METHODOLOGY
III METHODOLOGY

The methodology adopted for the present study entitled, “Prevalence of Obesity among School Children in Coimbatore and Impact of Intervention Strategies” consisted of the following phases:

Phase I: Assessment of the Prevalence of Obesity among School Children in Coimbatore

Phase II: Identification of Factors Associated with Childhood Obesity

Phase III: Assessment of the Physical Activity Pattern, Energy Balance, Psychosocial and Behavioural Adjustment Problems and Biochemical Profile of Selected Obese Children

Phase IV: Development and Implementation of Intervention Strategies on Selected Obese Children

Phase V: Evaluation of the Impact of Intervention Strategies on Selected Obese Children

PHASE I: ASSESSMENT OF THE PREVALENCE OF OBESITY AMONG SCHOOL CHILDREN IN COIMBATORE

A. Selection of Area

In India, very few studies have been carried out on the prevalence of overweight and obesity among school children and a majority of these studies have been carried out in metropolitan cities. Coimbatore, a city in Tamilnadu, South India was selected for the study since data on the prevalence of obesity among school children in this area is not available and hence the investigator felt the need for the study in this area. Moreover, the investigator is familiar with the area and could establish good rapport with the school authorities.
Coimbatore was divided into four zones (east, west, north and south) for the study purpose. From each zone, three types of schools comprising of Government schools (fully financed by government), private schools (financed by private management without any government grant) and aided schools (financed by government partly) were identified using the list obtained from the Department of Education, Government of Tamilnadu. A total of 35 schools, comprising of 10 government, 15 private and 10 aided schools were selected through purposive sampling method for the conduct of the prevalence study.

Necessary permission was obtained from the school authorities for selecting the children from their schools to participate in the study and convenient dates were fixed for obesity screening and data collection.

The investigator explained the purpose, method and significance of the study to the school authorities and teachers to motivate them in extending their co-operation and support for the conduct of the study. Special schools for disabled children, training schools and the schools in which the authorities were non-cooperative to the study were excluded. The list of the selected schools is given in Appendix I.

B. Selection of Children

According to World Health Organization (2006), prevalence of obesity in children has increased at a fast pace worldwide and has become one of the most significant public health challenges internationally, emphasizing an urgent need for understanding the prevalence trend, contributory factors and developing strategies for effective intervention. A study in India, based on the Centre for Disease Control and Prevention cutoffs (2000), revealed that among school going children 9.9 per cent of boys and 12.0 per cent of girls were overweight and 5 per cent of the boys and 6.3 per cent of the girls were obese (Sidhu et al., 2005).
With these points in mind, the investigator selected children in the age group of 7-12 years for the study. A total of 11,470 children comprising of boys and girls which included 6121 children from private schools, 3270 children from aided schools and 2079 children from government schools of Coimbatore were screened for the prevalence of overweight and obesity.

C. Screening for Obesity

Obesity status is usually indicated by Body Mass Index (BMI), which is a measure in which weight is adjusted for height. Weight status is based on the absolute BMI level for adults but for children on BMI percentiles. Among most children, a BMI level at or above the 95th percentile indicates elevated body fat and reflects the presence of risk of related chronic diseases (Institute Of Medicine, USA, 2007). In order to screen for obesity, the standing height and body weight of all the 11,470 children were recorded.

1) Height

A stadiometer was used to measure the height of the children. The children were made to stand erect without shoes on a flat floor by the scale with heels together and toes apart. The head was comfortably held erect and the arms were relaxed and held in a natural manner. The head piece of the stadiometer was lowered slowly and was placed in the sagital plane over the head of the child applying a slight pressure to reduce the thickness of hair and make contact with the top of the head (Brahmam et al., 2005). Using this technique, the height of the children was measured to the nearest 0.1cm accuracy (Plate I).

2) Weight

Body weight is the most widely used and the simplest reproducible anthropometric measurement for the evaluation of nutritional status of young children. Weights of children are typically evaluated in relation to average
PLATE I
MEASUREMENT OF HEIGHT

PLATE II
MEASUREMENT OF WEIGHT
weight for age, height and gender. Body weight of all the children was measured using a digital weighing balance. The balance was adjusted to zero and the readings were noted. The children were made to stand erect with minimum clothing, barefoot. The weight was noted to the nearest 0.1 kg (Plate II) The balance was checked regularly for accuracy using standard weights (Brahmam et al., 2005).

