

**Digital Health Intervention on the Role of Vitamin D in the Management of  
Obesity and Sleep Apnoea among Overweight and Obese adults**

**SAGARIKA BHATTACHARYA**

**(20PFN019)**

**THESIS SUBMITTED TO**

**AVINASHILINGAM INSTITUTE FOR HOME SCIENCE AND HIGHER  
EDUCATION FOR WOMEN**

**COIMBATORE -641043**

**IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR DEGREE OF  
MASTER OF SCIENCE IN FOOD SCIENCE AND NUTRITION**

**MAY 2022**

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# Certificate

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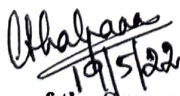
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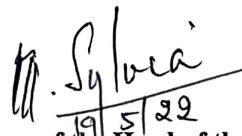
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19/5/22

**Signature of the Supervisor**

  
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**Signature of the Head of the Department**

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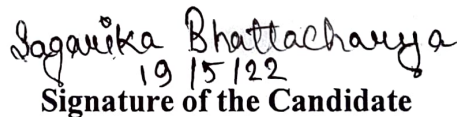
# Declaration

## DECLARATION

I hereby declare that the dissertation entitled “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese adults**”, submitted to the Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore, in partial fulfilment of the requirement for the award of the **Degree of Master of Science in Food Science and Nutrition** is a record of original research work done by me under the supervision and guidance of **Prof. (Mrs.) C. A. Kalpana**, Professor, Department of Food Science and Nutrition, Avinashilingam Institute for Home Science and Higher Education for Women, Coimbatore and that it has not formed the basis for the award of any Degree/ Diploma/ Associateship /Fellowship or similar title to any candidate of any other University and it represents entirely an independent work on the part of the candidate.

  
19/5/22

**Signature of the Supervisor**

  
19/5/22

**Signature of the Candidate**

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# Contents

# CONTENTS

<b>CHAPTER NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
	<b>LIST OF TABLES</b>	
	<b>LIST OF FIGURES</b>	
	<b>LIST OF PLATES</b>	
	<b>LIST OF APPENDICES</b>	
<b>I</b>	<b>INTRODUCTION</b>	<b>1-5</b>
<b>II</b>	<b>REVIEW OF LITERATURE</b>	<b>6-17</b>
	A. Obesity- Prevalence and Consequences	<b>6-9</b>
	B. Vitamin D and Obesity	<b>9-12</b>
	C. Obstructive Sleep Apnoea	<b>12-15</b>
	D. Digital Health Intervention for Obesity and Vitamin D Deficiency	<b>15-17</b>
<b>III</b>	<b>METHODOLOGY</b>	<b>18-35</b>
	<b>PHASE I:</b> Selection of Study Area and Respondents	<b>18-23</b>
	<b>PHASE II:</b> Selection and Formulation of Data Collection Tools	<b>23-24</b>
	<b>PHASE III:</b> Selection of Participants	<b>24</b>
	<b>PHASE IV:</b> Assessment of Nutrient Intake	<b>25</b>
	<b>PHASE V:</b> Conduct of Survey	<b>25-27</b>
	<b>PHASE VI:</b> Development and Implementation of Digital Health Intervention	<b>27-29</b>
	<b>PHASE VII:</b> Impact Evaluation	<b>29-35</b>
<b>IV</b>	<b>RESULT AND DISCUSSION</b>	<b>36-63</b>
	A. Background Information of the Study Participants	<b>36-43</b>
	B. Dietary Pattern of the Respondents	<b>43-46</b>
	C. Health Status of the Participants	<b>47-50</b>

	D. Sleep Pattern of the Respondents	<b>50-55</b>
	E. Nutrient Intake of the Selected Participants	<b>55-58</b>
	F. Impact of “D”-Obesa on Selected Obese and Overweight Adults	<b>59-63</b>
<b>V</b>	<b>SUMMARY AND CONCLUSION</b>	<b>64-69</b>
	<b>BIBLIOGRAPHY</b>	<b>70-77</b>
	<b>APPENDIX</b>	<b>78-79</b>

## LIST OF TABLES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
<b>I</b>	Background Information of the Study Participants	<b>37</b>
<b>II</b>	BMI Status of Respondents	<b>47</b>
<b>III</b>	Classification of Obesity among Obese Respondents	<b>48</b>
<b>IV</b>	Serum Vitamin D Level of Respondents	<b>49</b>
<b>V</b>	Classification According to Nutritional Status	<b>55</b>
<b>VI</b>	BMI Status and other Factors	<b>55</b>
<b>VII</b>	Mean Daily Nutrient Intake by Male Respondents (N = 52)	<b>56</b>
<b>VIII</b>	Mean Daily Nutrient Intake by Female Respondents (N = 48)	<b>57</b>
<b>IX</b>	Nutrient Intake, BMI Status and Sleep Apnoea	<b>58</b>
<b>X</b>	Improvement in KAP Scores after First Intervention	<b>59</b>
<b>XI</b>	Improvement in KAP Scores after One Week	<b>60</b>
<b>XII</b>	Improvement in KAP Scores after One Month	<b>61</b>
<b>XIII</b>	Mean Difference in KAP Scores	<b>62</b>
<b>XIV</b>	Difference in Mean KAP Scores of Three Phases	<b>62</b>
<b>XV</b>	Difference in Mean Scores of Knowledge, Attitude, and Practice	<b>63</b>

## LIST OF FIGURES

TABLE NO.	TITLE	PAGE NO.
1	Research Design	19-21
2	Sex of Respondents	38
3	Age of Respondents	38
4	Marital Status of Respondents	39
5	Area of Residence of Respondents	40
6	Educational Qualification of Respondents	41
7	Occupation of Respondents	42
8	Income Status of Respondents	43
9	Food Habits of Respondents	43
10	Intake of Dietary Supplements by Respondents	44
11	Night time eating by Participants	45
12	Type of Foods Consumed by Respondents at Night Time	46
13	BMI Status of Respondents	47
14	Physical Activity Level of Respondents	48
15	Serum Vitamin D Level of Respondents	49
16	Snoring while Sleeping by Respondents	50
17	Breathing Problem during Sleep	51
18	Sleep Paralysis Experience	52
19	Insomnia Experience by Respondents	53
20	Bed Time Phone Usage by Respondents	53
21	Nutrient Gap in Male Participants	56
22	Nutrient Gap in Female Participants	57
23	Mean Difference in KAP Scores	63

## LIST OF PLATES

<b>TABLE NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
<b>I</b>	Prevalence rates of obesity among adults at the national level and per state and union territory	<b>22</b>
<b>II</b>	Prevalence rates of overweight among adults at the national level and per state and union territory	<b>22</b>
<b>III</b>	Snapshots of Website “D”- OBESA	<b>30</b>
<b>IV</b>	Snapshot of YouTube Channel	<b>31</b>
<b>V</b>	Snapshot of Facebook Page	<b>31</b>
<b>VI</b>	Snapshots of WhatsApp Group	<b>32</b>
<b>VII</b>	Snapshot of Instagram Page	<b>32</b>
<b>VIII</b>	Snapshots of Virtual Meet	<b>33</b>
<b>IX</b>	Snapshots of Digital Health Intervention Materials	<b>34</b>

## LIST OF APPENDICES

<b>APPENDIX NO.</b>	<b>TITLE</b>	<b>PAGE NO.</b>
<b>I</b>	Survey Questionnaires	<b>78</b>
<b>II</b>	Ethical Committee Clearance Certificate	<b>79</b>

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# Introduction

## I. INTRODUCTION

Overweight and obesity, as defined by the World Health Organization, are abnormal or excessive fat accumulation that poses a health risk. A body mass index (BMI) of more than 25 kg/m<sup>2</sup> is considered overweight, and one of more than 30 kg/m<sup>2</sup> is considered obese.

Obesity is one facet of malnutrition's double burden. Except for Sub-Saharan Africa and Asia, every region now has more obese people than underweight people. Although it was once thought that overweight and obesity were only a problem in high-income countries, they are now dramatically on the rise in low- and middle-income nations, particularly in urban areas. The large bulk of overweight or obese children live in developing countries, where the rate of increase is more than 30 percent higher than in developed countries.

According to the global burden of disease, the issue has reached epidemic proportions, with over four million people dying each year as a result of being overweight or obese in 2017. Obesity and being overweight are major risk factors for a variety of chronic diseases, including cardiovascular diseases like heart disease and stroke, which are the leading causes of death worldwide.

Obesity can also lead to diabetes and its complications, such as blindness, limb amputations, and the need for dialysis. Diabetes prevalence has quadrupled worldwide since 1980. Excess weight can also cause musculoskeletal disorders such as osteoarthritis.

Obesity has also been linked to cancers such as endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon. Even if a person is only slightly overweight, the risk of these noncommunicable diseases increases and becomes more serious as the body mass index (BMI) rises. Obesity in childhood is linked to a variety of serious health complications, as well as an increased risk of the onset of related illnesses at a young age. According to studies, obese children and adolescents are likely to remain obese into adulthood if no intervention is implemented.

Many of the causes of overweight and obesity can be avoided or reversed. However, no country has been able to stop the spread of this epidemic. Obesity is caused by an imbalance of calories consumed and calories expended, despite the presence of other factors. Consumption of energy-dense foods high in fat and free sugars has increased as global diets

have changed in recent decades. Physical activity has also decreased as a result of the changing nature of many types of work, increased access to transportation, and increased urbanization.

Overweight and obesity rates in adults and children continue to rise. From 1975 to 2016, the global prevalence of overweight or obese children and adolescents aged 5–19 years has increased more than fourfold, from four per cent to 18 per cent (Obesity. <http://www.who.int/topics/obesity/en/>, 2022).

Obesity can be caused by both genetic and environmental factors. The majority of environmental causes are caused by lifestyle changes, which can be remedied through public health and other interventions. Genetic factors, on the other hand, are linked to vitamin D metabolism, storage, and action (Chauhan & Medithi, 2021).

Vitamin D (Scientific name: Ergocalciferol) is a fat-soluble vitamin. It is an essential micronutrient that serves a variety of functions in the human body. The inactive form of vitamin D, 25-hydroxyvitamin D [25(OH)D], is considered to be an indicator of the body's circulating vitamin D level (Alathari *et. al.*, 2020).

Adipogenesis has been shown to be influenced by vitamin D (Chauhan & Medithi, 2021).

Lower vitamin D is a consistent occurrence in obese population, across different ages, ethnicity, and geography. Obese people require higher doses of vitamin D to achieve the same serum 25(OH)D levels as people with normal weight (Walsh *et. al.*, 2017).

Epidemiological studies suggest that VDR plays a central role in regulating lipids by mediating its activity in adipocyte calcium metabolism and energy homeostasis, implying a link between VDR genetic variation and an increased risk of obesity susceptibility (Chauhan & Medithi, 2021).

Sleep apnoea is a clinical condition that can be characterised by loud snoring and daytime sleepiness (Mehra *et. al.*, 2008).

Among the different types of sleep apnoea, the most common type is Obstructive Sleep Apnoea Syndrome (OSAS). OSAS refers to recurrent episodes of partial or complete upper airway occlusion during sleep. As a result, sleep is disrupted and fragmented, there is arterial hypoxia, intermittent hypoxia, ventilatory overshoot hypoxia, local airway oedema

and inflammation, changes in intrathoracic pressure, and sympathetic nervous system surges.

Sleep apnoea is now common in most developed countries, with a male prevalence of 10-17 percent and a female prevalence of 3-9 percent. Sleep apnoea pathogenesis is multifactorial. It can develop as a result of inflammation or oxidative stress. Obesity, on the other hand, is a risk factor in approximately 70 per cent of reported cases (Archontogeorgis *et. al.*, 2018).

Obesity and sleep apnoea frequently coexist. Both of these conditions are associated with increased levels of inflammation and oxidative stress, and studies show that one disorder's pro-inflammatory effects influence the expression of another.

Obesity increases the risk of sleep apnoea by altering upper airway passages, lowering Functional Residual Capacity (FRC), and creating an imbalance in the respiratory drive and load compensation relationship. Sleep apnoea is strongly associated to central obesity caused by metabolic abnormalities; additionally, since sleep apnoea causes reduced sleep duration and sleep fragmentation, it may lead to weight gain through impacts on metabolism and appetite regulating hormones. Obesity and sleep apnoea are thus associated through bidirectional pathways.

The pathogenesis of low serum vitamin D levels in OSAS is complex. Chronic nocturnal intermittent hypoxia, manifested as fluctuations in oxyhaemoglobin saturation during sleep, is a key feature of OSAS. Hypoxia and dyspnea have been linked to lower serum 25(OH)D levels in studies. Serum Vitamin D levels in sleep apnoea patients were found to be associated with several hypoxia indices, including average and minimum oxyhaemoglobin saturation during sleep.

Vitamin D receptors in the skeletal muscles produce a number of transcription factors that are responsible for muscle cell proliferation and differentiation into mature, type II muscle fibres. Vitamin D also influences sarcomeric muscular contraction by controlling calcium transport into the sarcoplasmic reticulum. As a result, vitamin D deficiency is linked to proximal myopathy and can cause muscle weakness. This can lead to decreased pharyngeal dilator muscle strength, decreased pharyngeal patency, and finally, apnoeic events while sleeping (Archontogeorgis *et. al.*, 2018).

Digital health interventions offer immense potential as scalable solutions to improve the effectiveness, efficiency, accessibility, safety, and personalisation of health and healthcare delivery. Digital health interventions (DHIs) are the interventions that are delivered through digital technologies such as smartphones, websites, or text messaging. Digital health interventions have enormous opportunities to provide effective, cost-effective, safe, and scalable interventions to improve health and healthcare (Murray *et. al.*, 2016).

They are typically complex interventions with multiple components, and many have multiple goals, such as enabling users to be better informed about their health, sharing experiences with others in similar situations, changing perceptions and cognitions about health, assessing and monitoring specific health states or health behaviours, titrating medication, clarifying health priorities and reaching treatment decisions congruent with these, and improving communication between patients and healthcare professionals (HCPs).

Digital health interventions (DHIs) have the potential to improve the quality of life for the growing number of chronic disease patients (Kowatsch *et. al.*, 2019).

Obesity is a common condition with serious health consequences. Face-to-face interventions to treat obesity necessitate a large number of human resources and time, imposing a significant burden on individuals and the health-care system. Because of the anonymity, 24-hour accessibility, scalability, and reachability associated with Web-based programmes, the internet is an appealing tool for delivering weight loss programmes in this context (Beleigoli *et. al.*, 2019).

Self-monitoring is an essential component of standard behavioural obesity treatment. DHI helps with this component of obesity and overweight management (Patel *et. al.*, 2021).

Sleep disorders, particularly sleep-disordered breathing, are more common than previously thought. Many patients who experience apnoea and hypopnea suffer, while others do not complain or show cardiovascular consequences. Innovative methods provide smart solutions to problems that have received insufficient attention. Telemedical concepts aid in the early identification of patients who require sleep medicine expertise (Penzel *et. al.*, 2021).

The majority of people with sleep disorders go undiagnosed and untreated. The use of novel tools and mobile technology has the potential to improve diagnostic access (Rosa *et. al.*, 2018).

Novel eHealth methods are already providing smart solutions to previously unaddressed problems in the field of sleep-disordered breathing. Telemedical concepts such as video consultation assist in bringing affected patients to medical expertise at an early stage. Cloud-based diagnostics can aid in the reduction of existing intra- and inter-sectoral issues, as well as the improvement of interdisciplinary communication within established diagnostic pathways (Schöbel & Woehrle, 2020).

In this study, the information, education, and communication (IEC) approaches were used to reach adult men and women in which communication regarding various aspects of Vitamin D, Obesity, and Sleep Apnoea has been produced in various forms, such as Virtual Meeting Platforms, Web-based information, Social Media Posts, and text messages, using Google Meet, a website and mobile applications like Instagram, Facebook, and WhatsApp. The concept was to sensitise the selected adult men and women about the concepts related to Vitamin D, Obesity, and Sleep Apnoea as its prevalence is increasing every day.

With this in view the study was conducted with the following objective:

To

- Identify obese and overweight adult men and women.
- Elicit their background information related to health, dietary pattern, lifestyle physical activity, and sleep pattern.
- Develop a website for digital health intervention.
- Communicate nutritional information through the developed website.
- Evaluate the impact of digital health intervention on the Knowledge, Attitude, and Practice of the study participants.

### **Hypothesis:**

**H<sub>0</sub>:** There is no significant effect of the digital health intervention on the knowledge, attitude, and practice scores of the study participants.

**H<sub>1</sub>:** There is a significant effect of the digital health intervention on the knowledge, attitude, and practice scores of the study participants.

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# *Review of Literature*

## II. REVIEW OF LITERATURE

The review of literature pertaining to the study entitled, “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese adults**” is presented under the following headings:

- A. Obesity- Prevalence and Consequences**
- B. Vitamin D and Obesity**
- C. Obstructive Sleep Apnoea**
- D. Digital Health Intervention for Obesity and Vitamin D deficiency**

### **A. Obesity- Prevalence and Consequences**

Obesity and overweight are terms used to describe abnormal or excessive fat accumulation that poses a health risk (Obesity. <http://www.who.int/topics/obesity/en/>, 2022).

It is a multifactorial chronic state characterised by positive energy balance and excessive fat accumulation, which is associated with a lower life expectancy (Blüher, 2019).

The World Health Organization defines obesity as having a body mass index (BMI) of  $\geq 30$  kg/m<sup>2</sup> or higher (Noncommunicable Diseases Country Profiles, WHO, 2018).

The body mass index (BMI) is a crude population level measure of obesity that is calculated by dividing a person's weight (in kilograms) by the square of his or her height (in meters). Obesity is generally defined as having a BMI of  $\geq 30$  kg/m<sup>2</sup>. Overweight is defined as having a BMI of  $\geq 25$  kg/m<sup>2</sup> or greater (Pradhan *et. al.*, 2019).

According to WHO obesity is ‘abnormal or excessive accumulation of fat that presents a risk to health’. Body mass index (BMI) is used to classify and know about the extent of obesity. BMI is computed as the ratio of the body weight in kilograms by the height of the individual in meter square (kg/m<sup>2</sup>). Along with BMI, waist circumference (WC) is also used as an indicator of central fat mass.

Overweight and obesity are regarded as serious and growing public health issues worldwide. In several countries (NCD Risk Factor Collaboration. 2016), including India

(Luhar *et. al.*, 2018), the prevalence of overweight and obesity (ranging from 26% to 3%, respectively) and associated deaths (6.5%) are increasing rapidly.

A cross-sectional study conducted by Pradhan *et.al.*, 2019 among 510 adults was conducted to investigate the prevalence of overweight and/or obesity in Bengal's rural population. According to the WHO BMI guidelines for Asians, the overall prevalence of obesity among adults was 30.4 per cent, and the prevalence of overweight was 22.4 per cent in the study population. Recent developmental changes in rural India, such as better transportation, electricity, and mechanised agriculture, have greatly influenced the day-to-day lifestyle of the rural people, resulting in an increased burden of overweight/obesity (Pradhan *et.al.*, 2019).

According to recent studies, more than 1.9 billion adults worldwide are overweight, with 650 million obese. Overweight or obesity has been linked to approximately 2.8 million deaths. Obesity and its negative consequences are prevalent in developing countries due to the consumption of energy dense foods, sedentary lifestyles, a lack of health care services, and a lack of financial support. Obesity afflicted more than 135 million people in India. Obesity prevalence in India varies (Ahirwar *et. al.*, 2019).

Luhar *et al.*, 2020, forecasted the future prevalence of overweight and obesity based on the association between overweight and obesity and many noncommunicable diseases. Between 2010 and 2040, the prevalence of overweight will more than double among Indian adults aged 20 to 69, while the prevalence of obesity will triple. By 2040, the prevalence of overweight and obesity among men will be 30.5 per cent (27.4 per cent -34.4 per cent) and 9.5 per cent (5.4% -13.3%), respectively, and 27.4 per cent (24.5% - 30.6%) and 13.9 per cent (10.1% - 16.9%) among women. The largest increases in the prevalence of overweight and obesity are expected to occur in older age groups between 2010 and 2040, and we found a greater relative increase in overweight and obesity in rural areas compared to urban areas. The older age groups were expected to experience the greatest relative increase in overweight and obesity prevalence (Luhar *et al.*, 2020).

An imbalance in the weight of the body exceeding the height of an individual leads to development of obesity. This impairment is from the result of dietary habits, genetic factors, hormone level, and physical activity level, psychological and physiological condition. A positive energy balances due to lack of satiety in the body favours the development of obesity. There persist specific factors due to which the size of adipose

tissue of our body exceeds the normal limits during the metabolic activities. The prevalence of obesity have been increasing and have doubled in the last three decades with females being on the more risk compared to males. A report given by WHO in 2016, revealed that 650 million of the individuals in the world were obese and 1.9 million were overweight. From 1975 to 2016, the obesity rate of the adolescents has increased by one per cent to six per cent in females (Ugur K *et al.*, 2017).

The occurrence of obesity has increased the health and economic burden in the developing countries. By year 2030, it is estimated that overweight and obesity will reach the level of 89 per cent in males and 85 per cent in femaless (Engin, 2017).

Obesity is regarded as a major public health concern and is ranked as the fifth leading cause of death worldwide. Overweight and obesity are two of the most common lifestyle illnesses that cause additional health problems and contribute to a variety of chronic diseases such as cancer, diabetes, metabolic syndrome, and cardiovascular disease. The World Health Organization predicted that by 2030, 30 per cent of deaths will be caused by lifestyle diseases, which can be avoided by identifying and addressing associated risk factors and implementing behavioural involvement policies (Safaei *et. al.*, 2021).

