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Obesity Related Metabolic Disorders and Risk of Renal Disease: Impact of Hypocaloric Diet and Avena Sativa Supplement

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Keywords: Obesity; Metabolic disorders; Avena sativa oat; Dietary supplement; Hypocaloric diet

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Abstract

BACKGROUND: The recognition of the complications of obesity in various organs and systems should make clinicians and dietitians aware of the importance of early strategies to fight obesity in all age groups.

AIM: The objective of this study was to evaluate the early effect of using *Avena sativa* (oat) flour supplement compared to a hypocaloric diet in the management of obesity-related metabolic disorders.

MATERIAL AND METHODS: Snack was prepared from wholemeal wheat flour (100% extraction) and oat flour. Chemical analysis of the raw materials and the formulae was carried out. 106 obese women with their mean body mass index were 37.73 ± 0.56 kg/m² volunteered for 8 weeks period. They were divided into two groups; group (A), consumed hypocaloric diet supplemented by the prepared snack, while group (B) subjects followed the low caloric balanced diet. All patients were monitored clinically, anthropometrically, dietary 24 h recall and biochemically.

RESULT: Data demonstrated significantly decreased in the mean levels of the anthropometric parameters. Group (A) showed a higher decrease in the waist circumference, WHR, body fat% and SBP; while in group (B) weight, BMI, chest circumference and DBP were the most affected parameters. The reduction in the biochemical parameters was higher in the group (A). At the baseline, high values of cystatin-C were found in both groups which may indicate early renal injury. At the end of the study, a significant reduction of the cystatin concentration was observed among both groups (-24.54 & -12.23%).

CONCLUSION: The healthy effect of the dietary oat supplement on the reduction of central obesity, percentage body fat and different metabolic disorders criteria was confirmed than with hypocaloric diet.

Introduction

James, (2008) reported that obesity is a standout amongst the most genuine general medical issues in the 21st century [1]. Eighty-five per cent of Egyptian women are overweight with 48 per cent of that rate enduring obesity, as indicated by Egypt Demographic and Health Survey (EDHS 2014) reported by Egypt's health minister, the per cent of obese women was twice that of men [2].

Fat accumulation, especially in the abdominal region, is associated with metabolic disturbances such as dyslipidemia, hypertension, insulin resistance, cardiovascular complications and non-alcoholic fatty liver disease. Recent studies demonstrated that obesity independently of diabetes might have a role in the development of kidney disease (obesity-related nephropathy) and may lead to end-stage renal disease. The prevalence of obesity runs in parallel with the prevalence of renal failure. The intrarenal changes associated with the cardiometabolic syndrome result in elevated glomerular filtration rate, impaired pressure natriuresis, endothelial dysfunction related to changes in nitric oxide and, hence, impaired renal autoregulation and enhanced chronic inflammation [3] [4].

Cystatin C is a protein of 120 amino acids delivered in every nucleated cell of the human body and is found in practically all tissues and body liquids. It has a low atomic weight, so it is unreservedly filtered by the glomerulus and reabsorbed and debased by the proximal tubules. It is an endogenous filtration marker that is being considered as a potential substitution of serum creatinine in the evaluation of renal capacity, predominantly for the identification of

little changes in the glomerular filtration rate, since it is asserted to be free of age, sex, skeletal bulk and protein consumption [5]. Sledzinsk and others demonstrated that human obesity is associated with an abnormality in cystatin-C value, and that fat tissue elevated serum cystatin-C in obese subjects [6].

Oat (*Avena sativa*) has a nutritional profile and multifunctional attributes. It is considered a richer source of dietary fibre particularly beta-glucan, minerals and different elements. Wholegrain oat-based breakfast grains considered as prebiotics and have low glycemic index (GI) [7].

The present study aimed to evaluate the early effect of using *Avena sativa* (oat) flour supplement compared to a hypocaloric diet in the management of obesity-related metabolic disorders and the risk of renal disease.

Materials and Methods

The snack was prepared from wholemeal wheat flour (WMWF) (100% extraction) and oat flour (OF) added in equal amounts (at the level of 50%). The flour was mixed with the other ingredients (Skimmed milk, corn oil, baking powder and vanilla) and a suitable amount of water was added. These formulae were baked at 180°C for about 15 minutes [8] (Figure 1). WMWF 100% extractions had more beneficial health effect than Wheat flour (WF) 72% extraction [9].

