CHAPTER 5

SUMMARY & CONCLUSION

This chapter aims to summarise the objectives, research methods, and salient findings of the research work entitled “Impact of lifestyle interventions on nutritional status, physical activity and sleep pattern of overweight and obese 18-25 year old women during Covid-19”.

Introduction

In an era when maintaining optimal health has become crucial to modern life, the fight against non-communicable diseases is profound. Of all these health issues, non-communicable diseases (NCDs) including overnutrition or obesity is one of the most significant and multifaceted concern. In public health discussions, NCDs, sometimes known as “lifestyle diseases”, have gained prominence because of their rising prevalence and significant economic impact on healthcare systems across the globe. Overnutrition's main symptom, obesity, has become a significant NCD spanning international borders for the past three decades (WHO, 2020). Obesity is a disease in which an individual's body fat accumulates to the point where it can be detrimental to their general health. Obesity has several complex underlying causes, including a combination of behavioural, environmental, genetic, and social variables (Apovian, 2016). Sedentary habits, inadequately nourishing diet including mostly calorie-dense foods, heredity, and socio-economic differences are a few of these factors. Obesity has serious negative effects since it increases the risk of many NCDs, including cardiovascular disease, type 2 diabetes, and some types of cancer.

Definition of the Problem Statement

Aware of how urgent it is to combat the global pandemic of obesity, academics and medical professionals have developed a variety of treatment approaches to manage obesity. The cornerstone of the battle against obesity is physical activity, which not only helps people burn extra calories but also enhances their general health and well-being. A balanced diet that lowers calorie intake while increasing the intake of foods with a higher nutritional value is essential for optimal nutrition. Combining these tactics and customizing them to

each person's requirements can help fight obesity, promote improved health, and lower the risk of non-communicable diseases. Defining the problem statement of the present study in this manner aims to extend the groundwork for a more thorough examination of overnutrition, especially obesity, and the non-invasive, individual-centric, behaviour change based approaches designed to address this widespread health concern.

Rationale of Study

Reduced access to nutritious food (which may be due to lack of awareness or lack of time on their hands) and declining levels of physical activity, along with urbanization, technological advancements, and rising economic stability of urban families that put an electronic device in the hands of most people, are contributing to the trend of obesity. Monitoring current developments in noncommunicable illnesses and the hazards associated with them is essential in order to develop policies, organize public health efforts, and make choices based on the most relevant information available. It is a crucial first step in improving population health including overall wellbeing and lowering the growing burden of noncommunicable illnesses.

Objectives

The primary objectives of this study are as follows:

- To study the socio-economic status, dietary pattern, nutritional status and frequency of morbidities of 18 – 25 years old women.

- To determine the nutritional status, physical activity levels, sleep quality, and the Knowledge, Attitudes and Practices (KAP) of healthy lifestyles of these women.

- To develop aerobic exercise routines and nutrition education modules as interventions for the women based on their nutrition knowledge and health status.

- To assess the impact of intervention on the nutritional status, physical activity levels, sleep quality, and the knowledge, attitudes and practices of the selected women.

Methodology

The second wave of Covid-19, which ran from April 2021 to April 2022, was the period during which the longitudinal research study (Institutional Human Ethics Committee acceptance number: AUW/IHEC/FSN-19-20/XPD-38) was carried out among college-going women in Coimbatore, TN, India. Participants who were women, who self-reported as being between the ages of 18 and 25, were going to college, had lived in Coimbatore for at least three years, and their initial body mass index (BMI) suggested that they were overweight or obese were included as participants of the present study. Sample size of the study was calculated utilising the formula as described by Daniel and Cross (2018), and Liu *et al*., (2021) and determined to require at least 670 subjects.

As part of Phase I of the study, pre-tested and validated, structured survey forms and globally accepted questionnaires were determined to be used after obtaining necessary permissions. Surveys were developed by the researcher to gather information on the socio-economic status, anthropometric assessment, physical examinations, dietary habits, food consumption, and Knowledge Attitudes and Practices (KAP) of study participants regarding the management of obesity. The questionnaires were tested for construct validity with feedback from 50 subject and 50 non-subject experts and for reliability using the test-retest method, which was spaced one month apart. The Pittsburgh Sleep Quality Index (PSQI) questionnaire (Buysse *et al.,* 1989) was implemented to get information on the sleep quality of the study subjects, while the Global Physical Activity Questionnaire (GPAQ) (WHO, 2012) was utilized to gather data about physical activity.