Obesity has been linked to a wide range of cardiovascular diseases (CVD), including coronary heart disease, heart failure, hypertension, stroke, atrial fibrillation, and sudden cardiac death, according to a wealth of clinical and epidemiological evidence. Obesity can both directly and indirectly increase CVD morbidity and mortality (Koliaki *et. al.*, 2019).

While obesity has been shown to have negative cardiometabolic effects, the determinants of inter-individual variability are largely unknown. The extremely heterogeneous nature of obesity as a human trait makes elucidating the molecular underpinnings of this relationship difficult. Recent technological advancements have enabled a more detailed characterization of body composition on a large scale. It is feasible to improve characterisation of obesity and to advise individuals based on detailed body composition combined with tissue-specific molecular signatures at the current rate of data acquisition and resolution. Individualized health prediction would allow for more personalised and effective public health interventions (Sulc *et. al.*, 2020).

Obesity is closely linked to the rising prevalence and severity of nonalcoholic fatty liver disease (NAFLD). Obesity has been linked to not only simple steatosis (SS), but also advanced diseases, such as nonalcoholic steatohepatitis (NASH), NASH-related cirrhosis,

and hepatocellular carcinoma. As a result, obesity appears to increase liver-specific mortality in NAFLD patients, in addition to increasing all-cause mortality (Polyzos *et. al.*, 2019).

Obesity has negative psychological effects in addition to physical consequences, lowering human life quality. Depression, impaired body image, low self-esteem, eating disorders, stress, and poor quality of life are major psychological consequences of this disorder (Chu *et. al.*, 2019).

Obesity has become a major public health concern due to its rising prevalence. Obese people are more likely to develop heart disease, stroke, osteoarthritis, diabetes, and reproductive problems. Menstrual irregularities, pregnancy complications, and infertility due to anovulation affect women, while lower testosterone and sperm count affect men. Obese women, in particular, have lower levels of both gonadotropin hormones, and in obese men, lower testosterone is accompanied by lower LH. These findings point to central dysregulation of the hypothalamic-pituitary-gonadal axis, specifically at the level of GnRH neuron function, which is the final brain output for reproduction regulation. Obesity is a metabolic disorder characterised by hyperinsulinemia, hyperlipidemia, hyperleptinemia, and chronic inflammation (Lainez *et. al.*, 2019).

## **B. Vitamin D and Obesity**

Vitamin D is a fat-soluble vitamin and a secosteroid prohormone that plays an important role in bone mineralization by regulating calcium and phosphate levels (Khundmir *et. al.*, 2016).

According to Wang *et. al.*, 2016, vitamin D<sub>3</sub> (cholecalciferol) is the natural form of vitamin D, which the body can produce in response to sunlight exposure. Skin irradiation with ultraviolet-B (UVB) light (290–315 nm wavelength) initiates the photochemical conversion of 7 DHC (provitamin D<sub>3</sub>) to previtamin D<sub>3</sub> by breaking the 9,10 carbon-carbon bond, which is then quickly thermally isomerized to vitamin D<sub>3</sub>. Another source of vitamin D<sub>3</sub> is animal foods, which include oily fish, egg yolk, liver, butter, fortified milk, and cheese. Vitamin D<sub>2</sub> (ergocalciferol) is derived from the conversion of a plant sterol, ergosterol, and is obtained solely through diet, which includes plant-based foods such as yeast and mushrooms. Although vitamin D<sub>3</sub> has a higher bioavailability than vitamin D<sub>2</sub>,

they both go through the same metabolic pathway to produce active hormonal forms (Pilz *et al.*, 2016; Wang *et al.*, 2016).

The vitamin D endocrine system controls calcium homeostasis as well as a variety of physiological functions including cell growth, proliferation, differentiation, immune function, inflammation, and apoptosis (Archontogeorgis *et al.*, 2018).

Vitamin D is best known for its impact on bone health. However, there is growing recognition that vitamin D has non-skeletal actions that may have important implications for understanding the consequences of vitamin D deficiency. Vitamin D deficiency has consistently been linked to an increased risk of cardiovascular disease and hypertension in epidemiologic studies. In animal models, disrupting vitamin D signaling promotes hypertension, cardiac hypertrophy, and atherosclerosis. This evidence has prompted the start of prospective randomised trials of vitamin D supplementation in people at high risk of cardiovascular disease (Wang *et al.*, 2016).

Pilz *et al.*, 2016, linked vitamin D deficiency to a wide range of diseases, with research indicating that it is a risk factor for all-cause mortality, obesity, diabetes, cardiovascular risk, hypertension, dyslipidaemia, multiple sclerosis, Alzheimer's disease, and some types of cancer. Vitamin D is biologically inactive and must be hydroxylated twice before it can carry out its physiological functions. The key transport protein is vitamin D binding protein (DBP/GC), which binds over 85 per cent of the circulating 25(OH)D and vitamin D metabolites and transports them to target cells. The enzyme 25-hydroxylase (CYP2R1) in the liver converts vitamin D (cholecalciferol and ergocalciferol) into 25-hydroxyvitamin D [25(OH)D], also known as calcidiol, which is the primary circulating form of vitamin D. Following that, the kidney, acting as an endocrine gland, converts 25(OH)D via the enzyme 1-hydroxylase (CYP27B1) to the active hormonal form 1,25(OH)<sub>2</sub>D, also known as calcitriol, which then binds to VDR and regulates calcium homeostasis and bone metabolism. The VDR, a member of the nuclear receptor family, is a vitamin D receptor through which vitamin D functions, and it has been discovered in a variety of cell membranes of tissues with no musculoskeletal function; this implies that vitamin D is involved in various extra-skeletal biological functions (Pilz *et al.*, 2016).

There is a plethora of studies that have reported association of genetic variants with low vitamin D levels and a wide spectrum of associated diseases like obesity and type 2 diabetes (T2D) (Pantovic *et al.*, 2019).

Vitamin D is known to play a variety of roles in the body, including bone remodeling, insulin secretion, and adipogenesis. As a result, vitamin D deficiency (VDD) has a

significant impact on the normal functioning of the human body. VDD has been linked to the two most common health conditions today, type 2 diabetes mellitus and obesity. Vitamin D Receptor (VDR) polymorphisms have been linked to changes in gene expression and function, according to research. Obesity, also known as the "Pandemic of the Twenty-First Century," has been linked to the VDR gene polymorphisms FokI, TaqI, BsmI, and ApaI. Adipogenesis has been shown to be influenced by vitamin D. While obesity has both an environmental and a genetic basis, recent research has focused on the latter (Chauhan & Medithi, 2021).

Obese people have lower serum 25(OH)D levels than healthy people, and serum 25(OH)D levels are inversely related to body weight, BMI, and fat mass. Serum 25(OH)D levels are about 20 per cent lower in obese people than in normal weight people, and the prevalence of 25(OH)D deficiency is higher in obese people, estimated to be between 40 and 80 per cent (Walsh *et. al.*, 2016).

Parathyroid hormone is frequently used to assess vitamin D status. PTH levels are higher in obesity, but the relationship between serum calcium and PTH is left-shifted, making interpreting the clinical significance of higher PTH difficult. Low serum 25(OH)D levels are most likely a result of obesity rather than the cause of obesity. A large genetic study discovered that high BMI and genes associated with obesity reduce serum 25(OH)D, whereas low 25(OH)D and genes associated with low 25(OH)D have very little effect on obesity. There are a number of possible mechanisms that could cause low 25(OH)D in obesity. There could be lower input because of lower dietary intake, lower sunlight exposure, or impaired skin synthesis of vitamin D. Alterations in protein binding or faster metabolic clearance in obesity could lead to lower serum 25(OH)D. The lower serum 25(OH)D could be because of the distribution of 25(OH)D into a larger whole body tissue volume, particularly if 25(OH)D was actively sequestered in other tissues (Walsh *et. al.*, 2017).

Meta-analyses consistently show an inverse relationship between vitamin D levels and body weight; however, the impact of weight loss on improving vitamin D status is small. Volumetric dilution, sequestration into adipose tissue, limited sunlight exposure, and decreased vitamin D synthesis in adipose tissue and liver are the underlying pathogenetic mechanisms associated with low vitamin D in obesity. Low vitamin D levels have been linked to adipose tissue differentiation and growth, which leads to obesity, either through gene expression regulation or through modulation of parathyroid hormone, calcium, and leptin (Karampela *et. al.*, 2021).

Obesity and hypovitaminosis D are two pandemic conditions that are sometimes associated with each other. Because preadipocytes and adipocytes express the receptors and are involved in vitamin D metabolism, it appears that low levels of this vitamin may be involved in adipogenesis and thus the development of obesity. When considering obesity-related diseases, this association is critical (Barrea *et. al.*, 2021).

### **C. Obstructive Sleep Apnoea**

Obstructive sleep apnoea (OSA) is a condition caused by repeated episodes of upper airway collapse and obstruction during sleep associated with arousal from sleep with or without oxygen desaturation. The oropharynx in the back of the throat collapses during OSA events to cause arousal or oxygen desaturation or both resulting in fragmented sleep. OSA is a highly prevalent condition, particularly in individuals with established risk factors and comorbid conditions (Rundo, 2019).

According to research by Rundo, 2019, OSA is common. According to a 2015 study, 50 per cent of men and 23 per cent of women had at least moderate OSA. According to the Sleep Heart Health study from 2002, 24 per cent of men and nine per cent of women have at least mild OSA. According to the Wisconsin Sleep Study Cohort, ten per cent of men and three per cent of total of women aged 30 to 49 have at least moderate OSA, while 17 per cent of men and nine per cent of women aged 50 to 70 have at least moderate OSA. OSA is widely underdiagnosed, with an estimated 82 per cent of men and 93 per cent of women suffering from it going undiagnosed. There are several common sleep and daytime symptoms associated with OSA, though the number and combination of symptoms reported by patients varies. Snoring is one of the most common symptoms of sleep apnoea. Excessive daytime sleepiness or fatigue are common daytime symptoms of OSA. Excessive daytime sleepiness is defined as feeling drowsy or sleepy at times, whereas fatigue is defined as feeling tired, low on energy, and unmotivated. Another symptom is feeling tired despite getting the recommended seven to nine hours of sleep. Obesity (BMI > 30 kg/m<sup>2</sup>) and its correlates of increased waist-to-hip ratio and neck circumference are associated with an increased risk of OSA. A ten per cent increase in body weight results in a sixfold increase in moderate to severe OSA and a 32 per cent increase in the apnoea–hypopnea index (AHI; number of breath pauses or respiratory events per hour), whereas a ten per cent decrease in weight results in a 26 per cent decrease in the AHI (Rundo, 2019).

Obstructive Sleep Apnoea is linked to an increase in all-cause mortality. Other negative health outcomes associated with untreated OSA include cardiovascular disease,

cerebrovascular events, diabetes, and cognitive impairment. Furthermore, OSA is associated with a lower quality of life and a higher risk of motor vehicle accident injuries (Jonas, 2017).

The estimated prevalence of OSA in middle-aged adults in the United States is ten per cent for mild OSA, 3.8 per cent for moderate to severe OSA, and 6.5 per cent for severe OSA. In Taiwan, the average prevalence of OSA in adults is 2.6 per cent (3.4% in adult males and 1.9% in adult females). However, due to a lack of awareness of OSA in the general public and among health professionals, an estimated 80 to 90 per cent of people with OSA go undiagnosed. Untreated OSA is a risk factor for all-cause mortality, and the risk appears to increase with the severity of OSA. Given the serious health consequences of untreated moderate-to-severe OSA, effective treatment is critical (Chang *et. al.*, 2020).

Behavioral modification, weight loss, medication, continuous positive airway pressure, oral appliance therapy (e.g., use of tongue-retaining devices or orthodontic or mandibular advancing appliances), and surgical procedures are all options for treating OSA (e.g., tracheostomy, uvulopalatopharyngoplasty, laser-assisted uvulopalatoplasty, surgically assisted rapid maxillary expansion, maxillomandibular advancement, and hypoglossal nerve stimulation). Behavioral treatments target factors that may aggravate the risk of OSA. Alcohol and sedatives should be avoided by all OSA patients. Weight loss improves airway patency in some patients by reducing apneic events and snoring. In some patients, avoiding the supine position during sleep may reduce the frequency of sleep apnoea events (Aslan *et. al.* 2019).

OSA is a serious medical condition that has an impact on the health, safety, and quality of life of patients. It has an impact on a wide range of neurologic conditions, including stroke, epilepsy, headache, and neuromuscular conditions (Kirsch, 2020).

Several studies have found a link between 25-hydroxyvitamin D (25(OH)D) levels and patients with obstructive sleep apnoea (OSA). When compared to control patients, OSA patients had a relative deficiency in serum 25(OH)D levels, which was exacerbated incrementally as the severity of sleep apnoea increased. It was unclear whether having a low 25(OH)D was a risk factor for OSA or if having a low 25(OH)D was a risk factor for OSA. It was also possible that the link between 25(OH)D and OSA was due to BMI (BMI) (Neighbors *et. al.*, 2018).

Vitamin D receptors have been found in several brain areas, including the hypothalamus, which regulates changes in the sleep–wake cycle, among other things. OSAS and vitamin D deficiency share many of the same risk factors and comorbidities,

including older age, obesity, renal failure, and diabetes, and both conditions share pathogenic features (e.g., inflammation). The pathogenesis of vitamin D deficiency in OSAS is complex and poorly understood. Low serum vitamin D levels may contribute to the development of OSAS via the following mechanism. Vitamin D receptors, which are found in skeletal muscles, regulate several transcription factors in muscle cells and are thought to be involved in muscle cell proliferation and differentiation into mature type II muscle fibres. Furthermore, vitamin D is involved in active calcium transport into the sarcoplasmic reticulum, which regulates sarcomeric muscular contraction (Archontogeorgis *et. al.*, 2018).

Vitamin D deficiency has been linked to proximal myopathy, whereas low vitamin D levels have been linked to an increased incidence of statin-induced myopathy in patients taking statins. Increased parathyroid hormone levels, hypophosphatemia, and decreased calcitriol levels may all contribute to muscle weakness when combined with vitamin D deficiency. Thus, it has been proposed that decreased pharyngeal dilator muscle strength in vitamin D deficiency reduces pharyngeal patency and predisposes to apnoeic events during sleep. T-cells, B-cells, and monocytes Vitamin D deficiency is linked to increased autoimmunity and susceptibility to infection. Calcitriol enhances the antimicrobial effects of monocytes and macrophages, which play critical roles in infections such as tuberculosis. Low serum 25(OH)D levels are linked to an increased risk of upper respiratory tract infections, chronic obstructive pulmonary disease (COPD), allergic asthma, and allergic rhinitis. Recurrent infections and immune system dysregulation may promote the development of tonsillar hypertrophy and chronic rhinitis, both of which increase the risk of OSAS. Furthermore, vitamin D reduces the production of pro-inflammatory T-helper cell (Th)1 cytokines (interleukin (IL)-2, interferon-, and tumour necrosis factor (TNF)-) while increasing the production of anti-inflammatory Th2 cytokines (IL-3, IL-4, IL-5 and IL-10). In patients with OSAS, the inflammatory state plays an important role in the development of cardiovascular disease (Archontogeorgis *et. al.*, 2018).

OSAS may be a risk factor for vitamin D deficiency. OSAS patients are more likely to have limited access to outdoor activities and, thus, limited sunlight exposure due to excessive daytime sleepiness or obesity, resulting in lower vitamin D synthesis. Vitamin D deficiency has been associated to the pathophysiology of a variety of diseases. Obstructive sleep apnoea syndrome (OSAS), a disorder linked to increased cardiovascular and cerebrovascular morbidity, has been linked to low vitamin D levels. When compared to

non-apneic controls, OSAS patients had lower vitamin D levels. Several indices of OSAS severity were also found to be related to Vitamin D levels (Archontogeorgis *et. al.*, 2018).

Obese patients frequently have snoring, sleep apnoea, and diurnal hypersomnia. Central obesity is important because it reduces the size and conformation of the upper airways, as well as preventing lung expansion and thus lowering lung volumes. Furthermore, obese people are resistant to leptin, which physiologically stimulates ventilation; as a result, awakening during apnoea is limited (Salzano *et. al.*, 2021).

Epidemiological studies suggested an association between obesity and sleep disturbances. Obstructive sleep apnoea is the most prevalent forms of obesity-related sleep disorder, which increases the risk of a variety of chronic health conditions. Furthermore, increased visceral adipose tissue may be responsible for the secretion of inflammatory cytokines, which may contribute to the disruption of the sleep-wake cycle. Unhealthy food, defined by high fat and carbohydrate consumption, appears to have a negative impact on sleep quality, whereas a fiber-rich diet is associated with more restorative and deeper sleep. Although obesity may alter sleep through a variety of pathogenetic mechanisms, it has been reported that subjects with sleep disorders are more likely to develop obesity. Several laboratory studies have shown that reducing the amount or quality of sleep increases the risk of developing obesity. Experimenting with sleep deprivation also results in physiological, hormonal, and food behavioural changes that promote a positive energy balance and a compensatory disproportionate increase in food intake, decrease in physical activity, and weight gain (Muscogiuri *et. al.*, 2019).

Obesity-related respiratory disease, particularly sleep-disordered breathing, is becoming more common. The rise in clinically significant obstructive sleep apnoea and obesity hypoventilation syndrome is associated with an increase cardiopulmonary morbidity, quality-of-life impairment, and an increase in the frequency of traffic accidents. Obesity-related respiratory disease is becoming more prevalent in both inpatient and outpatient settings. It is critical to understand the impact of obesity on pulmonary physiology in order to properly care for this population and plan for the future (Meurling *et. al.*, 2019).

#### **D. Digital Health Intervention for Obesity and Vitamin D deficiency**

Clinical trials have been increasingly evaluating digital applications (Al-Durra *et. al.*, 2018)

The United States Food and Drug Administration (USFDA) has identified device software functions that are eligible for regulatory review (Policy for Device Software Functions and Mobile Medical Applications, 2022).

The WHO provides a definitive recommendation that digital means of training and education for healthcare professionals be used to supplement, rather than replace, traditional educational efforts. According to the WHO, this additional delivery channel can dramatically enhance access to health education at a lower expense (WHO guideline: recommendations on digital interventions for health system strengthening, 2019).

A systematic review of 93 studies (N = 16,895; January 1990 to March 2017) found that online and blended educational measures were equivalent to face-to-face trainings for postintervention knowledge, skills, attitude, and satisfaction in medical doctors undergoing post registration training (George *et. al.*, 2019).

Another systematic review of 12 studies (1990–2017) found that digital education was more effective than traditional education in improving knowledge and skills for diabetes management (Huang *et. al.*, 2019).

The WHO has thoroughly evaluated and identified research gaps in terms of effectiveness, acceptability, feasibility, resource requirements, and issues of equity and rights for digital health intervention. It recommends that any digital health tool or technology be developed and implemented in accordance with digital development principles (Jandoo, 2020).

The WHO describes some of the key gaps in patient and healthcare professional knowledge and attitudes, as well as their behaviours regarding digital health. These are primarily for interventions such as targeted patient communications, decision support for health workers, digital tracking, and mobile learning. Satisfaction levels, apprehensions, hesitations, and fears should be identified, and mitigation measures should be defined. The knowledge–attitude–behavior model has been extensively used to investigate the effect of education on patient and provider acceptance, as well as an understanding of healthcare measures and practices and associated safety (Lau & Donyai, 2017; Liu *et. al.*, 2016).

With the widespread use of laptops, tablet computers, smartphones, and wearable devices, the potential for digital health intervention has grown rapidly. Simultaneously, the understanding of how digital interventions can be theorised and intervention components chosen to improve intervention effectiveness has grown. User-centered approaches to digital health intervention design can promote participation in interventions with potential

health benefits. Nonetheless, the problems of low intervention use, high drop-out rates, and low efficacy persist (Michie *et. al.*, 2017; Yardley *et. al.*, 2016).

The increasing availability of Internet access via smartphones opens up a new avenue for treating severe obesity. Several smartphone apps have shown at least some effectiveness in helping overweight and obese people lose weight (Wang *et. al.*, 2017).

Routine weighing with wireless scales has also been shown to aid in clinically significant weight loss through behavioural change (Thomas *et. al.*, 2017).

A remote weight-loss programme combining mobile applications, daily self-weighing, and calorie restriction via meal replacement resulted in dramatic weight loss among active users in a large cohort of individuals with class II or III obesity, according to a retrospective observational study. The mean weight loss after 42 days (N = 6781) was 8.1 kg (margin of error (MOE) = 0.126 kg), with 73.6 per cent of users losing more than five per cent of their total body weight. Both men (9.1 kg; MOE = 0.172 kg; 7.9% from baseline) and women (7.1 kg; MOE = 0.179 kg; 7.2% from baseline) lost significant amounts of weight. At the 120-day interval (N = 2914), the mean weight loss was 14 kg (MOE = 0.340 kg), representing a 13 per cent total body weight loss from baseline, and 82.3 per cent of participants had lost more than five per cent of their starting weight. Body-fat per centage reduction correlated well with weight loss (R = 0.92; p 0.001) (Senecal *et. al.*, 2020).

The results of a genome-wide association study of serum 25(OH)D concentration in the Finnish Health 2011 cohort (n = 3339) were used to develop a population-matched genetic risk score (GRS) for serum 25(OH)D. This GRS was used to personalise vitamin D supplementation for 96 participants in the Digital Health Revolution (DHR) Study. Participants received the GRS, serum 25(OH)D concentrations, and personalised supplementation and dietary advice electronically. It demonstrated how to tailor vitamin D supplementation using electronic returns of individual genetic risk, serum 25(OH)D concentrations, and factors affecting vitamin D status. This model has the potential to be applied to other populations and countries (Sallinen *et. al.*, 2021).

