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Ketogenic Diet Practices for Weight Management and Health Outcomes

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Abstract

ketogenic diets or very-low-carbohydrate ketogenic diets (VLCKD) have been in use long time ago as treatment for epilepsy and thereafter being become widely known as one of the most common methods for obesity treatment. Therefore, the aim of the present work was to determine the efficacy of ketogenic diet in weight reduction program and also point out the health outcome and blood biochemical changes during time of dieting. A cross sectional study was carried out in 100 participants used ketogenic diet for their weight management from week 1 to approximately week 13 (29 male and 71 female) with those regard less their body mass index but with ages 32.48 ± 2.27, respectively. Pre-design questionnaire was used and data were analyzed by paired Student's *t* test or chi-square accordingly. There were no significant changes in liver and renal function test, potassium ALT, AST, and blood creatinine except slightly decreased in sodium and increased acetone . The significant ($P < 0.05$) reduction in BMI (32.45 Kg/m2 to 27.4 Kg/m2), body weight (94.0 kg to 78.9 Kg) have been found. Furthermore, the total weight loss found significant (19%) by which repsresent by 15 kg. Waist circumference and waist hip ratio were improved. The result also shown significant increased platelet count ($P< 0.05$). All lipid profile shown normal except slightly increased in LDL.The three significant top food were mostly consumed meat, chicken and eggs ($P< 0.05$). Although, there was some minor side effect reported by the participant include constipation, bad breathing and lack of appetite and no other clinical signs reported. The more weight reduction has been shown in age groups 20-30 years old (20 kg) ($P< 0.05$) during time of dieting. No differences in weight reduction among male and female. The ketogenic diet lead to weight reduction, improvements in a number of risk markers included cardiovascular events and showed good compliance.

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Furthermore, ketogenic diet considered safe, an effective strategy for the management of overweight and obesity and promoting non-atherogenic lipid profiles, improving fasting blood glucose levels. Future research should include a larger sample size, a longer term use and a comparison with other ketogenic diets.

Keywords: Ketogenic diet; BMI; body weight; health outcomes; WHR.

1. Introduction

ketogenic diets or very-low-carbohydrate ketogenic diets (VLCKD) have been in use since the 1920s as treatment for epilepsy and in some cases, can completely remove the need for medication [1]. After 1960s being become widely known as one of the most common methods for obesity treatment. Furthermore, in last decade provided evidence of the therapeutic potential of ketogenic diets in many pathological conditions, such as diabetes, polycystic ovary syndrome, acne, neurological diseases, cancer and the amelioration of respiratory and cardiovascular disease risk factors [2]. In addition, modifying dietary intake can be useful for reducing or eliminating pharmaceutical methods of treatment, which are often lifelong with significant side effects [3]. Ketogenic diets in which a reduction in carbohydrates (usually to less than 50 g/day) and a relative increase in the proportions of protein and fat [4, 5]. There is an a growing evidence to support the notion that a ketogenic diet can lead to an improvement in some metabolic pathways and have beneficial health effects [6]. Obesity represents one of the major public health problems since associated with several diseases, including type 2 diabetes mellitus (T2DM), dyslipidemia, coronary heart disease, and cerebral vasculopathy, arterial hypertension, which contribute to a reduction of both life quality and expectancy [7, 8]. Recently, there has been a rapid increase in the global rates of obesity in both men and women, which has further increased the burden of this disease [9, 10]. However, the achievement of a weight loss of at least 5–10% is associated with significant clinical benefits on most of the obesity-related comorbidities [11–13]. In order to achieve this target, several strategies are available. Among which is ketogenic diet protoctol [14-16]. This diet is characterized by three stages, which including an active, a metabolic stabilization and a maintenance stage. In the First stage, patients started on a short period of calories and limited amounts of carbohydrates intakes (<700-800 kcal/day, <30-50 g/day, 13-25% of total calories), with an amount of protein corresponding to 0.8-1.2 g/day per kg of ideal body weight. The duration of the first step lasts up to 12 weeks and accompany with increased ketone bodies production by the liver [17-19]. The next stages in which second and third phases, calories and carbohydrates are gradually increased to a low-calorie and, then, to a balanced diet with a daily intake of 800-1500 and 1500-2250 kcal, respectively, depending on the characteristics of patients [20-22]. The significant restriction of both calories and carbohydrates associated with an adequate protein intake allows for a fast and consistent weight loss, fat loss (particularly visceral fat), sparing of free fat mass, inhibition of hunger and craving. The subsequent steps are needed to allow a stabilization of these changes [23]. Overall ketogenic diets, there are numbers of studies conducted and found that ketogenic diet is an appropriate diet for weight loss in which fasting results were obtained in short times with minimum side effects [2, 6,8]. Ketogenic diet still receiving a lot of changellge therefore , no or little studies performed locally for study the relationship between most common weight loss protocol and blood biochemistry changes during the weight management of patients with ketogenic diets at short time included 3 months. Therefore the aim of the present study was to determine determine the efficacy of ketogenic diet in weight reduction program and also point out its health outcome.

