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Original Research Article

Impact of dietary and lifestyle modification on nutrient intake and energy expenditure in overweight women: An intervention study

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Abstract: The prevalence of overweight and obesity is increasing at an alarming level, globally. Dietary and lifestyle modifications combined with physical activity form a cornerstone for significant reductions in energy intake and improving diet quality in women to reduce body weight. The objective of the study was to investigate the effect of dietary and lifestyle modification of nutrient intake and energy expenditure. In this study, a low calorie, high protein multipurpose flour was developed as a part of intervention. Overweight women were randomly assigned into 3 groups: a group that received experimental diet and nutrition education, a group that received only nutrition education and a control group. The developed flour provided 1/3rd of calories and contained significant amount of protein, dietary fibre and micronutrients. Before intervention, nutrient intake showed that energy and fat were consumed in excess whereas protein, fiber and other micronutrients were consumed less than the RDA. Significant change in the individual nutrient intake and increasing energy expenditure was observed after the intervention with developed flour mix and lifestyle modifications. Both dietary and lifestyle intervention positively impacted the nutrient intake and energy expenditure.

Keywords: Body weight, lifestyle modification, energy expenditure, nutrient intake and overweight.

INTRODUCTION

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health. The major cause of obesity and overweight is an energy imbalance between calories consumed and calories expended. Increased intake of energy-dense foods that are high in fat and sugars and increase in physical inactivity due to the increasingly sedentary nature of many forms of work, changing modes of transportation, and increasing urbanization are the contributing factors of overweight and obesity (1). Overweight and obesity increase the risk for chronic diseases such as diabetes, and cardiovascular diseases. Obese people are at a higher risk of suffering from certain kinds of cancers (including endometrial, breast, ovarian, prostate, liver, gallbladder, kidney, and colon). Moreover, being overweight also places the individual at an increased risk of death due to COVID-19.

Once considered a high-income country problem, overweight and obesity are rising worldwide affecting more than 44% of the world's population. The NFHS 5 data shows that obesity has increased by 4 per cent in both men and women in India during the last five years. In NFHS-5, the percentage of overweight or obese women is 24, up from 20.6 per cent in NFHS-4 (2015-16) (NFHS, 2019). With increase in overweight and obesity, there is a need to focus on prevention of obesity related malnutrition.

Numerous studies have examined relationships between single nutrients, particularly dietary fat, and obesity, but dietary determinants of weight gain remain controversial (Motswagole et al., 2020). However, since food is consumed in combinations, it is important to analyze interaction of different nutrients on predisposition of weight gain. The main cause of obesity is an imbalance between calories consumed and calories expended, although in a small number of cases, genetics and diseases such as hypothyroidism, Cushing's disease, depression, and use of medications such as antidepressants and anticonvulsants are responsible for fat accumulation in the body (Fock and Khoo, 2013).

Sedentary lifestyles and high intakes of energy-dense, micronutrient-poor foods increase the risk of obesity. Also, the intense marketing of energy-dense foods and fast-food outlets, high intakes of sugar-sweetened soft drinks and fruit juices with adverse socio-economic conditions are contributing to the increased risk of obesity (Seidel et al., 2005).
Nutrition remains the cornerstone for the management of obesity, supplemented by physical exercise and supported by cognitive behavioral therapy. Calorie-restriction strategies are one of the most common dietary plans. Regular physical exercise enhances the efficiency of diet through increase in the satiating efficiency of a meal, and is useful in maintaining diet-induced weight loss (Fock and Khoo, 2013).

Increasing physical activity is an effective way to maintain body composition and potentially prevent obesity. Physical activity has been shown to induce health related benefits in males and females of all age groups. In fact, physical activity appears to be the most beneficial prevention practice (Richardson et al., 2019).

Behavioral therapy is an effective method of preventing obesity, when combined with low calorie diet. Behavior changes strategies involve techniques in stimulus control. The simplest form of behavior therapy involves advice to avoid situations that tempt overeating. Other forms of advice are keeping food out of sight or eating only at the table. Practice eating management such as eating slowly is also included under behavior therapy. Behavior substitution, such as exercising instead of eating when angry can also be adopted (Ogunbode et al., 2011). With this background, a study was conducted to study the effect of dietary approach and lifestyle intervention on nutrient intake and energy expenditure.

Material and Methods

Selection of subjects

Forty-five subjects were selected for the intervention study and allotted to either of the following groups consisting of 15 subjects each.
G I- Experimental diet providing 1/3rd of the RDA for calorie and fiber along with nutrition education and awareness on lifestyle practices; G II- Nutrition education and awareness of lifestyle practices only; G III- Control.

