MACHINE LEARNING APPROCH TO STUDY THE IMPACT OF OBESITY ON AUTONOMIC NERVOUS SYSTEM USING HEART RATE VARIABILITY FEATURES

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ABSTRACT: Obese people have high chances of cardiovascular disease (CVD), which is supposed to be due tothe alteration in autonomic nervous system (ANS) activity. The changes in ANS activity can be identified using heart rate variability (HRV). HRV is a non-invasive tool to measure the ANS activity using linear and non-linear HRV features. The paper presents an aim to understand the effect of obesity on ANS using HRV parameters. Initially, sixteen control and sixteen obese subjects of both the gender between ages 20 to 50 were involved in the study after that synthetic minority oversampling technique (SMOTE) was used to increase the sample size of control and obese subjects from sixteen to forty-eight. The statistically significant difference between two groups was observed using the independent t test. The statistical results of the study indicate the sympathovagal imbalance due to reduced parasympathetic activity. The statistical results were validated by incorporating the machine learning technique into the study. Machine Learning (ML)algorithm helps to identify the most important predictor that can clearly differentiate control and obese subjects. The statistical and ML algorithm result shows changes in the sympathovagal balance due to decreased parasympathetic activity.

INDEX TERMS: –Obesity, Cardiovascular disease (CVD), Autonomic nervous system (ANS), Heart rate variability (HRV), Synthetic minority oversampling technique (SMOTE), Machine Learning (ML).

I. INTRODUCTION

One of the leading disorders that enhance mortality in an obese person. The definition of obesity says an excessive fat accumulation in the body that resulted in chronic diseases like hypertension, CVD, myocardial infarction (MI), and diabetes. Many researchers have found a strong correlation between obesity and CVD. The study has suggested that an imbalance of autonomic activity increases CVD chances in obesity. The ANS is a control mechanism of the body that generally maintains homeostasis in the body. ANS regulates the glands, blood vessels, and internal organs. The ANS is divided into two branches sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS mobilizes the body systems to provide energy for the fight or flight response, whereas PNS conserve the energy by regulating the rest and digest response. HRV measures the effect of the ANS function on heart as the vagal nerve is the mediator between ANS and heart. Even a small change in ANS resulted in changes in heart rhythm. HRV is a variation

in the RR interval of electrocardiogram (ECG). Thus, HRV could be the most important and noninvasive method to investigate the impact of obesity on ANS. The significantly decreased HRV in obesity increase the chances of CVD. ANS control vital organs of the body, fluctuation in these organs can be represented using linear and non-linear HRV parameters. The paper is organized as follows- Section II presents the methodology where subjects, criteria for obesity, statistical test, and machine learning algorithm are discussed, section III discussed the statistical and machine learning results, and finally, the conclusion is given in section IV.

II LITERATURE SURVEY:

Obesity is the next major epidemiologic challenge facing today's doctors, with the annual allocation of healthcare resources for the disease and related comorbidities projected to exceed $150 billion in the United States. The incidence of obesity has risen in the United States over the past 30 years; 60% of adults are currently either obese or overweight. Obesity is associated with a higher incidence of a number of diseases, including diabetes, cardiovascular disease, and cancer. Consumption of fast food, trans fatty acids (TFAs), and fructose—combined with increasing portion sizes and decreased physical activity—has been implicated as a potential contributing factor in the obesity crisis. The use of body mass index (BMI) alone is of limited utility for predicting adverse cardiovascular outcomes, but the utility of this measure may be strengthened when combined with waist circumference and other anthropomorphic measurements. Certain public health initiatives have helped to identify and reduce some of the factors contributing to obesity. In New York City and Denmark, for example, such initiatives have succeeded in passing legislation to reduce or remove TFAs from residents' diets. The obesity epidemic will likely change practice for gastroenterologists, as shifts will be seen in the incidence of obesity-related gastrointestinal disorders, disease severity, and the nature of comorbidities. The experience gained with previous epidemiologic problems such as smoking should help involved parties to expand needed health initiatives and increase the likelihood of preventing future generations from suffering the consequences of obesity.