2. Materials and methods

2.1 Participants

Healthy adults or any obese, and overweight on ketogeinc diet were recruited from different clinics . A total number of the participans were 100 (71 women, 29 man) with ages ranging from 18-44 years old.

2.2 Ethical consideration

The study was approved by the regional ethics committee and conducted according to the guidelines laid down in the protocol. All participants provided written informed consent before commencement.

2.3 Anthropomteric measurements

Participants were required to be filling out the questionaniers for all information and body weight were measured by using scale at nearset 01.kg with minimal cloths, height were measured by Tape to the nearest 0.2 cm, waist, and hip circumferences were measured as indicated by WHO [24]. BMI and WHR was calculated and categorized as decrsibed by WHO [25].

Waist circumferences cut off points as following:

Men > 40 inches (102 centimeters)

Women > 35 inches (89 centimeters)

The WHO states that abdominal obesity is defined as a waist-hip ratio above 0.90 for males and above 0.85 for females, or a body mass index (BMI) above 30.0

In this study the weight before and during using keto diet were undertaking as following

-Usual weight. Is the weight before starting dieting (ketogenic diet)

-Current weight. Is the weight during or after using ketogenic diet.

2.4 Questionniars

Pre-design questionnaire was used in the study which included 4 sections with 20 items questions for personal information, anthropometric data, clinical data, sign and symptoms and biochemical data..

2.5 Ketogenic diets

All participant on ketogenic diets for 13 weeks were included in the study. Used 13 weeks in the study based on the recommended ketogenic diet for short term weight reduction by Nymo and his colleagues [26] and Bruci and his colleagues [27]. The foods content of ketogenic diets were also reported.

2.6 Study design

This was a cross sectional study with repeated measurements. Participants were provided with an 13-week of ketogenic diets.

2.7 Statistical analysis

Statistical analysis was performed with SPSS version 22 (SPSS Inc., Chicago, IL, USA), and data presented as estimated marginal means±SD or frequencies and percenatges . Statistical significance was set at P <0.05. Data were analysed using either by Chi-sqaure or students T test based on the types of data.

3. Results

One hundred patients involved in weight management program by using ketogenic in which 29 (29%) men and 71 (71%) women were consecutively evaluated (Figure 1). The mean age was 37.3 ± 5.2 years, and age categories shown that almost similar age groups participate in the study between 20-30 years, 31-40 years and above 41 years 31%, 34% and 31% respectively and age younger than 20 years old being the least (4%) (Table 1).

