ORIGINAL ARTICLE

Glycaemia, renal function and body mass in men and women with type 2 diabetes

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ABSTRACT

Aim To determine parameters of glycaemic control, renal function and anthropometric measurements in patients with type 2 diabetes in family medicine offices and to examine whether there is a difference in these parameters between genders.

Methods This cross-sectional study included 136 patients of both genders diagnosed with type 2 diabetes, with an average age of 69.33±10.87. General and demographic data were collected, anthropometric measurements were taken, as well as data on fasting plasma glucose, HbA_1c and creatinine level from laboratory findings. Estimated glomerular filtration rate (eGFR) was calculated.

Results The average results of fasting plasma glucose test were 8.43 mmol/L, of HbA1c 7.15%, and of creatinine 79.00 μmol/L. In 19.12% of patients eGFR was <60 mL/min/1.73m^2. 80.15% were overweight and 38.97% had a body mass index (BMI) of 30 kg/m^2 or higher. Morbid obesity was recorded in 2.94% of patients. Females had a statistically significantly higher hip circumference (p=0.002) and BMI (p=0.019), while males had a statistically significantly higher waist-to-hip ratio (p=0.006) and BMI (p=0.007).

Conclusion The patients did not reach the target value of fasting plasma glucose (<7mmol/L) and HbA1c was above recommended (<7%). Given that the patients were elderly, glucoregulation can be considered as adequate. The average eGFR classified the patients into G2 group (mildly decreased glomerular filtration). The mean BMI was not within the recommended values. It is important to educate patients on a healthy diet and physical activity, to control their weight, but also to choose medications that reduce weight in addition to glycaemic control.

Key words: blood glucose, body weight, glomerular filtration rate

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INTRODUCTION

Diabetes is a chronic metabolic disease and one of the most important public health problems in the Republic of Croatia and worldwide (1). The International Diabetes Federation (IDF) estimates that more than 420 million people worldwide suffer from diabetes, and the number of patients increases every year (2). Currently, as many as 40% of patients have not yet been diagnosed with diabetes, making the problem even more complex (3). Furthermore, among the diagnosed patients there are many of those who do not get adequate therapy or do not take the recommended therapy, which often results in the development of microvascular and macrovascular complications of diabetes, requiring further efforts in managing complex clinical conditions (3). According to the data from the National Diabetes Registry (CroDiab), there are 254,296 persons with diabetes registered in the Republic of Croatia, and if patients who have not yet been diagnosed are taken into account, the total number reaches as many as 400,000 (3). The complex pathophysiology of diabetes includes the interaction of various factors: increased lipolysis, increased gluconeogenesis in the liver, increased secretion of glucagon in pancreatic α-cells, decreased insulin secretion from pancreatic β-cells, decreased incretin effect, increased renal glucose reabsorption and disturbance of neurotransmitters (4). That is why the treatment of diabetes requires individual determination of treatment objectives, but it also relies on universal recommendations primarily related to encouraging physical activity and changing eating habits.

The adequate glycaemic control in diabetes implies the lowest possible glycaemic values without the occurrence of side effects, and treatment is aimed at achieving HbA1c values < 7% (5). However, target values have recently been determined individually, taking into account the patients' age, the frequency of hypoglycaemia and comorbidities (5). Target HbA1c value of < 8% is recommended for elderly patients with advanced microvascular and macrovascular complications, numerous comorbidities, and frequent hypoglycaemia (5,14).