Dietary intervention:

A formulated multipurpose mix of 100 gm meeting 1/3rd of energy, rich in protein, dietary fiber and other micronutrients, was provided to the subjects and instructed to consume in various forms such as dumpling, dosa and chapati by replacing one of their meals in a day for a period of 180 days. In addition to the dietary intervention, orientation towards lifestyle practices related to food, physical activity, and behavior modification, was provided. The control group was included to compare the results of the study.

RESULTS

Table 1: Nutrient composition of low-calorie high fiber food formulation (100g)

Nutrients	Quantity
Moisture (g)	5.0
Protein (g)	18.6
Fat (g)	5.8
Carbohydrate (g)	67.00
Crude fiber (g)	2.75
Total dietary fiber (g)	10.45
Ash (g)	3.32
Energy (Kcal)	396
Calcium (mg)	309
Iron (mg)	7.00

Nutrition education and awareness of lifestyle practices

Selected subjects were educated about the causes, consequences, and measures to be followed for weight loss and maintenance of a healthy weight. Education material was developed, which included prevalence, causes, complications, and prevention of overweight and obesity. Good food habits, maintenance of energy balance, and importance of physical exercise were also included and used to educate the experimental groups (G1 and G2).

Evaluation of effectiveness of an intervention

To know the effect of dietary intervention and lifestyle modification, the subjects' dietary intake in terms of food and nutrients were assessed through 24-hour recall method for 3 consecutive days using standardized cups.

Energy expenditure was calculated by using factorial method (Warwick, 2006), which collects the minute-to-minute record of all activities undertaken by an individual in a day. The activity undertaken is coded to one of the 9 categories of activities. After coding, all the activities under different categories, the total time under each activity coded (1-9) is recorded and totaled to 1440 minutes, which are total minutes in 24 hours. Next, the energy cost of each category, is recorded as MET value, which indicates Kcal/minute requirement for 60 kg person. The total time spent in each category is then multiplied by the MET value given for that category to get Kcal/ minute spent on a particular activity. However, for a particular activity, MET value is given in terms of Kcal/min/60 kg. But, the weight of the individual whose energy expenditure is being estimated may be different than the standard 60 kg taken in this method. To accommodate this, therefore, a correction factor is considered which can be calculated using the formula given below:

$$\text{Correction factor} = \frac{\text{Subjects body weight (Kg)}}{\text{60 (kg)}}$$

Kcal/min/subject is then calculated by multiplying the MET value with the correction factor. The value so obtained for each code is then multiplied with total time spent in doing various activities of that group. These resulting values are then added up to give energy output/ energy expenditure of the day.

Data obtained is statistically tested for significance using the paired 't' test.

Results and Discussion:

Table 2: Baseline characteristics of subjects selected for intervention (N=45)

Characteristics	Group I		Group II		Group III		χ^2
	Number	%	Number	%	Number	%	
Age (years)							
26-35	04	26.66	05	33.34	04	26.66	
36-45	11	73.34	10	66.66	11	73.34	0.67^{NS}
>46	00	00	00	00	0	00	
Marital status							0.12^{NS}
Married	13	86.67	15	100	14	93.34	
Unmarried	02	13.33	00	00	01	6.66	
Educational status							
Primary	02	13.33	03	20.00	04	26.67	0.026^{*}
SSLC	05	33.34	06	40.00	05	33.34	

PUC	05	33.34	05	33.34	04	26.66	
Degree	03	20.00	01	6.66	02	13.33	
Type of family							
Nuclear	12	80.00	10	66.67	13	86.67	0.56^{NS}
Joint	03	20.00	04	26.66	02	13.33	
Number of children							
One	05	33.34	07	46.66	07	46.66	0.79^{NS}
Two	08	53.34	05	33.34	06	40.00	
Three	02	13.33	03	20.00	02	13.33	
Family income							
Rs.10,000-20,000	04	26.66	03	20.00	06	40.00	0.001^{*}
Rs.20,000-30,000	06	40.00	05	33.34	05	33.34	
Rs.30,000-40,000	03	20.00	03	20.00	02	13.33	
> Rs.40,000	02	13.33	04	26.66	02	13.33	

*Significant at 1% level
Group I: Low calorie high fiber food formulation+ Nutrition education and awareness on lifestyle practices;
Group II: Nutrition education and awareness on lifestyle practices;
Group III: control

