Переломы дистального отдела предплечья у лиц с сахарным диабетом и без нарушений углеводного обмена в популяционной выборке старше 50 лет (Новосибирск)

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Обоснование. Внимание к переломам дистального отдела предплечья (ДОП) как к остеопоротическим важно для раннего выявления лиц с повышенным риском будущих переломов и принятия превентивных мер.
Цель. Оценить частоту переломов ДОП у лиц с сахарным диабетом 2-го типа (СД2) и без СД и ассоциацию переломов ДОП с факторами риска хронических неинфекционных заболеваний (ХНИЗ).
Методы. В 2015–2017 гг. в Новосибирске была одномоментно обследована случайная городская популяционная выборка мужчин и женщин 58–84 лет (*n*=3878). В исследование включались лица, подписавшие информированное согласие на участие; исключались лица, отказавшиеся от взятия проб крови для определения биохимических показателей. Всего в анализ включено 3393 человека, из них с СД2 – 718 (21,2%). Проведен сбор информации о переломах ДОП за последние 3 года. Выполнен анализ ассоциаций СД2 и факторов риска ХНИЗ с шансом перелома ДОП.
Результаты. Частота переломов ДОП за последние 3 года у лиц с СД2 и без него не различалась и составила 2,4 и 2,8% соответственно (*p*=0,557). Мужчины с переломами имели более высокие показатели общего холестерина (ОХС) и холестерина липопротеинов высокой плотности (ХС-ЛПВП), а женщины – более низкий индекс массы тела (ИМТ), чем лица без переломов ДОП. У женщин, куривших в прошлом при концентрации ОХС >200 мг/дл шанс перелома ДОП повышается и снижается по мере увеличения ИМТ. У мужчин шанс перелома ДОП повышается с увеличением концентрации ОХС. Связи СД2 с переломами ДОП не выявлено.
Заключение. Полученные данные свидетельствуют о необходимости профилактики остеопоротических переломов, как у лиц с СД2, так и без него.

Ключевые слова: сахарный диабет, остеопороз, переломы дистального отдела предплечья, популяция.

The forearm fractures in patients with diabetes and without diabetes in population sample aged over 50 years (Novosibirsk)

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BACKGROUND: The attention to the forearm fractures, as to osteoporotic fractures, is important for ensuring early detection of individuals at increased risk of future fractures and taking preventive measures.
AIMS: To determine the frequency of a history of forearm fractures in patients with type 2 diabetes mellitus (DM2) and without diabetes, and their association with risk factors for chronic non-communicable diseases (NCD).
MATERIAL AND METHODS: In 2015–2017, in Novosibirsk, a random urban population sample of males and females, 58–84 years old (*n*=3878), was surveyed. The study included persons who signed the informed consent to conduct the study, excluded individuals who wrote a waiver of taking blood to determine biochemical parameters. In total, the analysis included *n*=3393 people, 718 of them with DM2 (21.2%). Work design is cross-sectional research. The collection of information on fractures during for the last 3 years, the registration of socio-demographic data; and risk factors for NCD, a study of biochemical blood parameters. The analysis of the association of DM2 and a complex of risk factors for NCD with a chance of a forearm fracture.
RESULTS: The prevalence of forearm fractures in the last 3 years did not differ in patients with DM2 compared with those examined without diabetes and was 2.4% and 2.8%, respectively (*p*=0.557). Men with fractures had higher cholesterol and HDL values, women had lower body mass index (BMI), compared with people without fractures. According to the results of a multivariate analysis in women, the chance of a forearm fracture is directly associated with smoking in the past, a total cholesterol level of more than 200 mg/dl and inversely associated with a BMI. In men, associations were found of the chance of a forearm fracture with an increase in the level of cholesterol. There was no evidence of DM2 with forearm fracture.
CONCLUSION: The obtained data on the incidence of fractures and their association with risk factors for chronic low risk infections suggest the need for preventive measures for osteoporotic fractures, both in people with and without DM2.

Keywords: Diabetes, osteoporosis, fractures of distal forearm, population.

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Background

The prevalence of DM2 is growing rapidly. Globally, there are 425 million patients with this pathology [1]. In the Russian Federation (RF), as of 31 December 2016, this number exceeded 4.348 million [2]. In Novosibirsk, according to the population screening of 2003–2005, the prevalence of DM2 in individuals aged 45–69 years was 11.4% [3, 4]. Pathological changes in DM2 affect all systems, including the musculoskeletal system. Osteoporotic changes in the bone tissue are asymptomatic; however, the prevalence of this pathology is high since the disease is generally diagnosed after a fracture. A high comorbidity rate of severe osteoporosis with chronic noncommunicable diseases —CNCD—(DMs, cardiovascular diseases [CVDs], cognitive impairment, sarcopenia, chronic obstructive pulmonary disease) has been observed [5]. Generally accepted risk factors of CNCD also contribute to the development of osteoporosis. Based on recent studies, severe osteoporosis is recognised as one of the DM2 complications [6, 7]. An increase in bone fragility in patients with DM2 can be determined by not only a decrease in the bone mineral density (BMD) but also by a disorder of the bone architectonics and change in the process of bone remodelling [8]. Currently, there are a number of contradictions that are related to the BMD and frequency of fractures in patients with DM2. The BMD in patients with DM2 is increased [7, 9]. Concurrently, the increased risk of fractures in these patients is a major concern. The process of glycation of bone components in DM2 is considered responsible for the phenomenon of more fragile bone with an increase in mineral density, and microangiopathy and distal neuropathy can contribute to falls in these patients [10]. DM2 increases the risk of hip fracture by 18% in men and 11% in women [6, 9]. Osteoporosis is a significant global public health and healthcare problem with dire consequences, accompanied by high disability and mortality rates. According to previous studies, the prevalence of forearm distal segment (FDS) fractures is the highest worldwide compared with that of other fracture localisations, and the risk of death within 5 years after an FDS fracture ranges from 12% in women aged 65–74 years to 43% in women aged ⩾85 years [11]. In the general structure of fractures in the RF, an unexpected finding was a higher frequency of fractures of the forearm and humerus compared to those in other countries [12, 13]. In a continental climate, winters in Novosibirsk are significantly colder (by 5°C–10°C) than in European regions of Russia. FDS fractures represent a serious problem since most of them occur as a result of falling on ice-covered ground. Low air temperatures in Novosibirsk force the population to wear closed clothes, which causes a high risk of vitamin D deficiency. Such climatic conditions contribute to the disruption of the calcium–phosphorus metabolism in the population, thereby increasing the risk of osteoporosis. Increased attention to FDS fractures is important in identifying women with increased risk for fractures and conducting preventive measures [14]