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# Methodology

### III. METHODOLOGY

The methodology adopted for the present study entitled “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese adults**” is presented as follows:

**Phase I:** Selection of study area and respondents

**Phase II:** Selection and formulation of data collection tools

**Phase III:** Selection of participants

**Phase IV:** Assessment of Nutrient Intake

**Phase V:** Conduct of survey

**Phase VI:** Development and implementation of Digital Health Intervention

**Phase VII:** Impact evaluation

The Research Design of the study is presented in Figure 1.

#### **PHASE I: Selection of study area and respondents**

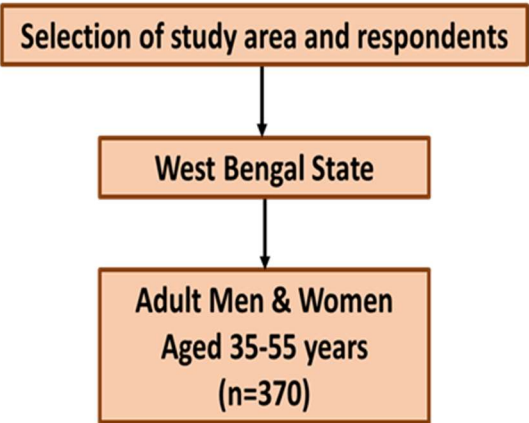
##### **A. Selection of area:**

West Bengal is a state in the eastern part of the country, located between the Himalayas and the Bay of Bengal, having an estimated population of 101.4 million (10.14 crores) (<http://cencusindia.gov.in/>). The state of West Bengal was selected for this study, because obesity is a major health problem in the state, having a prevalence rate of approximately 6000 per 100,000 adults. The state of West Bengal has the highest prevalence of obesity and the third-highest prevalence of overweight in India (Vennu *et. al* 2019). Prevalence rates of obesity and overweight in various states and union territories of India are given in Plate I and Plate II respectively.

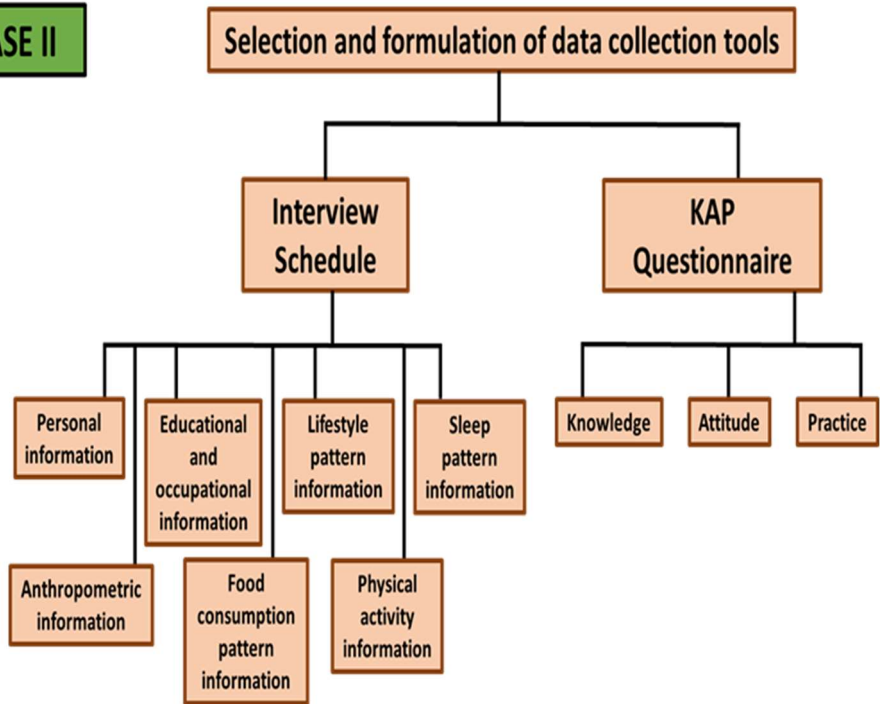
##### **B. Selection of respondents:**

The study’s target population was adult men and women in the age group of 35 to 55 years. Hence, a working population of men and women, as well as homemakers within the specified age group, who use smartphones and are well versed in the English language, were approached for conducting the study. Appropriate briefing was given, and convenient dates and times were fixed with the respondents for data collection.

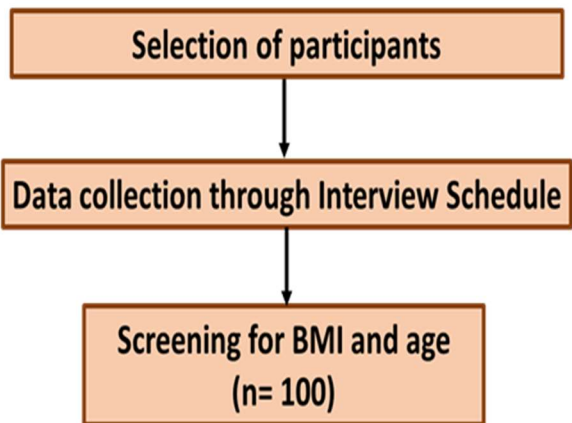
**PHASE I**



**PHASE II**

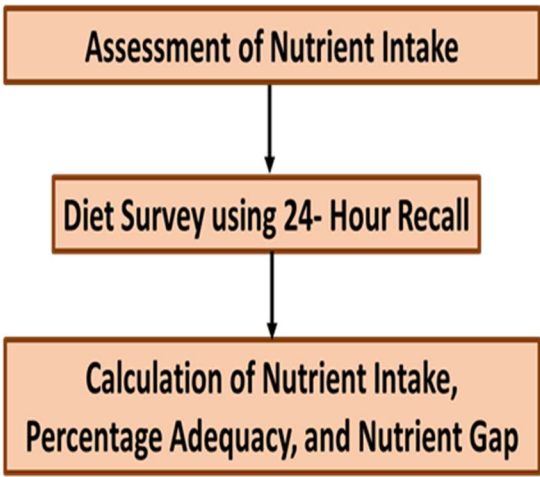


**PHASE III**

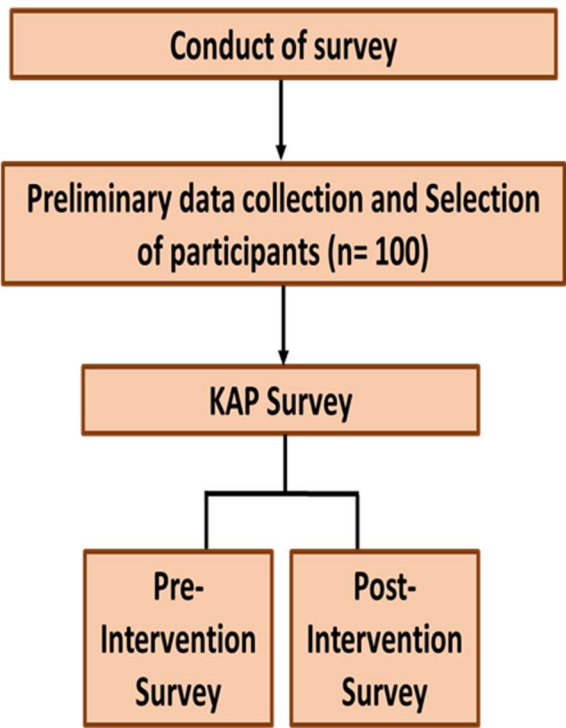


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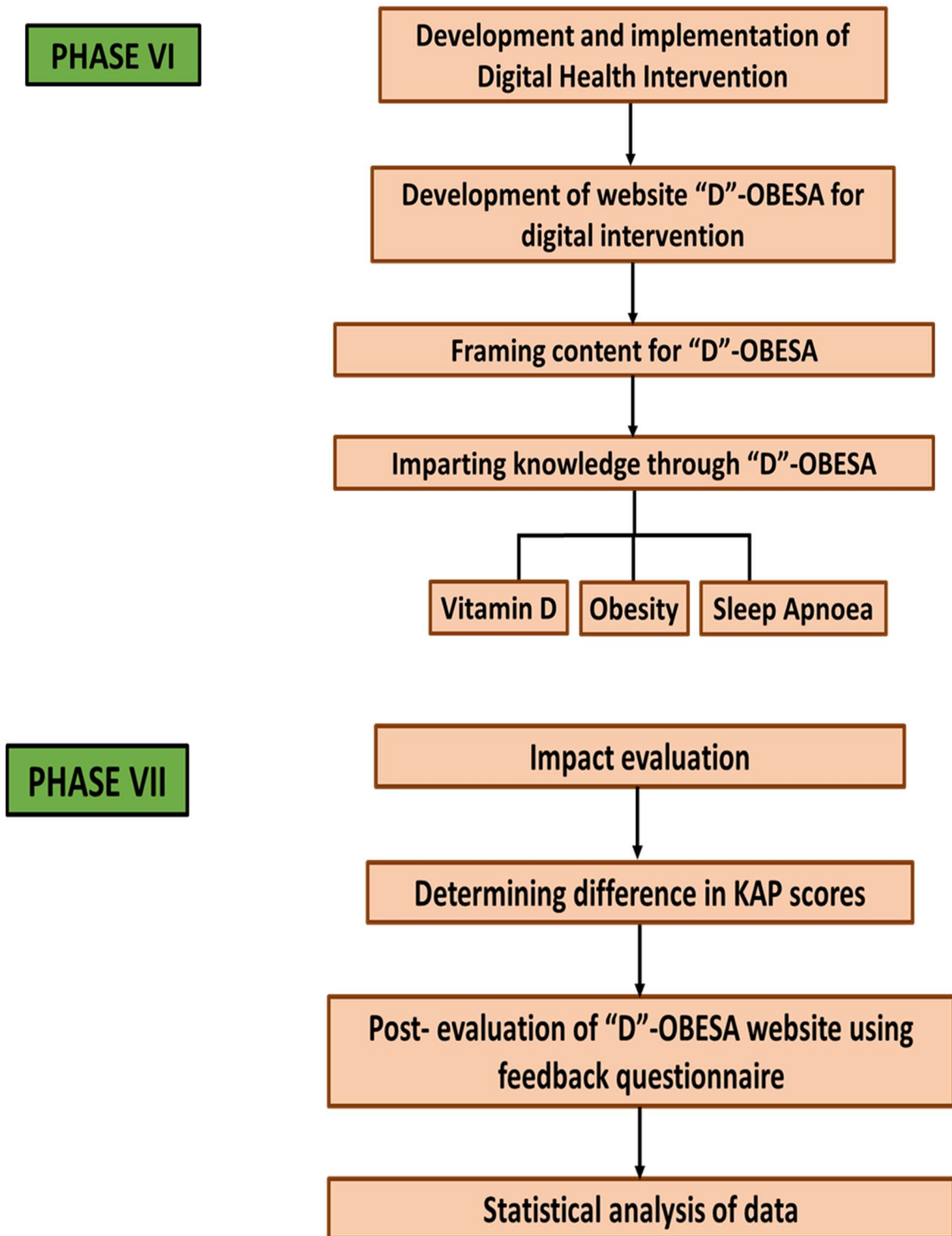
**PHASE IV**



**PHASE V**



**Contd...**



**Figure 1: Research Design**

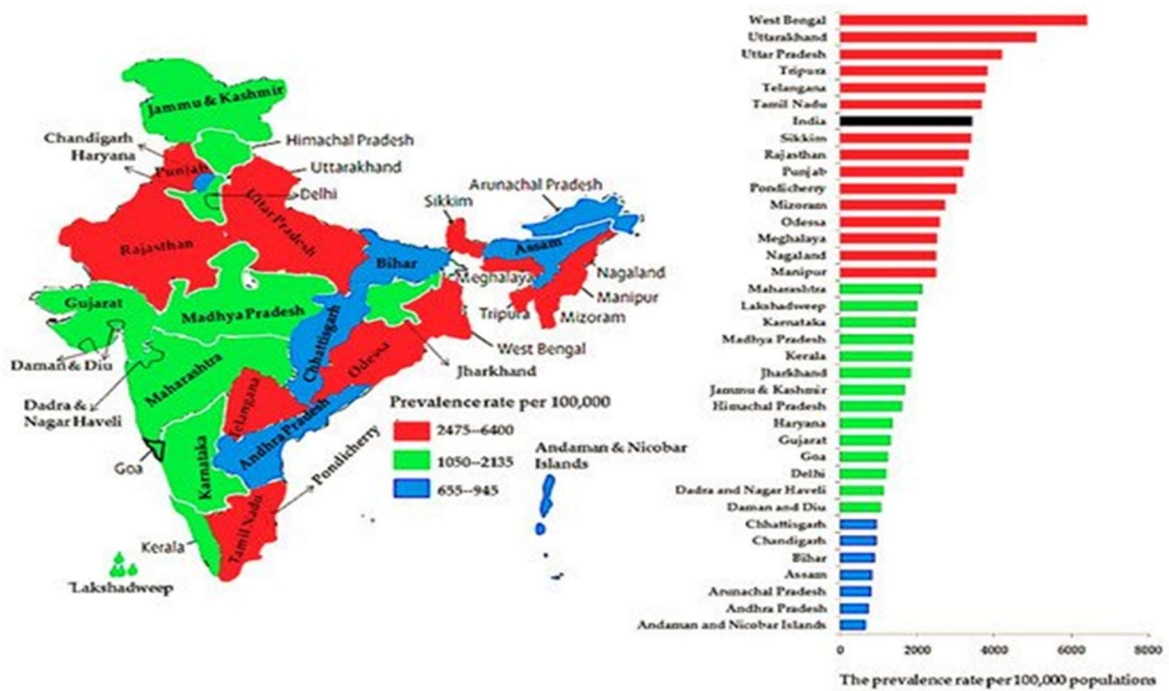


Plate I

Prevalence rates of obesity among adults at the national level and per state and union territory

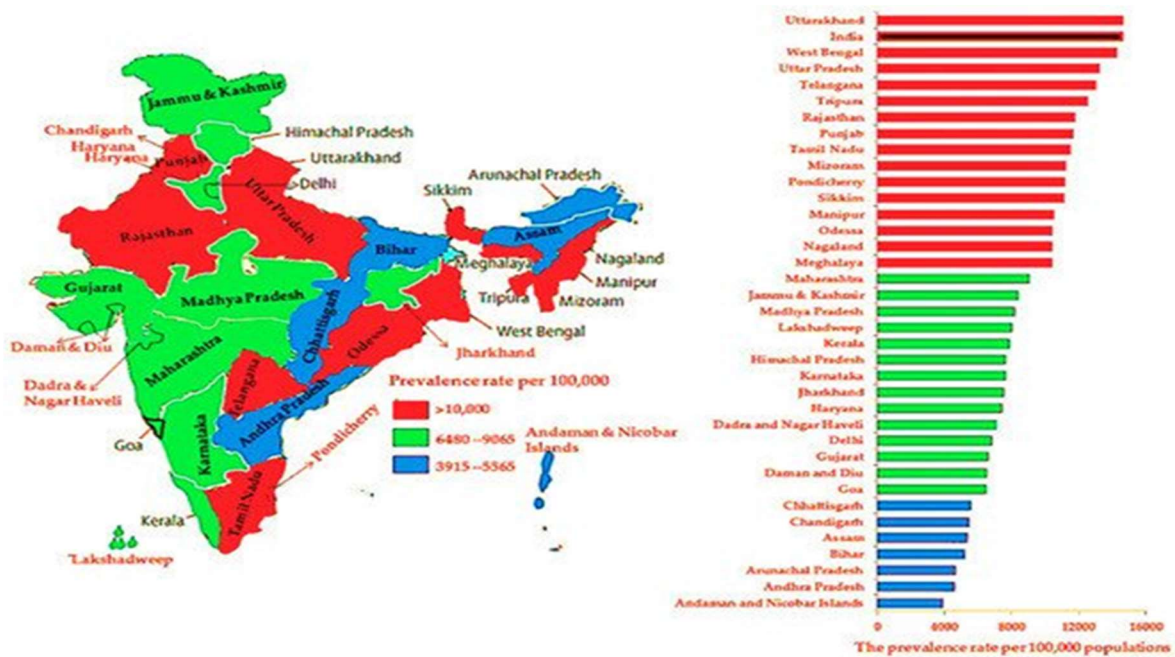


Plate II

Prevalence rates of overweight among adults at the national level and per state and union territory

**i. Selection of sample:**

Purposive sampling was employed by the investigator to determine the sample for imparting knowledge on vitamin D, obesity, and sleep apnoea.

The screening was done based on BMI and 100 respondents out of 370 samples were selected.

**ii. Sampling Procedure:**

The investigator selected purposive sampling method for the study with the following criteria:

**Inclusion Criteria:**

- >35 <55 years of Men and Women
- Obese (WHO Classification, <https://www.who.int>)
- Overweight (WHO Classification, <https://www.who.int>)

**Exclusion Criteria:**

- <35>55 years of men and women
- Pregnant women and lactating mothers
- Normal weight and Underweight population
- Individuals having primary and secondary diseases.

**PHASE II: Selection and formulation of data collection tools**

**A. Selection of data collection tool:**

The selection of tools for data collection included an interview schedule, a diet survey form, and a KAP questionnaire. The interview schedule had both open-ended and close-ended questions, while the KAP questionnaire was close-ended. The interview schedule was used for the collection of the background information and screening of respondents according to the purpose of the study. The diet survey form was used to collect 24- hour food recall of the selected participants. While the questionnaire was used for the assessment of the knowledge, practice, and attitude regarding vitamin D, obesity, and sleep apnoea.

**B. Formulation of data collection tool:**

**i. Formulation of interview schedule:**

The interview schedule was designed by the investigator for the purpose of collection of primary data. It had both open-ended and close-ended questions.

The schedule was framed to collect information on the following,

- Personal data
- Anthropometric details (due to COVID – 19 pandemic, measurements could not be taken physically)
- Education and occupation
- Food consumption pattern
- Lifestyle pattern
- Physical activity pattern
- Sleep pattern

The google form link for the interview schedule is given in Appendix I.

**ii. Formulation of Diet Survey Form**

The diet survey form was used by the investigator to collect information on the daily food and nutrient intake of the selected participants, using a 24-hour recall questionnaire.

**iii. Formulation of questionnaire:**

A close-ended KAP questionnaire was formulated by the investigator to assess the knowledge, practice, and attitude of the adult men and women regarding vitamin D, obesity and sleep apnoea. It was divided into three sections, Knowledge, containing 14 questions, Attitude, containing 15 questions, and practice containing 12 questions.

Both the interview schedule and the KAP questionnaire were checked for their validity and reliability through a pilot study among ten adult men and ten adult women.

**PHASE III: Selection of participants:**

**A. Screening for BMI and age:**

The responses obtained from the interview schedule were analysed, to screen the respondents for their BMI. Purposive sampling method was used for carrying out the screening process. Only obese ( $BMI \geq 30 \text{ kg/m}^2$ ) and overweight ( $BMI \geq 25 \text{ kg/m}^2$ ) (<https://www.who.int>) adults (>35 <55 years of age) were selected for conducting the study and those outside the specified BMI range and age group were excluded.

#### **PHASE IV: Assessment of Nutrient Intake**

A three day 24- hour recall questionnaire was used by the investigator, to obtain the average daily intake of food and nutrients. The questionnaire contained questions regarding,

- Time of meal
- Type of Food
- Ingredients
- Amount of Ingredients
- Amount of Cooked Food

The respondents were asked to recall these details, for their previous day's meals. This information was collected for three days to calculate the average intake of nutrients.

The nutritive value of daily Calorie, Carbohydrate, Protein, Fat, and Vitamin D intake was calculated for each respondent. The average estimated intake of these nutrients was compared with the Recommended Dietary Allowances given by ICMR, 2020, to calculate the percentage adequacy and nutrient gap.

The google document link for the questionnaire is given in Appendix I.

#### **PHASE V: Conduct of survey:**

The study endorsed falls under the research design of before and after study; hence, the KAP survey was conducted before and after the intervention.

The data for the survey was collected in three phases, namely preliminary, pre-intervention and post-intervention.

##### **A. Preliminary data collection:**

The interview schedule was used to collect primary data from the respondents using a combination of open-ended and close-ended questions. The primary data was collected from the respondents on their personal information, anthropometry, education and occupation, food consumption pattern, lifestyle pattern, physical activity, and sleep patterns.

This information was used to screen the number of respondents (n=370), for their age and BMI and select the participants (n=100), fulfilling the criteria required for the present study.

## **B. Pre-intervention data collection:**

The close-ended pre-intervention KAP questionnaire was used to assess the knowledge, attitude, and practice of the study participants (n=100), relating to vitamin D, obesity, and sleep apnoea.

The questions were framed to determine the issues to be focused on during the digital intervention.

The knowledge part of the questionnaire was designed to assess the knowledge or understanding of participants regarding vitamin D, obesity, and sleep apnoea.

The attitude section of the questionnaire was framed to assess the beliefs and preconceived notions of the respondents regarding the subject.

The practice section of the questionnaire was designed to understand how the respondents implement or demonstrate their knowledge and attitude through their actions in their day-to-day activities.

This was followed by digital health intervention, to communicate to the study participants about various aspects of vitamin D, obesity, and sleep apnoea.

## **C. Post-intervention data collection**

The digital intervention was carried out over a period of a month. Immediately after the first intervention, a post-intervention evaluation was conducted, by administering the same questionnaire as the pre-intervention to the study participants (N = 100), to assess whether there had been any change and/or improvement in their knowledge particularly, as well their attitude and practices.