3) Body Mass Index (BMI)

BMI has become the primary index of relative weight. It is based on reference curves representing BMI values as a function of age. More specifically, BMI is a simple index and is defined as weight in kilograms divided by height in meters squared (WHO, 2000). BMI is calculated by dividing an individual’s weight in kilograms by the square of their height in metres (kg/m²).

\[
\text{BMI} = \frac{\text{Weight (kilograms)}}{\text{Height (metres)}^2}
\]

After calculating the BMI for the children, the BMI value obtained was plotted on the CDC BMI-for-age growth charts (for either girls or boys) to obtain a percentile ranking (Appendix II). Similar rankings were used in studies conducted on school going children by Parimala and Purushothaman (2006), Manu Raj et al (2007) Bharati et al. (2008) and Ramzan et al. (2009).

Percentiles are the most commonly used indicator to assess the size and growth patterns of individual children and they indicate the relative position of the child’s BMI value among children of the same age and sex.

BMI-for-age weight status categories with the corresponding percentiles and the number of children classified according to these percentiles in the present study are depicted in Table IV.
### TABLE IV

**WEIGHT STATUS CATEGORY OF THE SCHOOL GOING CHILDREN**

<table>
<thead>
<tr>
<th>Weight Status Category</th>
<th>Percentile Range*</th>
<th>Present study (No. of children)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td>Less than 5th percentile</td>
<td>5136</td>
</tr>
<tr>
<td>Healthy weight (Normal)</td>
<td>5th percentile to less than 85th percentile</td>
<td>4818</td>
</tr>
<tr>
<td>Overweight</td>
<td>85th to less than 95th percentile</td>
<td>871</td>
</tr>
<tr>
<td>Obese</td>
<td>Equal to or greater than 95th percentile</td>
<td>645</td>
</tr>
</tbody>
</table>

*Source: Department of Health and Human Services, Center for Disease Control and Prevention (CDC), 2007.*

Out of the 11,470 children screened, 4,818 children had BMI between 5th and 85th percentile and were considered to be normal whereas 5136 children having BMI below the 5th percentile were considered as underweight. 871 children had BMI between 85th and 95th percentile and were classified as overweight and 645 children were found to have BMI more than the 95th percentile and were categorized as obese.

### 4) Measurement of skinfold thickness

BMI is widely used to screen for obesity, overweight, healthy weight, or underweight among children. However, BMI is not a diagnostic tool. For example, a child may have a high BMI for age and sex, but to determine if excess fat is a problem, then assessment of skinfold thickness is essential (WHO, 2006). It has been suggested that skin fold thickness be measured among overweight children to confirm the presence of excess adiposity (Wang and Ogden, 2008).
PLATE III
MEASUREMENT OF SKINFOLD THICKNESS
The skin fold thickness at triceps was measured using a Harpenden’s skinfold calipers for all overweight and obese children to assess the amount of body fat (Plate III). A vertical fold of skin was held with left thumb and index finger, one inch above the midpoint on mid-line on the back of the left arm of the child taking care not to include muscle. The skinfold caliper was held with right hand, horizontal to the skin fold and was released slowly so that the contact surfaces touched the middle of the skin fold. The readings were noted immediately as any delay will lead to gradual decrease in the measurement. The measurements were read to the nearest millimeter and calibrated using previously published empirical equation (Brahmam et al, 2005).

**PHASE II: IDENTIFICATION OF FACTORS ASSOCIATED WITH CHILDHOOD OBESITY**

**A. Survey on the Socio-economic Background, Dietary Habits, Food Consumption and Lifestyle Pattern of Overweight and Obese Children**

**1. Formulation of Interview Schedule**

Interview schedule is a method of collecting data where questions are asked and the responses are written by the investigator through face to face interview with the interviewee (Gupta, 2005). The investigator formulated an interview schedule to elicit information on the socio-economic, demographic profile, family background and lifestyle pattern of overweight and obese children. The developed interview schedule contained questions related to details including age of the child, gender, birth order, birth weight, common illness, hours of television viewing, type and duration of games played and details on the type of family, education and occupational status of the head of the family, total monthly income, monthly food expenditure and family history of diseases. The interview schedule developed was pretested and is given in Appendix III.
The investigator used the interview schedule to collect information on all the overweight and obese children in their respective schools and collected the details. Parents' help was obtained for details related to family such as income, expenditure, occupation, family history of illness, birth order and birth weight.