In Phase II, the age, educational attainment, living locations, family structure, income, and, if relevant, the age at which the participants were married were among the background details that were examined. Using the modified Kuppuswamy scales (Sood & Bindra, 2022), socio-economic profiling was carried out by assigning the research respondents to one of five categories: higher, upper middle, lower middle, upper lower, and lower based on the family head's employment, education, and income.

Phase III consisted of the data collection evaluating the nutritional status of the study subjects using the "ABCD" approach. The anthropometric parameters of

the subjects' including their height (in m), weight (in kg), resultant BMI (in kg/m^2), waist circumference (in cm), hip circumference (in cm), resultant waist-to-hip (WHR) ratio were recorded using the standard methods of measurements as per ICMR-NIMS (2021) guidelines and body composition parameters analysed through body impedance analysis pertaining to the subjects' skeletal muscle mass, percent body fat, basal metabolic rate and overall fitness score. Assessment of biochemical parameters of study subjects included conducting tests of random blood glucose, haemoglobin and thyroid function including serum triiodothyronine (T_3), thyroxine (T_4) and thyroid stimulating hormone (TSH) following the good clinical laboratory practice guidelines (GCLPG by ICMR, 2021). Clinical examination of the study subjects consisted of the researcher conducting the physical examination of the study subjects with the assistance of a qualified medical practitioner for physically observable signs and symptoms of diseases related to the hair, skin, eye, mouth, teeth, and musculature including nutritional oedema, problems with vision, texture of skin, anaemia, muscle wasting, oral health and dental hygiene etc. through a pre-tested checklist. Self-reported responses from subjects were used to detect the morbidity pattern up until 3 months prior to the study utilising a pre-tested questionnaire that included queries on covid, episodes of cold/fever, bouts of diarrhoea, nausea/vomiting and their frequency, whether subjects consumed medication for the above morbidities and the presence or absence of food allergies. Dietary pattern / preferences and food consumption were assessed by food frequency questionnaires, and 24-hour-recall (24HR) questionnaire. As for the indicators of their lifestyle, the data collected included their physical activity through the GPAQ, sleep patterns through the PSQI, and their knowledge, attitudes, and practices on managing obesity through a pre-tested and validated questionnaire.

In Phase IV, the intervention methods to be used in the present study were identified and validated based on the data of the pre-study responses of the initial KAP survey. Firstly, nutrition education modules through PowerPoint presentations, posters focusing on general health, a calendar for the following year (2023) with positive messages were developed to be used along with nutrition counselling and secondly, online exercise routines that could be followed

by prospective study subjects were identified and subjected to pre-testing, approval and validation by a representative sub-sample population.

Phase V included implementing the interventions aimed at lifestyle modifications of the study subjects. A computerized approach was used to randomly allocate participants into one of the four intervention groups, with a total of 158 subjects divided among the four groups. Since Group zero consisted of the control group, no intervention was given to them. While subjects of experimental Group 1 were imparted a physical activity intervention for five days a week, subjects in experimental Group 2 received weekly dietary instruction and counselling and the subjects of Group 3 received a combination of nutrition education and counselling interventions in addition to physical activity.

In Phase VI, after 26 weeks of the intervention period culminated, using the pre-tested and validated questionnaires as before the intervention, the study participants were evaluated once more for their nutritional status, dietary habits, level of physical activity, sleep quality, and KAP. All 632 study participants' responses (or 164 sub-samples) were documented as post-intervention data by the end of the study period to be studied and interpreted by using the Statistical Package for the Social Sciences (SPSS) software's version 26 for Windows (SPSS Inc., Illinois, USA). To determine key or significant differences between the control and experimental groups for the implemented interventions, two significance thresholds of $p \leq 0.05$ and $p \leq 0.01$ were chosen.

Salient Findings

The key conclusions of the current study are summarised below:

- To validate the Knowledge, Attitudes and Practices (KAP) questionnaire to be employed in this study, a pilot study was conducted among randomly selected 100 women, of which 50 had pre-requisite level of education in nutrition and 50 did not have any educational connection to the field of nutrition. The maximum number of pilot study participants came from the 24 to 25 years among the nutrition students while for the non-nutrition students, the highest number of participants came from the ages between 18 and 20.

