Original paper

Overweight, obesity, and carbohydrate metabolism disorder in workers of an industrial facility in Kazakhstan: early prevention and its management

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Gastroenterology Rev
DOI: https://doi.org/10.5114/pg.2023.134368

Key words: diabetes mellitus, physical activity, body weight, primary prevention, rational nutrition.

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Abstract

Introduction: In recent years, the issue of widespread increased body weight in combination with blood glycaemic changes in the able-bodied population of Kazakhstan has become especially acute, which in turn leads to dangerous complications and an increased burden on the country's healthcare structures.

Aim: To investigate the effectiveness of early prevention of overweight, obesity, and carbohydrate metabolism disorders in the able-bodied workers at an industrial facility in Kazakhstan.

Material and methods: The study was conducted in 2019–2021 using elements of both empirical (observation, comparison, measurement) and theoretical (analysis and synthesis, statistical processing of results with the calculation of the reliability criterion) models of scientific knowledge.

Results: The factors that have a correlation with this pathology and the strength of their interaction have been studied. New approaches to primary prevention have been developed, and algorithms have been formulated not only for the early detection of pathologies but also for the most effective and efficient methods of combating the occurrence of such pathologies in the population.

Conclusions: To prevent the further spread of the phenomenon of overweight among workers in the industrial sector of Kazakhstan, the following measures are necessary: daily walking (more than 10,000 steps), dosed physical activity in the form of cardio and swimming, and nutrition correction (Mediterranean diet) with alcohol restriction. This prevention significantly reduces body weight and optimizes carbohydrate metabolism.

Introduction

In the new millennium, the issue of the negative impact of overweight and obesity on health indicators is becoming more and more relevant, and it poses a growing threat all over the world, including Kazakhstan. Overweight and obesity both comprise excessive accumulation of adipose tissue in the body. The body mass index (BMI) is used according to the European recommendations for the control of abdominal obesity, and waist circumference. In 2021, based on published data from the WHO (World Health Organization), about 1.65 billion of the world's adult population were overweight, of whom more than 300 million were obese, and by 2025 this figure is projected to be significantly higher [1]. The trend of the spread of this pathology in Kazakhstan is not fundamentally different from the rest of the world, and limited progress has been demonstrated in achieving the targets of non-communicable diseases related to nutrition: about 25% of adult women (aged 18 years and older) and 21% of adult men suffer from obesity. In addition, the prevalence of this pathology in Kazakhstan is higher than the average in the Asian region (10.3% in women and 7.5% in men, respectively) [2]. As shown in the mathematical forecasting model of the Centre for the Control of Noncommunicable Diseases, it can be assumed that by 2030 66% of men and 74% of women will suffer from obesity [3].

The number of people with BMI above 25–30 kg/m^2 is steadily increasing with the increase in the number of patients with endocrine disorders, in particular, carbohydrate metabolism disorders (impaired carbohydrate tolerance or diabetes mellitus) [4]. There is no doubt that there is a common pathogenesis of excessive accumulation of adipose tissue and an increase in serum glucose levels. In turn, diabetes mellitus is an extremely dangerous chronic disease, the complications of which are critical to the cardiovascular system and visual organs, and it is the leading cause of the development of chronic kidney disease and significantly worsens the quality of life of patients. According to published statistics, about 15–20% of the world's population has various forms of impaired carbohydrate tolerance, and by 2030 this figure may approach 439 million adults in the world [5]. A similar trend is observed in the Republic of Kazakhstan – the number of patients with diabetes mellitus has increased over the past decades and amounts to more than 420,000 people. Under official statistics for 2018, the average incidence of diabetes mellitus in Kazakhstan is about 185.5 per 100,000 population and may vary slightly depending on the region of the country and the level of urbanisation of the locality [6].