Following the first post-intervention evaluation, two more surveys were conducted using the same questionnaire, one after a week and another after a month to check the validity of the participant's attitude and practice, about aspects of vitamin D, obesity, and sleep apnoea.

During this one-month period, nutrition communication through digital intervention was carried out on a periodic basis.

The pre-and post-intervention KAP questionnaire is given in Appendix I.

## **D. Determining difference in KAP scores**

The knowledge, attitude, and practice of the respondents both pre-intervention and post-intervention were measured by assigning scores depending on the questions correctly answered by the respondent. Out of 41 questions, each one answered

correctly was credited with one score, while the wrong answers were not given any score. Hence the total score of the participants varied from 0 to 41.

Research involving human subjects raises ethical and legal issues, therefore, during the data collection, the privacy and dignity of the respondents were maintained.

Verbal administration of informed consent was obtained from each and every respondent.

Further, the respondents were most importantly empowered to draw back from the study at any instance as per their will. The application of the study advocating the need and design was subjected to Institutional Human Ethical Committee and the ethical clearance was obtained with the approval number of AUW/IHEC/FSN-21-22/XPD-19.

The approval certificate of ethical clearance for the study is given in Appendix II.

## **PHASE VI: Development and implementation of Digital Health Intervention**

### **A. Development of a website for digital intervention**

A website named “D”-OBESA was created by the investigator for sharing information and communicating to the study participants regarding various aspects of vitamin D, obesity, and sleep apnoea.

Google Sites is a structured wiki and web page creation tool included as part of the free, web-based Google Docs Editors suite offered by Google. The service also includes Google Docs, Google Sheets, Google Slides, Google Drawings, Google Forms, and Google Keep. Google Sites is only available as a web application. The app allows users to create and edit files online while collaborating with other users in real-time ([sites.google.com](https://sites.google.com)).

The website could be accessed using the URL: <https://sites.google.com/view/dobesa/home>

The website was designed in a user-friendly manner, which was easy to access and understand. The materials consisted of digital posters, presentations, and audio-visual aids, which could be viewed by the study participants free of cost. The website also had a section for feedback from the viewers.

Social media platforms like a WhatsApp, Facebook, Instagram, and YouTube were used to promote the website. A WhatsApp group named, “D”-OBESA, an Instagram page named sb\_d\_obesa, a Facebook page named, D-obesa, and a YouTube channel named, D-OBESA, for the website were created by the investigator, where information regarding the website was updated periodically. Links for accessing these pages were provided on the website.

Additionally, the contact information of the investigator was provided on the website.

Snapshots of the website and the social media platforms used are given in Plates III to VII.

## **B. Framing content for the website**

The information obtained from the pre-intervention phase of the survey was utilised for framing the content of the website. The questions relevant to vitamin D, obesity, sleep apnoea, and their related aspects were drafted for the respondents to answer. A total of ten materials containing information relevant to the subject of the present study were uploaded to the website over a period of a month. The materials included digital posters, presentations, and audio-visual aids.

The materials were designed so that the participants can easily understand the information provided. Pictorial demonstrations of phenomena, for easy understanding as well as reading material for engagement of the respondent’s interest, were included.

Words were carefully selected to avoid any ambiguousness in the information provided. Care was taken to make the material as simple and understandable as possible.

A virtual meeting through google meet was arranged prior to uploading the first material to brief the respondents on how to access the website and another at the end of the one-month period, for thanking the respondents for participating in the study.

Snapshots of the virtual meeting are given in Plate VIII.

## **C. Imparting knowledge on vitamin D, obesity, and sleep apnoea to the respondents:**

Communication on vitamin D, obesity and sleep apnoea, and related aspects was provided to 100 respondents (adult men and women). The website created by the investigator was used to distribute the material for a period of one month.

The website was shared with the respondents to access free of cost. As per the time preference of the respondents, a single material (i.e., digital posters, presentations,

and audio-visual aids) was uploaded periodically for the period of one month, available for viewing by the respondents.

Snapshots of the materials received by the respondents are given in, Plate IX.

#### **D. Implementation of intervention:**

The website was created by the investigator for the implementation of the digital intervention. The website named “D”-OBESA can be accessed from all android and iOS mobile phones as well as from desktops and tablets and is easy to use.

The “D”-OBESA website was shared with the respondents, available to access free of cost. The materials shared were viewed by the respondents over a period of a month.

All the shared materials were tracked and necessary documentation with the reference to study was done.

#### **PHASE VII: Impact evaluation of digital health intervention among the respondents**

The impact of the digital health intervention on vitamin D, obesity, and sleep apnoea related aspects among the respondents was evaluated. The material shared with the respondents served as a source of information to enhance their existing knowledge on vitamin D, obesity, and sleep apnoea and modify their attitude and practice to improve their quality of life.

Communication related to vitamin D, obesity, and sleep apnoea in the domain of general information, sources, nutrition-related information, physical activity, symptoms, deficiency disorders, and the interrelationship between vitamin D, obesity and sleep apnoea were provided for a period of a month. The knowledge obtained from the materials was evaluated with the help of a post-intervention questionnaire. To determine the mean changes in knowledge, attitude, and practice scores before and after the intervention, the scores were computed and analysed for any statistically significant changes.

Apart from this, the respondents who were provided with the intervention were also asked for their opinion on the “D”-OBESA materials shared regarding the content, efficacy, and usefulness. Recommendation on the changes to be made in the content of materials was assessed by administering a designed questionnaire given in Appendix I.



[Learn More](#)

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## About Us

You can now manage Obesity and Sleep Apnoea with the help of Vitamin D.

"D"-OBESA is a Nutrition Communication website, created for Digital Intervention in the field of Nutrition and Public Health.

### Disclaimer

This website has been developed and posted solely for the purpose of an ongoing research.

Copyright @ "D"-OBESA



## Areas of Focus



Vitamin D

[Know More](#)



Obesity

[Know More](#)

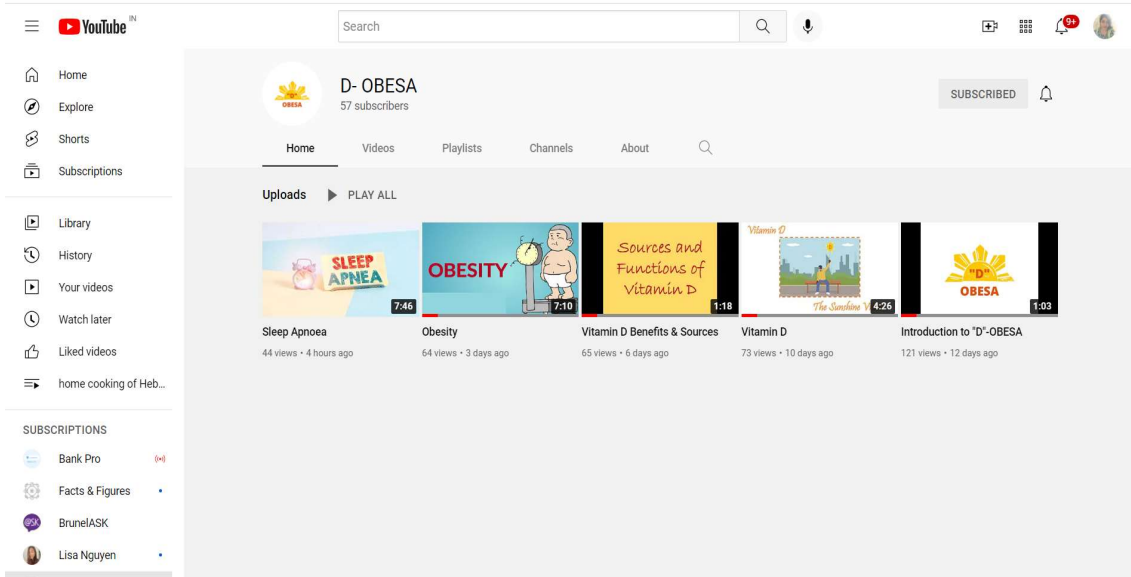


Sleep Apnoea

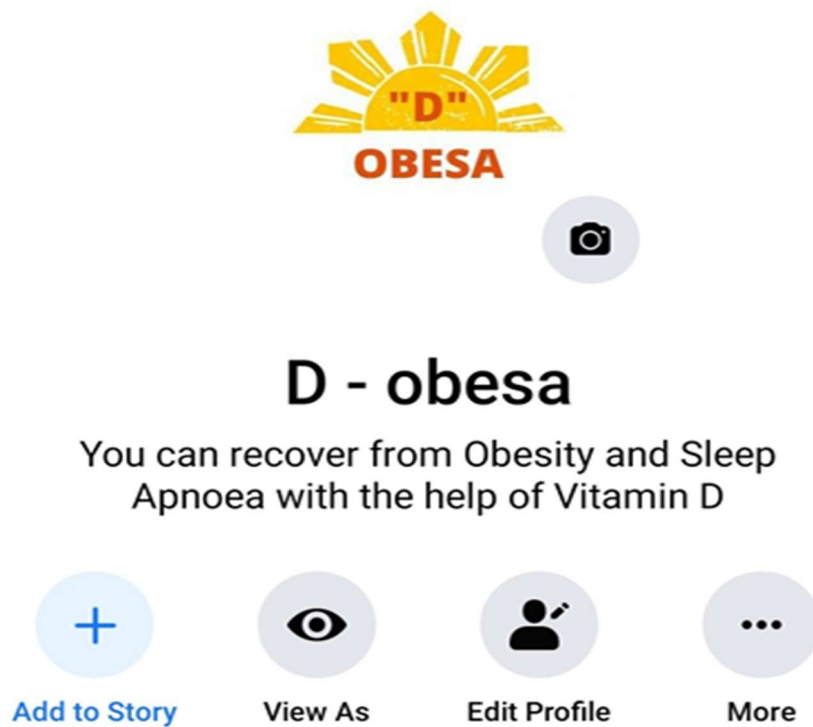
[Know More](#)

### Plate III

## Snapshots of Website "D"- OBESA



**Plate IV**  
**Snapshot of YouTube Channel**



**Plate V**  
**Snapshot of Facebook Page**

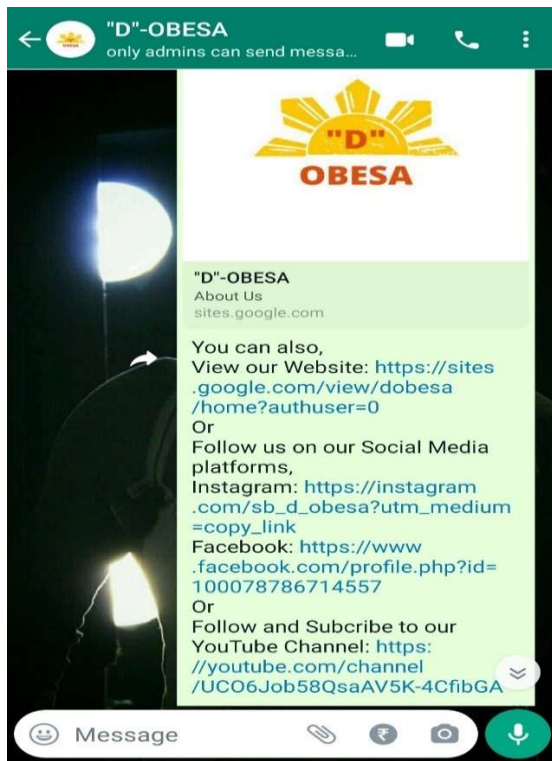


Plate VI

Snapshots of WhatsApp Group

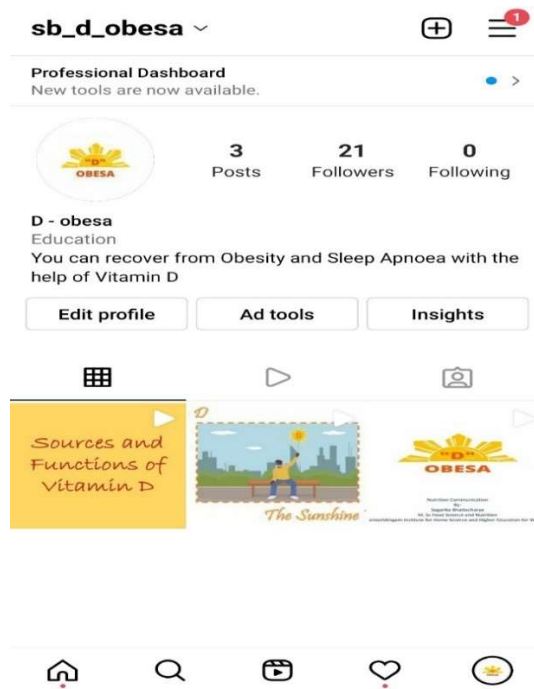
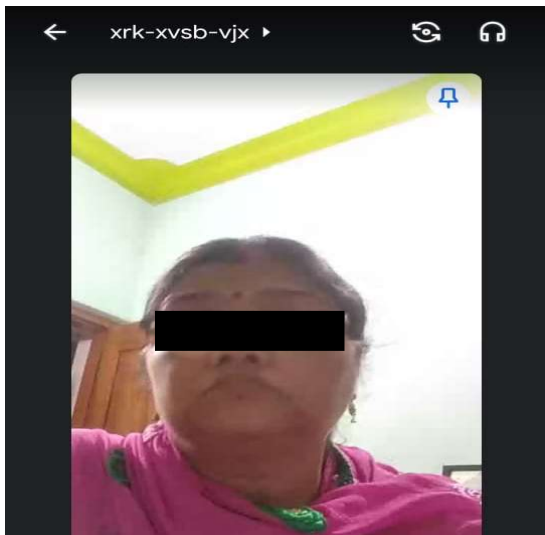
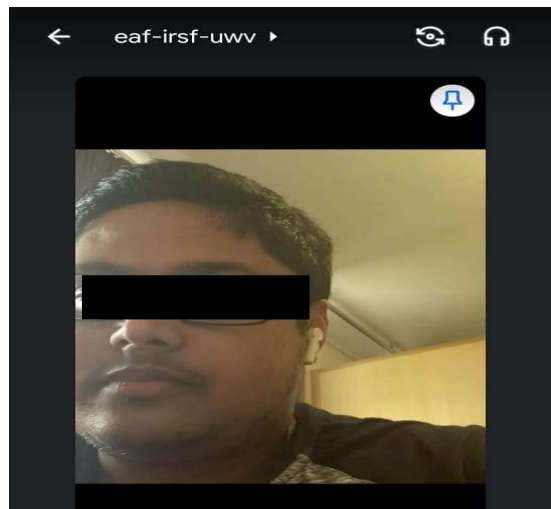
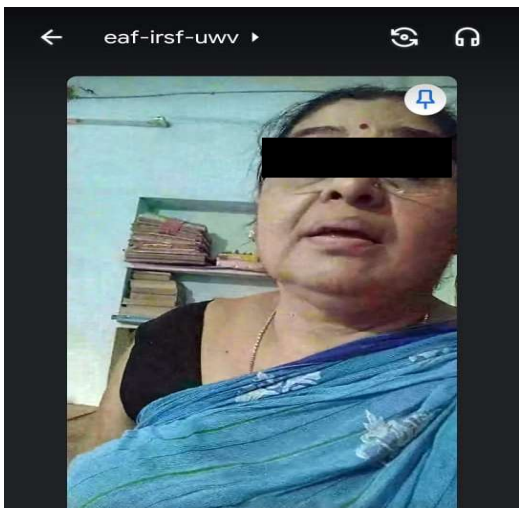
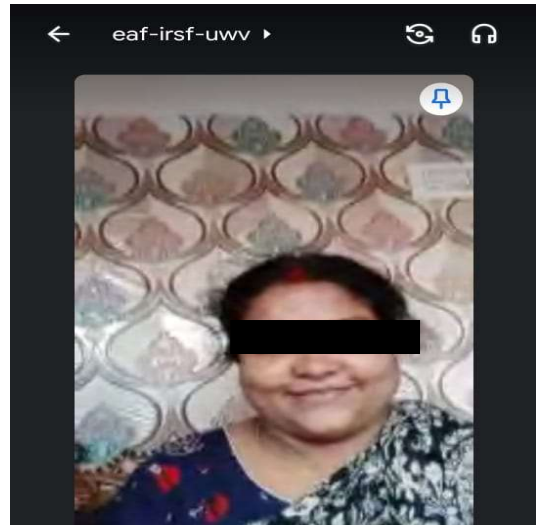
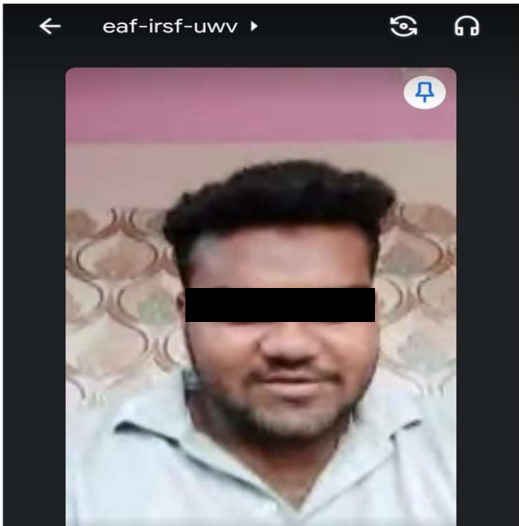


Plate VII

Snapshot of Instagram Page



**Plate VIII**  
**Snapshots of Virtual Meet**

# Vitamin D

## Are you getting enough?

Vitamin D is essential for strong, healthy bones throughout life.

Everyone age 5 years and above should take a daily supplement containing 10 micrograms (µg) of vitamin D especially during the autumn and winter months.

Vitamin D is often referred to as the sunshine vitamin. Your body makes vitamin D when you expose your skin to the sun.

VITAMIN D DEFICIENCY CAN LEAD TO SOFT BONES AND WEAKENED MUSCLES

It is difficult to get enough vitamin D from food alone. You can help your body get more by eating vitamin D-rich foods.

Oily fish    Red Meat    Eggs    Fortified Foods

# Vitamin D can...

- Modulate the Immune System
- Protect against Cancer
- Induce Autophagy
- Prevent Cognitive Decline
- Improve Chronic Fatigue
- Promote Bone Health
- Improve Anxiety & Depression
- Reduce Joint Pain
- Improve Sleep Apnoea
- Prevent Endometriosis & PCOS

Sources

# Relationship between Vitamin D deficiency & Obesity

**Low Vitamin D causes Obesity**

- Adiposity related gene regulation
- Increased Parathyroid Hormone
  - Decreased Calcium
  - Regulation of Leptin
  - VDR gene polymorphism

**OBESITY**

Inflammation

↓ Vitamin D

**Obesity causes Low Vitamin D**

- Decreased cutaneous synthesis of Vitamin D
  - Decreased expression of Vitamin D metabolizing enzymes
  - Limited sunlight exposure
- Negative feedback on hormonal Vitamin D

# The Relationship between Obesity & Sleep Apnoea

Obesity is the clinical condition resulting from excess deposition of adipose tissue in the body

Sleep apnoea is a medical condition where one repeatedly stops and starts breathing while sleeping

**Obesity & Sleep Apnoea are inter-linked by a Bi-directional pathway**

**OSA**

- Fat deposit in UPRM lumen
- Reduced tracheal lumen
- Over UPRM shape
- Fat deposit in UPRM muscles

**The Vicious Cycle**

- Weight gain through affects on metabolism and appetite-regulating hormones
- Alteration of upper airway passages
- Sleep Apnoea
- Reduced sleep duration and sleep fragmentation

Plate IX

Snapshots of Digital Health Intervention Materials

### **Statistical analysis and interpretation of data:**

The data collected were checked for the completeness and consistency. Then it was edited, organised, coded and entered to Microsoft Excel 2019.

Statistical analysis was performed to correlate the information on BMI status, Vitamin D status, and Sleep Apnoea and the factors affecting them, collected through the interview schedule; to calculate the mean nutrient intake of the selected participants; and to analyse any significant difference in the mean scores of knowledge, attitude and practice between the pre- and post-intervention phases, obtained through the KAP questionnaires.

All statistical analysis was performed by Statistical Package for Social Sciences software (IBM SPSS Statistics version 26.0).

Pearson's Correlation Coefficient was calculated to find out the correlation between BMI status, Vitamin D status, and Sleep Apnoea and the factors affecting them.

Standard descriptive statistics, including mean, standard deviation (SD), minimum and maximum values for each nutrient was calculated.

Student's t-distribution was used to analyse whether there was any significant difference between the mean scores obtained before and after imparting the nutrition communication through the "D"-OBESA website.

2- way ANOVA test was used to analyse if there was any significant difference between the KAP scores the three phases of evaluation and between the scores of knowledge, attitude and practice within the three phases, as a result of the digital health intervention.

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## *Result and Discussion*

## **RESULT & DISCUSSION**

The result and discussion of the study entitled, “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese adults**” is presented under the following headings:

- A. Background Information of the Study Participants**
- B. Dietary Pattern of the Respondents**
- C. Health Status of the Participants**
- D. Sleep Pattern of the Respondents**
- E. Nutrient Intake of the Selected Participants**
- F. Impact of “D”-OBESA on selected Obese and Overweight Adults**

### **A. Background Information of the Study Participants**

Table I presents the background information of the study participants taken for investigation.