The correlation between being overweight and the risk of developing type 2 diabetes has been examined in detail, and evidence of this correlation is the occurrence of excessive weight gain in as many as 80% of patients with type 2 diabetes (6). The problem of overweight people, which was primarily related only to the developed countries, has now become a major public health problem in the developing countries, but also in the least developed countries (7). The main cause is considered to be the modern way of life in which physical activity level is unsatisfactory and the diet is based on industrially processed food with a high percentage of carbohydrates and saturated fatty acids (7). Adipose tissue, which has long been considered exclusively a storehouse of energy, is an active endocrine organ that greatly affects insulin resistance, endothelial dysfunction and the development of chronic inflammation, and all of the above often leads to the development of the metabolic syndrome – a combination of visceral obesity, arterial hypertension, dyslipidaemia, and impaired glucose metabolism (8). Many studies have confirmed the correlation between higher body mass index and a higher risk of developing diabetes, and special attention is paid to visceral obesity, i.e. the increased accumulation of visceral adipose tissue since it is metabolically more active and more significantly involved in the creation of higher levels of proinflammatory cytokines (9,10). Consequently, it is evident that weight loss and body mass index reduction, especially waist circumference, prevents the progression of prediabetes to diabetes, but also slows down the natural course of type 2 diabetes, having a beneficial effect on preventing or alleviating the complications of diabetes (10).

The objectives of this research were to determine the parameters of glycaemic control (fasting plasma glucose, HbA1c), renal function and anthropometric measurements (body height, body mass, waist circumference, hip circumference, body mass index and waist-to-hip ratio) in patients with type 2 diabetes in family medicine offices and to examine whether there is a difference in these parameters between males and females. Also we wanted to examine a quality of achieving recommended goals for patients with type 2 diabetes in family medicine offices in Croatia.

PATIENTS AND METHODS

Patients and study design

This cross-sectional research was conducted in two family medicine offices in the Health Centre Osijek during the period of three months (March to June 2019).

Patients were over 18 years of age, of both sexes, diagnosed with type 2 diabetes. Before the research patients were provided with detailed information on the planned research and they read and signed the informed consent document.

A total of 136 patients were included in the research, of which 55 were men and 81 were women, with an average age of 69.33±10.87. Selection of the patients and the size of the sample ensured the representativeness of the sample and objective results. The patients were anonymised, with each patient being assigned a unique code.

Before the research, the patients were provided with detailed information on the planned research and they read and signed the informed consent document.

The research was approved by the Ethics Committee of the Health Centre Osijek and the Ethics Committee of the Faculty of Medicine Osijek of Josip Juraj Strossmayer University of Osijek.

Methods

The following data were collected: demographic data (sex, age), data on duration of diabetes, data on body mass and height, data on waist and hip circumference. Body mass index (BMI) was calculated by dividing the body weight in kilogram by body height in meter square and waist-to-hip ratio was calculated by dividing waist circumference in centimetres by hip circumference in centimetres.

Laboratory findings were used to collect data on fasting plasma glucose, HbA_1c and creatinine levels (reference values 4.4 – 6.4 mmol/L, < 6 % and 79 – 125 μmol/L, respectively), and estimated glomerular filtration rate (eGFR) was calculated.

Creatinine level was determined photometrically using the Jaffe reaction by picric acid. Samples of serum, plasma (EDTA or heparin) and urine (24-hour or single sample) were used. The level of glycated haemoglobin was determined by turbidimetric inhibition immunoassay, where the sample for analysis was whole blood with EDTA as an anticoagulant. Visceral obesity was determined according to the NCEP (National Cholesterol Education Program) measures and IDF (International Diabetes Federation) measures. According to the IDF visceral obesity is defined as a waist circumference ≥ 94 cm in male and ≥ 80 cm in female (11) and according to the NCEP it is defined as a waist circumference ≥102 cm in men and ≥88 cm in women (12).

Statistical analysis

Categorical data were presented as absolute and relative frequencies. Numerical data were described as the arithmetic mean and standard deviation in case of normal distribution and as the median and interquartile range in other cases. Differences between categorical variables were tested by $\chi 2$ test and Fisher's exact test if necessary. Numerical variable differences between two independent groups were tested by Student's t-test and Mann–Whitney U test in case of deviation from normal distribution. Correlation between the variables was expressed as Pearson's correlation coefficient in cases where variables follow a normal distribution or Spearman's correlation coefficient in cases where variables do not follow a normal distribution. All P values are two-tailed. The level of significance was set at p=0.05.