AIM

This study aimed to assess the frequency FDS fractures in patients with DM2 and without carbohydrate metabolism disorders as well as their association with CNCD risk factors in the population sample ranging from middle to senile age.

Methods

Study design

In 2015–2017 in the city of Novosibirsk, a random urban population sample of men and women aged 58–84 years (*n*=3898) was examined with a cross-sectional controlled single-site sampling study. The analysis included data from 3393 patients, including 718 patients with DM2 (21.2%). A subgroup consisted of 91 patients with FDS fractures (79 [3.9%] women and 12 [0.9%] men, in which 13 women and four men had DM2). This is a cross-sectional study.

Inclusion criteria

The study included men and women aged 58–84 years who provided written informed consent to participate. To assess the relationship of risk factors for CNCD and FDS fractures, patients who answered the questionnaire on the occurrence of FDS fractures in the last 3 years were included. Patients who refused to undergo blood examination for the analysis of biochemical parameters were excluded.

Conditions

The study was conducted at the screening centre of the Research Institute of Therapy and Preventive Medicine, Institute of Cytology and Genetics, Siberian Branch of Russian Academy of Sciences (RAMS), within the framework of the international project Health, Alcohol and Psychosocial factors In Eastern Europe (HAPIEE) [15]. A representative sample of the population of the Oktyabrsky and Kirovsky districts of Novosibirsk was examined. The districts selected by national composition, employment, presence of large industrial enterprises and educational and cultural institutions are typical administrative districts of the city of Novosibirsk. The total number of residents of all ages in the two districts is 340,000.

Study duration

Data were collected from 2015 to 2017.

Description of medical intervention

All project participants underwent an examination that included collecting information using a structured questionnaire of the project (http://www.ucl.ac.uk/easteurope/hapiee-cohort.htm), including FDS fractures in the past 3 years, presence and duration of DM2, presence of arterial hypertension and major CVDs and CNCDs, duration of menopause in women, smoking habits and other risk factors for CVD and CNCD, physical functioning and social and demographic data. Anthropometric measurements were obtained (height, weight, waist circumference [WC] and hip circumference [HC], WC/HC ratio and body mass index [BMI]). The standing height was measured, without outerwear and shoes, on a standard height metre with an accuracy of 0.5 cm. Body weight was determined, without outerwear and shoes, on standard lever scales after metrological control (measurement accuracy, 0.1 kg). BMI was calculated using the following formula: BMI (kg/m^2) = body weight (kg)/$height^2$ (m^2).

Serum biochemical parameters were analysed in patients who provided written informed consent to undergo the procedure. Blood was collected from the ulnar vein with a vacutainer, in a sitting position, on an empty stomach. After centrifugation, the serum was stored in a low-temperature chamber (−70°C). A biochemical blood test was performed at the Clinical Biochemistry Laboratory of the Research Institute of Therapy and Preventive Medicine, Institute of Cytology and Genetics, Siberian Branch of RAMS, which has standardisation for internal and external federal quality control. For biochemical studies, blood was collected from the ulnar vein with a vacutainer, in a sitting position, on an empty stomach. After centrifugation, the serum was stored in a low-temperature chamber (−70°C). The levels of total cholesterol (TC), high-density lipoprotein (HDL) cholesterol (HDLC), HDL and triglycerides (TG) were determined by the enzymatic method using commercial standard Biocon kits (Germany) on a Konelab autoanalyser (USA). Serum glucose was converted to plasma glucose (PG) using the following formula: PG (mmol/L) = −0.137+1.047×serum glucose (mmol/L) (EASD, 2005). A diagnosis of diabetes mellitus was established according to epidemiological criteria with fasting blood glucose levels ⩾7.0 mmol/L (WHO, 1999) and/or normoglycaemia in patients with a medical history of established DM2.

Primary outcome of the study

In an epidemiological study on a population sample of Novosibirsk, the frequency of FDS fractures that occurred in the past 3 years in patients with DM2 and in those without carbohydrate metabolism disorders was evaluated. Data on sociodemographic characteristics, education, main risk factors of CNCD and restrictions in physical activity were collected.

Additional outcomes of the study

The associations of DM2 and risk factors of CNCD with a risk of FDS fracture were analysed.

