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COMPARING DIABETIC WITH NON-DIABETIC OVERWEIGHT SUBJECTS THROUGH ASSESSING DIETARY INTAKES AND KEY PARAMETERS OF BLOOD BIOCHEMISTRY AND HAEMATOLOGY

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ABSTRACT

Introduction. An important way of preventing type 2diabetes is by adopting a proper diet by which means appropriate control over blood glycaemia and lipids can be achieved.

Objectives. To assess selected biochemical and haematological markers in overweight subjects or those suffering from type 2 diabetes in relation to their estimated dietary intake.

Material and methods. The study was conducted in 2012 on n=86 overweight or obese subjects living in Warsaw or its environs, of whom n=43 had type 2 diabetes. Dietary intakes were compared between non-diabetics (control group) and diabetics (test group) by 3 day records, whilst the relevant blood biochemistry and haematology results were obtained from medical records; with patient consent.

Results. Diabetic subjects had significantly higher serum glucose and CRP levels than controls, respectively; 190 vs 98 mg/dl and 1.4 vs 1.1 mg/dl. Lipid profiles were however more significantly abnormal in controls, compared to diabetics with respectively; total cholesterol 220 vs 194 mg/dl, LDL-cholesterol 131 vs 107 mg/dl and triglycerides 206 vs 157 mg/dl. There were no significant differences in HDL-cholesterol; respectively 55 vs 51 mg/dl. In the diabetics, calorific intakes from carbohydrates, especially sugars, were significantly lower than controls i.e. 9% vs 13%. The proportional share of calories derived from dietary fats did not differ between groups, nevertheless a positive correlation was observed between dietary fat content with blood cholesterol concentrations in diabetics.

Conclusions. Disorders of carbohydrate metabolism were confirmed in both overweight and diabetic (type 2) subjects. In addition, both groups demonstrated untoward lipid profiles that correlated with their improper nutrition.

Key words: *overweight, obesity, type 2 diabetes, nutrition, lipid profile, C-reactive protein (CRP), adults*

STRESZCZENIE

Wprowadzenie. Prawidłowe żywienie, którego celem jest wyrównanie glikemii oraz profilu lipidowego odgrywa zasadniczą rolę w profilaktyce cukrzycy typu 2.

Cel pracy. Ocena wybranych wskaźników biochemicznych krwi (glukoza, lipidogram, białko CRP) u osób z nadmierną masą ciała oraz cukrzycą typu 2 w aspekcie ich sposobu żywienia.

Materiał i metody. Badanie przeprowadzono w 2012 roku, wśród 86 mieszkańców Warszawy i okolic, z nadwaga i otyłością, w tym u 43 osób z cukrzycą. Do oceny sposobu żywienia wykorzystano metodę trzydniowego bieżącego notowania. Dane dotyczące wskaźników biochemicznych krwi, za zgodą badanych uzyskano z ich kart zdrowia.

Wyniki. U pacjentów z cukrzycą odnotowano istotnie wyższe średnie stężenie glukozy w surowicy krwi (190 vs. 98 mg/dl), jak również wyższe stężenie białka CRP (1,4 vs. 1,1 mg/dl). Biorąc pod uwagę wskaźniki gospodarki lipidowej stwierdzono większe nieprawidłowości w grupie kontrolnej (cholesterol ogółem 220 vs. 194 mg/dl; cholesterol LDL 131 vs. 107 mg/dl; triacyloglicerole 206 vs. 157 mg/dl). Stężenie cholesterolu frakcji HDL nie różniło się istotnie w obydwu grupach (55 vs. 51 mg/dl). Spożycie energii z węglowodanów, zwłaszcza prostych u chorych na cukrzycę było istotnie statystycznie niższe niż w grupie kontrolnej (9 vs. 13%). Procentowy udział tłuszczu w dostarczeniu energii nie różnił się znacząco pomiędzy grupami, przy czym w grupie z cukrzycą odnotowano dodatnią korelację pomiędzy ilością tłuszczu w diecie, a stężeniem cholesterolu we krwi.

Wnioski. Uzyskane wyniki potwierdzają występowanie zaburzeń gospodarki węglowodanowej u pacjentów z nadmierną masą ciała oraz cukrzycą typu 2. Ponadto w badanych grupach zaobserwowano niekorzystny profil lipidowy korelujący z ich nieprawidłowym sposobem żywienia.

