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Prediction of abdominal contouring response to low level laser using Artificial Neural Network

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Obesity has reached epidemic proportions globally, with more than 1 billion adults overweight, at least 300 million of them clinically obese, and is a major contributor to the global burden of chronic disease and disability. It is also an established health problem in Egypt by the World Health Organization (WHO). The purpose of this study is to investigate whether patients' sex, age, body mass index (BMI), and waist circumference can predict body contouring' response to low level laser therapy using Artificial Neural Network (ANN). One hundred thirty patients (53 male and 77 female) diagnosed clinically with localized obesity were enrolled in this study. All subjects' waistlines were treated by low level laser (LLL) with wave length 635 nm, 30 min three times a week for 6 weeks. The result of our study showed that there was significant decrease in waist circumference by using LLL.

Keywords: Obesity, Abdominal contouring, neural network, low level laser therapy.

INTRODUCTION

Obesity is over fat accumulation due to disturbed balance between energy intake and expenditure which caused by many possible causes and number of factors associated with its development (Gardner, 2003). There is high evidence that fat accumulation area has genetic basis but also increased tendency toward sedentary life style and over admission of high caloric food are strong promoters of central obesity (Ford, 2003). Abdominal obesity which is known by increased waist to hip ratio and associated with increased risk of cardiovascular disorders, type 2 DM, metabolic syndrome and obstructive sleep apnea (Arner, 2003).

Increased waist round measurement instead of body mass index (BMI), can show the strong relationship between obesity, hypertension and insulin resistance (Bajaj, 2004). Low level laser (LLL) treatment is application of low level laser that stimulate certain cellular activities and biochemical reactions (David and Abrahamse, 2009). Application of low intensity laser therapy (LLLT) at 635 nm with 10 mw intensity on adipose tissue show formation of transitory pores and complete adipocytes deflation (Neira et al., 2002).

The use of medical datasets has attracted the attention of researchers worldwide.

Data mining techniques have been widely used in developing decision support systems for diseases prediction through a set of medical datasets. As early as 1997, the potential of data mining for improving the problems in the medical domain had been identified by World Health Organization (WHO) The usefulness of knowledge detection from medical data repositories has been emphasized by WHO as it benefits medical diagnosis and prediction. Data mining is a process of discovering useful knowledge from database to build a structure (i.e., model or pattern) that can

meaningfully interpret the data (Esteva, et al., 2017).

Data mining uses many machine learning techniques to discover hidden pattern in data.

Artificial neural networks (ANN) have been successfully used in various biomechanical modeling scenarios, ANNs are universal function approximators that use supervised learning to create the desired nonlinear input–output relationship (black-box modeling) (Esteva, et al., 2017)

. The artificial neural network is comprised of nodes (shown as circles in Figure 1), an input layer represented as $x_1, x_2, \ldots x_n$, an optional hidden layer, and an output layer y. The ANN's objective is to determine a set of weights w (between the input, hidden, and output nodes) that minimize the total sum of squared errors. These weights w_i are adjusted according to a learning parameter $\lambda \in [0, 1]$ during training, until the outputs become consistent with the output. Too drastic changes to the weights may be made when the value of λ is large, while more iterations (called epochs) may be required when the value are too small before the model sufficiently learns from the training data. Finding parameters that learn from training data without over fitting (i.e. memorizing the training data) is considered a difficulty of using artificial neural networks, and therefore perform poorly on unseen data. The system may over fit the current data if there are too many hidden nodes, while it can prevent the system from properly fitting the input values if there are too few. Also, a choice of stopping criterion has to be chosen. This can include stopping based on when the total error of the network falls below some predetermined error level or when a certain number of epochs (iterations) has been completed (Mousa, et al, 2015)

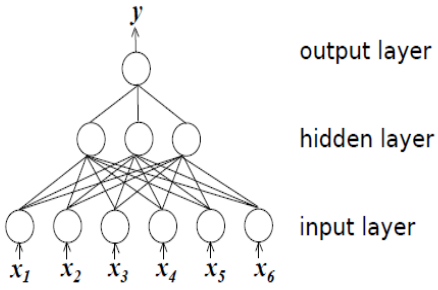

Figure 1:Multi-layer neural network

Therefore; the objective of our study was to predict the efficacy of LLL on abdominal contouring using artificial neural network which already used before in many medical fields with significant results (Esteva, et al., 2017). So this study may help clinical practitioners as a clinical guidance to save time and get better results with the patients.