- The average scores of the students from the nutrition background before the pilot intervention ranged from 11.2 to 12 points, making the total average score to be 34.8±0.06 points. For the non-nutrition students, the pre-pilot study average scores ranged from 7.8 to 8.6 points, making the total average score to be 24.9±0.11 points. However, after the pilot intervention, the average scores of the students from the nutrition background ranged from 12.7 to 14.6, slightly, yet significantly increasing the total average scores to 40.4±0.71. Among the non-nutrition students, the average scores ranged from 12.08 to 13.5 points, making the total average score to be 38.5±0.43 points, indicating the pronounced and significant improvement in the KAP of students from the non-nutrition background after the pilot intervention.
- Assessing the Cronbach's alpha (α) and the Pearson's coefficient (r) statistical correlations revealed that the pilot tested KAP questionnaire was found to have desirable levels of construct validity (0.87) and inter-reviewer reliability (0.90). Therefore, $H_0$1 is rejected.
- A majority of the 632 women participants of the study belonged to the subjects who were 18 years of age (15%) while the least number of participants were 25 years old (10%). Observing the education level of the subjects, most of them were either pursuing or had completed the graduation over 41%. There were 33 (5.2%) study subjects who were married of whom 12% were married below the age of 21 years while a 51% were married above 21 years. Examining the family type of the study subjects, there were mostly nuclear families (89%) with only 11% belonging to joint families. Out of these nuclear and joint families, over 91% had at least three to four family members while there were no subjects with single parents and an 8% with the number of family members exceeding five. The maximum of 56% of the study sample belonged to the lower middle-income category while the minimum of 21% belonged to the upper middle-income category. Initial BMI positively correlated with age ($r=0.192$, $p<0.001$) and was positively associated with income level of the study subjects ($F=13.75$, $p<0.001$).
- On analysing the initial anthropometric parameters of the study subjects, it was seen that the average height of both the main and sub-sample

subjects were significantly lower i.e., 1.56±0.34 m as compared to the standard. The average weight of the women was higher by almost 10 kg as compared to the standard. This in turn resulted in the average BMI also to be 26.23±1.11 kg/m^2 higher than the normal category as defined by the BMI cutoffs for Asians and the recorded WHR to be 0.88±0.15 confirming the presence of overnutrition in the selected women population. The initial BMI and WHR were found to be slightly positively yet significantly correlated ($r=0.16$, $p<0.001$).

- From the extensive initial body composition analysis, the average height of the sub-sample of the present study subjects was 1.56±0.002 m. The average weight was 64.77±0.32 kg, while the BMI was 26.32±0.75 kg/m^2 and the WHR was 0.88±0.001. Body impedance analysis revealed that the average SMM was 17.35±0.74 kg, the average PBF was 31.30±0.11 percent, the average BMR was 1268.61±14.96 kcals and the average fitness score was 54.34±0.17 points. The initial BMI of the study subjects was positively and significantly correlated with the PBF ($r=0.623$, $p<0.001$).
- Assessing the initial random blood glucose levels of the sub-sample subjects showed that the average was 104.25±14.3 mg/dl while the average content of haemoglobin was 11.73±1.05 g. Assessing the serum thyroid levels through the thyroid function tests revealed that the average levels of T_3 was 100.89±3.53 ng/dl, T_4 was 5.61±0.33 mcg/dl and TSH was 4.50±0.261 mc IU/ml.
- Outcomes of the initial clinical examination conducted for the sub-sample showed that tenderness of muscles was seen in 21.4%, xerosis or pigmentation of the cornea in 20.7%, and nutritional oedema was visible in 14.6% of the women. 10.3% did not have any observable symptoms at the time of the initial clinical examination.
- Assessing the initial morbidity pattern of all the women subjects revealed that the most common ailments were cold or cough (33%), fever (37%), vomiting or diarrhoea (5.2%) and food poisoning (3.3%). 21.4% of the study samples were not sick up to three months prior to the initiation of the study. Episodes of these morbidities occur as frequently as once in two months to 41% and once a month to 25.8% of the study population. Considering the

use of medicines during episodes, 7% used them all the time, 12.3% used them sometimes while 81% did not use medicines at all.