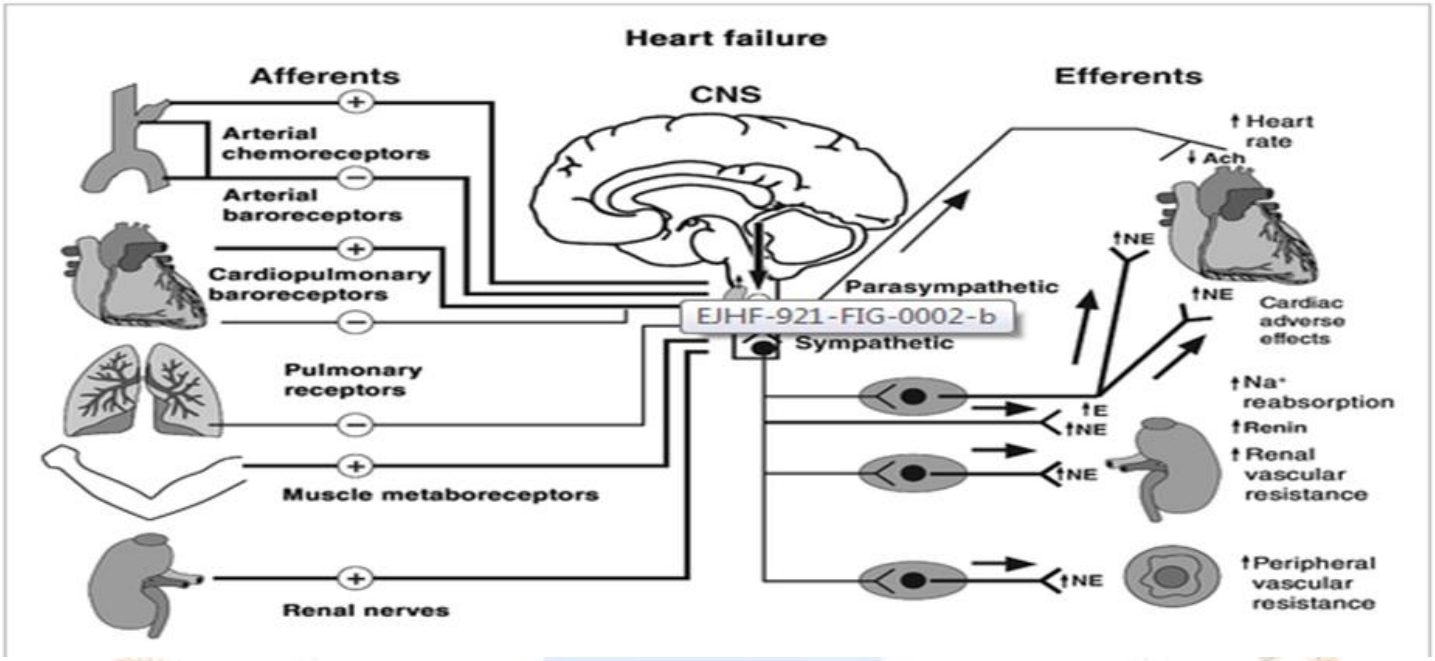
III. EXISTING SYSTEM

One of the leading disorders that enhance mortality in an obese person. The definition of obesity says an excessive fat accumulation in the body that resulted in chronic diseases like hypertension, CVD, myocardial infarction (MI), and diabetes. Many researchers have found a strong correlation between obesity and CVD. The study has suggested that an imbalance of autonomic activity increases CVD chances in obesity. The ANS is a control mechanism of the body that generally maintains homeostasis in the body. ANS regulates the glands, blood vessels, and internal organs. The ANS is divided into two branches sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS mobilizes the body systems to provide energy for the fight or flight response, whereas PNS conserve the energy by regulating the rest and digest response.