2. Conduct of Diet Survey

Diet surveys constitute an essential part of any complete study of nutritional status of individuals or groups, providing information on nutrient intake levels, sources of nutrients, food habits and food preferences. (Swaminathan, 2005).

The frequency of use of different food items in the dietaries of the respondents will clearly indicate the quality of the diets consumed by them. In this study, information on food frequency and preference were obtained from all the overweight and obese children using a check list on an eight point scale and a three point scale respectively (Appendix IV). The check list consisted of locally popular foods and those frequently advertised through media and the respondents were asked to rate the use and preference for each item accordingly.

The food use frequency and preference score for each of the food groups used by the respondents were calculated using the formula.

$$\text{Mean score} = \frac{\sum RiSi + RiSi + \ldots\ldots\ldots RiSi + RiSi + \ldots\ldots\ldots RnSn}{100}$$

Percent of total score = Mean score / n

- $Si = \text{Scale of rating given for preference or frequency of use of a food item (i=1, 2 \ldots \ldots n)}$
- $Ri = \text{Percentage of children selecting a rating under each group (i = 1, 2 \ldots \ldots n)}$
- $n = \text{Maximum scale of rating (8 and 3 in this case).}$
3. Anthropometric measurements of parents

Children were at greater risk of being overweight if at least one parent was overweight and their BMI correlated positively with those of their parents (Griffiths and Bentley, 2006). If one parent is obese, a child has 40 per cent chances of becoming obese and this becomes 80 per cent, if both parents are obese and only seven per cent if neither parent is obese (Ahuja, 2004).

In this study, the height and weight of the father and mother of all the overweight and obese children were also measured and their BMI was calculated.

**PHASE III: ASSESSMENT OF PHYSICAL ACTIVITY PATTERN, ENERGY BALANCE, PSYCHOSOCIAL AND BEHAVIOUR ADJUSTMENT PROBLEMS AND BIO-CHEMICAL PROFILE OF THE SELECTED OBESE CHILDREN**

Childhood obesity is associated with a number of problems and co-morbidities; hence the following parameters were studied on one tenth of obese children (32 obese boys and 32 obese girls) from a total of 645.

1. Assessment of Physical Activity Pattern

Time utilization pattern of both obese boys and girls (n=64) was studied to assess their physical activity and energy expenditure levels. An equal number of normal boys and girls (n=64) were also assessed for their time utilization pattern for comparison with the obese children. For studying the time utilization pattern, each child was asked to prepare an activity time log for a week stating the time spent on each activity from the time one gets up in the morning to the time one goes to bed. The activities were then classified into sedentary, moderate and heavy based on the type of activity. The time spent for each type of activity was calculated for the whole day along with the time spent for sleep for determining the difference in activity pattern and
sleep hours of obese children. The schedule developed for obtaining the time utilization pattern of the selected obese children is given in Appendix V.

**2. Determination of Energy Balance**

Energy balance is the state in which an individual’s energy expenditure equals his or her metabolizable energy intake. Negative energy balance occurs when expenditure is greater than intake and positive energy balance occurs when intake is greater than expenditure. Hence, an indepth study on energy balance was carried out on the same 64 obese children.

Basal Metabolic Rate (BMR) and physical activity are the two major factors which determine the energy expenditure of an individual. The energy expenditure of the obese children was assessed using the time utilization pattern. The average workload per day was computed with the number of hours spent for each activity in school and at home along with hours spent for sleep.

Energy expenditure for sedentary, moderate, heavy activities and sleep was determined using the formula given by Swaminathan (2005) as follows.

- **Sedentary activity** - 0.02 Kcal X body weight X minutes
- **Moderate activity** - 0.04 Kcal X body weight X minutes
- **Heavy activity** - 0.08 Kcal X body weight X minutes
- **Sleep** - 0.01 Kcal X body weight X minutes

The basal energy requirement is regularly estimated as the energy need per kg of body weight which is assumed as one calorie for every hour per kilogram of body weight. Thus the basal energy expenditure for 24 hours for children is calculated as 1 X 24 X body weight. Energy that is saved during sleep is calculated as 0.1 X body weight X hours of sleep. This is reduced from the total basal energy expenditure for 24 hours to get the
basal energy expenditure of the individual. Total Energy Expenditure (TEE) was calculated from the Basal Metabolic Rate (BMR) and the type of physical activities of the children. The actual food intake was determined from 24 hour recall method. From the average daily food intake, the energy intake was computed using the nutritive value of Indian Foods (ICMR, 2006) and compared with the recommended dietary allowances. The energy balance was thus calculated by finding the difference in the energy intake and energy expenditure of the children.