Table 1: Composition of the supplement (g/100g dry weight)

Items	Snack
Oat Flour	38.7
Whole Meal Wheat Flour 100% extraction	38.7
Vanilla	0.5
Skimmed milk	10.8
Baking powder	0.5
Corn oil	10.8

One hundred and six obese females with BMI more than 30 kg/m² were included in this study with their age ranged from 39 to 57 years old, and their mean body mass index (BMI) was 37.73 ± 0.56 kg/m². They were all enrolled in a program for losing weight in the Nutrition Department, National Research Centre. The participants were informed about the purpose of the study and their permission in the form of written consent was obtained. The protocol was approved by the "Ethical Committee" of the "National Research Centre". All participants have followed a low caloric balanced regimen (1000-1200 KCal/day) for eight weeks. They were divided into two groups, sixty-six patients (group A) consumed the snack, two with breakfast and one with dinner (each weighed 20 g), and the rest of the sample (40) group (B) followed a low caloric balanced regimen without supplement for eight weeks. All the subjects were examined at baseline, and the end of the study with weekly follow up.

Figure 1: Prepared snack

Exclusion criteria: Obese patients on pharmacological treatment, known to have renal failure or thyroid dysfunction.

Body weight and height (subjects were standing with minimum clothing and no shoes to the nearest 0.01 centimetre). Minimal waist circumference (MWC) was measured in centimetre using non-extendable tape during minimal normal respiration and hip circumference. The body mass index (BMI) was Calculated, where BMI = weight in kg/square height in meters [10] (Jelliffe, 1966). Body fat (BF) as a per cent of body weight, body muscle mass and the basal metabolic rate was measured using Geratherm Body Fitness (B-5010), German.

Blood pressure was measured by cuff sphygmomanometer while the subjects sat quietly on a chair, and the mean of three readings was taken.

Data on dietary intake before the intervention were reported using the 24 hours dietary intake recall. All food items and portions were recorded in details. Total nutrients intake was calculated using Nutrisurvey 2007.

Blood samples were obtained on the day of clinical examination after an overnight fast. Fasting blood glucose (FBG) was determined in fresh samples using the glucose oxidase method [11]. Serum total cholesterol (TC), High-density lipoprotein cholesterol (HDL-C) and triglycerides (TG) were done using; cholesterol proceed No 1010, StanBio Liquicolor [12]. HDL-C proceed No 0599 StanBio Liquicolor [13], and triglycerides proceed No 2100, (Enzymatic method) [14] respectively. Low density lipoprotein- cholesterol (LDL-C) was calculated according to the Friedewald equation [15]. Fasting C-peptide level was measured by ELISA method [16] (Monobind Inc. Lake Forest, CA 92630, USA). According to Li et al., [17] (2004), insulin resistance was expressed by modified homeostasis model assessment-insulin resistance (modified HOMA-IR = 1.5 + FBG (mg/dl) × fasting C-peptide (nanograms per milliliter)/2,800), in which insulin was replaced by C-peptide so as to be applied

on diabetic patients using exogenous insulin. Aspartate aminotransferase (AST/GOT) and alanine aminotransferase (ALT/GPT) were measured by colourimetric method [18]. DeRitis ratio was calculated as AST/ALT. Serum Cystatin-C was determined using Human Cystatin-C ELISA, Lot E12-076, BioVendor Research and Diagnostic Product CZECH REPUBLIC [19].

All values were expressed as mean value ± SE. Two-tailed student t-test was used to compare between data in the same group and between groups. P values < 0.05 were considered statistically significant. SPSS window software version 17.0 (SPSS Inc. Chicago, IL, USA, 2008) was used. Changes in different data were expressed as % change from baseline.

Results

Table 2 summarised the average of protein, fat and crude fibre of the raw materials and the oat prepared snack, in addition to some mineral contents of the product.