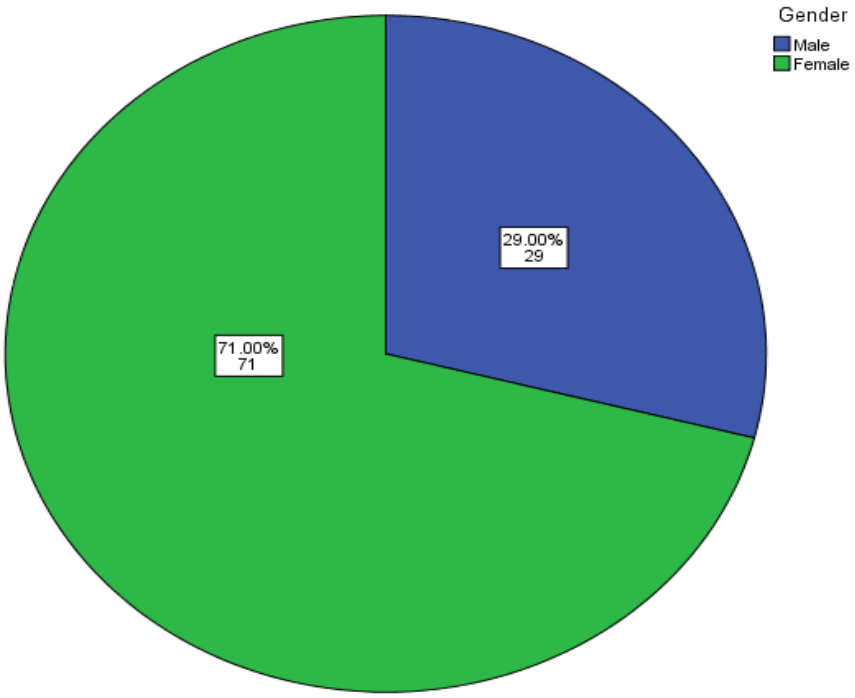

Figure 1: Gender distribution of the participants.

Nutritional status has been assessing by weight, waist circumferences, waist hip ratio and BMI. The mean ± SD of the usual weight was 94± 19 kg and current weight 78.9± 14 kg, the differences between usual and current weight was 15± 3 and significant weight loss during the weight management was 19%. The mean of waist circumferences found 90 ± 2, and WHR 0.89± 0.16. The mean usual BMI reported 32.6± 6 kg/m2 and current

BMI was 27.4± 4 kg/m2 (Table 2).

Table 1: Age categories and distribution of the subjects:

Age categories (Years)		N	N %
Ages (Years)	< 20	4	4.0%
	20-30	31	31.0%
	31-40	34	34.0%
	➢ 0	31	31.0%
	Total	100	100.0%

Table 2: overall anthropometric measurements:

	Mean ± SD	P values
usual weight	*94.0± 19	
current weight	*78.9±14	0.000
waist circumference	90±20	
W/H ratio	.89± 0.16	
usual BMI	#32.6±6	
current BMI	#27.4± 4	0.000
differences weight loss	15±3	
Significant weight loss	19%±3%	

Student T test was performed and considered significant at $\alpha < 0.05$.

* compared between usual and current weight. P=0.000

#compared between usual and current BMI. P=0.000

Table 3: categorized anthropometric measurements:

		N	N %	P values
WC	Normal	41	41.0%	
	risk	59	59.0%	0.07
	Total	100	100.0%	
WHR categories	Normal	42	42.0%	
	Risk	58	58.0%	0.08
	Total	100	100.0%	
Usual BMI categories	Normal	7	7.0%	
	Overweight	22	22.0%	
	Obesity	71	71.0%	0.000
	Total	100	100.0%	
Current BMI categories	Normal	28	28.0%	
	Overweight	51	51.0%	
	Obesity	21	21.0%	
	Total	100	100.0%	

Chi-square test was performed and considered significant at $\alpha < 0.05$.

Analysis of waist circumferences and WHR shown that 59% and 58% have risk for abdominal obesity. For

analysis of Body mass index, found that, there was dramatic changes between usual and current BMI, for normal or healthy BMI between usual and current 7% vs 28%, and between overweight 22% vs 51% and for obesity 71% vs 21% this indicated great changes in body weight after using ketogenic diet (Table 3).

About 70% of patients were found healthy, 11% have hypertension, 6% suffering from Diabetes (Table 4).

Table 4: chronic disease reported by patients:

Chronic disease		N	N %
	DM	6	6.0%
	HTN	11	11.0%
	Epilepsy	1	1.0%
	Other	11	11.0%
	No disease	69	69.0%
	Total	100	100.0%

For the knowledge of patients with ketogenic diets there were numbers of questions listed in table 5. Approximately 91% of patients used ketogenic diet by his or her own (*P*=0.000) and about 79% of patients used ketogenic diet for manage their obesity (*P*=0.000) (Table 5).

Table 5: patients desire and knowledge for ketogenic diets:

		N	N %	P values
Recommendation use keto diet	Doctor	9	9.0%	
	Desire of patient	91	91.0%	0.000
	Total	100	100.0%	
use keto diet for management of obesity	Yes	79	79.0%	0.000
	No	21	21.0%	
	Total	100	100.0%	

Chi-square test was performed and considered significant at $\alpha < 0.05$.

Food contents of ketogenic diet have also been investigated and found that, the three top foods highly significant consumed were eggs (91%) chicken (80%) and meat 70% (*P*=0.000) (Table 6).