RESULTS

The research included 136 patients, of which 55 were males and 81 were females, with an average age of 69.33±10.87. The average duration of diabetes was 9 years, with an interquartile range of 4 to 14; no statistically significant difference in duration of diabetes between the sexes was found (p=0.984). The recommended target values of fasting plasma glucose were not achieved in patients, but the recommended HbA_1c values were achieved. No statistically significant difference was found in values of fasting plasma glucose and HbA1c between males and females (p=0,402) (Table 1).

Table 1. Average values of fasting plasma glucose and average values of HbA_1c –according to the genders

Parameter	No of patients	Mean (SD)	p
Plasma glucose (mmol/L)			
Male	55	8.20 (2.45)	0.458
Female	81	8.59 (3.31)	
Total	136	8.43 (2.99)	
HbA_1c (%)			
Male	55	7.20 (1.63)	0.402
Female	81	7.35 (1.75)	
Total	136	7.15 (1.60)	

SD, standard deviation; HbA_1c, glycated haemoglobin A^1C

The average values of creatinine were within the reference range. The average value of creatinine in plasma in males was 89.00 (72.25 – 98.50) μmol/L, in females it was 71.00 (58.00 – 81.25) μmol/L (p<0.001).

The estimated glomerular filtration rate in patients was 80.56±20.28 mL/min/1.73 m^2, and the difference in values between the genders was not statistically significant (p=0.536). A total of 110 (80.88%) patients had normal and mildly decreased glomerular filtration, while 26 (19.2%) had eGFR < 60 mL/min/1.73 m^2 (Table 2).

Table 2. Distribution of patients into glomerular filtration rate (GFR) categories according to estimated (e)GFR values

GFR categories	eGFR (mL/min/1.73m^2)	No (%) of patients
G1 normal or high GF	≥ 90	47 (34.56)
G2 mildly decreased GF	60-89	63 (46.32)
G3a mildly to moderately decreased GF	45-59	20 (14.71)
G3b moderately to severely decreased GF	30-44	3 (2.20)
G4 severely decreased GF	15-29	1 (0.74)
G5 kidney failure	< 15	2 (1.47)

The majority of patients, 109 (80.15%) were overweight; 53 (38.97%) patients met the criteria for diagnosing obesity, i.e., had a BMI of 30 or higher. Morbid obesity was recorded in 4 (2.94%) patients.

Visceral obesity was determined in 66 (48.53%) patients if NCEP (National Cholesterol Education Program) measures were used as limit values and in 88 (64.71%) if IDF (International Diabetes Federation) measures were used as limit values (Table 3).

Table 3. Body mass index (BMI) and waist circumference in patients with type 2 diabetes

Parameter	Reference values male/female (cm)	No (%) of patients
BMI (kg/m^2)		
< 25		27 (19.85)
25 – 29.99		56 (41.18)
30 – 34.99		30 (22.06)
35 – 39.99		19 (13.97)
>40		4 (2.94)
Waist circumference according to NCEP classification		
Normal	≤ 102/≤ 88	70 (51.47)
Increased	>102/>88	66 (48.53)
Total		136 (100.00)
Waist circumference according to IDF classification		
Normal	≤94/≤80	48 (35.29)
Increased	>94/>80	88 (64.71)
Total		136 (100.00)

NCEP, National Cholesterol Education Programme; IDF, International Diabetes Federation

The average body mass of patients in this research was 79.96 kg, and the average of BMI was 29.48 kg/m^2. Body height, body weight, and waist-to-hip ratio were statistically significantly higher in males than in females (p<0.001, p=0.007, and p=0.006, respectively), while body mass index and hip circumference were significantly higher in females than in males (p=0.019 and p=0.002, respectively). No statistically significant difference in waist circumference was found between males and females (p=0.693) (Table 4).