**Table I**  
**Background Information of the Study Participants**

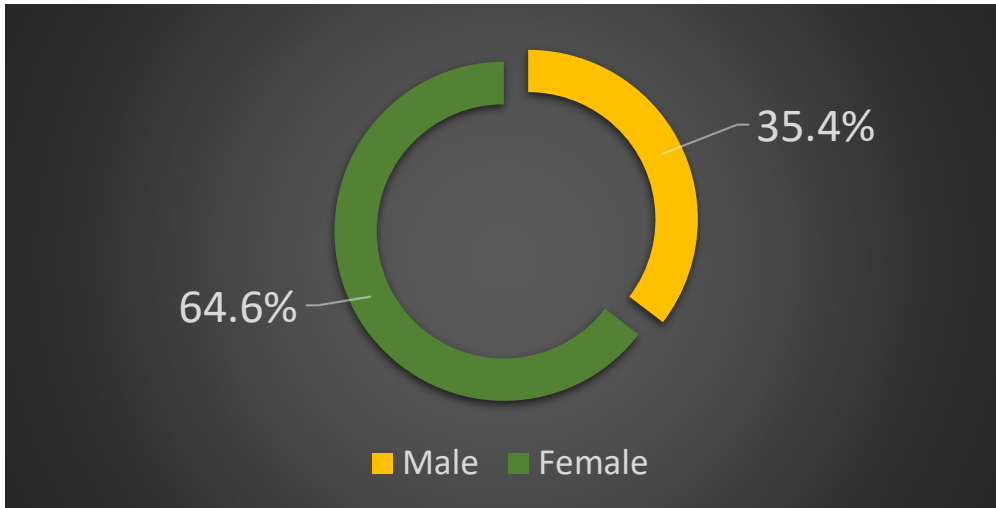
Parameters	Criteria	Respondents (N=379)	
		Number	Per centage (%)
Sex	Male	134	64.6
	Female	245	35.4
Age (in years)	35-40	288	76
	41-45	47	12.4
	46-50	28	7.4
	51-55	16	4.2
Marital Status	Married	367	96.8
	Unmarried	12	3.2
Area of Residence	Urban	377	95.5
	Rural	2	0.5
Education	Post Graduate	137	36.2
	Graduate	214	56.5
	Higher Secondary	21	5.5
	Dropout	7	1.8
Occupation	Govt. Job	104	27.4
	Private Job	215	56.7
	Business	21	5.5
	Home Maker	39	10.3
*Annual Income	3,00,000-6,00,000 (LIG)	245	64.6
	6,00,000-12,00,000 (MIG-I)	95	25.1
	NA	39	10.3

\*HUDCO 2021, LIG-Low Income Group, MIG-Middle Income Group

Table I shows that a total of 379 respondents were taken as the initial sample, whose background information is as follows:

**a. Sex of respondents**

The distribution of sex of the respondents is given in Figure 2.



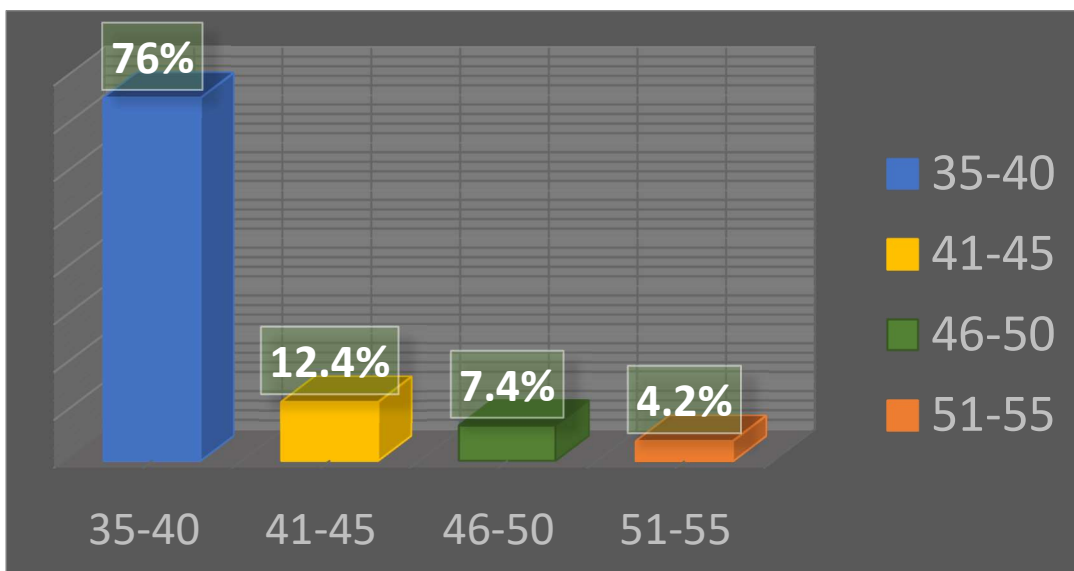
**Figure 2: Sex of Respondents**

As evident from Figure 2, 64.4 per cent of the respondents were females and 35.4 per cent of the respondents were males.

According to Census 2011 data, West Bengal has a population of 9.13 million people, of which 46,809,027 are males and 44,467,088 are females (Census, 2011).

**b. Age of respondents**

The distribution of age of the respondents is given in Figure 3.



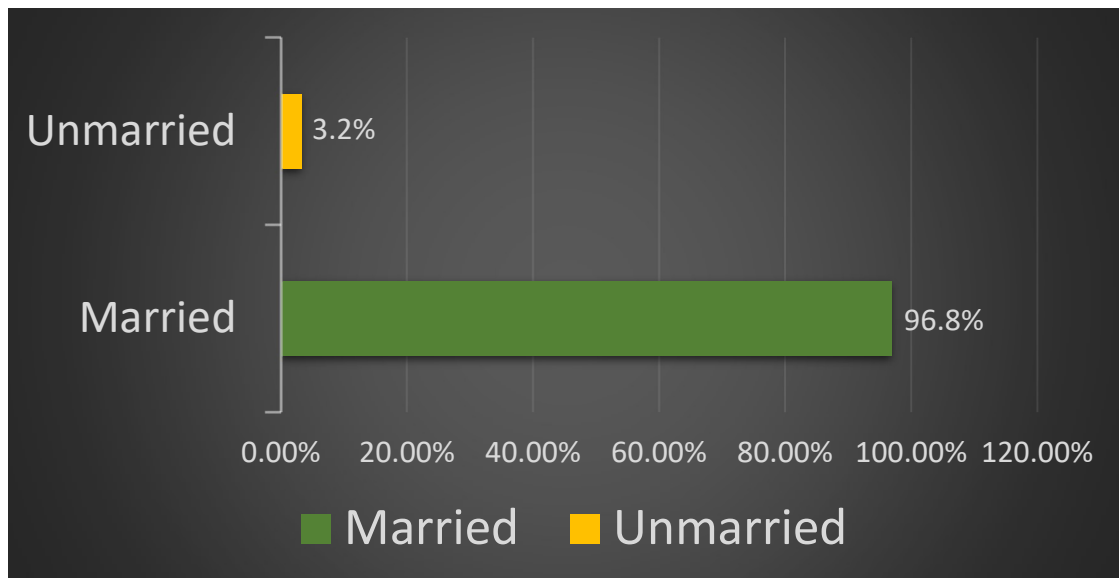
**Figure 3: Age of Respondents**

Figure 3 shows that 76 per cent of the respondents were in the age group of 35-40 years, 12.4 per cent were in the age group of 41-45 years, 7.4 per cent were in the age group of 46-50 years and the remaining 4.2 per cent were in the age group of 51-55 years.

These findings can be supported by the Census data of 2011, according to which, 7.1 per cent of West Bengal's population belong in the age group of 35-40 years, 5.7 per cent belong to the age group of 41-45 years, 4.9 per cent belong to the age group of 46-50 years and 3.6 per cent belong to the age group of 51-55 years (Census, 2011).

### c. Marital Status of respondents

The distribution of marital status of the respondents is given in Figure 4.



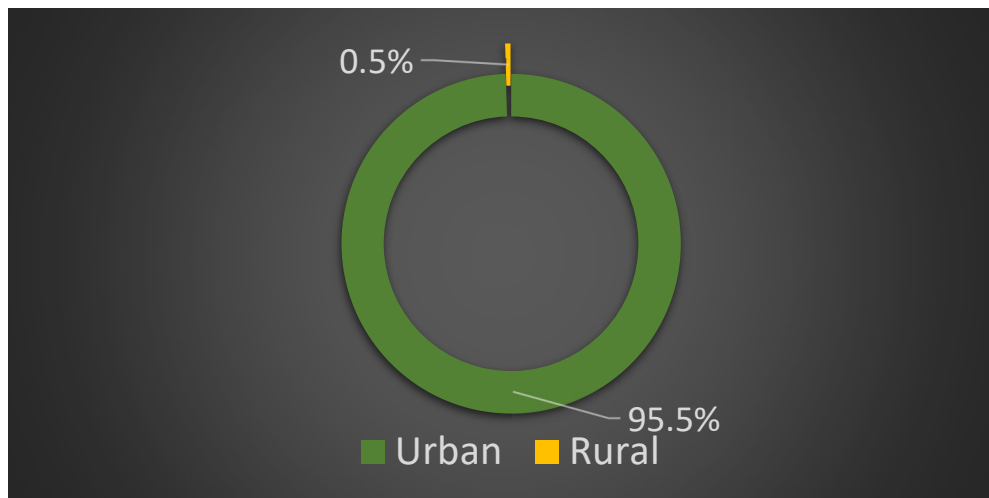
**Figure 4: Marital Status of Respondents**

Among the total respondents, majority (96.8%) of the respondents were married, while, 3.2 per cent of the respondents were unmarried.

These findings can be supported by the Census data, 2011, according to which 91 per cent of males in the age group of 30-49 years were married, while 89.4 per cent of females in the same age group were married in West Bengal. In the age group of 50-69 years, although the per centage of the married male population remained the same at 91 per cent, the same for women went down to 55.5 per cent (Census, 2011).

**d. Area of Residence of respondents**

The distribution of the area of residence of the respondents is given in Figure 5.



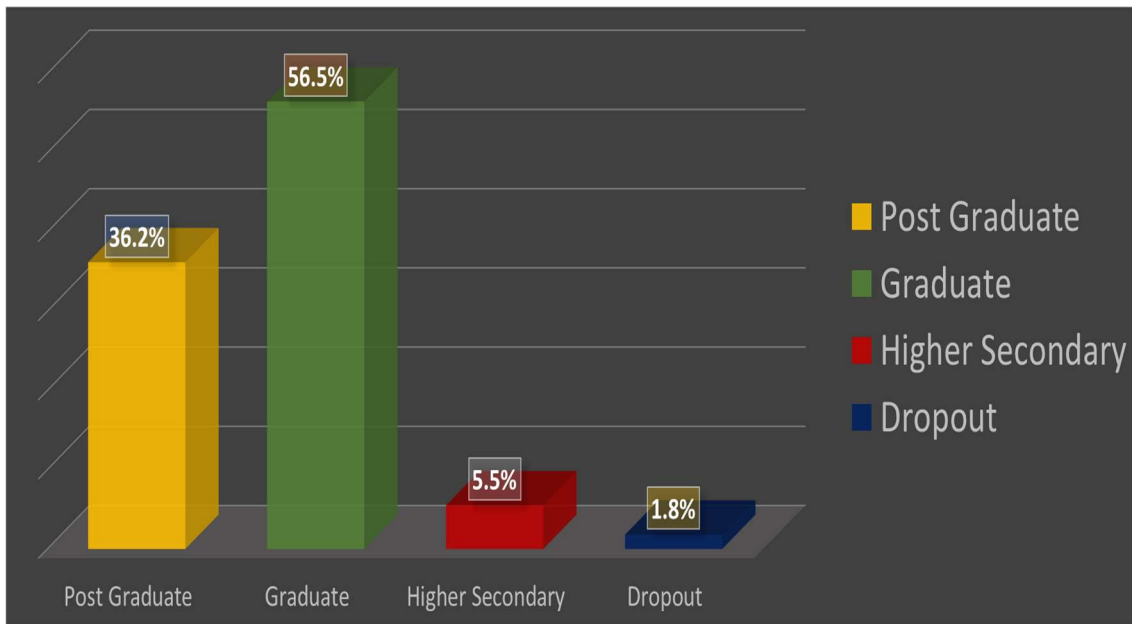
**Figure 5: Area of Residence of Respondents**

As evident from Figure 5, the majority of the respondents (95.5%) belonged to urban areas, while the remaining 0.5 per cent of the respondents belonged to rural areas.

According to the Census data of 2011, which revealed that out of the total population of West Bengal, 31.87 per cent of people lived in urban regions. The total figure for the population living in urban areas was 29,093,002 of which 14,964,082 were males and while the remaining 14,128,920 were females. The same data revealed that 68.1 per cent of the population lived in rural areas (Census, 2011).

**e. Educational Qualifications of respondents**

The distribution of educational qualifications of the respondents is given in Figure 6.



**Figure 6: Educational Qualification of Respondents**

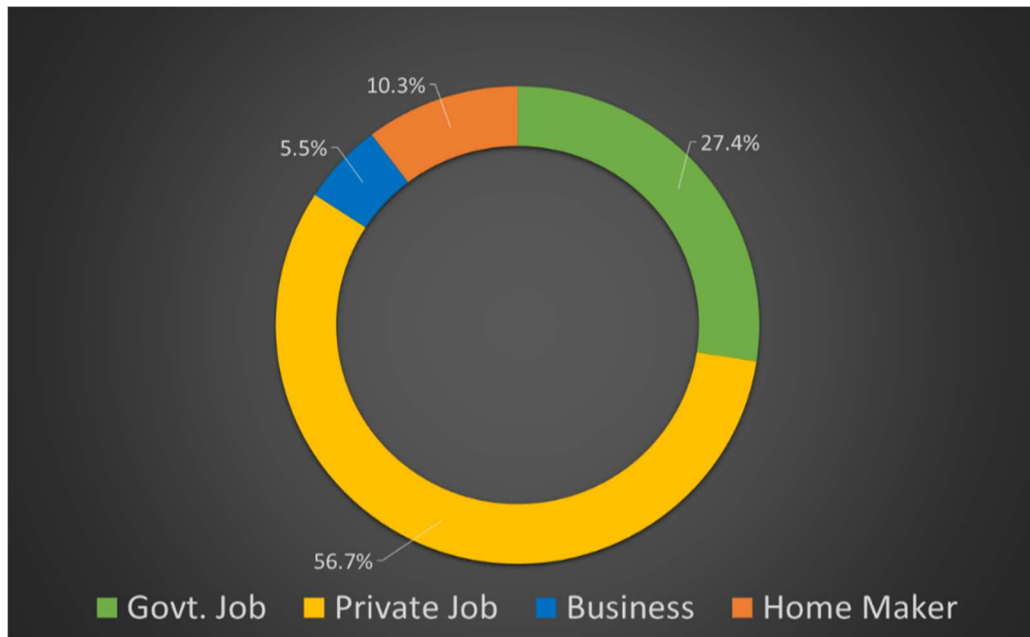
The survey revealed that 36.2 per cent of the respondents were postgraduates, 56.5 per cent were graduates, 5.5 per cent had studied upto higher secondary and 1.8 per cent were dropouts.

West Bengal's literacy rate has risen to 76.26 per cent, according to the 2011 population Census. Male literacy rates are 81.69 per cent, while female literacy rates are 70.54 per cent. West Bengal had a literacy rate of 68.64 per cent in 2001, with male and female literacy rates of 77.02 per cent and 59.61 per cent, respectively (Census, 2011).

The total number of literates in West Bengal is 61,538,281, with 33,818,810 males accounting for 82.6 per cent of the total literates and 27,719,471 females, accounting for 71.2 per cent of the total literates in the state ([wb.gov.in](http://wb.gov.in)).

**f. Occupation of Respondents**

The distribution of occupation of the respondents is given in Figure 7.



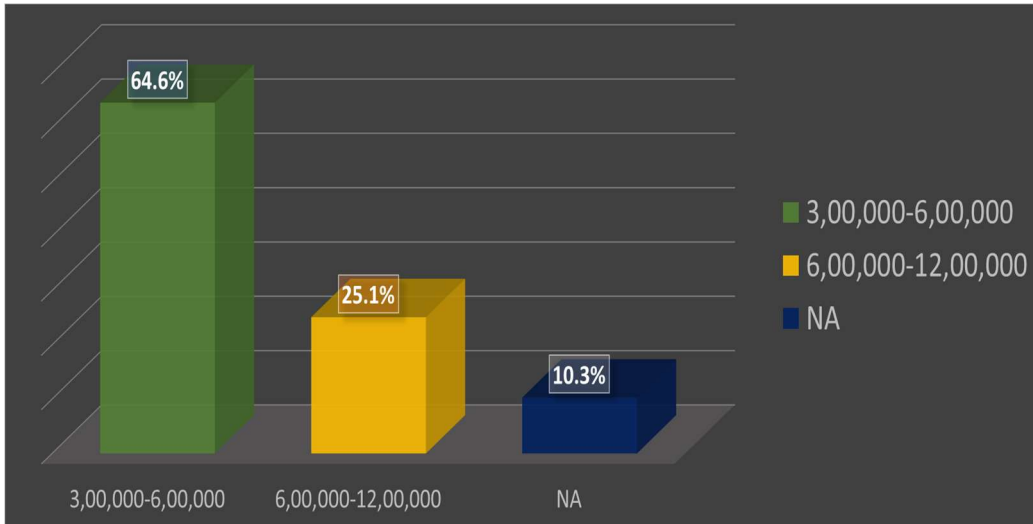
**Figure 7: Occupation of Respondents**

Figure 7 indicates that 56.7 per cent of the respondents had private jobs, 27.4 per cent had government jobs, 10.3 per cent were homemakers, and 5.5 per cent ran businesses.

The public sector in West Bengal employs less than four per cent of the total workforce. The remaining 94 per cent of the workforce are employed in the private sector, out of which the formal private sector accounts for less than five per cent are in the formal sector and the rest are in the informal sector (Roy *et. al.*, 2015).

**g. Income Status of Respondents**

The distribution of income status of the respondents is given in Figure 8.



(HUDCO, 2021)

**Figure 8: Income Status of Respondents**

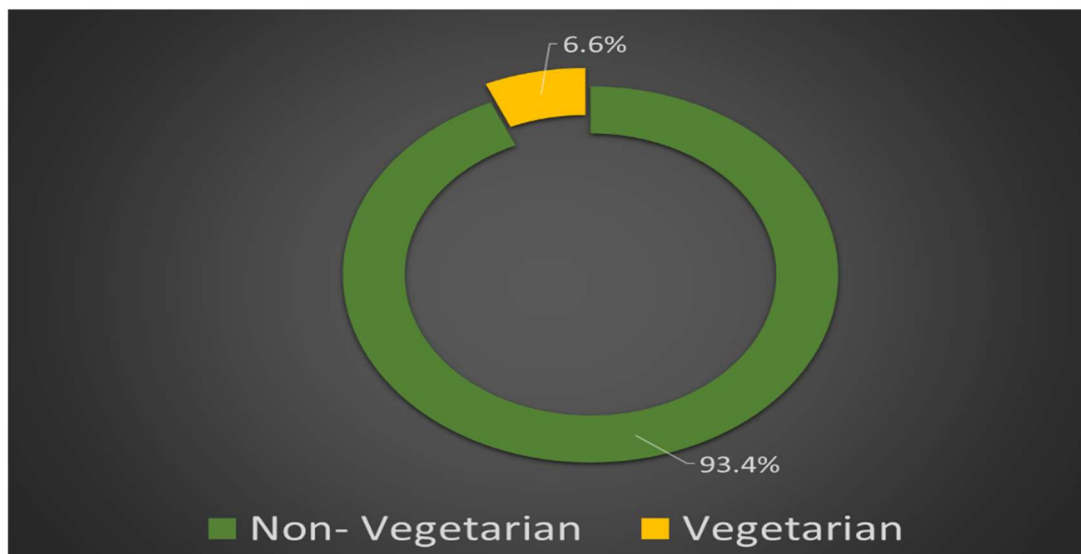
The survey revealed that among the respondents, 64.6 per cent belonged to the Low Income Group, 25.1 per cent belonged to Middle Income Group-I, while the remaining 10.3 per cent didn't have any income as they were home makers.

## B. Dietary Pattern of the Respondents

The information pertaining to the dietary pattern of the respondents is given as follows:

### a. Food Habits of Respondents

The distribution of food habits of the respondents is given in Figure 9.



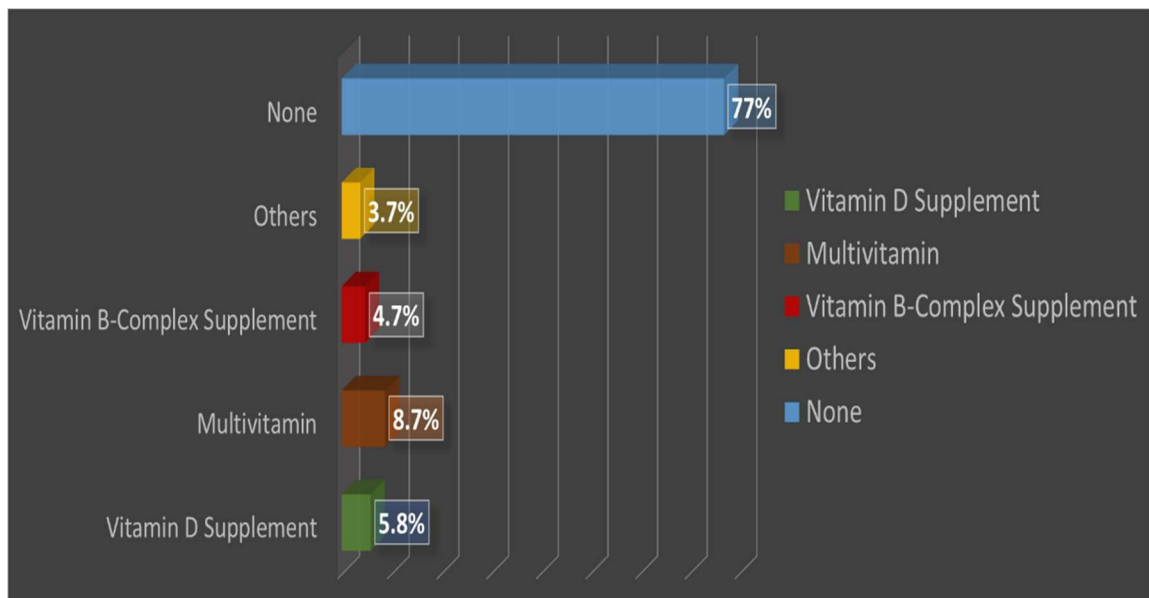
**Figure 9: Food Habits of Respondents**

Figure 9 indicates that the majority of the respondents (93.4%) were non-vegetarians, while the remaining 6.6 per cent were vegetarians.