MATERIALS AND METHODS

This was a 6-weeks study with two measurement points' baseline and 6 weeks of waist circumference. One hundred thirty Patients (n=130), men (m =53) and women (f=77) diagnosed clinically with localized obesity were enrolled in this study. Inclusion Criteria: Their age between 20 to 55 years. BMI 25-35 kg/m2 and initial waist circumference between 90–120 cm. Exclusion criteria includes, the participants did not have any previous surgical intervention for treatment area, any endocrine problems and any associated co-morbidities such as; neurological diseases, malnutrition, and other inflammatory and/or infectious diseases. All participants were given a full explanation of the treatment protocol and a written informed consent form giving agreement to participation and publication of results was signed by the patients.

Low level laser therapy:

Lipo Genie machine made in UK 635 nm wave length was used in this study which includes 10 inch-loss bars containing 60 laser diodes in total with 2 single-diode lymph probes, 2 pairs of protective laser goggles and 6 fabric straps. All participants' waistlines were treated 30 min three times a week for 6 weeks by low level laser with wave length 635 nm.

Outcome measures:

Waist circumference:

The waist circumference was measured with the participants in fully relaxed supine position by using a horizontal tape at the end of gentle expiration midway between the lower rib margin and iliac crest 3 times and the means of 3 measurement trials was used for statistical analysis. The waist circumference was classified according to the decrease in the waist measurement as follow; the degree of improvement will be good when the circumference decreased 5 cm and it will be very good when it is more than 5 cm.

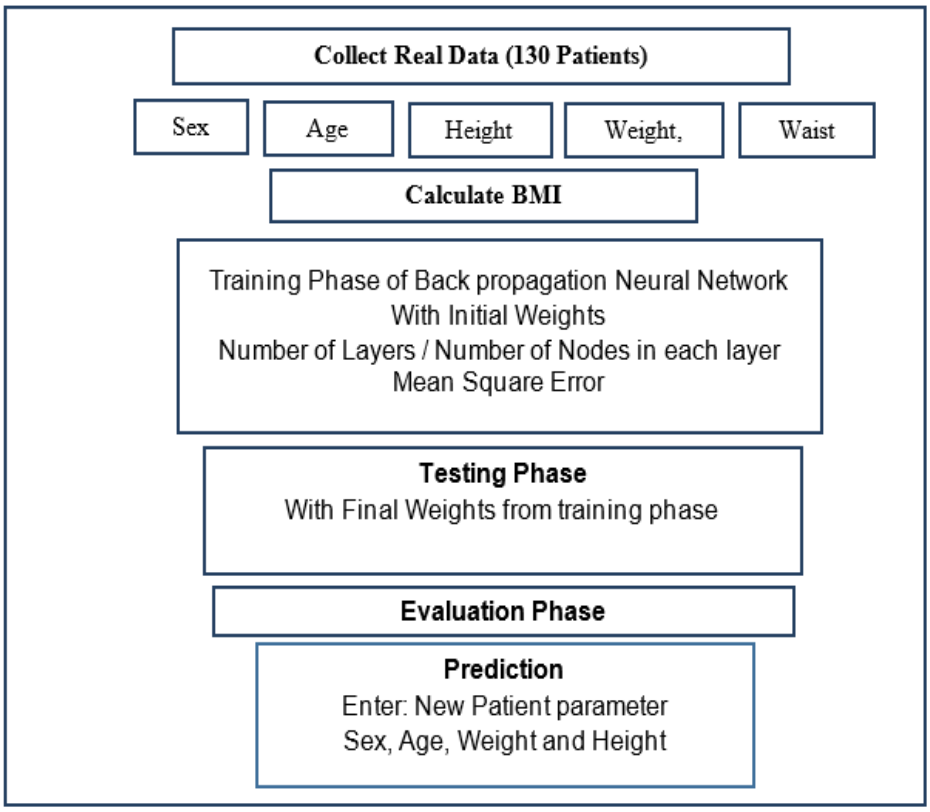

Figure 2: introduce the phases of the proposed system that used to predict the efficacy of low level laser on abdominal contouring using ANN.

Proposed System:
the phases of the proposed system that used to predict the efficacy of low level laser on abdominal contouring using artificial neural network includes the following phases (figure 2),

Training phase:
in this phase collecting all training data for each patient (age, height, weight, and Sex), calculate BMI, representing each case by ne feature vector, with initial weights, learning rate, and mean squared error and train the ANN to find the final weights given the samples that collected in step.

Testing phase;
Representing each testing case by one feature vector and applying the final weights from the training phase to determine the final medical decision. Evaluation phase; with different k-fold cross validation, we evaluate the proposed model and *finally* the Prediction phase; the proposed model was used to predict the waist circumference of a new patient.