- Analysing the dietary preferences of study subjects, it was observed that while 88% did not have food allergies and 5.4% remained undiagnosed, 6.6% were diagnosed with fish allergies (1.4%), lactose intolerance (2.8%), and nut allergies (2.4%). The food preferences showed that 3.2% of the subjects were vegan, 47% were vegetarian, 22% were ovo-vegetarian and 27.8% were non-vegetarian. Among 64.7% of the subjects, a four-meal pattern was the most preferred while 23.9% consumed six meals on an average, every day. Data on the frequency of eating out by subjects before study revealed that 54.9% ate out once a week, 37.1 ate out 2-3 times a week, 1.74% ate out once a month and 6.1% ate out rarely.
- At study initiation, cereals, vegetables, fats and sugar were consumed every day by 100% the subjects while pulses were mostly consumed weekly (44.7%), lean meat was never consumed by 50.2% but also consumed monthly (21.8%) or weekly (19.6%). Consumption of other meat was again never by 50.2% but also monthly (21.9%) or weekly (19.2%). GLVs were consumed mostly occasionally by 44.9% or monthly by 21.7%, and fruits were consumed mostly monthly (26.7%) or weekly (21.8%).
- Among the processed foods, pastry items were mostly consumed occasionally (49.5%) or monthly (33.4%). For fried foods, it was either occasionally (66.6%), rarely (9%) or monthly (8.9%). Spreads were mostly consumed either occasionally (62%) or rarely (20.4%) while pickles were consumed occasionally (28.9%) or weekly (28%). Frozen foods were either occasionally (50%) or rarely (44.3%) consumed. 33.8% of subjects consumed ice-cream occasionally while 31.4% consumed it monthly. Chocolates were consumed mostly occasionally (47.3%) or monthly (34.3%) while sweets and carbonated drinks were largely consumed occasionally (87.3% and 60.9% respectively).
- Based on the responses recorded from the initial twenty-four-hour recall questionnaires, considering the macronutrient intake, the average intake of energy among the study subjects was 2786.75±74.6 kcals, the average protein was 29.16±13.12 g, the average carbohydrate was 309.41±32.37 g and the average fat was 50.3±10.4 g. Considering the micronutrient intake,

the average iron intake was 13.8±4.1 mg, the average calcium intake was 702.01±101.82 mg, the average vitamin A intake was 741.21±12.19 mcg RAE, while the average thiamine intake was 1.21± 1.1 mg, the average riboflavin intake was 1.41±0.61 mg, the average cobalamin intake was 0.89±0.41 mg and the average total folate was 151.0±38.51 mcg and the average vitamin D intake was 8.3±7.25 mcg while the average vitamin C intake was 72.13±33.2 mg.

- Considering the overall calorie intake of subjects among intervention groups before the intervention for Group 0 was 2784.30±71.14 kcals, while it was 2787.13±73.36 kcals for Group 1. Group 2 had 2783.85±83.54 kcals while Group 3 had 2793.01±69.80 kcals. Initial BMI and initial overall calorie intake were positively correlated ($r=0.113$, $p<0.001$).
- Analysing the exercise habits of the subjects at the time of study initiation showed 41.3% of subjects as not having regular physical activity, 35.1% as having physical activity 2-3 times a week and 23.6% as having daily physical activity. Outdoors (48.7%) rather than indoors (37.8%) was the more preferred area of exercise. Considering the preferred time of day to exercise, 44.5% preferred early morning, 32.8 preferred morning, 9.2 preferred evening and 0.2 preferred night, just before bed. Stretching (25%), walking (27.8%), yoga (13.1%), jogging (7%), cycling (7.6%) and dance (6%) were the types of exercises preferred by the subjects.
- The initial GPAQ scores of the study subjects across intervention groups revealed that the average for all the subjects was 316.34±8.28 while Group 0 it was 314.97±8.10 and for Group 1 it was 315.06±8.09. For Group 2, it was 319.11±8.04 and for Group 3 it was 316.23±8.30, all below the standard 600. The inter-group variability was insignificant ($F=2.896$; $p=0.218$).
- The initial PSQI scores of the study subjects across intervention groups showed that the average for all the subjects was 19.11±1.50 while for Group 0 it was 19.16±1.41 and for Group 1 it was 19.05±1.25. For Group 2, it was 19.14±1.22 and for Group 3 it was 19.07±2.0, all below the standard of 21 to 25 points. The inter-group variability was insignificant ($F=0.206$; $p=0.892$).