Table 2: Chemical composition of raw materials and snack (mean ± SE)

Samples	Protein (%)	Fat (%)	Fibre (%)
WMWF	13.5 ± 0.10	2.5 ± 0.01	1.75 ± 0.001
Oat flour	16.8 ± 0.17	5.0 ± 0.05	4.82 ± 0.002
Snack	16.32 ± 0.12	12.15 ± 0.06	3.50 ± 0.007
Minerals	K %	Zn%	Na %
Snack	320.96	5.34	302.34

WMWF: Whole Meal Wheat Flour (100% extraction); Snack prepared by 50% WMWF+50% Oat Flour.

Table 3 showed a comparison between the different macronutrients and micronutrients and the per cent caloric distribution of the diet of the whole sample. The data showed the balanced and healthy distribution of the macronutrients in the two regimens compared to the habitual diet of the patients.

Table 3: Daily intake of calories, macronutrient (as a % of calories), Mean values and % of the recommended dietary allowance (RDAs) of some micronutrient intake of three types of diet

Macronutrient Intake	Habitual Diet	Low Caloric Regimen	Diet with Supplement
Energy (Kcal)	2802.61	1239.91	1229.87
Protein (% cal. supply)	13.99%	21.48%	25.44%
Fat (% cal. supply)	40.92%	29.94%	28.96%
Carbohydrate (% cal. supply)	45.09%	48.58%	45.60%
Micronutrient intake (RDAs)		Mean value %RDAs	
Vit. A (µg)	567.24	765.24	774.21
(800)	70.91	95.66	96.78
Vit. D (µg)	1.97	3.21	3.23
(5)	39.40	64.20	64.60
Potassium (mg)	929.93	1633.51	1669.95
(2000)	46.49	81.68	83.49
Calcium (mg)	731.63	891.46	920.32
(1000)	73.16	89.15	92.03
Iron (mg)	6.35	11.12	11.83
(15)	42.33	74.13	78.87
Zinc (mg)	6.27	10.45	10.98
(12)	52.25	87.08	91.50

Table 4 showed the mean ± SE of age, anthropometric, blood pressure measurements of the two groups at the start and the end of the study. All the anthropometric measurements except body muscle mass of the two groups decreased significantly at p < 0.05-0.01 by the end of the study. Comparing the % changes between the two groups; group (A) showed more % reduction of waist circumference, WHR, body fat % and SBP, while in the group (B) the higher per cent of reduction was observed in weight, BMI, chest circumference and the DBP.

Table 4: Mean ± SE of anthropometric parameters and blood pressure of obese women at the baseline and the end of the study

	Groups A (n = 66)			Groups B (n = 40)		
Parameters	Baseline	Last	% changes	Baseline	last	% changes
Age (year)	50.18±0.64			50.11±0.80		
Height (cm)	155.5±0.78			155.00±0.76		
Weight (Kg)	91.39±1.33	87.63±1.40^{**a}	-4.11	90.10±1.04	86.09±1.02^{**b}	-4.45^{**c}
BMI (Kg/m^2)	37.88±0.56	37.04±0.58^{**a}	-2.21	37.59±0.46	36.27±0.47^{**b}	-3.51^{**c}
Body fat (%)	47.83±0.65	46.37±0.73^{**a}	-3.05	48.83±0.84	47.94±0.84^{**b}	-1.82^{**c}
Body muscle (kg)	42.45±0.46	42.43±0.40	-0.04	42.15±0.36	41.98±0.37	-0.40
Chest (cm)	96.05±0.67	94.46±0.57^{**a}	-1.66	98.18±0.55	95.14±0.53^{**b}	-3.06^{**c}
Waist (cm)	95.32±0.76	92.33±0.99^{**a}	-3.14	95.00±1.19	93.62±1.03^{**b}	-1.45^{**c}
WHR	0.79±0.01	0.77±0.00^{**a}	-2.53	0.81±0.01	0.80±0.11^{**b}	-1.23^{**c}
SBP (mmHg)	132.67±1.37	116.67±1.77^{**a}	-12.06	126.88±2.80	117.64±1.79^{**b}	-7.85^{**c}
DBP (mmHg)	79.33±0.82	76.67±1.18^{*a}	-3.35	82.22±1.55	78.33±1.43^{**b}	-4.97^{*c}

*BMI: body mass index, WHR: waist-hip ratio, SBP: systolic blood pressure, DBP: diastolic blood pressure *P<0.05 **P<0.01, a: Baseline vs. last visit of group A; b: Baseline vs. last visit of group B; c: % changes group A vs. group B.*

Table 5 showed the mean± SE of the biochemical parameters of the two groups at the two visits. The level of HDL-C increased significantly, while the FBG concentration, other lipid parameters, liver enzymes and cystatin-C levels showed a significant reduction in the mean concentrations of both groups with more effect on group A except for AST serum level. The comparison between the two groups regarding the mean per cent changes approached significance on all parameters.