3. Psychosocial and Behavioural Adjustment Problems

Obesity is a stigmatized condition. Obese children are exposed to the consequences of public disapproval for their fatness. This stigma is seen in schools, homes and in the society.

Hence, the psychosocial and behavioural adjustment problems faced by obese children at school and home were studied for both the boys and girls. Based on the scale developed by Parikh and Das (1988), a Psychosocial and Behavioural Adjustment Scale (PSBA Scale) was constructed by the investigator after identifying 60 relevant statements through review of literature and in consultation with psychology experts and categorizing into six groups with equal number of positive and negative statements.

Self perception of physical attributes, behaviour in the family, emotional and behavioural problems, social and academic problems and problems with values and adjustment were the aspects included in the development of this scale. The children were asked to respond to each statement in terms of their own agreement and disagreement on a five point continuum. The scores given for positive statements were as follows:

- Strongly agree: 5
- Agree: 4
- Doubtful: 3
- Disagree: 2
- Strongly disagree: 1
The order was reversed for the negative statements. The total score was the summation of numerical weight assigned to each response. This 5 point scale was given scores 1,2,3,4 and 5 with 5 being the maximum score indicating least problems and 1 being the lowest score indicating most problems. The developed scale is given in Appendix VI. The reliability and validity of the scale was confirmed after pre-testing on a sample of 10 children.

4. Biochemical profile

Childhood obesity is associated with a wide range of serious medical complications including type II diabetes mellitus, increased levels of LDL cholesterol, triglycerides and decreased levels of HDL cholesterol (Singhal, 2005). Biochemical parameters namely blood glucose, haemoglobin and lipid profile which included total cholesterol, serum triglycerides, HDL, LDL and VLDL cholesterol were determined in the laboratory for the selected children (n=64) using the following standardized methods.

a. Blood Haemoglobin

Despite their excessive dietary and caloric intake, obese children may be at risk of iron deficiency anaemia because they tend to consume unbalanced meals, particularly rich in carbohydrates and fat (O Pinhas-Hamiel, 2003). Hence the blood haemoglobin level was determined for the obese children. The International Nutritional Anaemia Consultation Group and International Committee for Standardisation in Hematology have recommended cyanmethaemoglobin method (Cook, 1985) for anaemia prevalence studies in India and the National Institute of Nutrition, Hyderabad, has adopted this method for haemoglobin estimation (NIN, 1990).

In this method an accurate volume of blood (0.02ml) was drawn from a finger prick using a haemoglobin pipette and delivered on to a (1x1 cm) strip of Whatman No.1 filter paper. The filter paper with the blood sample
was dropped into Drabkin’s solution in a test tube and allowed to stand for 30 minutes. The solution was then centrifuged and the supernatant was read in a photo electric colorimeter (http://nutrition foundation of India. res.in). The mean haemoglobin levels were then compared with reference values.

b. Blood Glucose

The Center for Disease Control (CDC) predicts that 1 in 3 children born in 2000 could develop Type II diabetes during his or her lifetime because of childhood obesity (CDC, 2007).

To measure the blood glucose, a finger prick was done for the selected overweight and obese children and their blood sample was estimated using a Glucometer by GOD/PAP method (Trinder, 1969).

c. Blood lipid profile

With the help of a laboratory technician, 5ml of blood was drawn from the vein of obese children (Plate IV) and blood lipid profile comprising of Total cholesterol, Triglycerides, Low density Lipoprotein, High density Lipoprotein and Very Low Density Lipoprotein was estimated using the following methods

i. Serum Total cholesterol
   CHOD – PAP / End point method (Burtis, 1999)

ii. Serum Triglycerides
   GPO – PAP / End point method (Buccolo, 1973)

iii. HDL cholesterol (Naito, 1984)
   Direct HDL / Enzymatic method

iv. VLDL Cholesterol = \[ \frac{\text{Serum Triglycerides}}{5} \]
   where 5 is a constant factor

v. LDL Cholesterol = \[ \text{Serum Total Cholesterol} - (\text{VLDL cholesterol} + \text{HDL cholesterol}) \]
PLATE IV

COLLECTION OF BLOOD FOR BIOCHEMICAL ESTIMATION

PLATE V

MEASUREMENT OF BLOOD PRESSURE
d. Blood Pressure

Obesity and overweight may predispose children to increased blood pressure. Elevated blood pressure in children is an early risk factor for cardiovascular disease and is positively associated with BMI (Brion et al, 2007). Hence, blood pressure was measured for the selected obese children (n=64) with the help of an experienced medical officer (Plate V).