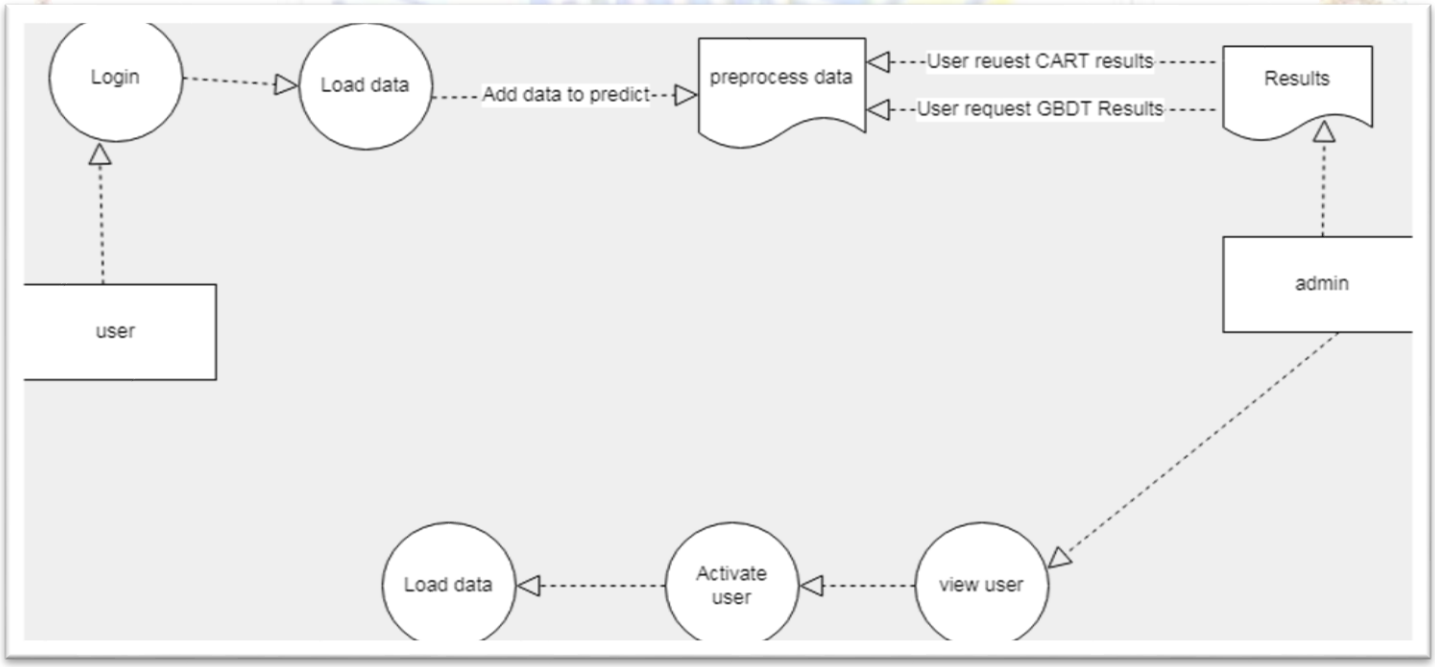
IV. PROPOSED SYSTEM

This study was performed solely for research purposes at the institute level with the permission of Dean Research and Development of College of Engineering Pune following all ethical guidelines. The researcher and subjects have made a voluntary agreement. The study involves the electrocardiogram (ECG) acquisition of sixteen normotensive obese individuals and sixteen control subjects between 20 to 50 years of age of both genders who participated in the study. However, sixteen sample size of control and obese are not sufficient to analyse the statistical results. Thus we have synthetically increased the sample size of control and obese subjects using the Synthetic Minority Oversampling Technique (SMOTE)[4]. It is powerful and most widely used technique. It creates random set of samples to balance minority class. New synthetic data samples are generated between randomly chosen minority class sample and its nearest neighbors' samples. The details about the implementation of SMOTE technique.

V.SYSTEM ACHITECTURE



Block Diagram



Data Flow Diagram

VI. RESULT ANALYSIS:

The time-domain HRV parameters mean RR, SDNN, and RMSSD were significantly reduced in the obese group. Reduced mean RR and SDNN indicate that the RR interval time series signal variability is reduced, and total variance is also reduced. The lower value of RMSSD represents reduced parasympathetic activity. The non-linear HRV parameters SD1 and SD2 were analyzed and found less in obese compared to control. The SD1 feature value was significantly less in obese that indicates the reduced short-term variability in the HRV signal. The ML algorithms are used to find the most important predictor that separates obese subjects from the control. However, in the statistical analysis, it was observed that most of the time domain, frequency domain, and non-linear HRV parameters are significantly reduced but do not give an important predictor. The important predictor can be found out using the feature importance technique, which provides a feature importance score to each feature. The feature importance scores greater than 0.90 or 90%, indicates the most important predictor. In this study, we found that mean RR, LF: HF ratio and HF (ms2) was the most important predictor. We have obtained mean RR and LF: HF important predictor using the CART algorithm, whereas HF (ms2) was the important predictor obtained using the GBDT. We have used only these predictors as input to the CART and GBDT ML algorithm. When we have applied the mean RR and LF: HF ratio as input to the CART algorithm, we got an accuracy of 96.55%, a sensitivity of 100%, a specificity of 92.86%, precision of 93.75%, F1 score of 0.96 with an AUC of 0.96. When we have used HF (ms2) as input to the GBDT algorithm, we observed accuracy of 93.10%, the sensitivity of 93.33%, the specificity of 92.86%, precision of 93.33%, F1 score of 0.93 with an AUC of 0.92. The important predictor indicates that the CART and GBDT ML algorithm can classify the obese and control subjects with an accuracy of 96.55%

VII. CONCLUSION:

In the present study, we have used short-term HRV analysis of obese and control subjects to study the impact of obesity on ANS. We have used real and synthetic HRV data for analysis. The results of the study are presented using statistical tests and a machine learning algorithm. The statistical analysis shows the significant reduction in HRV parameters of obese subjects compared to control and machine learning algorithm was used to found important HRV predictor. The statistical results suggest an alteration in sympathovagal balance due to less parasympathetic activity. Further, this was confirmed using the CART and GBDT algorithm, which showed a classification accuracy of 96.55% and 93.10%, respectively.

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