Subgroup analysis

The examined patients were divided into subgroups according to sex and were compared by age, anthropometric data, blood pressure levels, physical functioning, education, smoking, incidence of DM2 and FDS fractures, duration of menopause in women and serum biochemical parameters (fasting PG, lipid pattern). The parameters studied in subgroups of men and women who had FDS fractures were also analysed. To determine the association of risk factors of CNCD and DM2 with the risk of FDS fractures, non-standardised and standardised logistic regression models were used.

Outcome registration methods

The incidence of FDS fractures in the past 3 years, presence of DM2, presence of arterial hypertension and major CVDs and CNCDs, duration of menopause in women, smoking habits and other risk factors for CVD and CNCD and sociodemographic data were assessed using the analysis of the structured questionnaire of the HAPIEE project (http://www.ucl.ac.uk/easteurope/hapiee-cohort.htm). Restrictions in physical activity due to health problems were assessed using the Physical Functioning Scale (PF10) [16]. Indicators of PF10 < 75 U were regarded as low and indicated that the physical activity of the subject was significantly limited by his/her health status.

Ethical expertise

The study was approved by the Ethics Committee of the Research Institute of Therapy and Preventive Medicine of the Siberian Branch of RAMS (protocol dated December 26, 2014).

Statistical analysis

Principles of calculating the sample size. The preliminary calculation of the sample size (in each group) was conducted to ensure a minimum odds ratio (OR) of 2 (at a=0.05, b=0.10 and 0.20) for the prevalence of the tested factor of 10% and 20% in control.

Given the preliminary data on the prevalence of DM2 in the population, the expected frequency will be in the range of 10%–20%. The available sample of 3,393 patients is sufficient to detect differences in the frequency of DM2 in patients with and without fractures to provide an OR=2 with 90% power.

Table 1. **Calculation of sample size**

OR	10%		20%	
	Power 80%	Power 90%	Power 80%	Power 90%
2	307	402	186	244
3	112	146	72	93

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Methods of statistical data analysis. Statistical data processing was performed using the SPSS software package (version 13.0). Automated database cheque and statistical analysis were performed. The statistical significance of differences in average values was evaluated by Student's *t*-test for normally distributed variables. To determine the statistical significance of differences in qualitative characteristics, the Pearson chi-squared test (χ^2) was used. Comparison of two independent groups by quantitative variables with an abnormal distribution was performed using the nonparametric Mann–Whitney test. Data obtained in the tables and text are presented as absolute and relative values (*n*, %) and M±σ, where M is the arithmetic mean value and σ is the standard deviation. Differences were considered statistically significant at a *p*-value <0.05. To assess the relationship of risk factors and their combinations with FDS fractures that occurred in the past 3 years, logistic regression was used. We analysed models standardised by age (Models 1 and 2) and multivariate models (Models 3, 4, 5 and 6).

Results

objects (participants) of the study

A sample of the population of Novosibirsk was examined. There were 3,898 patients aged 58–84 years. The analysis included data from 3,393 patients (2,005 women and 1,388 men), in which 718 patients (21.2%) had DM2. Moreover, 21.7% of women and 20.3% of men provided written informed consent for the analysis of serum biochemical parameters and complete examination.

Primary results of the study

The characteristics of women and men with FDS fractures in the past 3 years are presented in **Tables 2** and **3**. Women with a history of wrist fractures had lower weight, BMI, WC, HC and WC/HC ratio compared with women without FDS fractures **(Table 2)**. Men with FDS fractures in the past 3 years had higher TC and HDLC levels than those without history of FDS fractures **(Table 3)**. The frequency of FDS fractures in the past 3 years in patients

Table 2. **Characterisation of groups of women with FDS fractures in the past 3 years and without a history of FDS fracture**

Indicators	FDS fracture+ *n* =79	FDS fracture– *n*=1926	*p*-value
Age, years	68,8±6,3	69,2±6,8	0,611
Height, cm	157,7±7,1	157,2±6,1	0,453
Weight, kg	70,9±13,2	75,9±14,7	0,003
BMI, kg/m²	28,5±4,7	30,7±5,7	0,001
WC, cm	89,7±11,9	95,2±12,4	0,001
HC, cm	105,9±10,3	109,1±10,7	0,013
WC/HC ratio	0,85±0,6	0,87±0,7	0,001
SBP, mmHg	143,4±20,9	144,9±21,6	0,528
DBP, mmHg	83,4±10,1	82,3±10,8	0,362
Fasting plasma glucose, mmol/L	6,3±5,1	6,3±1,8	0,937
TC, mg/dL	225,9±37,1	219,1±46,7	0,201
TG, mg/dL	133,5±103,1	136,8±84,1	0,739
HDLC, mg/dL	53,2±14,1	53,0±14,9	0,918
Physical functioning, *n*/%			
> 75 U	24/30,4%	732/38%	0,171
⩽ 75 U	55/69,6%	1194/62%	0,171
Education, *n*/%			
Higher	28/35,4%	580/30,1%	0,313
Secondary (complete)	48/60,8%	1214/63,0%	0,682
Basic general	3/3,8%	132/6,9%	0,288
DM2, *n*/%	13/16,5%	423/22,0%	0,245
Smoking, *n* (%)			
current smokers	3/3,9%	90/4,6%	0,717
previous smokers	8/10,3%	107/5,6%	0,087
non-smokers	67/85,9%	1727/89,8%	0,168
Menopause duration, years	19,5±7,9	19,7±8,4	0,834

Note: FDS fracture+, patients with a fracture of the forearm distal segment in the past 3 years; FDS fracture–, individuals without a fracture of the forearm distal segment in the past 3 years.