PHASE IV: DEVELOPMENT AND IMPLEMENTATION OF INTERVENTION STRATEGIES ON SELECTED OBESE CHILDREN

A. Selection of Obese Children

Using Breat’s classification (2005) the obese children were categorised as moderately obese children (20-40% overweight), obese children (40-60% overweight) and severely obese children (>60% overweight). Obese children who were 40-60 per cent overweight were selected for the intervention study.

Four schools from different areas of Coimbatore were selected to implement the different intervention strategies. Children and families who were keen, very co-operative and motivated to lose weight were selected for the intervention strategies. Necessary permission was obtained from the parents of the selected children and the school authorities for including them in the study.

Finally 240 obese children (120 obese boys and 120 obese girls) were selected by purposive sampling method and they were further divided into three experimental groups and one control group as follows:
<table>
<thead>
<tr>
<th>Groups</th>
<th>Intervention Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (n₁=60)</td>
<td>Nutrition education</td>
</tr>
<tr>
<td>B (n₂=60)</td>
<td>Nutrition education and physical activity</td>
</tr>
<tr>
<td>C (n₃=60)</td>
<td>Nutrition education, physical activity</td>
</tr>
<tr>
<td></td>
<td>and snack substitution</td>
</tr>
<tr>
<td>D Control (n₄=60)</td>
<td>No intervention</td>
</tr>
</tbody>
</table>

B. Assessment of Nutritional Profile and Nutritional Knowledge, Attitude and Practices (KAP) of the Selected Obese Children

1. Measurement of Height and Weight

The initial height and weight of the selected obese children of all the groups were recorded using standard techniques as described in Phase I and their Body Mass Index (BMI) was calculated before the conduct of the intervention study.

2. Determination of Body Fat Percentage

Body fat percentage refers to the percentage of body fat mass (the weight of the fat) in relation to body weight. The weight that is not fat is referred to as the fat free body mass. Tissues containing much water such as muscles, blood vessels and bones are highly conductive with electricity, but fat tissues are not so. Therefore, by using this principle, it is possible to determine the ratio of fat tissue compared to other tissues in the body.

Bio–electrical Impedance Analysis (BIA) using a small portable fat analyzing instrument or scale which is a non–invasive, safe, cheap and reliable estimation of body composition was used in this study to determine body fat. This method is more convenient and quicker to administer along with anthropometric measurements than any other methods (Bhave et al., 2004).
PLATE VI
MEASUREMENT OF BODY FAT PERCENTAGE
For measuring the body fat percentage of the children, data on their heights, weights and age of the children were given as input into the fat analyzer. The children were instructed to stand erect and hold the fat analyzer with their hands stretched (away from their body) at the chest level. The fat percentage was recorded with minimum clothing and accessories (Plate VI). From the electrical conductivity between both hands of the children, the fat percentage digitally displayed by the instrument was recorded.

3. Assessment of Food and Nutrient Intake

To assess the adequacy of food and nutrient consumption, a three day food recall method was used. According to Summerfield and Liane (2001), a three day diet record is advantageous because it is usually more representative of typical intake than one day record. Details regarding the food intake of 120 boys and 120 girls were collected using the three day dietary recall method (Appendix VII). The mean food intake per day was found out and the nutrient intake of the selected children was calculated using the ICMR Food Composition Tables (2006) and compared with Recommended Dietary Allowance (RDA) suggested by ICMR (2006).

4. Assessment of Nutritional Knowledge, Attitude And Practices (KAP) of selected obese children

Questionnaire is one of the most popular data collecting technique within the survey research and is a document consisting of closed and/or open ended structured questions covering research objectives, questions and variables (Pawar, 2004).

A pre-tested questionnaire consisting of 30 multiple choice questions each carrying one mark was formulated to assess the nutritional knowledge, attitude and practices of selected obese children. Questions on the importance of nutrients, skipping of breakfast, physical activity and role of balanced diet in providing good nutrition was administered to all the selected obese children (Appendix VIII) and the details were collected.
5. Development and Implementation of Intervention Strategies

Three different intervention strategies a) nutrition education, b) nutrition education cum physical activity and c) nutrition education, along with physical activity and snack substitution were developed for the study.

a) NUTRITION EDUCATION

Nutrition education materials on aspects like general health and nutrition, importance of balanced diet, causes and consequences of obesity, hazards of consuming junk foods, consumption of foods during television viewing and importance of physical activity were developed for effective nutrition education (Plate VII).

i) Development of education materials

1) Computer assisted instruction tool

A computer assisted instruction tool on obesity management was developed using HTML, Adobe photoshop, Javascript and MS Flash package with the help of a software professional (Appendix IX).