- The initial KAP scores of the study subjects across intervention groups revealed that the average for all the subjects was 12.51±1.71 while for Group 0 it was 12.46±1.67 and for Group 1 it was 12.41±1.67. For Group 2, it was 12.51±1. 97 and for Group 3 it was 12.70±1.70, all below the maximum score of 45. The inter-group variability was insignificant (F=0.874; p=0.454).
- The exercise routines were identified and tested among 100 women students aged between 18-25 where 50% of pilot study subjects had an educational background in physical education while the other 50% consisted of those who did not. Considering the screening of YouTube videos with selected exercise routines according to clarity of instruction, execution / demonstration and probability of compliance (30 points in total, 10 points each), the screening scores for video 1 and video 2 was 24.6 and 25.6 among the physical education students while it was 25.4 and 27.8 respectively for the non-physical education students, and video 2 was determined to have the greater acceptability.
- Analysing the validity and reliability of formulated exercise routines, it was found to have overall desirable levels of construct validity (0.88) and inter-reviewer reliability (0.90) among the physical education and non-physical education students.
- Considering the pre and post-exercise timings of participants of pilot testing with formulated exercise routines found an increase in the time dedicated towards exercise by both physical education and non-physical education students. Among the physical education students, the increased difference between the pre and post-exercise timings was 7.3 minutes (p=<0.001) in week 1, 4.95 minutes (p=0.218) in week 2 and 0.39 minutes (0.109) in week 3. Among the non-physical education students, the difference between the pre and post-exercise timings was a higher 21.71 minutes (p=<0.001) in week 1, 4.7 minutes (p=<0.001) in week 2 and a lower 1.38 minutes (2.54) in week 3.
- Analysing the validity and reliability of formulated nutrition education modules, it was found to have overall desirable levels of construct validity (0.80) and inter-reviewer reliability (0.82) among the nutrition students while it was 0.85 for both construct validity and inter-reviewer reliability among

non-nutrition students. The overall construct validity and inter-reviewer reliability was 0.90 for both nutrition and non-nutrition students.

- Considering the anthropometric parameters of the study subjects after intervention, the average weight of the subjects was 59.54±5.13 kg, while the average BMI was 24.27±1.81 kg/m^2 and the average WHR was 0.83±0.28. Group 0 did not have statistically significant changes in their anthropometric parameters while Group 1 subjects saw a 7 kg weight loss and 3 kg/m^2 loss of BMI. Group 2 subjects saw a 4 kg weight loss and 2 kg/m^2 loss of BMI and Group 3 subjects saw a 9 kg weight loss and 4 kg/m^2 loss of BMI. The WHR was a consistent 0.06 point reduction in the experimental Groups 1 and 3 while it was a 0.04 point reduction in Group 2. All the differences were statistically significant across the intervention groups. The final BMI and WHR were found to be slightly positively and significantly correlated ($r=0.603$, $p<0.001$).
- Considering the anthropometric parameters of the study sub-subjects after intervention, in body weight, there was an average decrease of 8 kg in Group 1 while there was an average decrease of 4 kg in Group 2 and an average decrease of 9 kg for Group 3. In BMI levels, there was a statistically significant difference of 2.92 kg/m^2 in Group 1, 1.53 kg/m^2 in Group 2 and 3.48 kg/m^2 in Group 3. Considering WHR, there was a statistically significant difference of 0.06 in both Group 1 and Group 3 while it was a 0.02 difference for Group 2. In the SMM parameter, there was an increase of 2.49 kg in Group 1, and a 2.56 kg increase in Group 3, there was no change in Group 2. Observing the PBF levels, there was a decrease across all the intervention groups, 4.05% in Group 1, 2.08% in Group 2, and 4.91% in Group 3. Considering BMR levels, there was an increase of 59.07 kcals in Group 1, a decrease of 33.76 kcals in Group 2 and an increase of 91.54 kcals in Group 3. The average fitness scores of Group 1 increased by 27.39, while the increase was 28.29 for Group 3. The degree of overweight/obesity was negatively correlated with SMM ($r=-0.545$, $p<0.001$), BMR ($r=-0.723$, $p<0.001$) and fitness score ($r=-0.736$, $p<0.001$) while it was positively correlated with PBF ($r=0.964$, $p<0.001$).
- Biochemical assessment of sub-subjects after intervention revealed that the average RBG levels was 107.39 ± 14.2 mg/dl while it was 15.06 ± 2.98 g of