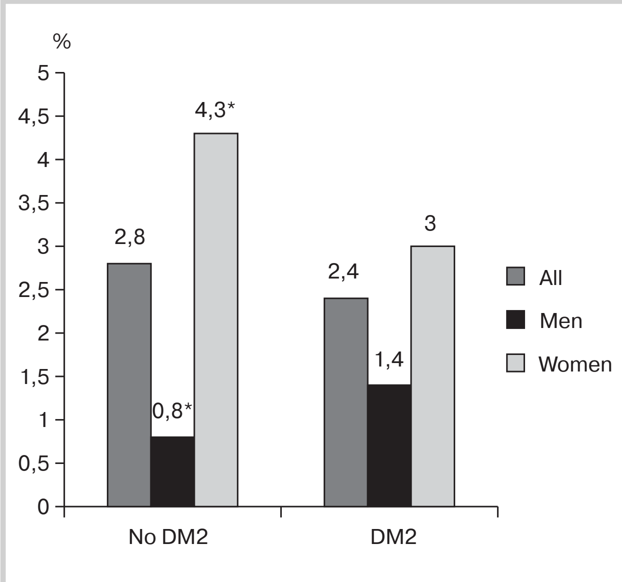
with DM2 and without carbohydrate metabolism disorders is presented in **Figure**. Among the participants without diabetes, fractures occurred more often in women than in men (p=0.001). The frequency of FDS fractures in the past 3 years did not differ in patients with DM2 compared with those without (p=0.557), in both men (p=0.191) and women (p=0.218) **(Figure)**.

Additional study results

According to the results of a multivariate analysis, it was determined that in women who previously smoked and had a TC level > 200 mg/dL, the risk of FDS fracture increases, and decreases with an increase in BMI, regardless of other factors **(Table 4)**, which is consistent with data from other Russian and foreign studies [7, 14, 17]. In men, the risk of FDS fracture increases with an increase in the TC level **(Table 5)**. In both women and men aged 58–84 years, no associations between DM2 and FDS fractures that occurred in the past 3 years were observed **(Tables 4 and 5)**.

Adverse events

Adverse events were not identified during the course of the study.



The frequency of FDD fractures over the past 3 years in individuals with diabetes mellitus and without carbohydrate metabolism disorders.

Table 3. **Characterisation of groups of men with FDS fractures in the past 3 years and without a history of FDS fracture**

Indicators	FDS fracture+ n=12	FDS fracture– n=1376	p-value
Age, years	69,6±7,4	69,1±7,0	0,824
Height, cm	168,9±6,6	170,9±6,3	0,262
Weight, kg	83,3±14,6	81,2±15,1	0,639
BMI, kg/m^2	29,2±5,0	27,8±4,6	0,284
WC, cm	101,6±12,9	98,2±12,7	0,353
HC, cm	104,0± 7,4	102,6±8,1	0,535
WC/HC ratio	0,97±0,07	0,95±0,08	0,368
SBP, mmHg	147,5±13,5	146,8±8,1	0,907
DBP, mmHg	89,9±10,0	85,7±11,9	0,224
Fasting plasma glucose, mmol/L	6,5±1,0	6,4±1,9	0,957
TC, mg/dL	246,1±70,4	199,2±434	0,001
TG, mg/dL	169,8±140,8	127,1±78,4	0,063
HDLC, mg/dL	57,0±24,6	47,5±14,3	0,024
Physical functioning, n/%			
> 75 U	5/41,7%	383/27,8%	0,287
⩽ 75 U	7/58,3%	993/72,2%	0,287
Education, n/%			
Higher	4/33,3%	555/40,3%	0,622
Secondary (complete)	8/66,7%	742/53,9%	0,378
Basic general	0/0%	79/5,7%	0,392
DM2, n/%	4/33,3%	278/20,2%	0,261
Smoking, n (%)			
current smokers	6/50%	368/26,8%	0,093
previous smokers	3/25%	572/41,6%	0,246
non-smokers	3/25%	435/31,6%	0,623

Note: FDS fracture+, patients with a fracture of the forearm distal segment in the past 3 years; FDS fracture–, individuals without a fracture of the forearm distal segment in the past 3 years.

Table 4. **Results of a logistic regression analysis of the relationship of the parameters studied with the risk of FDS fractures in the past 3 years in women**

Indicators	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
DM2												
DM2(–)	1,0				1,0		1,0		1,0		1,0	
DM2(+)	0,53	0,19–1,46			0,51	0,19–1,43	0,64	0,23–1,78	0,72	0,25–2,03	0,63	0,34–1,15
Age, per year	0,99	0,96–1,03	1,01	0,98–1,05	1,00	0,97–1,04	1,01	0,97–1,05	1,00	0,94–1,07	1,03	0,99–1,07
Blood plasma glucose, mmol/L			0,97	0,85–1,10								
Smoking												
non-smoker					1,0		1,0		1,0		1,0	
current smoker					1,03	0,43–2,46	0,95	0,39–2,27	0,91	0,31–2,63	0,82	0,25–2,70
previous smoker					2,73	1,25–6,01	2,68	1,21–5,91	2,94	1,17–7,38	2,23	1,10–4,55
BMI, per kg/m^2							0,91	0,87–0,96	0,91	0,86–0,96		
Menopause duration												
⩾10 years									1,0			
<10 years									0,89	0,42–1,90		
Physical functioning												
>75 U									1,0		1,0	
⩽75 U									1,13	0,66–1,95	1,00	0,99–1,01
TC												
>200.0 mg/dL											1,0	
⩽200.0 mg/dL											1,98	1,19–3,29