The instruction tool consisted of the following concepts:

i. Health and nutrition
ii. Overweight and obesity
iii. Causes and consequences of childhood obesity
iv. Diet modification
v. Foods to be avoided and included
vi. Importance of physical activity
vii. Calculation of Body Mass Index.
PLATE VII
EDUCATION MATERIALS DEVELOPED FOR NUTRITION EDUCATION
2) **Puppet show**

Puppet shows are more effective for conveying messages among children. Hence a puppet show on the importance of fruits and vegetables and basic five food groups was developed for the school children (Plate VIII).

3) **Exhibition**

An exhibition was planned on the importance of fruits and vegetables, basic five food groups, causes and consequences of childhood obesity and physical activity pattern of obese children using charts and models.

4) **Pamphlet**

A pamphlet on energy balance, food pyramid, foods to be avoided and included for obesity prevention was developed in English and printed for distribution to obese children and their parents (Appendix X).

5) **Cookery demonstration**

Preparation of low calorie, high protein and high fibre food items namely sprouted green gram sundal, salads, varagu and oats laddu, vegetable sandwich and horsegram kozhukattai were demonstrated to the mothers of obese children.

6) **Lecture**

Nutrition education in the form of lecture was also given to the children. Causes and consequences of childhood obesity, importance of consuming fruits and vegetables, basic five food groups, balanced diet, consumption of nutritious foods and beneficial effects of physical activity formed the major content of the lecture schedule (Plate IX).

7) **Individual counseling to mothers on diet modification**

It is important to involve the entire family when treating obese children. Many studies have demonstrated a familial aggregation of risk factors for obesity and the family provides the child’s major social learning environment.
PLATE VIII
PUPPET SHOW

PLATE IX
LECTURE
Joanna Briggs Institute (2007) and the American Dietetic Association (2007) recommended the Traffic Light Diet which was developed by Leonard H. Epstein to be used as a family-based intervention with parents helping to regulate the availability of 'green', 'yellow' and 'red' foods. The Traffic Light or Stoplight diet is a hypo-caloric strategy. This diet is a calorie controlled, normally in the range of 1200–1500 kcal/day, with recommended frequencies for consuming food categorised as: 'green' (very low in kilocalories and able to be eaten freely, e.g. fruits and vegetables); 'yellow' (core foods making up the bulk of food intake to provide a balanced diet, i.e. cereals, pulses, milk and milk products, meat and its products); and 'red' (high energy density foods that need to be taken cautiously, e.g. chocolates, crisps [chips] and take-aways).

The investigator had individual counseling sessions with the mothers stressing on the need for weight reduction through a family based dietary approach using the Traffic Light Diet Model. Handouts on recommended dietary allowances, height and weight tables were distributed to the mothers for assessing their children’s nutritional status by themselves (Plate X).

8) Booklet on obesity

A booklet on obesity management among children was also developed for this purpose and given to the mothers to help them to modify their child’s diet at home. The booklet contained information on childhood obesity including its contributory factors, consequences, treatment and prevention, traffic light diet, foods to be included, avoided and low calorie recipes suitable for children (Appendix XI).

ii. Conduct of Nutrition education

Nutrition education was conducted to parents and obese children on childhood obesity and associated problems and management of childhood
PLATE X
INDIVIDUAL COUNSELLING AND DISTRIBUTION OF HAND OUTS
obesity. Education was also given on the importance of eating a balanced diet, how to make right and healthy food choices based on the food guide pyramid, and proper cooking methods for nutrient conservation. The detrimental health effects of fast foods and other energy dense snacks and carbonated beverages, mechanism of energy balance from energy intake and expenditure, importance of physical activity for weight reduction and weight maintenance were the other important topics included for nutrition education.