Słowa kluczowe: *nadwaga, otyłość, cukrzyca typu 2, sposób żywienia, lipidogram, białko C-reaktywne (CRP), osoby dorosłe*

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INTRODUCTION

Having an excess body mass (overweight) and type 2 diabetes constitutes a serious health problem in both Poland and worldwide. According to a World Health Organisation (WHO) report, 1 billion people are now overweight (BMI 25-29.9 kg/m^2) and 300 million are obese (BMI>30 kg/m^2). It was also predicted that in 2015 such levels will rise to 1.5 billion overweight and 700 million obese [27]. The WOBASZ studies conducted in Poland during 2003-5, on subjects aged 20-74 years, demonstrated that respectively 40.4% and 27.9% of men and women were overweight and 20.6% and 20.2% were obese [2]. In somewhat likewise fashion, for type 2 diabetes, there were 285 million people, aged 20-79 years, with this disease worldwide in 2012, whereas in 2030, this figure is expected to rise to 439 million [19].

Studies have demonstrated a close relationship between excess body mass (by the amount of adipose tissue) with a significantly higher risk of suffering from type 2 diabetes [5, 17, 29]. The WHO recognises that obesity, particularly the abdominal variety, accounts for around 80% of type 2 diabetes incidence, with such cases ever increasing [28]. Obese females and males have respectively, an almost 30 and 40 fold risk of developing type 2 diabetes when compared to persons with a normal body mass [5]. An excess of adipose tissue in the body is responsible for a series of metabolic disorders (both endocrinological and immunological) that give rise to type 2 diabetes, hypertension and hyperlipidaemia and in turn lead to accelerated development of arteriosclerosis and increased risk of cardiovascular disease [17]. In recent years, the involvement inflammatory factors has been stressed in the pathogenesis and development of many disease complications that include diabetes [6]. Adopting a proper diet plays a key role in the prevention and treatment of these diseases, especially in the choices made in consuming certain nutrients [8, 14, 22, 26]. The study aim was to assess the significance of selected biochemical markers (ie. lucose, lipid profiles, CRP and haematological parameters) in overweight subjects and those with type 2 diabetes in relation to their diets.

MATERIAL AND METHODS

The study was conducted in 2012 on 86 adults with excessive body weight (mean age 51 ±14 years) of whom 43 had type 2 diabetes and which constituted the separate test group. Subjects came from Warsaw and the surrounding areas. Dietary intake was assessed by a three day dietary record which covered two working days and one that was work-free. Most of the consumed sizes of foodstuff dishes and meal portions were defined from a photographic album [23] especially designed for such purposes. The daily calorific value of the dietary intake, together with consumption of protein, total carbohydrates (including sugars) and total fat (fatty acids and cholesterol) was estimated by the 'Diet 5' computer programme based on 'Foodstuff composition and nutritional value tables' [11]. The obtained data were adjusted for nutritional losses incurred during food processing and then compared to reference standards and recommendations [10]. In order to assess the dietary composition of basic components, their proportional (%) share of supplied calories were calculated. For protein and total carbohydrate, this respectively amounted to 10-15% and 50-70% (with sugars being not greater than 10%). The amount of dietary calories obtained from total fat was taken as the reference value of 20-35%, whilst the intakes of saturated fatty acids were assumed to be as low as possible, given that a diet is nutritionally adequate. An acceptable dietary intake value for cholesterol was taken as not being higher than 300 mg/day, whereas for dietary fibre this was taken as being above 25 g/day [10].

Subjects were surveyed by questionnaire to obtain both socio-demographic data (i.e. gender, age, place of residence, self-assessment of health) and anthropometric parameters (height, body mass); the latter two being additionally confirmed during control visits. Blood analysis data were, with subjects' consent, recorded from their medical records. These consisted of measured concentrations of biochemical markers (glucose, total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides and CRP) and haematological parameters haemoglobin-HGB, hematocrit-HTC, erythrocytes-RBC and leukocytes-WBC). The biochemistry analyses were performed at the Warsaw ALAB medical laboratories. The lipid results were compared to those recommended by the Polish Diabetes Association; PDA [20], whereas the others were assessed according to reference values used at the aforementioned ALAB laboratories. Statistical analyses were performed using the 'Statistica ver. 10 software'. Data normality was evaluated by the *Shapiro-Wilk* test, whereas the *Mann-Whitney U* test determined the significance of differences between study groups for each studied parameter. The strength of any associations were calculated by the *Spearman* rank correlation coefficient. Significance levels were taken as a $p \leq 0.05$ throughout.