Note. OR, odds ratio; 95% CI, confidence interval with a level of 95%. Models 1 and 2, standardisation by age; Model 3, standardisation by age, DM2 and smoking; Model 4, standardisation by age, DM2, smoking and BMI; Model 5, standardisation by age, smoking, DM2, BMI, menopause duration and physical functioning; Model 6, standardisation by age, smoking, physical functioning and TC level

Table 5. **Results of a logistic regression analysis of the relationship of the parameters studied with the risk of FDS fractures for the past 3 years in men**

Indicators	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
DM2												
DM2(–)	1,0				1,0		1,0		1,0		1,0	
DM2(+)	1,87	0,40–8,62			1,90	0,41–8,87	1,73	0,36–8,41	1,69	0,34–8,28	1,42	0,44–4,66
Age, per year	0,99	0,92–1,08	1,02	0,94–1,09	1,0	0,92–1,09	1,00	0,92–1,09	0,99	0,91–1,09	1,02	0,95–1,11
Blood plasma glucose, mmol/L			1,00	0,77–1,31								
Smoking												
non-smoker					1,0		1,0		1,0		1,0	
current smoker					2,27	0,44–11,58	2,36	0,46–12,16	2,28	0,44–11,77	2,24	0,62–8,08
previous smoker					2,13	0,39–11,71	2,04	0,37–11,29	1,89	0,34–10,22	0,75	0,79–3,05
BMI, per kg/m^2							1,04	0,90–1,20	1,03	0,89–1,18		
Physical functioning												
>75 U									1,0		1,0	
⩽75 U									2,65	0,68–10,41	2,56	0,86–7,57
TC, mg/dL											1,01	1,00–1,02

Note. OR, odds ratio; 95% CI, confidence interval with a level of 95%. Models 1 and 2, standardisation by age; Model 3, standardisation by age, DM2 and smoking; Model 4, standardisation by age, DM2, smoking and BMI; Model 5, standardisation by age, DM2, smoking, BMI and physical functioning; Model 6, standardisation by age, DM2, smoking, BMI, physical functioning and TC level

Discussion

Summary of the primary result of the study

In the population sample of patients without diabetes, a high incidence of FDS fractures was noted, mainly in women (p=0.001). These data in the Siberian population are consistent with data on the prevalence of fractures in the Russian population. In the past 3 years, the incidence of FDS fractures in patients with DM2 did not differ compared with that in patients without diabetes (p=0.557), and there was no difference in the frequency of fractures in men and women with DM2 (p=0.179).

An analysis of the risk factors for CNCD confirmed an increased risk of FDS fractures in patients with a history of smoking and a decreased risk in those with higher BMI in women. An association between FDS fractures and increased TC level was found in both men and women. Regarding the indicators of carbohydrate metabolism, there were no associations between FDS fractures that occurred in the past 3 years and PG level and presence of DM2.

Discussion of the primary result of the study

According to the literature, the prevalence of FDS fractures worldwide is the highest compared to those of other fractures. In the Skine region (Sweden), based on the registry, the incidence of FDS fractures in patients aged 17–64 years was 278 per 100,000 individuals (male-to-female ratio, 1:1.5) [18]. Abrahamsen et al., in a recent large-scale study conducted in Denmark [19], showed that the incidence of FDS fractures in men (153 per 100,000 individuals) was almost similar to that in Jerrhag's study [18], but that in women was slightly higher (530 per 100,000 individuals).

In the city of Pervouralsk of the RF, in a 2-year period, 586 FDS fractures were registered (average of 540.7 per 100,000 individuals); moreover, fractures in women were registered five times more often than in men (787.9 and 171.1 per 100,000 women and men, respectively; p<0.00001) [13]. According to the study by Zavodsky et al., in the Volgograd region, in the period of 2008–2014, fracture of the radial bones was predominant, in both osteoporosis and normal BMD (p<0.0001) [12]. In the city of Ulan-Ude, in the period of 2009–2011, medical documentation of trauma centres was studied, and it was found that women had osteoporotic FDS fractures more often (44.4% of cases), while in men FDS fractures occurred in only 22.2% of cases [17]. Our study also noted a threefold predominance of the frequency of low-energy FDS fractures in women compared with those in men. In our study, the incidence of FDS fractures in the past 3 years in patients with DM2 aged 58–84 years was 2.4%. Similar data were obtained in a study by Yalochkina et al., in which in 214 patients with DM2 aged 44–88 years who participated in a questionnaire survey, 5.1% of the patients had history of FDS fractures [20].

The search for associations of CNCD risk factors and osteoporotic fractures is actively conducted in Russian and foreign studies. In our study, men with FDS fractures in the past 3 years, with a non-standardised analysis, had high TC and HDLC levels. The literature data on the analysis of the correlation of TC and HDL levels and BMD are contradictory. Some researchers did not find any relationship between them [21]; however, in the Tromso population study, in which 27,159 patients were observed for 6 years, lower HDLC levels were found in patients without fractures, and in patients with DM2, lower HDL levels were associated with increased BMD [22]. In our study, in women with a non-standardised analysis, BMI was significantly lower than that in patients without fractures, and a multivariate analysis showed that the risk of fractures decreases with an increase in BMI. Obesity is traditionally perceived as being protective of the bone. This is explained by an increase in the mechanical load on the skeleton and ability of adipocytes to convert androgens to 17β-oestradiol, which increases BMD [23]. According to Bonds et al., in obese patients, increased BMD was a hallmark of bones bearing the skeleton weight, in contrast to forearm bones [24]. This can probably explain the similar results in the incidence of FDS fractures in patients with DM2 (2.4%) and in those without (2.8%; p = 0.557).