Problems with the control and maintenance of optimal weight indicators are primarily related to lifestyle. In particular, lack of mobility, bad habits (smoking, alcohol abuse), and irrational and unbalanced diet are the main risk factors for the development of chronic conditions such as diabetes and cardiovascular diseases. Epidemiological data have shown that in the adult population, both individually and in combination, these factors have a cumulative negative effect on metabolic processes in the body [7]. A healthy lifestyle and primary prevention of these diseases, especially among the young, working-age population of the country, should play a primary role as the main factor in maintaining the health of the nation and overall economic stability [7].

Aim

The purpose is to investigate the effectiveness of early prevention of overweight, obesity, and carbohydrate metabolism disorders in the able-bodied workers at an industrial facility in Kazakhstan.

Material and methods

Consistent with the defined goal, the study is based on the analysis of the results of a comprehensive clinical, laboratory, and instrumental examination of the working population, aged 18 to 60 years, of an industrial facility in the Karaganda region. A total of 622 people aged 18 to 60 years were included in the study, which included the collection of personal data, analysis of medical documentation, anthropometric measurements, and detection of the level of serum glucose and glycosylated haemoglobin (HbA_{1c}). The anamnesis collection included verbal communication with the patient and filling out a questionnaire. It consisted of socio-demographic issues (age, gender, marital status, alcohol and smoking habits, level of physical activity, length of employment, family history) and dietary information for the last 6 months (number of meals, interval between meals, amount of vegetables/fruits, simple and complex carbohydrates, fish, and meat).

Anthropometric studies consisted of measuring height (in cm) and weight (in kg), calculating BMI, waist circumference, hip volume, and their ratio. To determine the height, a RAP 01 electronic height meter was used, and an OMRON BF 212 electronic floor scale was used for weight. To calculate BMI, it is necessary to divide the body weight in kilograms by the body height in square metres (kg/m^2). Indicators 17.0–18.4 are defined as underweight, indicators 18.5–24.9 – normal body weight, indicators 25.0–29.9 – overweight, and more than 30.0 – obesity, which, in turn, is divided into 3 stages (I – 30.0–34.9, II – 35–39.9, and III – more than 40). According to the recommendations of WHO experts, there are 2 levels of waist circumference indicators: waist circumference > 94 cm in men and > 80 cm in women represents a limit; waist circumference > 102 cm in men and > 88 cm in women corresponds to body weight indicators that should be reduced and may indicate abdominal obesity [6].

An Easy Touch GCHb portable glucose meter was used to measure glucose levels. Interpretation of indicators in accordance with modern recommendations: prediabetes – fasting blood glucose level 100–125 mg/dl (5.6–6.9 mmol/l); diabetes – fasting blood glucose level more than 126 mg/dl (7.0 mmol/l) [8]. Then an explanatory conversation was held with the patients about the state of health and the importance of primary prevention of diseases. Each patient was then given details about the importance of and ways to modify their lifestyle verbally and documented (a short bulletin was given in hard copy). The following methods of early prevention of obesity and diabetes mellitus were used: daily physical activity (walking more than 10,000 steps); metered physical activity (cardio, swimming, etc.); Mediterranean diet; and restriction of alcohol consumption. Evaluation of the results of the intervention was carried out after 3 months. Statistical processing of the results was performed using Microsoft Office Excel 2020 and Medstat 6.5. The data are presented in the form of an average value and a standard deviation M ± m, where M – average value, m – standard deviation. To assess the statistical reliability, Student's *t*-test and Pearson's χ^2 were used; the critical value of the reliability was considered at < 0.05. To compare the frequency characteristics and the average values, the hypothesis of the equality of the average values of the parameters in the studied groups was tested with given confidence of 0.95, and based on this, the significance of the corresponding indicator was concluded.

The study was conducted following the main documents and approved rules of working with patients, namely the World Medical Association Declaration of Helsinki [9]: ethical principles for medical research involving human subjects, and the current legislation of Kazakhstan. All participants were informed about the main stages of the study and gave informed voluntary consent.

