The results of present study showed that the sensitivity, specificity and accuracy of ANN based on experimental data in the diagnosis of obesity were equal to 0.941, 1 and 0.990, respectively; for high systolic blood pressure were 0.800, 1 and 0.970 and for high diastolic blood pressure were 0.875, 1 and 0.980, respectively. In addition, it was found that the sensitivity, specificity and accuracy of ANN based on the obtained total data in the diagnosis of obesity were equal to 0.945, 0.997 and 0.992, respectively; for high systolic blood pressure were 0.857, 0.993 and 0.970, respectively and for high diastolic blood pressure were 0.810, 0.997 and 0.900, respectively.

In the present study, it was shown that having 11 input variables, a system can be designed to predict obesity and blood pressure in students. The system designed in the present study is more accurate than previous studies in which they used fewer parameters to predict blood pressure and obesity. Also, the results of the present study showed that ANN designed to provide appropriate results for the diagnosis and prognosis of obesity and systolic and diastolic blood pressure in students. The results of the present study showed that this system predicts obesity, high systolic blood pressure and high diastolic blood pressure in students with 99, 97 and 98% accuracy, respectively.

In addition, based on the results of the present study, it was found that high blood pressure and obesity are the common health problems in children and adolescents. Also, the rate of hypertension in obese students is significantly higher than other adolescents with lower weight. According to the results of the present study, about 85% of obese adolescents have high blood pressure. In addition, the prevalence of risk factors for cardiovascular disease is higher in obese individuals with high blood pressure. Therefore, the need to design educational programs in the field of lifestyle improvement through social, cultural and nutritional effects and provide the correct pattern of food consumption and physical activity can be appropriate strategies to promote community health.

Conclusion

Based on the results, it can be concluded that the use of more input parameters predicts obesity and hypertension in children and adolescents with higher accuracy. Although using more effective variables complicates the analysis process, this can be done with intelligent tools

such as ANN. Based on the results of the present study, it can be concluded that ANN is designed to diagnose obesity and hypertension, so the use of ANN to diagnose other similar diseases was suggested.

Conflict of Interest

There is no conflict of interest.

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