These findings can be supported by a study conducted on Bengali adults in West Bengal, which revealed that 98.5 per cent of the study participants were non-vegetarians while the remaining 1.5 per cent were vegetarians (Bose *et. al.*, 2009).

### b. Intake of Dietary Supplements by Respondents

The distribution of intake of dietary supplements by the respondents is given in Figure 10.

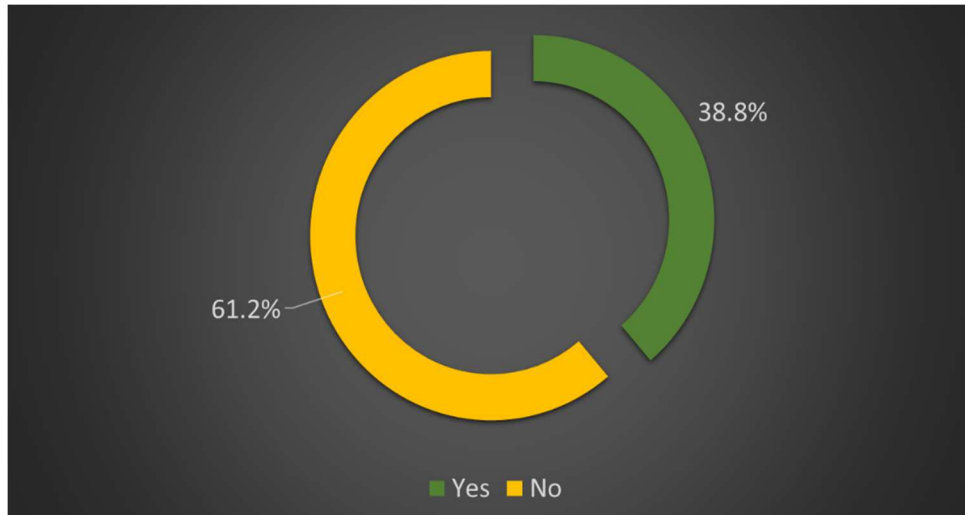


**Figure 10: Intake of Dietary Supplements by Respondents**

As evident from Figure 10, the majority of the respondents (292 respondents) accounting for 77 per cent did not consume any dietary supplement, followed by 33 respondents accounting for 8.7 per cent that consumed Multivitamins, and 22 respondents accounting for 5.8 per cent that consumed Vitamin D supplements. 18 respondents (4.7%) of the respondents consumed Vitamin B-Complex supplements, while the remaining 14 (3.7%) consumed other dietary supplements.

### c. Night time eating by Participants

The distribution of number of participants who partake night time food, is given in Figure 11.



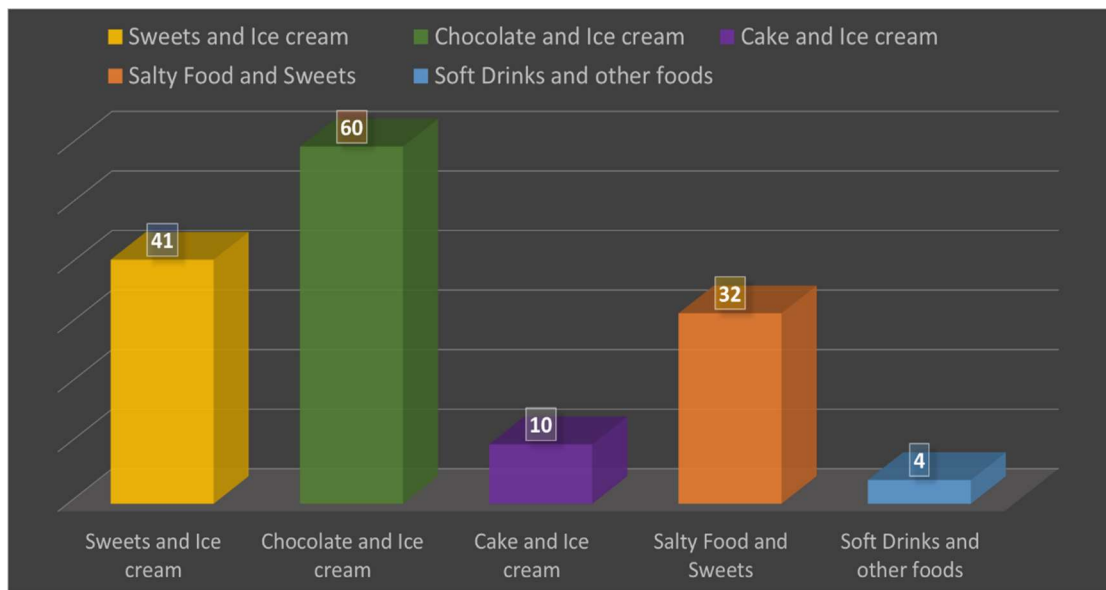
**Figure 11: Night time eating by Participants**

As indicated in Figure 11, 38.8 per cent (147) of the participants ate food at night time, while the remaining 61.2 per cent (232) did not eat food at night time.

These findings can be supported by a study conducted by Greer *et. al.*, 2013, which revealed that as compared to the sleep-rested state, sleep deprivation significantly diminished activity in all three cortical ROIs—the anterior cingulate cortex ( $T \frac{1}{4} 3.87$ ;  $P \frac{1}{4} 0.0008$ ), lateral orbital frontal cortex ( $T \frac{1}{4} 2.08$ ;  $P \frac{1}{4} 0.0491$ ) and anterior insular cortex ( $T \frac{1}{4} 2.63$ ;  $P \frac{1}{4} 0.0154$ )—as food desire progressively increased (Greer *et. al.*, 2013).

### d. Type of Foods Consumed by Respondents at Night Time

The distribution of the type of foods consumed by the respondents at night time is given in Figure 12.



**Figure 12: Type of Foods Consumed by Respondents at Night Time**

As Figure 12 indicates, out of 147 respondents that ate food at night time, 60 respondents (40.8%) consumed chocolates and ice cream at night time, 41 of them (27.9%) consumed sweets and ice cream, 32 respondents (21.8%) consumed salty foods and sweets, ten of them (6.8%) consumed cake and ice cream, and only four respondents (2.7%) consumed soft drinks and other foods at night time.

These findings can be supported by a study conducted on the impact of sleep deprivation on food desire in the human brain. The study reported that sleep deprivation significantly decreases activity in appetitive evaluation regions within the human frontal cortex and insular cortex during food desirability choices, combined with a converse amplification of activity within the amygdala. Moreover, this bi-directional change in the profile of brain activity is further associated with a significant increase in the desire for weight-gain promoting high-calorie foods following sleep deprivation, the extent of which is predicted by the subjective severity of sleep loss across participants, which provided an explanatory brain mechanism by which insufficient sleep may lead to the development/maintenance of obesity through diminished activity in higher-order cortical evaluation regions, combined with excess subcortical limbic responsivity, resulting in the selection of foods most capable of triggering weight-gain (Greer *et. al.*, 2013).

### C. Health Status of the Participants

Information regarding the health status of the initial sample is given as follows:

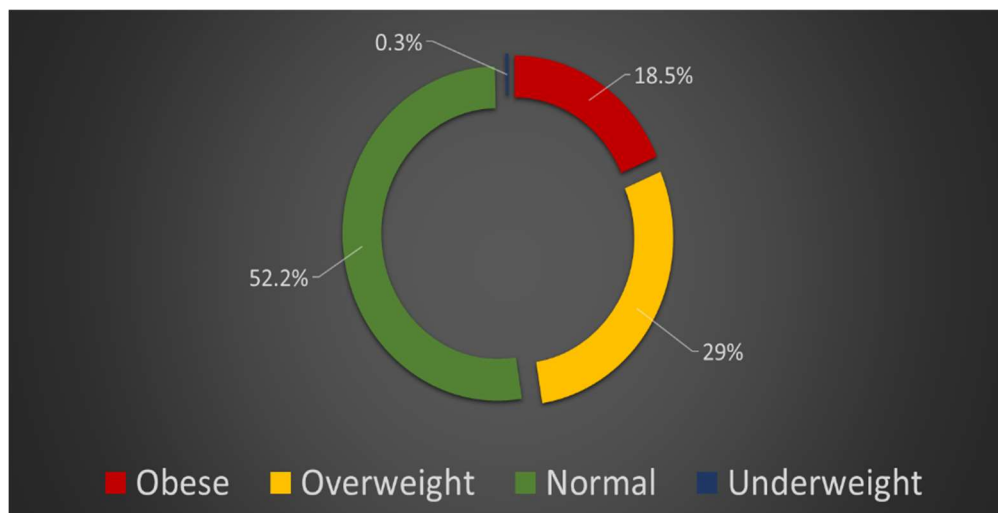
#### a. BMI Status of Respondents

Data regarding the BMI status of the respondents is given in Table II.

**Table II**  
**BMI Status of Respondents**

BMI Status	Number of Respondents (N = 379)
Obese	70
Overweight	110
Normal	198
Underweight	1

The distribution of BMI status of the respondents is given in Figure 13.



**Figure 13: BMI Status of Respondents**

As indicated in Figure 13, 18.5 per cent of the respondents (70 respondents) were obese and 29 per cent (110 respondents) were overweight. While, 52.2 per cent of the respondents (198 respondents) had a normal BMI, and only 0.3 per cent (one respondent) was underweight.

A study conducted among Bengali adults in West Bengal supports these findings, as it revealed that 22.4 per cent of the study participants were overweight and 30.4 per cent of them

were obese. 46.5 per cent of the participants, 21.2 per cent of males, and 68.2 per cent of females had abdominal obesity.

The prevalence of obesity was more in the age group of 30-40 years and 40-50 years with female participants being predominantly obese (58%) as compared to male participants (42%) (Pradhan *et. al.*, 2019).

Table III classifies the number of respondents belonging to Obese category, into the different classes of obesity.

**Table III**  
**Classification of Obesity among Obese Respondents**

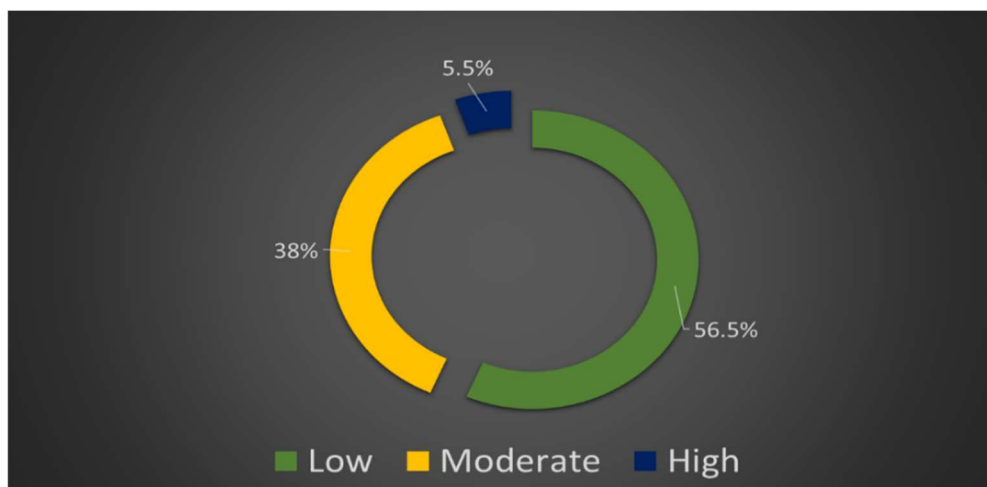
Obese	Number of Respondents (N = 70)	Per centage (%)
<b>Obese Class I</b>	49	70
<b>Obese Class II</b>	17	24.3
<b>Obese Class III</b>	4	5.7

(Centers for Disease Control and Prevention)

As evident from Table III, 70 per cent of the obese respondents belong to Obese Class I, 24.3 per cent belong to Obese class II and 5.7 per cent belong to Obese Class III.

**b. Physical Activity Level of Respondents**

The distribution of the daily physical activity level of the respondents is given in Figure 14.



**Figure 14: Physical Activity Level of Respondents**

The survey indicated that 56.5 per cent (144 participants) had a low daily physical activity level, followed by 38 per cent (214 participants) and 5.5 per cent (21 participants) who had moderate and high daily physical activity levels respectively.

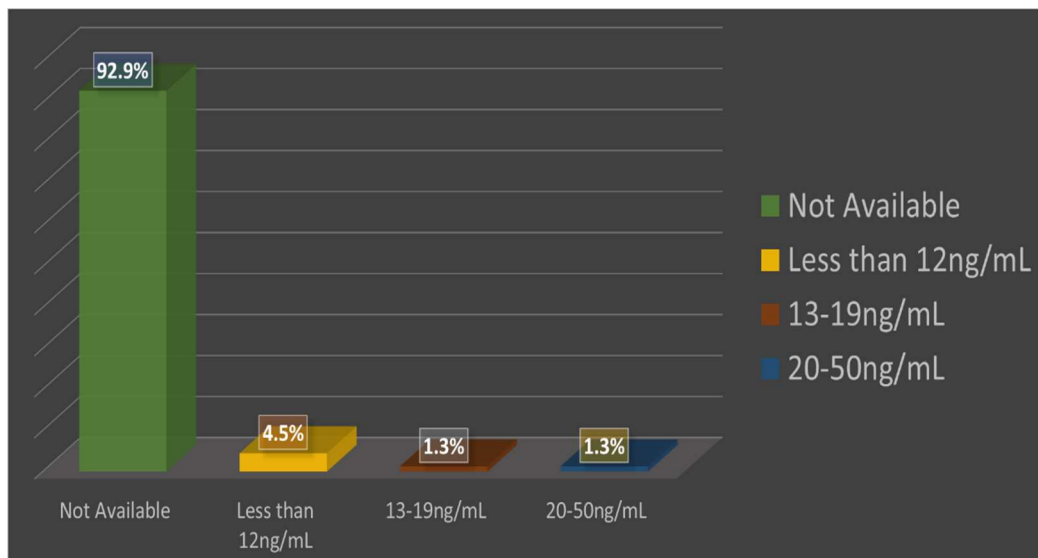
**c. Serum Vitamin D Level of Respondents**

Data regarding the serum vitamin D level of the respondents is given in Table IV.

**Table IV**  
**Serum Vitamin D Level of Respondents**

Serum Vitamin D Level	Number of Respondents (N = 379)
Not Available	352
Less than 12ng/mL	17
13-19ng/mL	5
20-50ng/mL	5

The distribution of the serum vitamin D level of the respondents is given in Figure 15.



**Figure 15: Serum Vitamin D Level of Respondents**

Figure 15 shows that for the majority of the respondents (92.9%) the serum vitamin D level was not available and was available only for 7.1 per cent. Among the total respondents, 4.5 per cent had serum vitamin D levels below 12ng/mL, 1.3 per cent had the same in the range of 13-19ng/mL, while the remaining 1.3 per cent had their serum vitamin D levels in the range of 20-50ng/mL.

A study conducted among the adult population of West Bengal indicated the prevalence of vitamin D insufficiency to be 19.5 per cent and that of vitamin D deficiency to be 34 per cent (Ghosh *et. al.*, 2020).

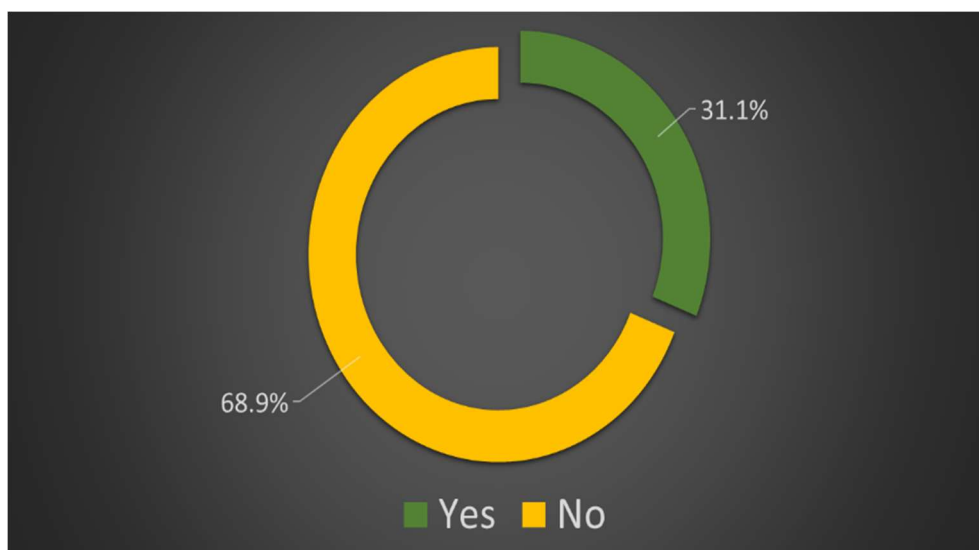
A study conducted on a similar population showed similar results. It revealed vitamin D insufficiency to be 19 per cent prevalent while vitamin D deficiency to be 51 per cent prevalent among the study participants (Srimani *et. al.*, 2017).

#### **D. Sleep Pattern of the Respondents**

Information regarding the sleep pattern of the respondents is given as follows:

##### **a. Snoring while Sleeping**

The distribution of snoring while sleeping by the respondents is given in Figure 16.



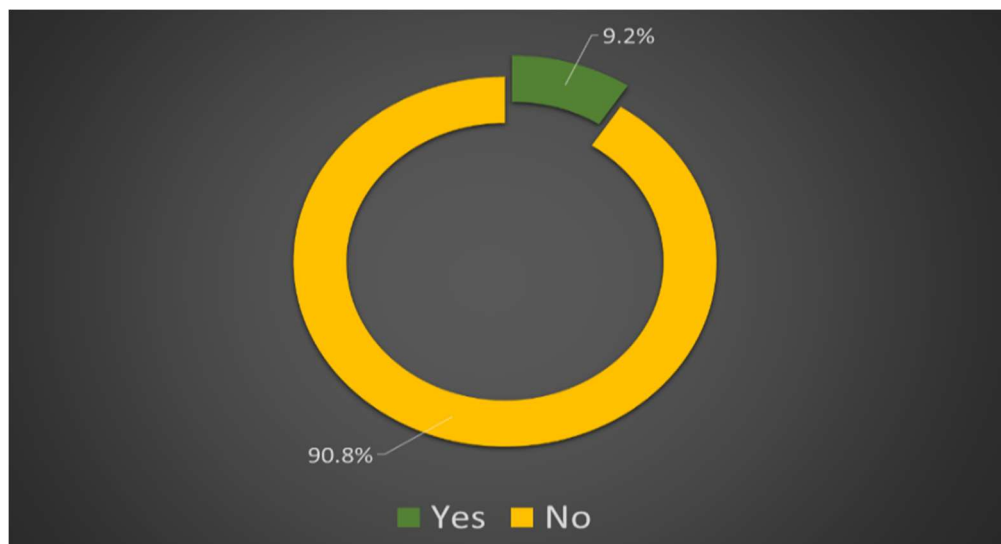
**Figure 16: Snoring while Sleeping by Respondents**

The survey revealed that 31.1 per cent (118 respondents) of the respondents snored while sleeping, while 68.9 per cent (261 respondents) did not snore while sleeping.

A study conducted among the adult urban population of West Bengal revealed that about 50 per cent of the male and a little less than 50 per cent of the female participants were snorers. 70 per cent of male snorers and 65 per cent of female snorers had obstructive sleep apnoea. 33.8 per cent of males had mild obstructive sleep apnoea, and 36.1 per cent of females had mild obstructive sleep apnoea. A higher proportion of males had moderate (11.9%) and severe obstructive sleep apnoea (8.4%) than females (Chakraborty *et. al.*, 2017).

### b. Breathing Problems during Sleep

The distribution of the incidence of breathing problems during sleep in the respondents is given in Figure 17.