In our study, we did not identify a relationship between FDS fracture and presence of DM2. However, a number of meta-analyses reported an increase in the risk of a proximal femoral fracture by 1.3–2.1 times and increase in the risk of other fractures in patients with DM2 by 1.2 times [25, 26]. A study in Manitoba (Canada) showed that in individuals aged ⩾40 years (n=6455/55,958), diabetes was a significant independent risk factor for major osteoporotic fractures (risk ratio, 1.32; 95% confidence interval = 1.20–1.46) [27]. However, in a study by Kanis et al., the risk of fracture in patients with DM2 did not increase during the first 5 years from the onset of the disease [28], while Ivers et al. noted a high risk of any fracture in patients with DM2 for at least 10 years [29]. A two-phase change in the risk of fractures in this category of patients has been proposed; with a newly diagnosed DM2, the risk of a fracture is actually reduced, which may be associated with some protective effects of high adipose mass in these patients, and significantly increases only after 5 years [27]. Some studies suggest that DM2 may also be associated with faster bone tissue loss, which may partially explain the increase in fracture rate. Schwartz et al. found that older women with diabetes lose bone strength faster than those without in many areas of the skeleton but not in the radial bone [30]. Leslie et al. recently published data showing that in the province of Manitoba, women with DM2 had a slightly larger loss of BMD in the femoral neck, but not in other areas, compared with the control population without diabetes [27]. The paradoxical increase in the number of fractures may be the result of complex mechanisms underlying the increased bone fragility in diabetes, and, probably, the localisation of fractures and degree of compensation for carbohydrate metabolism are important. Therefore, in this study, the lack of association of FDS fractures and DM2 can be quite natural. Since FDS fracture is the most common fracture, even a slight increase in the number of cases can affect significantly the need for healthcare resources, especially in individuals of working age, when patients are on sick leave, depending on their profession, for ⩾5–12 weeks. The NORA study demonstrated that a fracture of the forearm at the age of ⩾45 years increases the risk of fracture of the proximal femur by 1.9 times [31]. These facts make it possible to state an 'osteoporotic cascade' of fractures, when another and sometimes a series of new fractures occur after one fracture. National Bone Health Alliance Working Group experts note that FDS fractures are characterised as osteoporotic fractures if there is concomitant osteopenia or osteoporosis by measuring BMD (<−1.0 T-points) at the level of the lumbar spine or femur [32]. Data from the US National Osteoporosis Fund indicate that wrist fractures alone (patients without preliminary hip/vertebral fractures or with BMD in the range of osteoporosis values) are not indications for pharmacotherapy [33]. In the Russian recommendations for osteoporosis, the presence of fractures of the peripheral (non-axial) segments of the skeleton and a decrease in BMD in these segments are not diagnostic criteria for osteoporosis [34].

Thus, there is currently no consensus among specialised bone research societies regarding whether a low-energy wrist fracture should be considered as a criterion in the diagnosis of osteoporosis. Therefore, the identification and close follow-up of these patients as a high-risk group for fractures is one of the primary tasks of public healthcare.

Study limitation

A limitation of this study is its cross-sectional design. Another limitation is the assessment of the history of FDS fractures using a standardised questionnaire without considering the confirmation of fractures by X-ray examination.

Conclusion

In the study, a high incidence of FDS fractures in the past 3 years (3.9%) was found in women. The association of risk factors of CNCD, such as smoking and hypercholesterinaemia, with FDS fractures was found, which indicates the need for preventive measures to reduce the incidence of smoking and hypercholesterinaemia, including those aimed at primary prevention of FDS fractures. Data on the prevalence of fractures of various localisations in DM2 are contradictory; however, we did not found neither differences in the incidence of FDS fractures in the past 3 years in patients with and without DM2 (p=0.557) nor associations of fractures and blood glucose levels and presence of DM2.

Additional information

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ЛИТЕРАТУРА | REFERENCES

1. *International Diabetes Federation*. IDF atlas. 8th ed. Brussels: IDF; 2017.
2. Дедов И.И., Шестакова М.В., Викулова О.К. Эпидемиология сахарного диабета в Российской Федерации: клинико-статистический отчет по данным Федерального регистра сахарного диабета. // Сахарный диабет. – 2017. – Т. 20. – №1. – С. 13-41. [Dedov II, Shestakova MV, Vikulova OK. Epidemiology of diabetes mellitus in Russian Federation: clinical and statistical report according to the federal diabetes registry. *Diabetes mellitus*. 2017;20(1):13-41. (In Russ.)] doi: https://doi.org/10.14341/DM8664
3. Мустафина С.В., Рымар О.Д., Сазонова О.В., и др. Валидизация финской шкалы риска «FINDRISC» на европеоидной популяции Сибири. // Сахарный диабет. – 2016. – Т. 19. – №2. – С. 113-118. [Mustafina SV, Rymar OD, Sazonova OV, et al. Validation of the Finnish diabetes risk score (FINDRISC) for the Caucasian population of Siberia. *Diabetes Mellitus*. 2016;19(2):113-118. (In Russ.)] doi: https://doi.org/10.14341/DM200418-10
4. Мустафина С.В., Рымар О.Д., Малютина С.К., и др. Распространенность сахарного диабета у взрослого населения Новосибирска. // Сахарный диабет. – 2017. – Т. 20. – №5. – С. 329-334. [Mustafina SV, Rymar OD, Malyutina SK, et al. Prevalence of diabetes in the adult population of Novosibirsk. *Diabetes mellitus*. 2017;20(5):329-334. (In Russ.)] doi: https://doi.org/10.14341/DM8744
5. Thayer SW, Stolshek BS, Gomez Rey G, Seare JG. Impact of osteoporosis on high-cost chronic diseases. *Value Health*. 2014;17(1):43-50. doi: https://doi.org/10.1016/j.jval.2013.11.004
6. Janghorbani M, Van Dam RM, Willett WC, Hu FB. Systematic review of type 1 and type 2 diabetes mellitus and risk of fracture. *Am J*