The importance of eating a nutrient rich, low calorie diet with daily physical activity for weight reduction was emphasized. Children were advised to avoid or limit calorie dense fast foods, snacks, bakery items, fried foods, carbonated beverages and sweetened juices. Parents and children were also informed about the approximate caloric content of commonly used food items and educated on how to compute the calorie count of the day’s food intake for effective management of the calorie intake every day. They were advised to replace junk foods with plenty of vegetables and fruits. Mothers of the obese children were made aware of the importance of controlling portion sizes during the meal. They were also given information on effective cooking methods for weight reduction and advised to avoid the use of hydrogenated fats and animal fats for cooking purposes. Children were also encouraged to go to school / tuition classes either by walk or by bicycle if possible. They were motivated to follow these with the help of their parents.

Nutrition education was imparted to the children of the experimental groups A, B and C at the school premises once a week, for a period of four months during the hours permitted by the school authorities (Plate XI). Along with this, the developed pamphlets on obesity management were also distributed. Necessary infrastructure, equipment, support and co-operation were provided by the school authorities and the staff to conduct nutrition education.
PLATE XI
CONDUCT OF NUTRITION EDUCATION

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The investigator initially met the mothers and the students at the school and at homes, highlighted the significance of diet modification in overcoming the obesity problem and requested the mothers to modify the diets at home. Further follow-up was conducted by visiting a few homes (house wives) or communicating with the mothers through telephonic conversations (working women) and meeting mothers of selected obese children in schools.

Booklet, pamphlet and handouts with relevant nutrition information developed by the investigator on obesity management were given to each mother of selected children along with sample diet/menu pattern for weight reduction.

Apart from this planned programme, nutrition education was also imparted by using the same teaching aids for normal children and their teachers in a few schools as requested by the school authorities.

b) PHYSICAL ACTIVITY

It is generally recognized that human energy balance can be more readily modified by changes in dietary energy intake than through energy output (voluntary physical activity). However, most healthy children are naturally active and physical education is (or should be) a basic component of children’s early education, thereby providing an opportunity for school-based programs. Thus, physical activity is usually a core component of obesity prevention interventions.

i) Formulation of physical activity programme

A package of outdoor games which included circle kho-kho, Indian Club Up and Down Relay, Go home, Shadow game along with exercises which included warm up exercises like toe jumping, rotations like neck, shoulder, arm, wrist, hip, knee and ankle, stretching exercises like forward bending, backward bending, side stretching, arm stretching and leg stretching...
PLATE XII
CONDUCT OF PHYSICAL ACTIVITY
was formulated as physical activity programme in consultation with doctors and physical fitness instructors.

ii) Conduct of Physical activity programme

Obese children in Group B (n=60) and Group C (n=60) were asked to do physical exercises using the package of outdoor games developed for a duration of 40 minutes daily with the help of physical education teachers in the school playground for a period of four months (Plate XII). Children were also instructed to do the physical exercises at home during holidays under the supervision of their parents.

c) SNACK SUBSTITUTION

According to Gardener et al. (2007) a low calorie, low fat and high fibre diet is recommended for weight loss. Dietary fiber has important health benefits in childhood and adolescence, especially in promoting regular bowel habits and reducing the risk of chronic diseases such as cardiovascular disease, cancer and diabetes mellitus in adulthood (Evan, 2006).

i) Development of Low Calorie, Low Fat and High Fibre Snack

The investigator selected a millet varagu (Paspalum scrobiculatum), a legume horsegram (Dolichos biflorus) and curry leaves (Murraya koenigii) for developing the snack. Varagu and horsegram were selected because of their high fibre content of 9g and 11g/100g respectively. Curry leaves is a good source of calcium (830mg/100g) and fibre(6.4g). Varagu and horsegram were cleaned, roasted and powdered. Curry leaves were washed thoroughly, shade dried and powdered. All the ingredients such as varagu flour, horse gram flour and curry leaves powder were mixed thoroughly. Sliced onion, green chillies, chopped coriander leaves, salt and water were added and mixed to a dough consistency. Adequate amount of the mixture was taken and made into medium sized balls and pressed with the palm into
Varagu Horse gram Curry leaves
---
Varagu flour Horse gram flour Curry leaves powder
Chopped onions

KOZHUKATTAILS

PLATE XIII
DEVELOPED SNACK
kozhukattais (a steamed cereal based preparation of Tamilnadu) steamed for 15 minutes and served hot. The investigator formulated the kozhukattais in different proportions of the selected ingredients and three proportions were found to be satisfactory. The three different formulations are presented in Table V.