**Figure 17: Breathing Problem during Sleep**

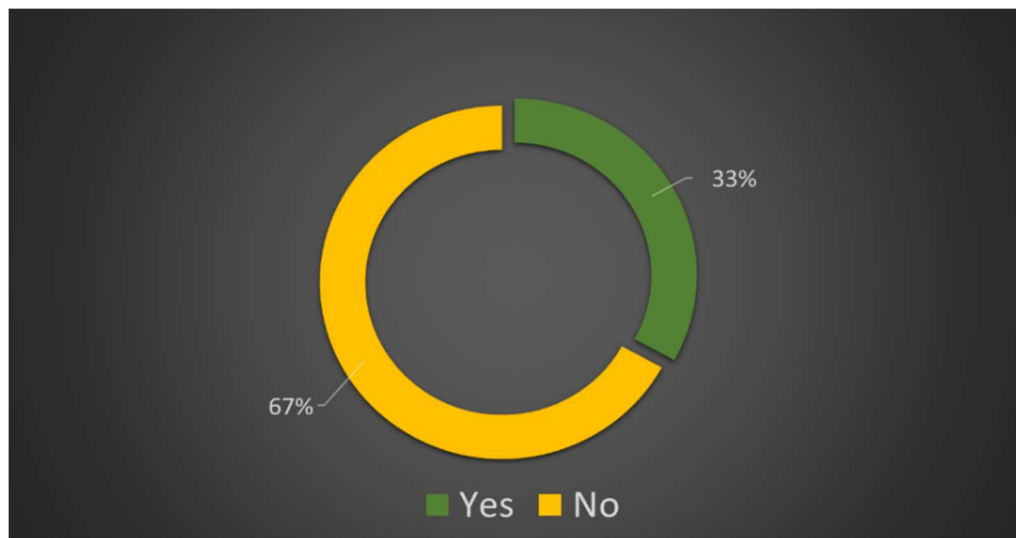
The survey indicated that, 90.8 per cent (344) of the respondents did not experience breathing problems during sleep while only 9.2 per cent (35 respondents) did experience breathing problem during sleep.

These findings can be supported by a study conducted on the adult population of West Bengal that indicated that 33.8 per cent of males had mild obstructive sleep apnoea, and 36.1 per cent of females had mild obstructive sleep apnoea.

The study also revealed that 11.9 per cent of the males had moderate and severe obstructive sleep apnoea as compared to 8.4 per cent of the females (Chakraborty et. al., 2017).

**c. Sleep Paralysis experienced by the Respondents**

The distribution of the respondents experiencing sleep paralysis is given in Figure 18.

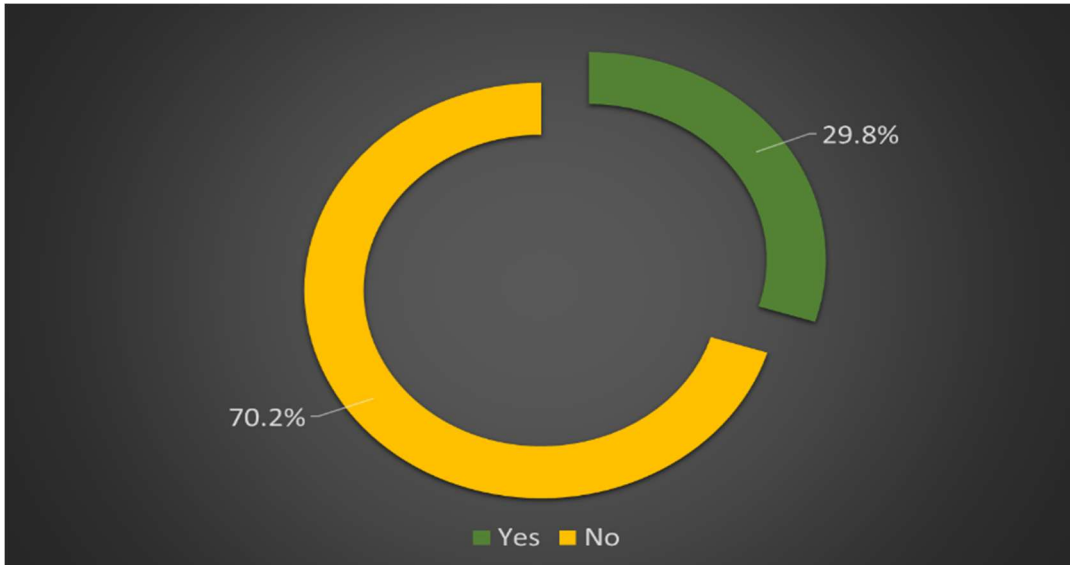


**Figure 18: Sleep Paralysis Experience**

Upon conducting the survey, it was revealed that 33 per cent (379 respondents) of the respondents experienced sleep apnoea while the remaining 67 per cent (254 respondents) did not experience sleep paralysis.

**d. Insomnia Experience by Respondents**

The distribution of the number of respondents experiencing insomnia is given in Figure 19.

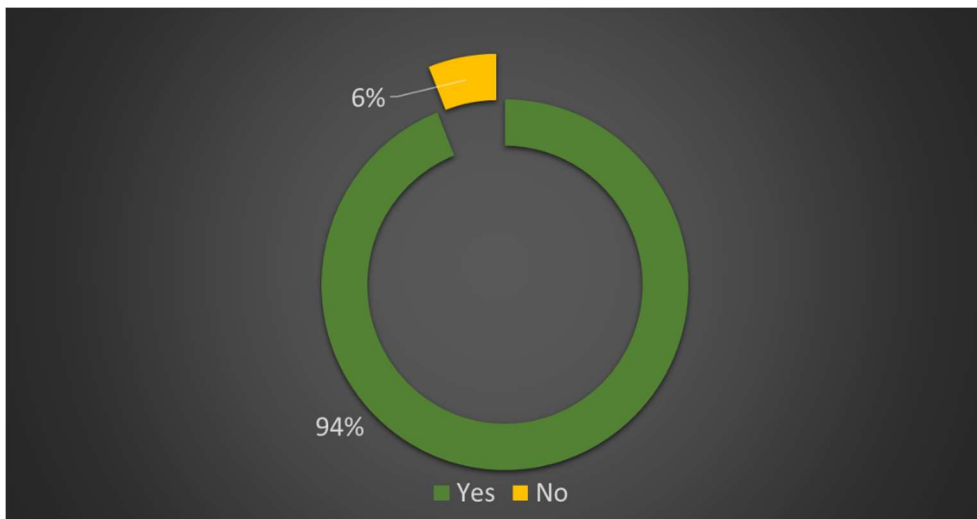


**Figure 19: Insomnia Experience by Respondents**

As indicated in Figure 19, 29.8 per cent of the participants (113 respondents) experienced insomnia, while 70.2 per cent (266 respondent) did not experience insomnia.

**e. Bed Time Phone Usage by Respondents**

The distribution of the number of respondents who used a mobile phone at bed time is given in Figure 20.



**Figure 20: Bed Time Phone Usage by Respondents**

Figure 20 indicates that 356 respondents (94%) used mobile phone at bed time, while only six per cent (23 respondents) did not use them.

Table V gives the classification of the various characteristics of the respondents according to their nutritional status.

**Table V**  
**Classification according to Nutritional Status**

<b>Characteristics of Respondents</b>	<b>N</b>	<b>Obese</b>	<b>Overweight</b>	<b>Normal</b>	<b>Underweight</b>
<b>Night Time Eating</b>	147	61	74	12	NA
<b>Physical Activity</b>					
<b>Low</b>	379	61	89	53	NA
<b>Moderate</b>		9	21	48	1
<b>High</b>		NA	NA	21	NA
<b>Snore while sleeping</b>	118	69	27	22	NA
<b>Breathing Problem during</b>	35	21	12	2	NA
<b>Sleep Paralysis</b>	125	58	49	18	NA
<b>Insomnia</b>	113	63	39	10	1

Table V indicates that 41.5 per cent of the respondents who ate food at night time were obese, 50.3 per cent of them were overweight, and the remaining 8.2 per cent belonged to the normal BMI category. 61 of the obese respondents had a low physical activity level, while nine of them had moderate physical activity level; in case of overweight respondents, 89 of them belonged to low physical activity category, while 21 of them belonged to moderate physical activity category; in the normal BMI category, 53 of the respondents had a low daily physical activity level, 48 had a moderate physical activity level, while, 21 of them had a high level of daily physical activity. 58.4 per cent of the respondents who snored while sleeping were obese, 22.8 per cent of them were overweight, and the remaining 18.6 per cent belonged to the normal BMI category. 60 per cent of the respondents who experienced breathing problems during sleep were obese, 34.2 per cent of them were overweight, and the remaining 5.7 per cent belonged to the normal BMI category. 46.4 per cent of the respondents who experienced sleep paralysis were obese, 39.2 per cent of them were overweight, and the remaining 14.4 per cent belonged to the normal BMI category. 55.7 per cent of the respondents who experienced insomnia were obese. 34.5 per cent were overweight, 8.9 per cent belonged to the normal category of BMI, and 0.8 per cent were underweight.

Table VI depicts the correlation between BMI status of the respondents and other factors.

**Table VI**  
**BMI Status and other Factors**

	<b>Factors</b>	<b>Pearson Correlation</b>	<b>Sig. (2-tailed)</b>
<b>BMI Status</b>	<b>Night Time Eating</b>	.695**	.000
	<b>Physical Activity</b>	.570**	.000
	<b>Snoring during Sleep</b>	.643**	.000
	<b>Breathing Problem during</b>	.365**	.000
	<b>Sleep Paralysis</b>	.600**	.000
	<b>Insomnia</b>	.668**	.000
	<b>**.</b> Correlation is significant at the 0.01 level (2-tailed).		

Table VI shows a significant ( $P < 0.01$ ) positive correlation between BMI Status of the respondents and night time eating, physical activity level, snoring, breathing problem during sleep, sleep paralysis, and insomnia. The values are significant at 99 per cent level of confidence.

#### **E. Nutrient Intake of the Selected Participants**

After screening of the respondents based on BMI, 100 adults (52 males and 48 females), belonging to low daily physical activity level were selected, who were either obese or overweight. Following that 24- hour diet recall for the selected 100 participants were collected, and their daily average intake of Energy, Carbohydrate, Protein, Fat and Vitamin D were estimated.

The mean nutrient intake values were then compared with RDA 2020 to find out the per centage adequacy and the nutrient gap. The mean daily nutrient intake, the nutrient gap, and the per centage adequacy of the male and female participants are given in Table VII and Table VIII respectively.

**TABLE VII**

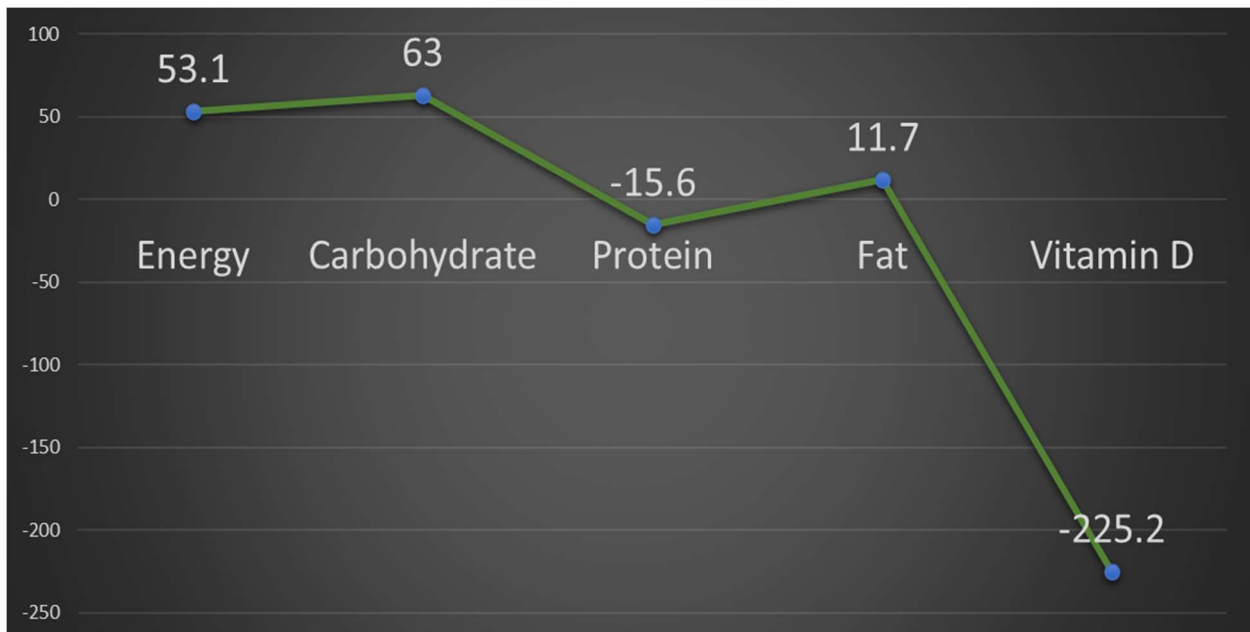
**Mean Daily Nutrient Intake by Male Respondents (N = 52)**

Nutrients	Mean $\pm$ SD	Minimum	Maximum	RDA*	Nutrient Gap	% Adequacy
<b>**Energy (Kcal)</b>	2163.1 $\pm$ 82.4	2034	2341	2110	+ 53.1	102.5
<b>Carbohydrate (g)</b>	193 $\pm$ 20.8	143	215	130	+ 63	148.4
<b>Protein (g)</b>	38.4 $\pm$ 6.5	29	49	54	- 15.6	71.1
<b>Fat (g)</b>	36.7 $\pm$ 5.4	29	46	25	+ 11.7	146.8
<b>Vitamin D (IU)</b>	374.8 $\pm$ 20.8	216	487	600	- 225.2	62.5

\*ICMR, 2020; RDA- Recommended Dietary Allowances; \*\*there is no RDA for Energy; here, energy was represented as Estimated Energy Requirements (EER); SD- Standard Deviation

(<https://nin.res.in/>, 2022)

The distribution showing the nutrient gap in the average daily intake of the male participants is given in Figure 21.



**Figure 21: Nutrient Gap in Male Participants**

Table VII and Figure 21 depict that the protein intake was deficit by 15.6 g and vitamin D intake was deficit by 225.2 IU. The excess in calorie intake was by 53.1 Kcal. Carbohydrate intake was 63 g in excess, while that of fat was 11.7 g respectively.

**Table VIII**

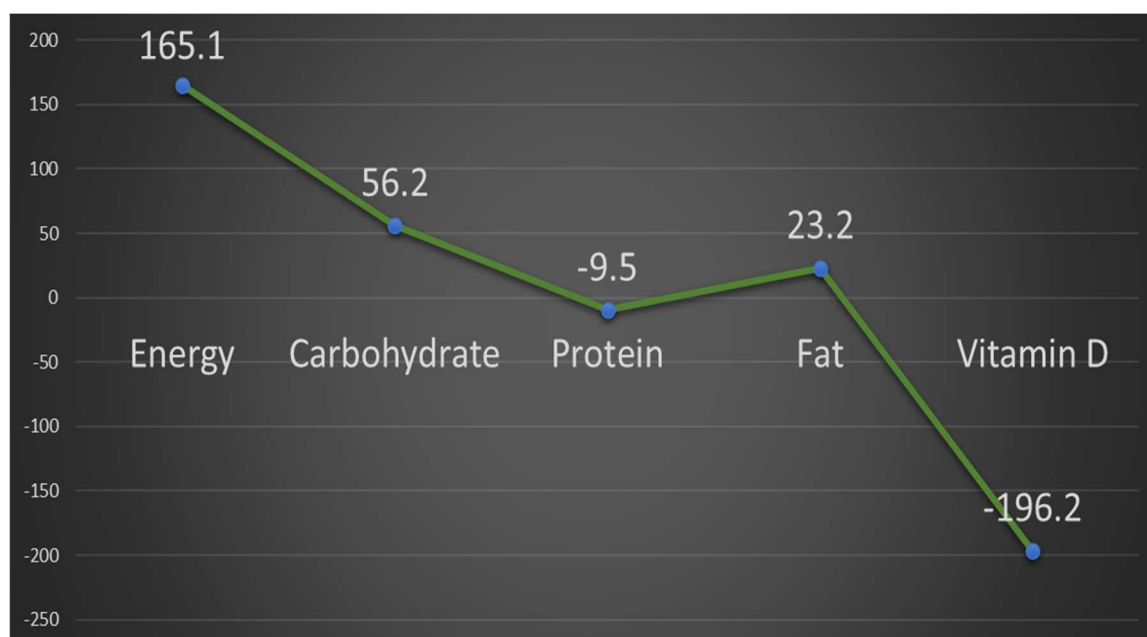
**Mean Daily Nutrient Intake by Female Respondents (N = 48)**

Nutrients	Mean $\pm$ SD	Minimum	Maximum	RDA*	Nutrient Gap	% Adequacy
<b>**Energy (Kcal)</b>	1825.1 $\pm$ 163.8	1466	2004	1660	+ 165.1	109.9
<b>Carbohydrate (g)</b>	186.2 $\pm$ 16.9	154	210	130	+ 56.2	143.2
<b>Protein (g)</b>	36.2 $\pm$ 5.6	24	47	45.7	- 9.5	79.2
<b>Fat (g)</b>	43.2 $\pm$ 4.9	35	51	20	+ 23.2	216
<b>Vitamin D (IU)</b>	403.8 $\pm$ 64.8	311	499	600	- 196.2	67.3

\*ICMR, 2020; RDA- Recommended Dietary Allowances; \*\*there is no RDA for Energy; here, energy was represented as Estimated Energy Requirements (EER); SD- Standard Deviation

(<https://nin.res.in/>, 2022)

The distribution showing the nutrient gap in the average daily intake of the female participants is given in Figure 22.



**Figure 22: Nutrient Gap in Female Participants**

Table VIII and Figure 22 depict that the protein intake was deficit by 9.5 g and vitamin D intake was deficit by 196.2 IU. The excess in calorie intake was by 165.1 Kcal. Carbohydrate intake was 56.2 g in excess, while that of fat was 23.2 g respectively.

These findings can be supported by a study by Fappi & Mittendorfer, 2020, which concluded that calorie-reduced, high-protein, low-carbohydrate diets are elemental in the maintenance of low weight (Fappi & Mittendorfer, 2020).

A study on the relation between vitamin D deficiency and the prevalence of obesity suggested a relation between low vitamin D intake and visceral obesity. It indicated that subjects with low vitamin D intake lack possible anti-inflammatory effects on chronic low-grade inflammation that could lead to an enhanced risk of obesity-related metabolic disorders (Vranić *et. al.*, 2019).

Table IX shows the correlation between BMI status of the respondents and calorie intake, carbohydrate intake, protein intake, fat intake, and vitamin D intake, and between sleep apnoea and vitamin D intake.

**Table IX**  
**Nutrient Intake, BMI Status and Sleep Apnoea**

	<b>Nutrient Intake</b>	<b>Pearson Correlation</b>	<b>Sig. (2-tailed)</b>
<b>BMI Status</b>	<b>Calorie</b>	.774**	.000
	<b>Carbohydrate</b>	-.966**	.000
	<b>Protein</b>	.964**	.000
	<b>Fat</b>	.838**	.000
	<b>Vitamin D</b>	.301**	.000
<b>Sleep Apnoea</b>	<b>Vitamin D</b>	.497**	.000
<b>**.</b> Correlation is significant at the 0.01 level (2-tailed).			

Table IX shows a significant ( $P < 0.01$ ) positive correlation between BMI status of the respondents and their calorie intake, protein intake, fat intake, and vitamin D intake, and between sleep apnoea and vitamin D intake, and a negative correlation between BMI status of the respondents and their carbohydrate intake. The values are significant at 99 per cent level of confidence.

## F. Impact of “D”-OBESA on Selected Obese and Overweight Adults

Digital intervention was conducted throughout a month and the impact was evaluated in three phases, once after the first intervention, once after a week, and finally once after a month, using a Knowledge, Attitude, and Practice (KAP) questionnaire. The improvement in knowledge, attitude, and practice of the respondents after each phase is given below.

### a. Phase 1-Evaluation after First Intervention

The changes in knowledge, attitude, and practice after the first intervention is presented in Table X.

**Table X**  
**Improvement in KAP Scores after First Intervention**

Questions	Pre-Intervention			Post-Intervention			t	*P value
	N	%	Mean ± SD	N	%	Mean ± SD		
<b>Knowledge (2-15)</b>	530	37.9	5.30 ± 2.213	1122	80.1	11.22 ± 1.829	42.805	0.000
<b>Attitude (16-30)</b>	633	42.2	6.33 ± 1.923	1038	69.2	10.38 ± 1.662	22.025	0.000
<b>Practice (31-42)</b>	452	36.7	4.52 ± 1.467	461	38.4	4.61 ± 1.530	3.129	0.002

\*Statistically Significant at  $P < 0.05$ ; Degree of Freedom (df) = (n-1) = 99; t- Paired t test for comparing between pre and post awareness; SD- Standard Deviation

Table X depicts the improvement in knowledge, attitude, and practice of the respondents after the first intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 80.1 per cent, 42.2 per cent to 69.2 per cent, and 36.7 per cent to 38.4 per cent respectively.

Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level. It further showed that the intervention provided to the respondents caused a significant improvement in their general knowledge attitude and practice.

### b. Phase II- Evaluation after One Week

The improvement in knowledge, attitude and practice after one week of intervention is presented in Table XI.

**Table XI**

#### **Improvement in KAP Scores after One Week**

Questions	Pre-Intervention			Post-Intervention			t	*P value
	N	%	Mean ± SD	N	%	Mean ± SD		
<b>Knowledge (2-15)</b>	530	37.9	5.30 ± 2.213	1364	97.4	13.64 ± 0.644	40.470	0.000
<b>Attitude (16-30)</b>	633	42.2	6.33 ± 1.923	1307	87.1	13.07 ± 1.380	28.108	0.000
<b>Practice (31-42)</b>	452	36.7	4.52 ± 1.467	609	50.8	6.09 ± 1.615	14.598	0.000

\*Statistically Significant at  $P < 0.05$ ; Degree of Freedom (df) = (n-1) = 99; t- Paired t test for comparing between pre and post awareness; SD- Standard Deviation

Table XI depicts the improvement in knowledge, attitude, and practice of the respondents after one week of intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 97.4 per cent, 42.2 per cent to 87.1 per cent, and 36.7 per cent to 50.8 per cent respectively.