Table 5: Mean ± SE of the Obesity-related metabolic disorders of obese women at the baseline and the end of the study

	Groups A (n = 66)			Groups B (n = 40)		
Parameters	Baseline	last	% changes	Baseline	last	% changes
FBG (mg/dl)	95.76±2.45	79.67±1.50^{**a}	-16.80	84.83±1.32	83.35±1'12	-1.74^{**c}
TC (mg/dl)	232.94±6.29	184.02±4.41^{**a}	-21.00	218.76±6.66	205.68±7.24^{**b}	-5.99^{**c}
LDL-C (mg/dl)	151.29±6.41	97.09±4.77^{**a}	-35.89	151.19±4.82	126.89±4.80^{**b}	-16.07^{**c}
HDL-C (mg/dl)	49.71±1.20	62.19±1.44^{**a}	+25.11	49.23±1.61	53.39±2.61^{**b}	+8.45^{**c}
Non HDL-C (mg/dl)	183.23±6.82	121.83±4.99^{**a}	-33.51	159.52±7.59	152.28±8.62^{**b}	-4.54^{**c}
Risk factor ((TC/ HDL)	4.99±0.23	3.12±0.13^{**a}	-37.47	4.90±0.16	3.99±0.14^{**b}	-29.35^{**c}
TG (mg/dl)	159.68±6.00	123.70±3.56^{**a}	-22.53	125.15±6.03	110.93±4.42^{**b}	-11.36^{**c}
AST (IU/L)	32.86±0.90	29.27±0.95^{**a}	-10.93	28.97±0.90	25.19±0.60^{**b}	-13.05^{*c}
ALT (IU/L)	50.85±0.79	38.28±0.79^{**a}	-24.72	51.72±0.48	49.80±0.96^{**b}	-3.71^{**c}
DeRitis ratio	0.65± 0.01	0.78±0.02^{**a}	+20	0.56 ±0.02	0.62±0.03	+10.71^{**c}
C peptide (ng/ml)	4.44±0.38	2.37±0.25**a	-46.62	5.22±0.28	3.40±0.18	-34.87^{**c}
M. HOMA-IR	1.67±0.01	1.58±0.01^{**a}	-5.39	1.66±0.01	1.58±0.01	-4.94^{*c}
Cystatin C (ng/ml)	965.25±38.23	728.37±24.11^{**a}	-24.54	957.44±45.99	840.37 ±42.12	-12.23^{**c}

FBG: fasting blood glucose; AST: aspartate transaminase; ALT: alanine transaminase; M.HOMA-IR: modified homeostatic model assessment of insulin resistance *P<0.05 **P<0.01; a: Baseline vs. last visit of group A; b: Baseline vs. last visit of group B; c: % changes group A vs. group B.

Discussion

Obesity is a state of low-grade inflammation and pro-oxidation which lead to vascular dysfunction and altered the metabolic states resulting in an alteration in the liver and kidney functions. The baseline information of this study uncovered that all volunteers had elevated levels of all the anthropometric measurements, lipid profile parameters and the cystatin-C concentration over the recorded reference values that indicated metabolic disarranges. At the beginning of the investigation, the diabetic members had a normal value of the FBG, as they were under medical treatment. Nonetheless, serum C-peptide as a marker of the functional-pancreatic cell mass, showed mild rise (> 3.75 ng/ml). Rosselli et al., (2013) expressed that C-peptide expects a role in early atherogenesis in diabetic patients; also it might be considered a marker to cardiovascular diseases risks in patients without diabetes [20].