Results

A total of 622 patients with an average age of 45.6 ±11.3 years were examined. By gender, there were significantly more men (71.4% vs. 28.6%), which meant there was a statistically significant difference between them ($p < 0.05$), and this can be explained by the use of a sample from the population of an industrial enterprise and its professional characteristics. At the time of inclusion in the study, 52% (323 patients) had a normal body weight, 34% (212 patients) had overweight, and 14% (87 patients) had obesity. Among the latter, statistically more ($p < 0.05$) were with grade I (9%), another 4% had grade II, and only 1% had grade III obesity (Figure 1).

It is extremely important to consider not only the weight figures and BMI but also the distribution of fat mass. It is known that an increase in the amount of abdominal fat (central obesity or abdominal type) is also associated with a significant increase in cardiovascular risk and the possibility of metabolic syndrome. In confirmation of this, the study found that 118 patients (19%) have abdominal obesity, despite the fact that this figure is significantly lower in BMI. Regarding carbohydrate metabolism, most serum glucose levels were within the normal range (70% of patients), but in 21% this indicator ranged from 5.6 to 6.9 mmol/l, and 9% of patients suffered from diabetes mellitus. It is important to note that only about half of them knew about the violation of carbohydrate tolerance and another 47.6% of patients were first identified with these changes. In addition, the study analysed the levels of glycosylated haemoglobin

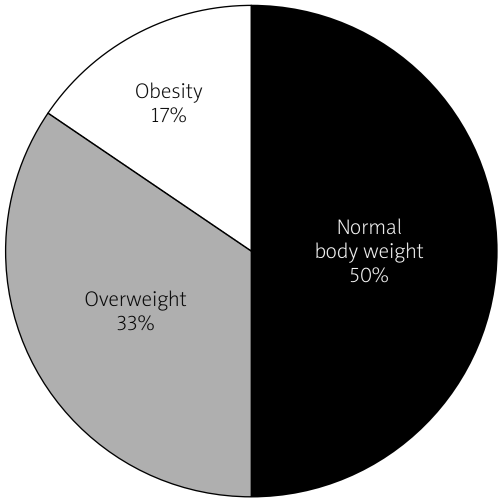

Figure 1. Distribution of patients according to body mass index

relative to BMI (Table I) and revealed a correlation between patients with obesity and diabetes mellitus (r = 0.54, $p < 0.001$), and the fact that patients with normal body weight have significantly lower levels of glycosylated haemoglobin ($p < 0.05$) than patients with overweight and obesity.

Table I. Comparative characteristics of body weight with glycosylated haemoglobin levels

Body mass indicators	HbA_{1c} level, %
Normal body weight	5.07 ±1.17
Overweight	6.12 ±1.31
Obesity	6.97 ±1.4

HbA_{1c} – glycosylated haemoglobin.

Table II. Characteristics of physical activity and nutritional characteristics in the study group

Indicators	Characteristics	Study group, *N* = 622 (%)
Physical activity	Satisfactory	156 (25)
	Moderate	373 (60)
	Sedentary lifestyle	93 (15)
Number of meals per day	1–2 meals per day	87 (14)
	3–4 meals per day	473 (76)
	More than 5 meals per day	62 (10)
Main meal	Breakfast	100 (16)
	Dinner	131 (21)
	Supper	391 (63)
Consumption of vegetables/fruit	Every day	193 (31)
	2–3 times a week	255 (41)
	Less than 2 times a week	174 (28)
The use of simple carbohydrates (pastries, baked goods, pasta)	Every day	392 (63)
	2–3 times a week	131 (21)
	Less than 2 times a week	99 (16)
Consumption of alcohol	No	75 (12)
	1–3 doses per week	472 (76)
	More than 3 doses per week	75 (12)

In line with the questionnaire data, most patients consider their physical activity as moderate (60%), another 25% as satisfactory, and another 15% as minimal (mainly sedentary lifestyle). Table II summarises all the data on lifestyle and diet.