**TABLE V**

PROPORTION OF INGREDIENTS IN THE SNACKS

<table>
<thead>
<tr>
<th>Ingredients (g)</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varagu flour</td>
<td>55.0</td>
<td>45.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Horse gram flour</td>
<td>20.0</td>
<td>30.0</td>
<td>37.5</td>
</tr>
<tr>
<td>Curry leaves powder</td>
<td>10.0</td>
<td>10.0</td>
<td>10.0</td>
</tr>
<tr>
<td>Onion</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

**ii. Acceptability Testing of the Formulated Snacks**

Acceptability testing of different formulations of steamed snacks $S_1$, $S_2$ and $S_3$ was conducted. The organoleptic evaluation was done using a score card developed based on characteristics such as appearance, colour, texture, flavor and taste by a group of ten trained and ten school going children (Appendix XII).

The mean score obtained by Snack 1 was 17.1, the score obtained by Snack 2 was 23.2 and the mean score of snack 3 was 19.6. Based on the acceptability scores, snack $S_2$ with the proportion of 45g varagu flour, 30g horse gram flour, 10g curry leaves powder and 15g onions was selected for substitution since it obtained the highest score of 23.2 out of 25 and was most acceptable (Plate XIII).
iii. Nutrient analysis of the developed snack

The developed snack was analysed for its nutrient content following the procedures suggested by NIN (2003). Moisture content of the developed snack was determined using a digital moisture balance. The carbohydrate content was estimated by anthrone method, protein content was assessed through macrokjeldahl method. Fat content of the developed snack was estimated by soxhlet method and the energy value was calculated from these proximate principles. The iron content of the developed snack was estimated colorimetrically and calcium content was estimated using the titrimetric method. Crude fibre and dietary fibre of the developed snack were also estimated using standard procedures (AOAC, 1995).

iv. Conduct of the Substitution Study

One serving which consisted of 50g of the developed low calorie, low fat and high fibre snack in the form of two kozhukattais (each weighing 25g) was given to 60 obese children (30 boys and 30 girls) in the experimental group C as an evening snack instead of the high calorie snacks usually consumed by them for a period of four months during working days. Evening snack was the meal preferred for substitution since most of the children ate a calorie dense fried item at home in the evenings. The investigator visited the school and prepared the snack in the school kitchen. The children were asked to assemble in a specified place at the school premises daily in mid evening and the prepared snacks were distributed to them for consumption and were asked to consume the snack without spilling or wasting (Plate XIV). Dry ingredients of the different foods were given to the mothers of the obese children and they were requested to prepare the snacks (in the same method explained by the investigator) and give it to the children during weekends.
PLATE XIV

OBESE CHILDREN CONSUMING THE DEVELOPED SNACK
The details of the substitution study were presented before an Ethical Committee constituted by the University and were approved by the Committee members with the approval number HEC.2007.07.

PHASE V: EVALUATION OF THE IMPACT OF INTERVENTION STRATEGIES ON SELECTED OBESE CHILDREN

The selected obese children were closely monitored and the intervention strategies was evaluated after a period of four months by recording the change in height, weight, BMI and body fat percentage of the children in Groups A,B,C and the control group D to find their impact. Apart from this, the change in nutritional knowledge, altitude and practice scores (KAP scores) after four months was also assessed for the children in Group A to whom nutrition education was intensely given.

The data collected through different tools were scored, coded, consolidated, tabulated and subjected to appropriate statistical analyses and interpretation. The experimental design of the study is given in Figure 3.
PHASE I  Prevalence of Obesity among Children in Coimbatore (7-12 years)

N=11470

PHASE II  Identification of Contributory Factors of Obesity

PHASE III  Assessment of Physical Activity Pattern, Energy Balance, Psycho-social and Behaviour Adjustment Problems and Biochemical Parameters
PHASE IV  Development and Implementation of Intervention Strategies

- Intervention
  - Obese (240)
    - Boys (120)
    - Girls (120)
  - 4 months
    - Group A (60) Boys (30) Girls (30)
    - Group B (60) Boys (30) Girls (30)
    - Group C (60) Boys (30) Girls (30)
    - Group D (60) Boys (30) Girls (30)
      - Nutrition Education
      - Nutrition Education and Physical Activity
      - Nutrition Education, Physical Activity and Snack Substitution
      - Control

PHASE V  Evaluation of Intervention Strategies

- Impact
  - Changes in
    - Height, Weight, Body Mass Index, Percentage body fat, Nutritional Knowledge, Attitude and Practice (KAP)

FIGURE 3
RESEARCH DESIGN