Epidemiol. 2007;166(5):495-505. doi: https://doi.org/10.1093/aje/kwm106

7. Vestergaard P, Rejnmark L, Mosekilde L. Diabetes and its complications and their relationship with risk of fractures in type 1 and 2 diabetes. *Calcif Tissue Int.* 2009;84(1):45-55. doi: https://doi.org/10.1007/s00223-008-9195-5
8. Климонтов В.В., Фазуллина О.Н., Лыков А.П., Коненков В.И. Взаимосвязь маркеров ремоделирования костной ткани с минеральной плотностью костей у женщин с сахарным диабетом 2-го типа, находящихся в постменопаузе. // Сахарный диабет. – 2016. – Т. 19. – №5. – С. 375-382. [Klimontov VV, Fazullina ON, Lykov AP, Konenkov VI. The relationships between bone turnover markers and bone mineral density in postmenopausal type 2 diabetic women. *Diabetes mellitus.* 2016;19(5):375-382. (In Russ.)] doi: https://doi.org/10.14341/DM800
9. Lipscombe LL, Jamal SA, Booth GL, Hawker GA. The risk of hip fractures in older individuals with diabetes: a population-based study. *Diabetes Care.* 2007;30(4):835-841. doi: https://doi.org/10.2337/dc06-1851
10. Руяткина Л.А., Полторацкая Е.С., Пахомов И.А., и др. Электронейромиография в диагностике ранних стадий диабетической нейропатии – приглашение к дискуссии эндокринологов, неврологов, электрофизиологов. // Медицинский совет. – 2016. – №10. – С. 156-162. [Ruyatkina LA, Poltoratskaia ES, Pakhomov IA, et al. Electroneuromyography in diagnostics of early stages of diabetic neuropathy – invitation of endocrinologists, neurologists and eletcrophysiologists to discussion. *Meditsinskiy sovet.* 2016;(10):156-162. (In Russ.)] doi: https://doi.org/10.21518/2079-701X-2016-10-156-162
11. Curtis JR, Beukelman T, Onofrei A, et al. Elevated liver enzyme tests among patients with rheumatoid arthritis or psoriatic arthritis treated with methotrexate and/or leflunomide. *Ann Rheum Dis.* 2010;69(1):43-47. doi: https://doi.org/10.1136/ard.2008.101378
12. Заводовский Б.В., Сивордова Л.Е., Полякова Ю.В., и др. Ведущие факторы риска развития остеопороза среди работников образовательных учреждений Волгоградской области. // Медицина труда и промышленная экология. – 2017. – №7. – С. 52-55. [Zavodovsky BV, Seewordova LE, Polyakova YV, et al. Leading risk factors of osteoporosis among education workers in Volgograd region. *Med Tr Prom Ekol.* 2017;(7):52-55. (In Russ.)]
13. Гладкова Е.Н., Ходырев В.Н., Лесняк О.М., и др. Анализ эпидемиологии остеопоротических переломов с использованием информации, полученной от врачей первичного звена. // Остеопороз и остеопатии. – 2011. – Т. 14. – №1. – С. 14-18. [Gladkova EN, Khodyrev VN, Lesnyak OM, et al. Analysis of epidemiology of osteoporotic fracturesusing data from primary care physicians. *Osteoporosis and bone diseases.* 2011;14(1):14-18. (In Russ.)] doi: https://doi.org/10.14341/osteo2011114-18
14. Crandall CJ, Hovey KM, Cauley JA, et al. Wrist Fracture and Risk of Subsequent Fracture: Findings from the Women's Health Initiative Study. *J Bone Miner Res.* 2015;30(11):2086-2095. doi: https://doi.org/10.1002/jbmr.2559
15. Peasey A, Bobak M, Kubinova R, et al. Determinants of cardiovascular disease and other non-communicable diseases in Central and Eastern Europe: rationale and design of the HAPIEE study. *BMC Public Health.* 2006;6:255. doi: https://doi.org/10.1186/1471-2458-6-255
16. Ware JE, Sherbourne CD. The MOS 36-ltem Short-Form Health Survey (SF-36). *Med Care.* 1992;30(6):473-483. doi: https://doi.org/10.1097/00005650-199206000-00002
17. Батудаева Т.И. Распространенность остеопоротических переломов среди жителей республики Бурятия 40 лет и старше. // Остеопороз и остеопатии. – 2016. – Т. 19. – №2. – С. 12. [Batudayeva TI. Rasprostranennost' osteoporoticheskikh perelomov sredi zhiteley respubliki Buryatiya 40 let i starshe. *Osteoporosis and bone diseases.* 2016;19(2):12. (In Russ.)] doi: https://doi.org/10.14341/osteo2016212-12
18. Jerrhag D, Englund M, Karlsson MK, Rosengren BE. Epidemiology and time trends of distal forearm fractures in adults – a study of 11.2 million person-years in Sweden. *BMC Musculoskelet Disord.* 2017;18(1):240. doi: https://doi.org/10.1186/s12891-017-1596-z