average Hb, 88.81 ± 2.31 ng/dl for average T_3, 4.67 ± 0.46 mcg/dl for average T_4, and 0.933 ± 0.33 mc IU/ml for average TSH levels. The RBG levels in Group 1 was higher than the pre-study data by 3.3 mg/dl, while it was higher by 2.5 mg/dl in Group 2 and 4.3 mg/dl in Group 3. In Hb, there was also an increase of 0.42 g in Group 1, 2.08 g increase in Group 2, and a 2.1 g increase in Group 3. As for the T_3 levels, there was a decrease of 12.55 ng/dl in Group 1, 12.6 ng/dl in Group 2 and a 13.85 ng/dl decrease in Group 3. In the T_4 levels, there was a 1.02 mcg/dl decrease in Group 1, 1.1 mcg/dl decrease in Group 2 and a 1.06 mcg/dl decrease in Group 3. In the TSH levels, decrease of 3.54 mc IU/ml in Group 1, a decrease of 3.55 mcg/dl in Group 2 and a 3.58 mc IU/ml in Group 3 and the differences in between groups were statistically significant. Final BMI levels and post-intervention biochemical parameters such as RBG ($r=0.133$, $p<0.001$) and Hb ($r=0.946$, $p<0.001$) were positively correlated while the thyroid parameters such as T_3 ($r=-0.169$, $p<0.001$), T_4 ($r=-0.198$, $p<0.001$) and TSH ($r=-0.188$, $p<0.001$) were negatively correlated.

- Examining the clinical symptoms of study sub-sample after intervention revealed that 38% of the subjects did not have any of the symptoms by the end of the study period. 7.4% of the women reported a reduction or complete withdrawal in the tenderness of muscles. For mild anaemia, there was a 1.3% reduction, while nutritional oedema decreased from 10.9% to 10.3%, corneal pigmentation was reduced by a 4.3%, angular stomatitis or angular cheilitis also reduced by a 2.4%, glazed tongue was reduced by a 2.4%, bleeding gums was reduced by 4.3%, dental caries, skin pigmentation decreased by a 0.2% each and rough skin reduced by 1.8%.
- Assessing the post-intervention morbidity pattern for the entire study sample revealed that there was an improvement in the episodes of morbidity (47.9%), especially food poisoning (0.8%) among the study participants after the study period. A marked improvement was also seen with respect to how the frequency of the above-mentioned morbidities occurred less (35.8%) in the months following the intervention. By the end of the study period, there was a decrease in those who hadn’t preferred taking medicines during bouts of sickness (72.9%) as well as those who preferred medicines each time they fell ill (2.5%). However, there was an

increase (24.5%) in those who wanted medicines for some of their morbidity episodes.