RESULTS

All subjects were overweight, with a high Body Mass Index (BMI) ranging 25-45 kg/m^2 (mean 31 ± 6 kg/m^2) of whom 50% had type 2 diabetes. Both groups

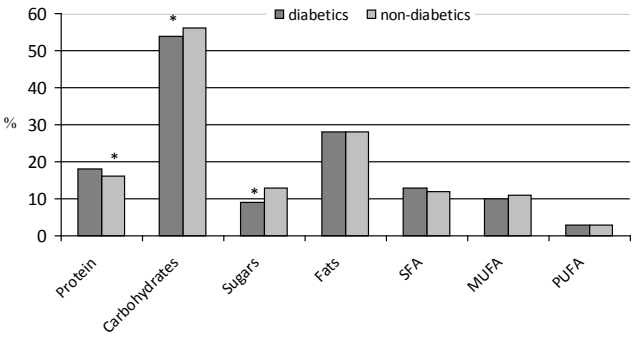
(ie. non-diabetics and diabetics) had similar BMIs. Those in the diabetic group were aged higher than controls; (56 ± 14 vs. 46 ± 13 years), however other socio-demographic features were much the same. In terms of dietary calorific value and nutritional content, there were more irregularities observed for the controls than in diabetics (Table 1, Figure 1). The latter group showed a significantly lower dietary intakes of calories (by 12%), total carbohydrates (by 12%) and total fats (by 11%); ($p \leq 0.05$). Cholesterol intakes varied widely from 135-590 mg/day, but with no significant differences between the groups. Mean dietary protein intakes were also similar in both groups at 85 ± 12 g/day. The diabetics, however, on average consumed significantly more dietary fibre (by 40%) than controls.

Table 1. Energy values and nutrient composition for the daily diets of studied subjects

Consumption	Overweight subjects		p[3]
	Diabetics	Non-diabetics	
	n=43	n=43	
Energy (kcal)	1947 ± 276[1] 969 – 2575[2]	2222 ± 387 1376 –2898	0.003
Total protein (g)	84.8 ± 11.2 56.5 – 107.0	84.9 ± 12.6 56.4 – 115.0	NS
Total carbohydrate (g)	294 ± 48 133 – 407	333 ± 64 188 – 460	0.0001
Sugars (g)	43.2 ± 12.6 6.5 – 80.3	70.6 ± 24.6 6.6 – 119.4	<0.0001
Dietary fibre (g)	35.0 ± 7.0 19.0 – 48.0	25.0 ± 5.0 12.6 – 33.8	<0.0001
Total fats (g)	62.6 ± 9.2 31.7 – 79.8	70.5 ± 18.5 32.2 – 120.0	0.06
SFA (g)	28.6 ± 5.8 8.6 – 37.0	30.9 ± 7.9 11.3 – 44.6	0.03
MUFA (g)	22.1 ± 4.3 13.8 – 34.3	26.6 ± 9.0 9.3 – 54.5	0.004
PUFA (g)	7.1 ± 2.4 5.0 – 16.4	8.2 ± 3.3 4.1 – 21.7	0.02
Cholesterol (mg)	283.5 ± 63.0 168.4 – 491.5	297.7 ± 100.0 135.0 – 590.0	NS

[1]Mean±SD; [2]min - max; Mann-Whitney-U test results; significant statistically significant differences, $p \leq 0.05$; NS –not significant differences, $p > 0.05$; SFA – saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids.

Targeted measurement of blood glucose is the most important means used for determining diabetes and evidence of glycaemic control. The diabetic group showed a twice higher fasting glucose compared to controls; 190 vs 98 mg/dl (Table 2). This high glucose concentration was positively and significantly correlated with LDL-cholesterol ($r=0.34$, $p \leq 0.05$), whilst the other lipid markers showed just a positive correlation



**Mann-Whitney-U test* results; statistically significant differences, $p \leq 0.05$; SFA – saturated fatty acids; MUFA – monounsaturated fatty acids; PUFA – polyunsaturated fatty acids

Figure 1. Proportions of calories derived from selected nutrients in the daily diets of studied subjects

alone. Both groups had higher than reference values for CRP; this being a marker of inflammation (acute phase response). Mean CRP levels in diabetics were 27% higher than controls and positively correlated with glucose concentration ($r=0.29$, $p \leq 0.05$), leukocyte count ($r=0.32$, $p \leq 0.05$) and the proportional daily share of dietary saturated fatty acids ($r=0.23$, $p \leq 0.05$). Compared to PDA reference values, all subjects demonstrated somewhat high total cholesterol, LDL-cholesterol and triglycerides; respectively 207 mg/dl, 119 mg/dl and 181 mg/dl. Significantly higher levels of these lipids were observed in those non-diabetics with the higher BMIs.