RESULTS

In this study 130 obese individuals was participated and the waist circumference (WC) was measured at the beginning of study (WC baseline) and at the end of 6weeks (WC 6 weeks).The proposed system was evaluated by using Matlab R2015b program to implement and test our system. A number of experiments have been conducted using laptop with the following specifications: 6 GB of RAM, Intel® Core™ i5-4210U CPU running at 2.40 GHz and under Windows® 64-bit operating system. And the data was analyzed by using SPSS version 16 (IBM, Inc.). For all measures, the significance was set at an alpha level of 0.05, and the data are presented as means and standard deviations (SDs).

Age

Regarding to the age distribution of patients in this study, more than 48% of the patient's ages were 30 to 40 years old, 30% between 20 to 30 and 20% between 41 to 50 years.

Table 1: Properties of variables with respect to waist improvement

Waist Improvement	age	BMI	WC (baseline)	WC (6 weeks)	Percentage of WC improvement %
Good	35.3±7.06	31.5±3.49	98.0±9.37	93.7±9.21	35.4 %
Very Good	34±6.9	33.6±4.78	108.1±11.55	100±10.7	64.6 %

Table 2: Correlations between variables

waist	Sex	Age	BMI	WC
Pearson correlation (Significant 2-tailed)	-.009	-.003	.227**	.603**

**Correlation is significant at the 0.05 level (2-tailed).

Table 3: Accuracy of ANN

layers	Nodes in layer 1	Nodes in layer 2	Nodes in layer 3	# of iteration	Accuracy
3	7	5	1	100	93%
3	7	7	1	100	96%
3	10	5	1	100	98%

Waist circumference improvement

Table 1. Shows that the mean ±SD of good waist improvement of the age was 35.3±7.06, BMI was 31.5±3.49 and waist circumference at baseline measurement was 98.0±9.37and 93.7±9.21 in the post 6 weeks measurement. While very good improvement were as mean of age was 34±6.9, BMI was 33.6±4.78 and waist circumference in initial measurement was 108.1±11.55 and 100±10.7 in the post 6 weeks measurement. Also; there was significant relation with BMI and waist circumference while no significant relation with sex and age (table 2)

Accuracy of ANN

Table 3 summarizes results for data set using different architecture of ANN, the authors pick number of layers and nodes in each layer to train the samples and get the weights of the network, we test the data in different cases in case of using three layers, in the first layer we pick 10 nodes, 5 nodes in the second layer and 1 node in the output layer we got 98% accuracy. According to the result of our study the training size effect was investigated on the classification accuracy, and the classification accuracy was improved as the training set size increased. Building the system is not developed through programming; it is actually developed through learning. Usually, the analyst is left by the interesting part of work as neural networks teach themselves using the patterns from the data. Building informative models whenever conventional approaches fail can be done by neural networks. As we can usually depend on neural networks to handle the most complex interactions as they can in a very easy way model data that is too difficult to be modeled with any traditional approaches such as inferential statistics or programming logic.

DISCUSSION

The main outcome of this study is that LLLT decreases waist circumference in obese persons. Noninvasive body reshaping has become a wide use solution to deal with unwanted fat. LLLT has previously been used for many medical conditions like wound healing, management of edema, and pain control (Hall et al., 1994). Within the past decade, it has become the newest modality for noninvasive body contouring, treating a patient population that is shying away from surgical cosmetic procedures and opting for less invasive and safer options (Caruso et al., 2007). Research has demonstrated that LLLT can reduce overall

body circumference measurements of specifically treated as well as non-treated remote regions. It has been proven effective, and cleared by the FDA for the reduction of circumference of hips, waist, thighs, and, most recently, upper arms. Recent studies indicate that the results of LLLT are long-lasting if not permanent. With no adverse events reported to date, LLLT appears to be both safe and effective for fat reduction and body slimming (Neira et al., 2002).

In this paper, we have proposed a system for prediction of abdominal Contouring Response to LLLT using Artificial Neural Network for real data set. In this system, we have applied software using neural network technique in prediction because it is used to solve complexity problems. Artificial network adapts itself by sequential training algorithm and its architecture and connected weights.(Chine, et al., 2016) The accuracy of the proposed technique is 95.1 accuracy that is used to help clinicians to treat local obesity.

In the future work, we will work to increase the number of cases in database and increase number of features to increase accuracy rate and evaluate our system whether it will give the same good results.

CONCLUSION

In this paper, we have proposed a system for prediction of Body Contouring Response to low level laser using Artificial Neural Network for real data set. In this system, we have applied software with accuracy 98% using three layers back propagation neural network that is used finally to help medical practitioner to treat local obesity with better results.

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CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

ACKNOWLEGEMENT

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AUTHOR CONTRIBUTIONS

AMN, ZMM, RAE designed and performed the experiments and also wrote the manuscript. AMN, ZMM, RAE performed treatment of laser protocol, data collection, and data analysis. AMN, ZMM, RAE designed experiments and reviewed the manuscript. All authors read and approved the final version.

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