- Average final food intake of subjects showed that the consumption of cereals was 273.17±51.2 g, while it was 53.1±4.81 g for pulses, 231 ± 29.2 g or ml for milk & milk products, 47.4±6.12 g for animal food, 72.4±15.9 g for vegetables, 24.7±11.17 g for GLVs, 132.61±11.7 g for roots and tubers, 128.3±7.12 g for fruits, 19.2±3.53 g for fats and oils and 15.2±2.74 g for sugar and jaggery.
- Considering the intervention group wise changes in food group consumption, Group 1 saw changes but were not statistically significant. In cereal consumption there was a statistically significant reduction of 44 g in Group 2 and 22 g in Group 3. In pulses, there was an increase of 9.7 g in Group 2 and a 15 gram increase in Group 3. Milk and milk products increased by 17 ml or g in Group 2 and by 30 ml or g in Group 3. Vegetable consumption increased by approximately 10 g in Group 2 and Group 3. In green leafy vegetables, there was an increase by 8.5 g in Group 2 and 11 g in Group 3. Consumption of roots and tubers also increased by 1.5 g in Group 1, 19 g in Group 2 and 6 g in Group 3. In fruits, because there was an increase of 35 g in Group 3. The intake of fats and oils lowered to 7.3 ml or g in Group 2 and only slightly decreased in Group 3 (1.92 ml or g). The intake of sugar decreased by six g for Group 2 and by nine g for Group 3.
- Considering the average final macro-nutrient intakes of the subjects, the energy consumption was 2314.16±31.91 kcals, the protein consumption was 43.12±27.1 g/kg body weight, the carbohydrate content was 238.24± 23.5 g, and fat intake was 43.27±19.2 g. In the average final micro-nutrient intakes of the subjects, iron intake was 16.21±2.14 mg, calcium intake was 763.0± 45.41 mg, vitamin A intake was 832.51± 92.19 mcg RAE, thiamine intake was 1.7±0.26 mg, riboflavin was 1.65±0.21 mg, and cobalamin was 1.8±0.13 mg. Vitamin D intake was 18.12±3.13 mcg while vitamin C intake was 68.87± 23.54 mg.
- There was little to no change in Group zero, and no significant changes in Group 1 regarding their macro and micro nutrient intakes. Energy consumption had reduced by 243 kcals in Group 2 and about 394 kcals in Group 3. There was an 18 g increase in Group 2 and a 12 g increase

among Group 3 of protein. In terms of carbohydrates, there was a decrease of about 22 g in Group 2 and a decrease of about 13 g in Group 3. The amount of fat consumed decreased by 20 g in Group 2 and by 6 g in the third intervention group. Dietary iron intake had gone up by by 2.8 mg for Group 2 and by 3.7 mg in Group 3. Dietary calcium intake had increased by 89 mg in Group 2 and by 78 mg in Group 3. Considering the dietary intake of vitamin A, it was up by 89 mcg RAE in Group 2 and by 78 mcg RAE in Group 3. Thiamine increased in Group 2 and Group 3, by 0.27 and 0.47 mg respectively. Riboflavin increased by 0.24 mg in Group 2 and 0.23 mg in Group 3. For cobalamin, the intake increased by 0.84 mg in Group 2 and 0.89 mg in Group 3. The intake of TDF had also increased by 18 mg in Group 2 and by 20 mg in Group 3. For vitamin D, there was an observed 0.8 mg increase in Group 2 and a 1.4 mg increase in Group 3. As for the vitamin C, there was an increase of 1.9 mg in Group 2 and an increase of 2.5 mg in Group 3. The overall calorie intake and the final BMI of the subjects were positively correlated ($r=0.272$, $p<0.001$).

- The GPAQ scores of subjects across intervention groups post-intervention showed that all the groups had 810.27±392.31 as the average. Group 0 had 314.58±7.93, Group 1 had 974.67±20.01, Group 2 had 651.71±30.20, and Group 3 had 1300.13±31.08. The differences between the control and experimental groups were significant when analysed with analysis of variances ($F=31.63$, $p<0.001$), with the highest difference being observed in experimental group, Group 3. Final levels of physical activity and BMI were found to be negatively correlated ($r=-0.743$, $p<0.001$).
- The average time spent by subjects for exercise daily at the end of the study period was compared with the time recorded before the intervention a significant and positive change was seen in all the experimental groups ($F=361.14$, $p<0.001$*). There was an increase in subjects having the regular habit of exercise i.e., from 25.7 percent at study initiation to 86.6 percent by the end of the study period.
- As per the final PSQI scores of the study subjects, there was a significant improvement ($F=35.85$, $p<0.001$) across all the intervention groups and the average for all the subjects was 10.27±6.12. Group 0 had 19.14±1.38, Group 1 had 6.33±1.04, Group 2 had 12.11±1.55, and Group 3 had

3.52±1.06. Final sleep quality and BMI of the subjects were positively correlated (r=0.771, p<0.001).