HDL-cholesterol concentrations were however similar in both groups and lay within the reference value range. There was much individual variation seen in the lipid parameters irrespective of diabetic status; the greatest being for triglycerides (41-702 mg/dl) and LDL-cholesterol (46-236 mg/dl). Those with diabetes showed respectively a 35%, 44% and 56% agreement with PDA reference levels for total cholesterol, LDL--cholesterol and triglycerides as well as respectively 72% and 50% for men and women in the case of HDL--cholesterol. More normal lipid profiles were seen in both the overweight and diabetic group for those subjects eating healthier diets, particularly in terms of calories, intakes of total fats, fatty acids and fibre compared to the overweight, non-diabetic subjects.

Blood morphology results conformed to reference values, however in diabetic women, the erythrocyte count, haemoglobin concentrations and haematocrit were significantly higher than in control women. All other haematological parameters were similar.

There was a positive relationship between glucose concentration with intakes of dietary macro-components and cholesterol but a negative association with fibre; but were not statistically significant. Furthermore, in all subjects, positive correlations were found between dietary characteristics, ie. intakes of carbohydrates,

Table 2. Results of selected biochemical parameters in blood for studied subjects

Analyte	Reference value	Overweight subjects		p[3]
		Diabetics	Non-diabetics	
		n=43	n=43	
Glucose (mg/dl)	<110.0	189.7 ± 112.8[1] 87.0 – 519.0[2]	98.0 ± 13.1 51.0 – 129.0	<0.001
CRP (mg/dl)	<0.5	1.4 ± 3.5 0.0 – 21.4	1.1 ± 3.3 0.0 – 21.4	NS
Total cholesterol (mg/dl)	<175.0	194.2 ± 44.9 83.0 – 324.0	219.6 ± 46.6 91.0 – 333.0	0.01
LDL-Cholesterol (mg/dl)	< 100.0	107.0 ± 36.1 46.0 – 236.0	130.8 ± 36.5 58.0 – 236.0	<0.001
HDL-Cholesterol (mg/dl)	W* > 50.0	54.9 ± 18.7 23.0 – 88.0	50.8 ± 13.1 33.0 – 85.0	NS
	M* > 40.0	55.5 ± 17.0 29.0 – 90.0	50.85 ± 16.9 29.0 – 99.0	NS
Triglycerides (mg/dl)	< 150.0	156.8 ± 109.6 41.0 – 702.0	205.8 ± 107.1 55.0 – 702.0	<0.001
Leukocytes (10^3/µl)	4.0-10.0	8.3 ± 2.9 2.2 – 15.6	8.1 ± 2.4 4.2 – 13.7	NS
Erythrocytes (10^3/µl)	W* 3.7-5.1	4.0 ± 0.6 2.2 – 5.0	4.6 ± 0.4 3.9 – 5.1	0.001
	M* 4.1-6.2	4.3 ± 0.7 2.4 – 5.3	5.1 ± 2.2 3.4 – 15.5	NS
Haemoglobin (g/dl)	W* 12.0-16.0	12.1 ± 2.2 6.9 – 15.9	13.6 ± 1.5 9.1 – 15.2	0.02
	M* 14.0-18.0	13.3 ± 2.2 7.8 – 16.9	13.8 ± 1.8 10.7 – 17.5	NS
Hematocrit (%)	W* 37.0-47.0	35.7 ± 5.9 20.2 – 45.0	40.1 ± 3.5 29.5 – 43.	0.002
	M* 40.0-54.0	38.9 ± 6.1 23.7 – 49.9	40.4 ± 5.1 31.1 – 51.8	NS
Platelets (10^3/µl)	150.0-450.0	280.7 ± 88.6 103.0 – 474.0	278.3 ± 79.5 126.0 – 480.0	NS

[1]Mean ±SD; [2]min-max, W* - Women, M* - Men; [3] *Mann-Whitney-U test* results, statistically significant differences, $p \leq 0.05$; NS – statistically not significant differences, $p > 0.05$

sugars, saturated fatty acids and LDL-cholesterol together with the effect of sugar intake on the increase in cholesterol. Such results indicate a relationship between the prevalent dietary habits and in achieving normal levels of lipids during treatment.

DISCUSSION

As defined by the American Diabetes Association [1], diabetes is a metabolic disease of varied aetiology, demonstrating hyperglycaemia resulting from disorders of insulin secretion or its action or a combination of both. The literature shows that this condition is chronic and is caused by disorders of carbohydrate metabolism, where eating an improper diet leads to glycaemic abnormalities and a disruption of the blood lipid profile [22]. Type 2 diabetes risk factors include genetic disorders and environmental factors, where in the latter, an improper diet, high dietary intakes of calories, saturated fat and cholesterol are important as well as the link to overweight and obesity [14, 21, 25]. In addition, the pathogenesis of type 2 diabetes also includes the role of adiponectin proteins (secreted by white adipose tissue) which improves glucose tolerance. Serum adiponectin levels depend on the BMI and also whether type 2 diabetes is present, where in such cases its levels are lower [15].