The improvement in scores of attitude and practice were found to be more than that after the first intervention. The score for attitude was 17.9 per cent more and that of practice was 12.4 percent more those after the first intervention.

Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level. It further showed that the intervention provided to the respondents caused a significant improvement in their general knowledge attitude and practice.

### c. Phase III- Evaluation after One Month

The improvement in knowledge, attitude and practice after one month of intervention is presented in Table XII.

**Table XII****Improvement in KAP Scores after One Month**

Questions	Pre-Intervention			Post-Intervention			t	*P value
	N	%	Mean ± SD	N	%	Mean ± SD		
<b>Knowledge (2-15)</b>	530	37.9	5.30 ± 2.213	1399	99.9	13.99 ± 0.100	39.005	0.000
<b>Attitude (16-30)</b>	633	42.2	6.33 ± 1.923	1441	96.1	14.41 ± 0.653	39.931	0.000
<b>Practice (31-42)</b>	452	36.7	4.52 ± 1.467	887	73.9	8.87 ± 1.383	26.600	0.000

\*Statistically Significant at  $P < 0.05$ ; Degree of Freedom (df) = (n-1) = 99; t- Paired t test for comparing between pre and post awareness; SD- Standard Deviation

Table XII depicts the improvement in knowledge, attitude, and practice of the respondents after one month of intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 99.9 per cent, 42.2 per cent to 96.1 per cent, and 36.7 per cent to 73.9 per cent respectively.

The improvement in scores of attitude and practice were found to be more than that after one week of intervention. The score for attitude was nine per cent more and that of practice was 23.1 percent more those after one week of intervention.

Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level. It further showed that the intervention provided to the respondents caused a significant improvement in their general knowledge attitude and practice.

**d. Mean difference in KAP scores**

The mean difference in scores of Knowledge, Attitude, and Practice in Phase 1 (evaluation after first intervention), Phase 2 (evaluation after one week), and Phase 3 (evaluation after a month) are given in Table XIII.

**Table XIII**

**Mean Difference in KAP Scores**

	<b>Phase 1</b>	<b>Phase 2</b>	<b>Phase 3</b>
<b>Knowledge</b>	6.0	8.0	8.3
<b>Attitude</b>	0.6	3.9	8.5
<b>Practice</b>	0	1.8	3.8

As depicted in Table XIII, the mean score of knowledge, attitude and practice, in Phases 1, 2 and 3 are, 6.0, 8.0, 8.3, 0.6, 3.9, 8.5, 0, 1.8, and 3.8 respectively.

The difference in the mean KAP scores of the three phases is presented in Table XIV.

**Table XIV**

**Difference in Mean KAP Scores of Three Phases**

	<b>Mean Square</b>	<b>F</b>	<b>*P Value</b>
<b>Phase 1*Phase 2</b>	.000	.000	1.000
<b>Phase 1*Phase 3</b>	.130	3.287	.000
<b>Phase 2*Phase 3</b>	.069	1.737	.017

\*Statistically Significant at  $P < 0.05$

Table XIV depicts the difference in mean KAP scores between Phase 1 and Phase 2; Phase 1 and Phase 3; and Phase 2 and Phase 3.

Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level in between Phase 1 and Phase 3, and Phase 2 and Phase 3.

The difference in the mean scores of knowledge, attitude, and practice is presented in Table XV.

**Table XV**

**Difference in Mean Scores of Knowledge, Attitude, and Practice**

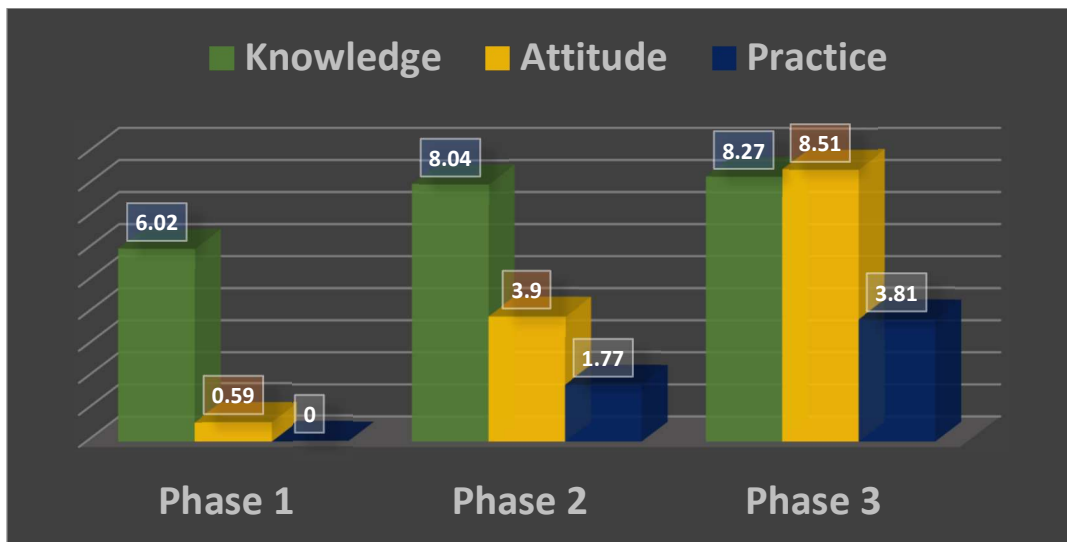
	<b>Mean Square</b>	<b>F</b>	<b>*P Value</b>
<b>Knowledge*Attitude</b>	.070	3.556	.000
<b>Knowledge*Practice</b>	.057	2.882	.000
<b>Attitude*Practice</b>	.075	3.822	.000

\*Statistically Significant at  $P < 0.05$

Table XV depicts the difference in mean scores between Knowledge and Attitude; Knowledge and Practice; and Attitude and Practice.

Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level in between Knowledge and Attitude, Knowledge and Practice, and Attitude and Practice.

The distribution of difference in mean KAP scores for the three phases are given in Figure 23.



**Figure 23: Mean Difference in KAP Scores**

Therefore, the null hypothesis ( $H_0$ ), is rejected and the alternate hypothesis ( $H_1$ ) stated, there is a significant effect of the digital health intervention on the knowledge, attitude, and practice scores of the study participants, is accepted.

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## *Summary and Conclusion*

## E. Summary and Conclusion

India is undergoing a rapid epidemiological transition, from underweight to overweight and obese population. Obesity is a major risk factor for numerous other metabolic, immunological, neurological, reproductive, and degenerative disorders. Obesity is widespread in India, affecting all regions. Obesity risk increases with age and is higher in urban dwellers. Obesity is highest among sedentary ageing urban men and women with a college education. Physical activity and ageing are the most powerful predictors of obesity.

Vitamin D deficiency is epidemic throughout the Indian subcontinent, with prevalence rates ranging from 70 per cent to 100 per cent in the general population. Dairy products, which are widely consumed in India, are rarely fortified with vitamin D. Indian socio-religious and cultural practices do not actively facilitate adequate sun exposure, thereby negating the potential benefits of abundant sunlight. As a result, subclinical vitamin D deficiency is common in both urban and rural areas, as well as across all socioeconomic and geographic strata.

Obstructive sleep apnoea (OSA) is a condition characterised by repeated episodes of upper airway collapse and obstruction during sleep, which are accompanied by arousal from sleep with or without oxygen deficiency. OSA is a common condition, especially in people who have pre-existing risk factors and comorbid conditions. Obesity is increasing the prevalence of OSA. While OSA is primarily an upper airway disorder during sleep, its pathophysiological impact on other body systems is becoming more recognised.

In the state of West Bengal, obesity is a major health problem, having a prevalence rate of approximately 6000 per 100,000 adults. It has the highest prevalence of obesity and the third-highest prevalence of overweight in India. Since, not many studies have been conducted to assess the impact of digital health intervention on knowledge, attitude and practice related to obesity, vitamin D deficiency, and sleep apnoea in West Bengal, the study entitled, “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese adults**” was carried out to assess the impact of nutrition communication through digital health intervention, on the knowledge, attitude, and practice of obese and overweight adults residing in West Bengal.

A total of 379 adults residing in west Bengal were taken as an initial sample for carrying out the study. For investigation appropriate research tools were selected which included

structured interview schedule, 3 day 24-hour diet recall questionnaire and pre and post intervention KAP questionnaires. With the use of the interview schedule, demographic profile, anthropometric details, educational and occupational details, food consumption pattern, lifestyle pattern, physical activity pattern and sleep pattern. Screening was done based on age and BMI status of the respondents, and 100 adult men and women were selected, who were obese or overweight and within the age group of 35-55 years. Three day 24-hour recall questionnaire was used to collect information on the daily food intake of the selected respondents. The pre and post intervention KAP questionnaires were used to assess the improvement in knowledge, attitude, and practice of the selected respondents related to obesity, vitamin D, and sleep apnoea after intervention was conducted using digital aid. A website was developed, a YouTube channel and a WhatsApp group were created and two social media pages (Instagram and Facebook) were set up and content for nutrition communication were developed and shared to the selected respondents using these platforms. Finally, the impact of the digital health intervention was evaluated using the post intervention KAP questionnaire. The data obtained from the survey was recorded and further analysis was done using IBM SPSS Statistics version 26.0 and Microsoft Excel 2019. The results obtained from the study are summarized below.

**The salient findings of the study:**

- Among the respondents, 64.6 per cent were females and 35.4 per cent were males.
- Among the respondents, majority, (76%) were in the age group of 35-40 years, 12.4 per cent were in the age group of 41-45 years, 7.4 per cent were in the age group of 46-50 years, while the remaining 4.2 per cent were in the age group of 51-55 years.
- Among the respondents, 96.8 per cent were married whereas, only 3.2 per cent were unmarried.
- Among the respondents, 95.5 percent resided in urban areas, while 0.5 per cent resided in rural areas.
- Among the respondents, 56.6 per cent were found to be graduates, 36.2 per cent were found to be post graduates, 5.5 per cent had studied till higher secondary, while the remaining 1.8 per cent were found to be dropouts.
- Among the respondents, 56.7 per cent had private jobs, 27.4 per cent had government jobs, 10.3 per cent were home makers, while 5.5 per cent were engaged in businesses.

- Among the respondents, 64.6 per cent belonged to Low Income Group, 25.1 per cent belonged to Middle Income Group, while the remaining 10.3 per cent, did not have any income, as they were home makers.
- Among the respondents, 93.4 per cent were non- vegetarians, while 6.6 per cent were vegetarians.
- Among the respondents, 77 per cent did not consume any dietary supplement, 8.7 per cent consumed multivitamins, 5.8 per cent consumed vitamin D supplements, 4.7 per cent consumed vitamin B-complex supplements, while 3.7 per cent consumed other supplements.
- Among the respondents, 38.8 per cent ate food at of night time, while the remaining 61.2 per cent did not eat food at night time.
- Out of the 147 respondents who ate at night time, 27.9 per cent consumed sweets and ice cream, 40.8 per cent consumed chocolates and ice cream, 6.8 per cent consumed cakes and ice cream, 21.8 per cent consumed salty foods and sweets, while 2.7 per cent consumed soft drinks and other foods.
- Among the respondents, 18.5 per cent were obese, 29 per cent were overweight, 52.2 per cent had normal BMI, and only 0.3 per cent were underweight.
- Out of the 70 obese respondents, 49 belonged to obese class I, 17 belonged to obese class II, and four belonged to obese class III.
- Among the respondents, 56.5 per cent had a low daily physical activity level, 38 per cent had a moderate daily physical activity level, while only 5.5 per cent had a high daily physical activity level.
- With regard to serum vitamin D level of the respondents, for 92.9 per cent, report pertaining to serum vitamin D level was not available. 4.5 per cent of them had a low serum vitamin D level of less than 12ng/mL, 1.3 per cent had a low serum vitamin D level of 13-19ng/mL, while another 1.3 per cent had an adequate serum vitamin D level of 20-50ng/mL.
- Among the respondents, 31.1 per cent snored while sleeping, while 68.9 per cent did not snore.
- Among the respondents, 90.8 per cent did not experience breathing problem during sleep, while 9.2 per cent did experience breathing problem during sleep.
- Among the respondents, 67 per cent did not experience sleep paralysis, however, 33 per cent did experience sleep paralysis.

- Among the respondents, 29.8 per cent experienced insomnia, but 70.2 per cent did not experience insomnia.
- Among the respondents, 94 per cent used mobile phone at bed time, while six per cent did not use them.
- Statistically significant ( $P < 0.01$ ) positive correlations were found between BMI Status of the respondents and night time eating, physical activity level, snoring, breathing problem during sleep, sleep paralysis, and insomnia. The values were significant at 99 per cent level of confidence.
- In terms of the mean daily nutrient intake by the male respondents, the mean daily intake of calorie was  $2163.1 \pm 82.4$  Kcal, compared to the RDA of 2110 Kcal, causing a nutrient gap of + 53.1 Kcal and a per centage adequacy of 102.5 per cent. The mean daily intake of carbohydrate was  $193 \pm 20.8$  g, compared to the RDA of 130 g causing a nutrient gap of + 63 g and a per centage adequacy of 148.4 per cent. The mean daily protein intake was  $38.4 \pm 6.5$  g, compared to the RDA of 54 g, causing a nutrient gap of - 15.6 g and a per centage adequacy of 71.1 per cent. The mean daily intake of fat was  $36.7 \pm 5.4$  g, compared to the RDA of 25 g, causing a nutrient gap of + 11.7 g and a per centage adequacy of 146.8 per cent. The mean daily intake of vitamin D was  $374.8 \pm 20.8$  IU, compared to the RDA of 600 IU, causing a nutrient gap of - 225.2 IU and a per centage adequacy of 62.5 per cent.
- In terms of the mean daily nutrient intake by the female respondents, the mean daily intake of calorie was  $1825.1 \pm 163.8$  Kcal, compared to the RDA of 1660 Kcal, causing a nutrient gap of + 165.1 Kcal and a per centage adequacy of 109.9 per cent. The mean daily intake of carbohydrate was  $186.2 \pm 16.9$  g, compared to the RDA of 130 g causing a nutrient gap of + 56.2 g and a per centage adequacy of 143.2 per cent. The mean daily protein intake was  $36.2 \pm 5.6$  g, compared to the RDA of 45.7 g, causing a nutrient gap of - 9.5 g and a per centage adequacy of 79.2 per cent. The mean daily intake of fat was  $43.2 \pm 4.9$  g, compared to the RDA of 20 g, causing a nutrient gap of + 23.2 g and a per centage adequacy of 216 per cent. The mean daily intake of vitamin D was  $403.8 \pm 64.8$  IU, compared to the RDA of 600 IU, causing a nutrient gap of - 196.2 IU and a per centage adequacy of 67.3 per cent.
- Statistically significant negative correlation was found at  $P < 0.01$  and at 99 per cent confidence level between calorie intake and BMI status and between carbohydrate intake and BMI status.

- Statistically significant positive correlation was found at  $P < 0.01$  and at 99 per cent confidence level between protein intake and BMI status, between fat intake and BMI status, between vitamin D intake and BMI status, and vitamin D intake and incidence of sleep apnoea.
- In the first phase of evaluation, the improvement in knowledge, attitude, and practice of the respondents after the first intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 80.1 per cent, 42.2 per cent to 69.2 per cent, and 36.7 per cent to 38.4 per cent respectively.
- In the second phase of evaluation, the improvement in knowledge, attitude, and practice of the respondents after one week of intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 97.4 per cent, 42.2 per cent to 87.1 per cent, and 36.7 per cent to 50.8 per cent respectively.
- The improvement in scores of attitude and practice were found to be more than that after the first intervention. The score for attitude was 17.9 per cent more and that of practice was 12.4 percent more those after the first intervention.
- In the third phase of evaluation, the improvement in knowledge, attitude, and practice of the respondents after one month of intervention. The improvement in knowledge, attitude, and practice in the pre and post-intervention phases were found to be from 37.9 per cent to 99.9 per cent, 42.2 per cent to 96.1 per cent, and 36.7 per cent to 73.9 per cent respectively.
- The improvement in scores of attitude and practice were found to be more than that after one week of intervention. The score for attitude was nine per cent more and that of practice was 23.1 percent more those after one week of intervention.
- Statistically significant difference was found between the three phase at  $P < 0.05$  and 95 per cent confidence level. It further showed that the intervention provided to the respondents caused a significant improvement in their general knowledge attitude and practice.
- The mean difference in the knowledge scores for Phase 1 was 6.0, for Phase 2 was 8.0 and for Phase 3 was 8.3. This indicates that major difference in knowledge occurred in phase 2.

- The mean difference in the attitude scores for Phase 1 was 0.6, for Phase 2 was 3.9 and for Phase 3 was 8.5. This indicates that major difference in attitude occurred in Phase 3.
- The mean difference in the practice scores for Phase 1 was zero, for Phase 2 was 1.8 and for Phase 3 was 3.8. This indicates that major difference in attitude occurred in Phase 3.
- Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level in between Phase 1 and Phase 3, and Phase 2 and Phase 3.
- Statistically significant difference was found at  $P < 0.05$  and 95 per cent confidence level in between Knowledge and Attitude, Knowledge and Practice, and Attitude and Practice.

### **Conclusion:**

The study entitled, “**Digital Health Intervention on the Role of Vitamin D in the Management of Obesity and Sleep Apnoea among Overweight and Obese Adults**” thus concluded that Digital Health Intervention as a tool for communication on vitamin D, obesity and sleep apnoea among obese and overweight adults proposed positive changes in different areas of knowledge, attitude and practice in the respondents. Improvement was found in different areas of knowledge, like general knowledge on vitamin D, knowledge on food sources of vitamin D, knowledge on obesity and knowledge on sleep apnoea, as well as in attitude and practice. This showed the need and importance of the communication that was imparted to the obese and overweight adults.

### **Recommendations for further study:**

- Digital health intervention can be carried out for other age groups.
- User friendly and low-cost mobile application can be developed for providing education and increasing awareness on vitamin D, obesity and sleep apnoea.
- Study can be carried out with large population to generalize the level of knowledge, attitude and practice on vitamin D, obesity and sleep apnoea among adult men and women.

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# Appendix

**APPENDIX I**  
**Survey Questionnaires**

**Interview Schedule:**

<https://forms.gle/WYw5V81rgRQEhsSQ9>

**3 day 24- Hour Recall Questionnaire:**

<https://docs.google.com/document/d/1NevZNHxMPoz0bFilUine3hr4xl3OkXp4PxoYCE0xbYQ/edit?usp=sharing>

**Pre Intervention KAP Questionnaire:**

<https://forms.gle/fdF58t6GBveNEYz36>

**1st Post Intervention KAP Questionnaire:**

<https://forms.gle/5Ew9cx5SvHMi5SSa6>

**2nd Post Intervention KAP Questionnaire:**

<https://forms.gle/sSnE4PrtEc89oZNN6>

**3rd Post Intervention KAP Questionnaire:**

<https://forms.gle/vdjURR9e4YjoqWnk8>

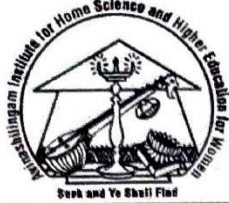
**Feedback Form:**

<https://forms.gle/3NkztzwiYxrasu5E9>

## APPENDIX II

### Ethical Committee Clearance Certificate

#### INSTITUTIONAL HUMAN ETHICS COMMITTEE



### *Avinashilingam*

Institute for Home Science and Higher Education for Women  
(Deemed to be University under Category 'A' by MHRD, Estd. u/s 3  
of UGC Act 1956) Re-accredited with 'A++' Grade by  
NAAC. Recognised by UGC Under Section 12 B  
Coimbatore-641 043, Tamil Nadu, India

26<sup>th</sup> February 2022

#### **Chairman**

Dr. Sudha Ramalingam  
Director-Research & Innovation,  
Professor-Community Medicine,  
PSG Institute of Medical Sciences  
& Research, Coimbatore

#### **Member Secretary**

Dr. S. Uma Mageshwari  
Professor and Head,  
Department of Food Service  
Management & Dietetics

#### **Members**

Mr. K. Arunmoli (Legal Expert)  
Dr. Subhashini K. Sripathi  
Dr. A. Saraswathy (Medical Officer)  
Ms. D. Kavitha  
Dr. A. R. Sudamani Ramasamy  
Dr. G. Victoria Naomi  
Dr. Judith Justin  
Dr. Aritha Subash

To  
Ms. Sagarika Bhattacharya  
Department of Food Science and Nutrition  
Avinashilingam Institute for Home Science and  
Higher Education for Women  
Coimbatore – 641 043

Dear Sagarika Bhattacharya,

Ref: Your proposal No. IHEC/21-22/FSN-19 entitled  
“Digital Health Intervention on the role of Vitamin D in the  
Management of Obesity and Sleep Apnoea among Overweight and  
Obese Adults” submitted for approval of IHEC on 23.11.2021.

The Institutional Human Ethics Committee of our University  
hereby grants approval to your research proposal No. IHEC/21-22/  
FSN-19 entitled “Digital Health Intervention on the role of  
Vitamin D in the Management of Obesity and Sleep Apnoea among  
Overweight and Obese Adults” submitted by you. The Approval  
number for the same is AUW/IHEC/ FSN-21-22/XPDP-19.

We wish you all the best in your research endeavours.

Regards,

*S. Uma Mageshwari*  
Dr. S. Uma Mageshwari  
Member Secretary