The serum biochemistry result shown in table (7). The mean ± SD of Glucose metabolism evaluation showed a frank improvement, with normalization in both fasting glycaemia and HbA1c. Lipid metabolism assessment demonstrated reduction in total cholesterol and triglycerides levels and normalization of HDL, VLDL but slightly high and LDL levels. Liver and kidney function evaluation showed no significant changes except in creatnine and acetone and also platelet increased . (Table 7).

Table 6: Food contents of ketogenic diets:

		N	N %	P values
egg	Yes	91	91.0%	0.000
	No	9	9.0%	
	Total	100	100.0%	
avocado	Yes	42	42.0%	
	No	58	58.0%	
	Total	100	100.0%	
chicken	Yes	80	80.0%	0.000
	No	20	20.0%	
	Total	100	100.0%	
meat	Yes	73	73.0%	0.000
	No	27	27.0%	
	Total	100	100.0%	
cheese	Yes	50	50.0%	
	No	50	50.0%	
	Total	100	100.0%	
nuts	Yes	54	54.0%	
	No	46	46.0%	
	Total	100	100.0%	
Tuna	Yes	44	44.0%	
	No	56	56.0%	
	Total	100	100.0%	
other	Yes	34	34.0%	
	No	66	66.0%	
	Total	100	100.0%	

Chi-square test was performed and considered significant at $\alpha < 0.05$.

Table 7: Laboratory and biochemical investigation of patients serum:

	Mean ± SD
Hb	13.2± 1.7
sodium	133±14
potassium	4.2±0.4
acetone	3.5±0.7
creatnine	1.04±0.22
urea	14.9±2.7
AST	14.5±5.5
ALT	17.0± 6.5
alkaline phosphatase	71.0±6.7
LDL	131± 41
HDL	41±7
VLDL	16.3±4.1
s.cho	178±34
s.TG	82±8
vitamin D	38±6
FBG	96±23
HB1Ac	5.0±1
PPBG	117±30
WBC	10.9±0.8
platelet	480±13

Finally, no clinical signs or symptoms significantly reported include of gout, kidney stones or gallbladder

disordered were reported by patients. The following symptoms and adverse events were reported by some patients: constipation (55%) bad breathing (42%) and lack of appetite (34%), whereas the other symptoms listed in table (8) were minors include fatigue dizziness, insomnia headache and etc.(Table 8).

Table 8: signs and symptoms reported by patients:

		N	N %
Laziness	Yes	22	22.0%
	No	78	78.0%
	Total	100	100.0%
Insomnia	Yes	23	23.0%
	No	77	77.0%
	Total	100	100.0%
constipation	Yes	55	55.0%
	No	45	45.0%
	Total	100	100.0%
headache	Yes	27	27.0%
	No	73	73.0%
	Total	100	100.0%
Dizziness	Yes	23	23.0%
	No	77	77.0%
	Total	100	100.0%
Fatigue	Yes	23	23.0%
	No	77	77.0%
	Total	100	100.0%
rash	Yes	4	4.0%
	No	96	96.0%
	Total	100	100.0%
lack of appetite	Yes	34	34.0%
	No	66	66.0%
	Total	100	100.0%
disorientation	Yes	14	14.0%
	No	86	86.0%
	Total	100	100.0%
joint pain	Yes	13	13.0%
	No	87	87.0%
	Total	100	100.0%
bad breathing	Yes	42	42.0%
	No	58	58.0%
	Total	100	100.0%

In the table 9, relation between gender and anthropometric indices were assessed and found, there was no differences in weight loss between usual and current weight and BMI between male and female after using ketogenic diet and both loss almost 15 kg (male and female usual weight 96.6 vs 93.3 kg and current weight79.9 and 78.5 kg respectively) but these loss significant in both gender during the timing of dieting (*P*=0.000).

Table 9: gender distribution and anthropometric indices of patients:

		usual weight	current weight	P values	usual BMI	current BMI	P values
		Mean± SD	Mean± SD		Mean± SD	Mean± SD	
gender	Male	95.6±15	79.9±13	0.000	33.4±7	28 ±4	0.001
	Female	93.3±10	78.5±9	0.000	32.3±6	27 ±6	0.005
	Total	94.0±12.5	78.9±11	0.000	32.6±5	27.4±5	0.000

Student T test was performed and considered significant at $\alpha < 0.05$.