Subjects all had excess body mass, which was likewise observed in a study by *Włodarek* and *Głąbska* [26], who showed that diabetics above the age of 40 years have, in 87% cases, excess body mass. Studies by *Pisarczyk-Wiza* et al. [17] and *Zielke* and *Reguła* [29] demonstrated that obesity is an important risk factor for acquiring type 2 diabetes, whose effect becomes more pronounced with increasing age.

A key factor in the pathogenesis of this condition is insulin resistance that depends on dietary habits which, if improper, leads to an abnormal lipid metabolism. In accordance with PDA guidelines [20], a given diet should not deviate from basic dietary recommendations for healthy people. *Nelson* et al. [13] found that the majority of diabetics, especially those overweight and obese, do not adopt healthy/appropriate diets. Studies

by *Mędrela-Kuder* [12] on type 2 diabetics have shown that the commonest failings in diets are a lack of eating regular meals, snacking between meals, eating sweets and using inappropriate cooking methods.

The presented study found structural shortcomings in dietary habits, particularly as demonstrated by an increase in the share of calories derived from carbohydrates (including sugars) and fats. Fibre intake is important to diabetics because of its beneficial effects in lowering glycaemia and improving the blood lipid profile [8]. Indeed, a high fibre intake was observed in the current study for type 2 diabetics, together with improved dietary habits which may have led to the blood lipid profiles approaching normality - relative to the non-diabetics. This may be reflected in the subject's conscious decision to eat smaller meals or dishes and the need to keep to dietary recommendations during adopting any dietary therapy for diabetics. Another contributing factor could be that this condition develops over a long period without symptoms, so that un-diagnosed diabetic persons seek treatment only when apparent complications arise. Both type 2 diabetes and obesity can occur independently, nevertheless an excess of body mass will significantly increase the risk of diabetes, and the incidence of hospitalisations [7, 21].

A twofold higher glucose concentration was noted in the presented study for overweight diabetics compared to controls ie. in 84% diabetics and only 16% controls. Similar results were seen in a study by *Tripathy* et al. [24] on diabetics with average fasting glucose levels of 171 mg/dl compared to normal healthy subjects of 73 mg/dl. Disorders in lipid metabolism are a recognised factor for the incidence of type 2 diabetes. Under non-physiological conditions of high glucose concentration, changes in the lipid profile occur, that are most frequently manifested by high triglyceride levels, low HDL-cholesterol and a normal –moderately high LDL-cholesterol [3]. Moreover, obesity and an excess of abdominal adipose tissue are linked with changes to lipoprotein structure depending on the genes coding for cholesteryl ester transfer protein (CETP). It has been shown that a lack of, or a disorder in its function are factors that affect HDL levels and the effectiveness of reverse cholesterol transport [16]. A study by *Fagot-Campagna* et al. [4] found that 97% of diabetics had at least one abnormal feature in their lipid profile.

Inflammation is recognised to play an important role in type 2 diabetic pathogenesis. In overweight and diabetic persons, hyperglycaemia and adipose tissue are factors that induce chronic inflammatory reactions that appear, amongst others, as an increase in acute phase reaction proteins (such as CRP), which in turn affects atherosclerosis development [6, 18]. The presented study has demonstrated CRP levels higher than the reference value in most subjects studied, with the diabetics being the most high. A study by *Pisaczyk-Wiza* et al. [17] has likewise found that obese and diabetic subjects had increased CRP concentrations which had been used as a sensitive marker of inflammation. This relationship was also observed in a Mexican study that a protein marker of inflammation is a significant factor affecting the development of type 2 diabetes and metabolic disorders in women [9].

CONCLUSIONS

1. An abnormal lipid profile in the studied subjects was related to shortcomings in their dietary habits, particularly in the intakes of carbohydrates (including sugars), as well as dietary fibre and fatty acids.
2. Raised serum CRP concentrations in those overweight persons suffering from type 2 diabetes may indicate an inflammatory state arising from long--term hyperglycaemia.
3. Obtained findings illustrate the need for nutritional education and for preventative studies on overweight subjects to reduce the risk of complications resulting from obesity and other conditions so accompanying.

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Conflict of interest
The authors declare no conflict of interest.

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