Table 3: Impact of intervention on nutrient intake of subjects

fore			After		Paired t test	Group II (n=15) Before		After		Paired t test	Group III (n=15) Before		After	
DA	Mean±SD	% adequacy	Mean±SD	% adequacy		Mean±SD	% adequacy	Mean±SD	% adequacy		Mean±SD	% adequacy	Mean±SD	
00	2300.9 ±245.7	121.10	2003.4 ±181.7	105.4	11.86*	2468.8 ±132.45	129.94	2375.51 ±149.21	125.03	7.35*	2585.77 ±131.28	136.09	2600.5 ±130.37	
	45.04 ±6.80	81.90	62.05 ±8.09	112.82	11.74*	48.54 ±6.33	88.27	53.76 ±5.34	97.75	8.85*	43.64 ±6.04	79.35	44.54 ±3.87	
	32.82 ±7.56	164.13	24.16 ±2.46	120.80	7.74*	31.22 ±5.64	156.13	27.40 ±3.69	136.98	11.45*	31.08 ±5.18	155.48	30.72 ±3.30	
	14.82 ±4.03	37.6	21.35 ±7.15	53.37	7.63*	15.54 ±1.92	38.87	19.74 ±3.04	48.55	7.55*	14.25 ±1.34	35.65	14.15 ±0.83	
	11.36 ±6.98	54.06	16.99 ±2.9	80.88	14.93*	12.35 ±6.39	58.79	14.58 ±1.18	69.45	7.23*	11.41 ±3.21	54.33	11.73 ±2.30	
0	459.87 ±83.16	76.65	569.72 ±103.07	94.95	11.82*	447.58 ±93.84	74.6	482.93 ±77.24	80.49	11.40*	374.79 ±107.55	62.47	380.87 ±56.89	
	1288.6 ±112.1	-	1434.7 ±161.11	-	6.52*	1323.82 ±107.92	-	1366.89 ±109.14	-	5.23	1374.3 ±72.34	-	1378.94 ±66	
	104.48 ±26.54	-	93.73 ±26.16	-	11.84*	102.02 ±13.66	-	96.27± 16.74	-	9.99*	104.15 ±8.34	-	102.39 ±8.49	
00	1786.6 ±2110	37.22	3525.18 ±2275.2	73.44	8.94*	1183.75 ±230.78	24.66	1817.26 ±216.79	37.86	8.96*	1170.7 ±274.67	24.39	1189.73 ±246.35	

*Significant at 5%, NS-non significant
Group I: Low calorie high fiber food formulation+ Nutrition education and awareness on lifestyle practices;
Group II: Nutrition education and awareness on lifestyle practices;
Group III: control

Effect of intervention on nutrient intake of subjects
Dietary interventions that include the use of energy controlled, nutrient dense meal replacements are effective in management of overweight/ obesity. An energy dense, high fat diet and low levels of daily physical activity are independent risk factors of weight gain and obesity in genetically predisposed individuals. Increasing daily physical activity and reducing dietary fat content may be more effective in combination than separately in preventing weight gain and obesity (Astrup, 1999). Hence a study on intervention of low-calorie high fiber diet along with lifestyle modifications was carried out to assess the effect on nutrient intake by subjects.

Impact of intervention on nutrient intake of subjects is depicted in the Table. 3. Mean intake of energy for group I and II changed significantly from 2300.9 ±245.7 to 2003.4±181.7 kcal and from 2468.8 ±132.45 to 2375.51±149.21 kcal respectively. Intake of energy is more than RDA (Recommended Dietary Allowance) (1900 kcal) in all the groups. There was

no significant difference found for the energy intake of group III before and after the intervention.

Protein intake was found to be increased after the intervention in group I (45.04 ±6.80 to 62.05 ±8.09 gm) and group II (48.54 ±6.33 to 53.76 ±5.34 gm) and no significant increase was found for group III (43.64 ±6.04 to 44.54 ±3.87 gm). However, intake of protein by subjects was found to be less than RDA.

A significant decrease in the consumption of fat was observed after the intervention from 32.82±7.56 to 24.16 ±2.46 gm in group I, 31.22 ±5.64 to 27.40 ±3.69 gm in group II and no significant decrease in fat consumption was found in group III. Per cent adequacy for fat adequacy was found be more than 150 among all the groups. This might be due to the inclusion of both visible and invisible fats by subjects in their daily diet. Group I and II showed a significant increase in the consumption of fiber after the intervention period from 14.82 ±4.03 to 21.35 ±7.15 and 15.54 ±1.92 to 19.74 ±3.04 gm respectively. No significant change was found after the intervention for group III.

A significant reduction in mean energy and fat intake was observed in intervention group consisting of diet and exercise along with lifestyle counseling as reported by Khadilkar *et al.,* (2012). Nutritional changes resulted in decrease in the average energy value of the food intake from 1928.0±591.8 to 1596.7±376.0 kcal/day. This aligns with the observation made by Stefanska *et al.,* (2016) that consuming a diet with high energy value than one's demand is a potential contributing factor to the development of obesity.

Intake of fat more than the recommendation causes energy imbalance and hence results in weight gain. These findings are supported by the study conducted by Bertz *et al.,* (2014). Study groups (control, diet, exercise and diet + exercise group) reported an intake of percent of calories from total fat and saturated fat above recommended levels, and carbohydrates and fiber below recommendations. Dietary treatment resulted in significant reductions in total fat, carbohydrate and sucrose, contributing to reduced total energy intake.