Based on the information in the table 7, the effect of duration of ketogenic diet on the serum biochemical results further investigated. The changes of serum biochemical during the time of ketogenic diet shown, improved of blood Hb in which shift from anemic to normal Hb from week 1 to week 4 and on words. Serum sodium shown fluctuated and decreased by 9 weeks. Serum platelet, LDL and acetone was increased from week one to the end of the week 9-13. The PPBG decreased with time progresses except between week 3-4 increased. While the other tests remaining under normal levels. (Table 10).

Table 10: Serum biochemical investigation related to duration of ketogenic diet:

	duration of ketogenic diet (1-13 weeks)					
	< One week	1-2 weeks	3-4 weeks	5-6 weeks	7-8 weeks	8 -13 weeks
	Mean	Mean	Mean	Mean	Mean	Mean
Hb	10.5	12.6	13.6	13.0	14.0	13.8
sodium	140	129	139	127	143	133
potassium	4.0	4.1	4.4	4.7	4.3	4.2
acetone	1.0	3.1	3.8	3.0	3.3	3.7
creatnin	1.00	1.01	1.13	1.20	.85	1.03
urea	18.0	14.5	15.6	13.0	13.4	14.9
AST	12.9	13.2	11.7	20.0	13.1	16.2
ALT	10.0	16.9	13.2	27.0	15.6	18.5
alkaline phosphatase	74.0	70.1	71.1	72.0	68.0	71.7
LDL	121	107	155	90	117	133
HDL	44	43	40	35	37	42
VLDL	9.0	12.1	11.1	10.0	9.2	14.0
s.cho	190	168	211	154	169	169
s.TG	90	78	83	88	83	83
vitamin D	39	38	36	39	39	38
FBG	85	102	107	91	101	85
HB1Ac	4.9	5.2	5.1	4.0	5.3	4.7
PPBG	124	110	149	100	131	102
WBC	11.1	10.7	11.1	12.0	11.2	10.7
platelet	479	481	485	490	472	477

In order to exclude any cofound factors could effect on the lab and blood biochemical results, patients with any disease excluded and investigate only the health one as shown in table 11. Significant decreased of sodium and increased acetone, LDL and platelet count ($P< 0.05$) while other serum biochemistry normal (Table 11).

Table 11: Relation between biochemical blood result of healthy patients to ketogenic diet:

	Conditions	P values compared to the reference values
	No disease (69 patients)	
	Mean± SD	
Hb	13.3± 2	N
sodium	132±3	D (P=0.01)
potassium	4.2±1	N
acetone	3.3±1	I (P=0.04)
creatnin	1.03±0.4	N
urea	14.6±2	N
AST	14.2±3	N
ALT	16.4±3	N
alkaline phosphatase	71.8±6	N
LDL	134±9	I
HDL	43±3	N
VLDL	12.3±2	N
s.cho	171±8	N
s.TG	81±4	N
vitamin D	39±4	N
FBG	89±6	N
HB1Ac	4.7±2	N
PPBG	108±10	N
WBC	10.7±12	N
platelet	478±25	I (P=0.000)

D= decrease, I= Increased, N=normal

Student T test was performed in which at $\alpha< 0.05$ is significant

The age between 20-30 years were achieved significant reduction in body weight, and BMI, in which more than 20 kg has been lost of body weight during the time of dieting , and differences in BMI was found 7 kg/m2. While similar achievement also found in WC and WHR by which normalization both indices. The other age groups shown less weight reduction and still WC and WHR were high (Table 12).

Table 12: Relation between age categorized and anthropometric indices:

Age (Years)	usual weight Mean± SD	current weight Mean±SD	usual BMI Mean±SD	current BMI Mean±SD	waist circumference Mean±SD	W/H ratio Mean±SD
Less than 20	91.3±9	85.3±5	32.9±3	30.8±4.5	107±12	1.08±0.1
20-30	99.8±10	78.6±10	34±5	26.7±5	88±8	0.86±0.3
30-40	89.9±11	78.8±10	31.6±4	27.8±5	88±8	0.85±0.3
More than 40	92.9±8	78.5±7	32.2±6	27.2±3	91±9	0.88±0.1
Total	94.0±7	78.9±6	32.6±3.6	27.4±4	90±11	0.89±0.24