Data in this study demonstrated the healthy beneficial effect of the supplement consumed by the patients on the central obesity measurements (waist circumference and WHR) and the blood pressure values. The higher per cent decrease was found in the systolic blood pressure percentage where it was -12.06 & -7.85% group (A) and group (B) respectively, that followed by the decrease in the body fat percentage values (-3.05 & -1.82%) and WHR (-2.53 & -1.23%). The body weight and BMI were significantly decreased more in the low caloric diet group (-4.11 & -4.45%) and (-2.21 & -3.51%) respectively. Furthermore, the improvement of the biochemical parameters was high in its value when compared to the supplements' effect on the anthropometric measurements. The mean level of the FBG decreased significantly (-16.8 & -1.74%) in both groups, but was much more in the group (A). All the biochemical parameters improved significantly in both groups, especially in group A.

Interest in β-glucan increased due to its bioactive and functional properties with no adverse effects following consumption of a diet rich in it as barley, oat or their extracts [21]. The health benefits of these foods arise from their high fibers content which ranges from 9.9-14.9 g for each 100 g serving and lipid-lowering effect of β-glucan, either by bile acid binding, delay in the absorption and/or digestion of fat, filling full, suppress appetite and finally β-glucan depress oxidative stress associated with inflammatory state caused by obesity [22].

Oats additionally contain more lipids (5-9%) than other grain edits and are rich in unsaturated fats, including the basic unsaturated fat linoleic acid. Oats contain antioxidant, called avenanthramides, and also the vitamin E-like compound, tocotrienols and tocopherols (Wursch and Pi-Sunyer, 1997) [23] [24] [25].

Body muscle mass decreased numerically in both groups; this result focuses the importance of consuming supplement enriched on amino acid as soy products, the preservation of body muscle mass is a must in any overweight, losing program [26].

Correlation between obesity and renal impairment has been demonstrated by several types of research. The gradual expansion of renal tubulointerstitial fibrosis by fibrous tissue destroys the normal structure of the kidney. More, the local release of inflammatory substances and active biological factors result in renal impairment. Other theory states that obesity leads to endothelial dysfunction and thickness of the intima-media resulting in vascular damage and leaking of albumin. Obesity, when present since childhood, is associated with a lower glomerular filtration rate even before the appearance of other comorbidities as diabetes and hypertension [27] [28] [29] [30].

Clinical markers used to reflect renal damage incorporate albuminuria and the assessed glomerular filtration rate (GFR). Given the same GFR level, urine albumin may be a superior marker to foresee the progression of chronic kidney disease (CKD) and the future of cardiovascular diseases (CVDs). Serum cystatin-C is rising as another biomarker for early identification of renal damage related to obesity, MetS and cardiovascular disease [31] [32] [33]. Weight control, strict control of blood pressure, glucose and lipid levels decrease renal damage and even the ensuing CVD [34].

In this study, high values of cystatin-C were detected in both groups at the beginning of this study which may indicate early renal injury. After the end of the study, a significant reduction of the cystatin-C concentration was observed among both groups more in the oat supplement group (-24.54 & -12.23%). Animal examinations revealed that oat consumption affects kidney function. In any case, the impacts of oat utilisation have not been completely evaluated in humans. However, Rouhani et al., (2016) conducted a study that investigated fifty-two patients with CKD; the authors reported that admission of oats might beneficially affect both serum albumin and potassium [35].

The results of this study showed the high value of the ALT enzyme and the De Ritis ratio was (< 1.0) at the beginning of the study in both groups, denoting the presence of early nonalcoholic fatty liver disease (NAFLD). At the end of the study, a significant reduction in the levels of both liver enzymes was detected, and the De Ritis ratio was improved in both groups. Improvement of insulin resistance with oat supplement or dietary interventions constitutes an essential step in the treatment of NAFLD. Excessive triglyceride accumulation in the liver in the absence of alcohol consumption results in a disorder known as NAFLD. Insulin sensitisers and antioxidant drugs hold promise for the management of NAFLD [36] [37].

In conclusion, whole wheat flour and oat flour snack prepared supplement have higher nutritive values. Oat is an essential food component used in the modulation of obesity-related metabolic disorders and renal impairment.

Ethics approval

The research was given ethical approval from Ethical Committee of National Research Centre; Signed written informed consents was a must to participate in the research project after they had been given a full explanation of the study.

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