Increased consumption of iron was found to be significant in group I (11.36 ±6.98 to 16.99 ±2.9 mg) followed by group II (12.35 ±6.39 to 14.58 ±1.18mg) and group III showed no significant increase in the iron consumption after the intervention.

Consumption of calcium increased significantly after the intervention in group I (459.87 ±83.16 to 569.72 ±103.07 mg) and in group II (447.58 ±93.84 to 482.93 ±77.24 mg) whereas no significant increase was found in the Group III. Consumption of calcium was below RDA (600 mg) in all the groups even after the intervention.

There was a significant increase in the intake of phosphorous from 1288.6 ±112.1 to 1434.7 ±161.11 mg in group I and 1323.82 ±107.92 to 1366.89±109.14 mg in group II after the intervention. No significant change was observed in group III after the intervention. Similar findings were reported by Manios *et al.,* (2007) that following a dietary intervention combined with nutrition education resulted in increased intake of calcium, phosphorous, magnesium, potassium in post-menopausal women.

Intervention had a significant effect on the consumption of sodium, which decreased from 104.48 ±26.54 to 93.73 ±26.16 mg and 102.02 ±13.66 to 97.17 ±14.09 mg in group I and II respectively. Group III had no significant change before after the intervention.

Consumption of β Carotene changed significantly from 1786.6±2110 to 3525.18±2275.26 µg and 1183.75 ±230.78 to 1817.26±216.79 µg in group I and II and no significant change were observed in group III after the intervention.

Table 4: Effect of intervention on energy expenditure of subjects

Study Group	Sample (n=45)	Energy expenditure (Kcal)			Paired 't' Test
		Before	After	Difference	
		Mean±SD	Mean±SD	Mean±SD	
Group I	15	1701.5±84.1	2217±83.21	515.5±0.89	14.24*
Group II	15	1761±162.7	2010.5±77.8	249.5±84.9	7.5*
Group III	15	1675±91.56	1660.3±98.53	14.7±6.97	2.24NS

*Significant at 5%, NS-non significant

Group I: Low calorie high fiber food formulation+ Nutrition education and awareness on lifestyle practices;
Group II: Nutrition education and awareness on lifestyle practices;
Group III: control

During the past half-century mechanization has impinged upon our modes of living in diverse ways. Consequently, energy expenditure required for daily living has continuously declined. A recent study has reported that daily energy expenditure due to work related physical activity has decreased by more than 100 kcal during the last 50 years in both men and women, and this reduction is associated with the

increase in mean body weight. Substantial reductions in daily energy expenditure have also occurred in developing countries such as China and Brazil, which have the highest absolute and relative rates of decline in total physical activity due to reductions in movement at work. For this reason, it is believed that the obesity epidemic has also penetrated to low-income countries, particularly urban areas (Wiklund, 2016).

Table 4 shows the energy expenditure of subjects before and after the intervention. Energy expenditure significantly increased from 1701.5±84.1 to 2217±83.21kcal in group I and 1761±162.7 to 2010.5±77.8 kcal in group II, whereas no significant change was observed in group III.

According to Wiklund, (2016), domestic mechanization of daily tasks (with the advent of labor-saving devices such as washing machines and dishwashers) has reduced energy expenditure over the years. Housework-related energy expenditure has been substantial contributors to the rise in prevalence of obesity in women, as labor-saving devices are habitually used in all affluent societies. Domestic mechanization has also contributed to increased sedentariness, as time spent in house work has been replaced by sedentary activities such as watching television and use of other screen-based media.

Drenowatz *et al.,* (2015) reported an increase in total daily energy expenditure upon exercise by 443± 126 kcal/day and 239± 152 kcal/day for aerobic and resistance exercise, respectively. A higher energy expenditure with physical exercise along with potentially decreased energy intake results in energy balance and hence a significant change in body weight can be achieved.

Conclusion: The findings of the study show a significant positive impact of a combined dietary intervention and lifestyle modification on overweight women. Nutrient intake of subjects showed that energy and fat were consumed in excess whereas protein, fiber and other micronutrients were consumed less than the RDA. Significant change in the individual nutrient intake was observed after the intervention with developed flour mix and lifestyle modifications. This is because, low calorie product contained good amount of nutrients such as protein, iron, calcium, β Carotene and was rich in fiber. Along with nutrition education and dietary counselling resulted in increased intake of essential nutrients and reduced consumption of energy and fat. Balanced intake of nutrients with reduced energy density combined with lifestyle modification to increase the energy expenditure can help in weight reduction, a long-term, sustainable approach, making the weight loss achievable and maintainable.

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