19. Abrahamsen B, Jorgensen NR, Schwarz P. Epidemiology of forearm fractures in adults in Denmark: national age- and gender-specific incidence rates, ratio of forearm to hip fractures, and extent of surgical fracture repair in inpatients and outpatients. *Osteoporos Int.* 2015;26(1):67-76. doi: https://doi.org/10.1007/s00198-014-2831-1
20. Ялочкина Т.О., Белая Ж.Е., Рожинская Л.Я., и др. Переломы костей при сахарном диабете 2 типа: распространенность и факторы риска. // Сахарный диабет. – 2016. – Т. 19. – №5. – С. 359-365. [Yalochkina TO, Belaya ZE, Rozhinskaya LY, et al. Bone fractures in patients with type 2 diabetes mellitus: Prevalence and risk factors. *Diabetes mellitus.* 2016;19(5):359-365. (In Russ.)] doi: https://doi.org/10.14341/DM7796
21. Ersoy GS, Simsek EE, Vatansever D, et al. Lipid profile and plasma atherogenic index in postmenopausal osteoporosis. *North Clin Istanb.* 2017;4(3):237-241. doi: https://doi.org/10.14744/nci.2017.61587
22. Ahmed LA, Schirmer H, Berntsen GK, et al. Features of the metabolic syndrome and the risk of non-vertebral fractures: the Tromso study. *Osteoporos Int.* 2006;17(3):426-432. doi: https://doi.org/10.1007/s00198-005-0003-z
23. Muka T, Trajanoska K, Kiefte-de Jong JC, et al. The Association between Metabolic Syndrome, Bone Mineral Density, Hip Bone Geometry and Fracture Risk: The Rotterdam Study. *PLoS One.* 2015;10(6):e0129116. doi: https://doi.org/10.1371/journal.pone.0129116
24. Bonds DE, Larson JC, Schwartz AV, et al. Risk of fracture in women with type 2 diabetes: the Women's Health Initiative Observational Study. *J Clin Endocrinol Metab.* 2006;91(9):3404-3410. doi: https://doi.org/10.1210/jc.2006-0614
25. Dytfeld J, Michalak M. Type 2 diabetes and risk of low-energy fractures in postmenopausal women: meta-analysis of observational studies. *Aging Clin Exp Res.* 2017;29(2):301-309. doi: https://doi.org/10.1007/s40520-016-0562-1
26. Fan Y, Wei F, Lang Y, Liu Y. Diabetes mellitus and risk of hip fractures: a meta-analysis. *Osteoporos Int.* 2016;27(1):219-228. doi: https://doi.org/10.1007/s00198-015-3279-7
27. Leslie WD, Morin SN, Lix LM, Majumdar SR. Does diabetes modify the effect of FRAX risk factors for predicting major osteoporotic and hip fracture? *Osteoporos Int.* 2014;25(12):2817-2824. doi: https://doi.org/10.1007/s00198-014-2822-2
28. Kanis J. *Assessment of osteoporosis at the primary healthcare level.* Sheffield: World Health Organization Collaborating Centre, University of Sheffield; 2008.
29. Ivers RQ, Cumming RG, Mitchell P, Peduto AJ. Diabetes and Risk of Fracture: The Blue Mountains Eye Study. *Diabetes Care.* 2001;24(7):1198-1203. doi: https://doi.org/10.2337/diacare.24.7.1198
30. Schwartz AV, Ewing SK, Porzig AM, et al. Diabetes and change in bone mineral density at the hip, calcaneus, spine, and radius in older women. *Front Endocrinol (Lausanne).* 2013;4:62. doi: https://doi.org/10.3389/fendo.2013.00062
31. Barrett-Connor E, Sajjan SG, Siris ES, et al. Wrist fracture as a predictor of future fractures in younger versus older postmenopausal women: results from the National Osteoporosis Risk Assessment (NORA). *Osteoporos Int.* 2008;19(5):607-613. doi: https://doi.org/10.1007/s00198-007-0508-8
32. Siris ES, Adler R, Bilezikian J, et al. The clinical diagnosis of osteoporosis: a position statement from the National Bone Health Alliance Working Group. *Osteoporos Int.* 2014;25(5):1439-1443. doi: https://doi.org/10.1007/s00198-014-2655-z
33. Cosman F, de Beur SJ, LeBoff MS, et al. Clinician's Guide to Prevention and Treatment of Osteoporosis. *Osteoporos Int.*

2014;25(10):2359-2381. doi: https://doi.org/10.1007/s00198-014-2794-2

34. Мельниченко Г.А., Белая Ж.Е., Рожинская Л.Я., и др. Федеральные клинические рекомендации по диагностике, лечению и профилактике остеопороза. // Проблемы эндокринологии. – 2017. – Т. 63. – №6. – С. 392-426. [Melnichenko GA, Belaya ZE, Rozhinskaya LY, et al. Russian clinical guidelines on the diagnostics, treatment, and prevention of osteoporosis. *Problems of endocrinology.* 2017;63(6):392-426. (In Russ.)] doi: https://doi.org/10.14341/probl2017636392-426

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