Table 4. Body height and weight, body mass index (BMI), waist circumference, hip circumference and waist-to-hip ratio in patients with type 2 diabetes – comparison between the genders

Parameter	No of patients	Mean (SD)	p
Body height (cm)			
Male	55	173.29 (7.65)	< 0.001
Female	81	159.06 (6.29)	
Total	136	164.68 (9.81)	
Body mass (kg)			
Male	55	84.20 (13.54)	0.007
Female	81	77.09 (15.68)	
Total	136	79.96 (15.21)	
BMI (kg/m^2)			
Male	55	28.11 (4.27)	0.019
Female	81	30.43 (6.27)	
Total	136	29.48 (5.64)	
Waist circumference (cm)			
Male	55	94.36 (14.23)	0.693
Female	81	93.30 (16.18)	
Total	136	93.73 (15.38)	
Hip circumference (cm)			
Male	55	103.33 (8.52)	0.002
Female	81	109.30 (12.45)	
Total	136	106.88 (11.38)	
Waist-to-hip-ratio			
Male	55	0.88 (0.13)	0.006
Female	81	0.84 (0.13)	
Total	136	0.94 (0.17)	

SD, standard deviation

DISCUSSION

Patients with type 2 diabetes in our research do not have fully satisfactory glycaemic control taking only values of fasting plasma glucose and HbA_1c into account. Taking into account the mean age of patients, which was 69.33 ± 10.87 and by applying an individualized approach in setting target values of fasting glucose values and HbA1c, depending on the patients' age, glycaemic control can be considered appropriate. The problem of achieving appropriate glycaemic regulation exists not only in the Republic of Croatia but also in many other countries across Europe and the World, and the values of parameters are variable in some countries. In England, 28-66.5% patients achieve target values of HbA1c ≤7.5%, and in France, 24 to 52% (13,14). Patients who took part in our research achieved the mean value of fasting plasma glucose of 8.43 mmol/L and value of HbA_1c of 7.15%, which is similar to the results of the study conducted in the Republic of Croatia in 2015 including 10,275 patients treated in family medicine offices, where the mean va-

lue of fasting plasma glucose was 8.60 mmol/L and the mean value of HbA_1c was 7.60% (15). After a long period in which universal and strict guidelines for glycaemic control in patients with type 2 diabetes were recommended and applied, the ADA/EASD 2018 guidelines recommend an individualized approach to patients when determining target HbA1c values. HbA1c value of <7% is recommended for most patients with diabetes, but special emphasis is placed on individual patient characteristics, where target HbA1c value <8% is recommended for elderly patients with advanced microvascular and macrovascular complications, numerous comorbidities and frequent hypoglycaemia (16).

In addition to glucoregulation, it is extremely important to monitor renal function in patients with type 2 diabetes, and the best indicator of the preserved renal function is the estimated glomerular filtration rate (eGFR) (17). Serum creatinine level is often used as an indirect indicator of glomerular filtration, but it largely depends on body mass and a daily diet and is therefore not recommended as a substitute for estimated glomerular filtration values (18). Estimated glomerular filtration rate in our patients was 80.56 ± 20.28 mL/min/1.73 m^2 measured by the CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula, and the difference in values between the sexes was not statistically significant. According to the KDIGO 2012 guidelines, the average measured value of estimated glomerular filtration classifies our patients into G2 group, i.e. the group of persons with mildly decreased glomerular filtration (19). The values of estimated glomerular filtration rate in our patients can be compared to the values obtained. In the research conducted on 146 patients in family medicine offices in Brazil, 34.2% of patients had eGFR < 60 mL/min/1.73 m^2, while in our country only 19.12% of patients had eGFR < 60 mL/min/1.73 m^2 (20).

The average creatinine values were slightly higher in men than in women and were within the reference interval for both genders confirming the previously known physiological difference, which can be explained, among other things, by lower muscle mass in women than men (21).