4. Discussion

Management of obesity is of steadily increasing nowadays and among the available strategies for weight loss and maintenance use ketogenic diets [28]. The current work, reported that a significant overall weight reduction, with a mean body weight decrease of nearly (15 kg) 19 %, in less than 3 months of dietingand this finding is inconsistent with previous studies [15, 16]. Lipid and glucose metabolism significantly improved. Furyhermore, Lipid profile and glucose hemostasis were also established in numbers of studies by which improved blood glucose levels and lipid profile with exception of LDL [16-18]. In fact, hepatic enzymes AST and ALT showed a tendency to decrease, despite not reaching significance, and triglycerides were profoundly decreased, all of which is consistent with reduced intrahepatic triglyceride content as previously described in patients with obesity undergoing a VLCKD before bariatric surgery [29,30]. No changes were detected in potassium but slightly decreased of sodium levels, and increased acetone levels suggesting that a ketogenic diet does not impair the hydroelectrolytic balance. However, changes of sodium has been observed between week 5-6 and after week 8 of dieting. This find also reported by Brehm and his colleagues [31] and Pellegrini and his colleagues [32]. We also observed a significant increase in platelets levels, that might be attributable to increased fat precursors and this is demonstrated for the first time. The results of this study also demonstrate, that weight loss obtained through a Ketogenic diet regimen was associated with an increase in serum 25(OH)D (Vitamin D) concentrations. This findings was in contrast with previously published literature, which suggested a negative effect of VLCKD on bone composition, because ketoacidosis generated by low-carbohydrate/high-protein diets results in hypercalciuria [33] which consequent to the renal compensatory response to the dietary acid challenge. In turn, the skeleton supplies serum buffer by active reabsorption of bone, thereby leading to hypercalciuria and an adverse effect on bone quality. It has been demonstrated that dietary regimens rich in animal protein may exert deleterious effects on bone quality in rats, but less is known about the effect of low-carbohydrate diets in humans. Indeed, the majority of the studies demonstrated a loss of bone mineral content in subjects following ketogenic diets were conducted in children following a low-carbohydrate, high-fat regimen [34,35]. On the other hand, Colica and his colleagues demonstrated that ketogenic diet did not cause negative changes in global measurements of nutritional state including sarcopenia, bone mineral content, and hepatic, renal, and lipid profiles as well as an increase vitamin D levels in the short term [36, 37]. Another important finding in this study was ketogenic diet more significantly effective for greater weight reduction in particular

age group between 20-30 years old. Therefore this is the second highlighted beyond the elevated platelet accounts. In the current work there were minor adverse effect have been reported which include constipation, loss of appetite and bad breathing due to ketone bodies. Lack of appetite was already explained aforementioned in [18] whereas constipation was a result of high fat diet [38, 39] while bad breathing is well known caused by liberating of keton bodies from fat metabolism and used fat as sources of energy in the body [40-42]. Taken together, these findings suggest that weight loss obtained through ketogenic diet might be useful in improving vitamin D status and hemoglobin levels and a greater reduction the risk of central obesity im obese patients. In conclusion, the most relevant strength of this study is that a as long as 13 weeks of ketogenic diet with a consequent marked loss of body weight , is a powerful therapeutic approach to improve vitamin D status, glucose homeostasis, lipid profile in obese patients. Its recommended for use ketogenic diet for those intended to reduced their weight but should be undersupervison. The limitataion of the study was small sample size; more data are needed and duration of the dieting program also limited to thirteen weeks ; our data need to be confirmed in large trials.

5. Conclusion

The present result reveal that, Ketogenic diet is effective in body weight reduction and by about 15 kg (19%) and BMI during the least 13 weeks of dieting and improve vitamin D and Hb status. Furthermore, Ketogenic diet improved the risk for WC and WHR. There was minor side effect due to dieting include constipation, bad breathing and lack of appetite and no clinical signs have been reported. Our result shown that more than 91% of patients used ketogenic diet by their own and due to this most patients did not know how much daily intake of their own Kcal. However, there were some changes of blood biochemistry include decreased serum sodium and increase platelet counting and increased acetone and LDL after 9 weeks of dieting . The top three significant foods have been used for ketogenic diet by patients found eggs, chicken and meat. Ketogenic diet was more significantly effective for greater weight reduction in particular age group between 20-30 years old. No differences in weight reduction among male and female. This data taken together, ketogenic diet could be used for weight reduction program and for those need to improved vitamin D and hemoglobin status and this study further need investigation in large sample and also intervention program.

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