- The average KAP scores of the subjects' post-intervention was 31.06±11.05 points. For Group 0, it was 12.58±2.08 points, while for Group 1 it was 21.70±1.91 points, for Group 2 it was 35.11±2.35 points, and for Group 3 it was 44.84±6.24 points. Final KAP scores were negatively correlated with BMI levels (r=-0.098, p<0.001). Therefore, $H_0$2 is rejected.
- Multiple regression analysis showed a 60% probability that educational awareness improved anthropometric parameters including a decrease in weight by nearly 2 kg, reduction in BMI by 2 kg/m^2 and reduction in WHR by nearly 3 points. There was a 77% likelihood that exercise improves SMM by 2.7 kg and BMR by 0.5 kcals. As a combined effect, there was a 42% chance that weight, BMI, WHR, and PBF could significantly decrease while SMM and BMR could increase (F=19.56, p<0.001).
- There was a 23% probability that the nutrition education intervention improved the haemoglobin content (by 2.70 g) as well as lowered the serum TSH (by 0.81 mc IU/ml) levels of the study subjects. There is a 31% chance that haemoglobin improved by 1.47 g while the individual's TSH reduced by 2.41 mc IU/ml as a result of the exercise intervention. Combining both the interventions, there is a 48% likelihood that serum parameters including RBG, and thyroid function parameters would decrease while Hb would increase (F=11.60, p<0.001).
- There was a 12% chance that nutrition education significantly explains the 1.75 reduction in dietary intake and a 0.29 reduction in the sleep scores. Exercise may explain both dietary intake and sleep scores to the extent of 81%, where there is a 0.87 reduction in the calorie consumption of food and a 5.48 reduction or improvement in the PSQI sleep scores. There was a 44% likelihood that both the interventions combined would significantly reduce dietary intake as well as improve the sleep quality of the study subjects (F=247.37, p<0.001). Therefore, $H_0$3 is rejected.

Conclusion

Physical activity and nutrition education interventions have demonstrated a positive and significant impact on the nutritional status, physical activity levels, and sleep patterns of overweight and obese women. These interventions in the present study involved a combination of 30-to-45-minute exercise routines and nutrition educational components. By encouraging regular physical activity, these interventions helped overweight and obese women reduce their excess weight, body composition indices, waist-to-hip ratios while increasing their serum haemoglobin levels, improving their thyroid function parameters, morbidity pattern, muscle-to-fat ratio, and boost their overall fitness. Simultaneously, the nutrition education aspect equipped participants with valuable information about the knowledge, attitudes and practices regarding the aspects of general nutrition including healthy exercising habits, healthier dietary modifications and cooking methods, portion control, balanced diets, and mindful eating, leading to healthier food choices and calorie consumption through improved food and nutrient intakes. Moreover, these interventions lead to notable improvements in sleep patterns among the over nourished women by promoting relaxation, reducing sleep disturbances and cultivating a more supportive environment for restful sleep and better sleep quality. Thus, combination of exercise and nutrition education serve as a multifaceted approach to tackle the complex issues of overweight and obesity in women, resulting in the women with over nutrition establishing healthier physical activity routines and dietary habits that may contribute towards an overall enhancement in their lifestyles and the potential for long-term weight management by improving their nutritional status, increased physical activity, and better sleep quality.

Limitations

- The longitudinal study was conducted during the second wave of Covid-19 and the challenging environment of Covid-19 safety regulations influenced some of the stages of the study including the sample selection, blood sample collection, and the drop-out rates among the study subjects
- Samples were initially purposively sampled, thereby preventing the adequate estimation of over nutrition among the young women of the state of Coimbatore

- Lack of face-to-face interaction and complete dependence on internet facilities for most of the intervention period seemed to make the data collection less effective and efficient.

Recommendations for Future Research

- Future treatments of the global epidemic i.e., obesity should prioritise lifestyle modifications, especially through improving physical activity and mindful eating instead of recommending diets solely focused on calorie restriction.
- Studies can examine the effect of long-term physical exercise and mindful eating on weight loss and over nutrition among the national as well as international populations across other age groups of the human lifecycle.
- The interdisciplinary nature of community health asserts the need to investigate relationships between nutritional status, stress, mental health and interventions aimed at lifestyle changes.
- Recommending the findings to the policy makers of the State of Tamil Nadu, and the Government of India through educational modules to promote awareness regarding the management of obesity in educational institutions and places of work to reduce the incidence of overnutrition in the country.
- Further, the concept of sustainable lifestyle changes at the individual level will go a long way towards conquering this public health concern to ensure healthier future generations for a healthier planet.