The average body mass index in our patients was 29.48 ± 5.64 kg/m^2, and as many as 38.97% of patients met the criteria for diagnosing obesity, i.e. they had BMI of 30 or higher, which does not deviate from the available results on the BMI at the level of the entire Republic of Croatia, according to which 25.3% of men and 34.1% of women are considered obese. Obesity is nowadays one of the biggest public health issues in the Republic of Croatia and worldwide, and it is pathophysiologically related to the development of cardiovascular diseases, diabetes, but also many other chronic diseases (22). The average value of BMI in our research was statistically significantly higher in women than in men, but this research does not fully explain the cause of this difference between the genders. It would be necessary to examine more thoroughly the possible differences in eating habits and the level of physical activity between men and women, and the possible correlation between changes in diet and physical activity with regard to age. Higher BMI can be related to the patients' sedentary lifestyle and poor eating habits, suggesting a healthy diet and weight loss are generally recommended for the treatment of diabetes and are valid regardless of the achieved glucoregulation parameters and therapy used for the treatment of diabetes (23).

There is a cause-and-effect relationship between the amount of visceral adipose tissue and the occurrence of type 2 diabetes and cardiovascular diseases, and data on the existence of visceral obesity is considered a better predictor of morbidity and mortality from cardiovascular diseases and diabetes than BMI calculation (24,25). According to the NCEP, 48.53% of patients in our research met the criteria for visceral obesity, while 64.71% of patients met the criteria according to the classification of the IDF. A large-scale research conducted in the Republic of Croatia, also on the population of patients with type 2 diabetes, had similar results. According to the NCEP visceral obesity was determined in 68.60% and according to the IDF in as many as 87.40% patients (15). Taking into account the average values of waist circumference it can be concluded that they are not within the recommended values in either men or women.

Waist-to-hip ratio is an indicator of the abdominal obesity, and the recommended values in our patients were achieved in both genders. Several large-scale European studies have classified higher hip circumference as a protective factor for the development of type 2 diabetes, but there are also studies

whose results show exactly the opposite (26). The correlation of the higher hip circumference with a lower risk for developing type 2 diabetes is attributed to the presence of a larger amount of adipose tissue in the gluteofemoral region (27,28). Adipose tissue in the gluteofemoral region was shown to be more sensitive to insulin than visceral abdominal adipose tissue, and therefore lower insulin levels, lower plasma glucose levels, and lower HbA1c levels were associated with the higher hip circumference (27-30). A correlation between hip circumference and risk for developing type 2 diabetes in men was not found, which is explained by the fact that, due to men's body constitution, higher hip circumference usually does not indicate to a larger amount of adipose tissue in that area, but to a larger amount of muscle tissue that does not have the aforementioned adipose tissue characteristics (31,32). Our research also showed significant difference in the mean values of hip circumference comparing to the women.

This study showed that our patients did not achieve recommended values for type 2 diabetes mellitus but taking into account that the patients were elderly, glucoregulation can be considered as adequate. However, the mean BMI was not within the recommended values and it is very important to educate patients in order to show them the importance of body mass on type 2 diabetes mellitus. In addition to a quality medical care, success of the treatment always depends on active participation of the patients.

In conclusion, monitoring of patients with type 2 diabetes is complex and each patient should be approached individually, while adhering to the universal recommendations for reference values, but also taking into account sex differences. In patients with type 2 diabetes, good glucoregulation is important, as well as monitoring of renal parameters, primarily the estimated glomerular filtration rate, both for the observation or monitoring of renal complications of diabetes and the possibility of correction of therapy. Regular measurements of body mass, body mass index, waist and hip circumference and waist-to-hip ratio are indispensable in any monitoring, which makes the basis for proper education on nutrition and physical activity, as well as the use of medications that reduce weight in addition to glycaemic control.

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Conflicts of interest: None to declare.

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