Basically, patients ate 3–4 meals a day (76%), but significantly more often the main meal was for dinner (391 patients, $p = 0.031$), while only 16% had a full breakfast, which is very important for healthy eating behaviour. In addition, it was calculated statistically that patients with obesity are characterised by a large number of meals per day ($r = 0.49$, $p < 0.05$), and the main energy load is in the evening ($r = 0.61$, $p < 0.001$). Also, the intake of fibre in the form of a portion of fresh vegetables and fruit was not optimal: only a third of patients (31%) have them in their daily diet, which is not enough to maintain a healthy eating habits. At the same time, the amount of rapidly digestible carbohydrates is much higher – 63% of patients consume them every day, another 21% – 2–3 times a week, and only 16% (99 patients) less than 2 times a week. Bad habits (in the form of alcohol consumption) were also taken into account. Only 15% of the respondents did not drink alcohol, the overwhelming majority (76%) took 1–3 doses per week. After 3 months of intervention (optimising nutrition and increasing physical activity), positive changes were observed in the studied parameters, which is demonstrated in Figure 2. Thus, the number of patients with overweight significantly decreased to 25%, and with obesity – to 9% ($p < 0.05$ in both cases). Simultaneously, the number of patients with normal body weight also had a positive trend. Furthermore, patients with an abdominal type of obesity decreased to 14% at the end of the study.

The study also found positive changes in the parameters of carbohydrate metabolism: statistically significantly increased number of patients with optimal blood glucose (70% vs. 83%) and statistically significantly decreased number of patients with prediabetes (21% vs. 10%). There was no significant difference between the number of patients with diabetes at the beginning and at the end of the study (9% vs. 7%, $p > 0.05$). The data are shown in Figure 3.

Because glycosylated haemoglobin is an independent and optimal marker for use in the treatment of diabetes compensation, the study also analysed its changes and identified some patterns. Thus, HbA_{1c} in patients with normal body weight practically did not change (5.07 ±1.17% vs. 5.11 ±1.19%, $p > 0.05$), but it significantly decreased both in patients with overweight (up to 5.98 ±1.23%, $p < 0.05$) and in patients with obesity (up to 6.12 ±1.32%, $p < 0.05$). Along with this, there was no statistically significant relationship between the degrees of obesity, which confirms an independent association with increased body weight (BMI > 25.0) and diabetes mellitus, regardless of the degree of obesity. In addition, the proposed methods of early prevention of overweight, obesity, and diabetes have a positive effect on eating habits.

During 3 months of nutrition optimisation, the number of patients with meals 1–2 times a day significantly decreased (6.5%, $p < 0.05$), and daily consumption of vegetables and fruit increased by 24%. Thus, the percentage of daily intake of rapidly digestible carbohydrates decreased statistically significantly (63% vs. 42%, $p < 0.01$). The study found a correlation between a decrease in the consumption of rapidly digestible carbohydrates and a decrease in the level of glycosylated haemoglobin ($r = 0.43$, $p < 0.05$), daily consumption of a portion of vegetables/fruit and normal body weight ($r = 0.54$, $p < 0.05$), and a negative relationship between alcohol intake of more than 2 doses per week and moderate physical activity ($r = -0.44$, $p < 0.05$). Along with the positive changes in nutrition, a larger number of patients also increased their physical activity: 75.4% of patients had an average number of steps of more

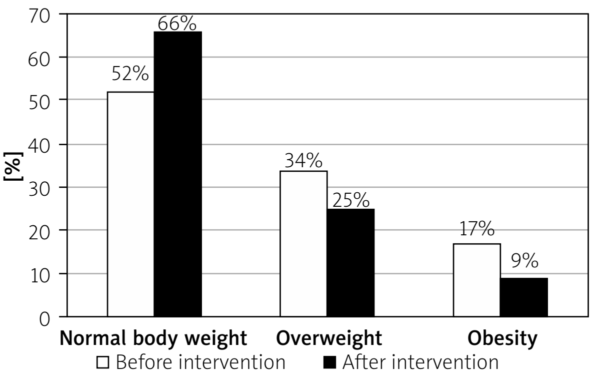

Figure 2. Dynamics of body weight indicators after 3 months

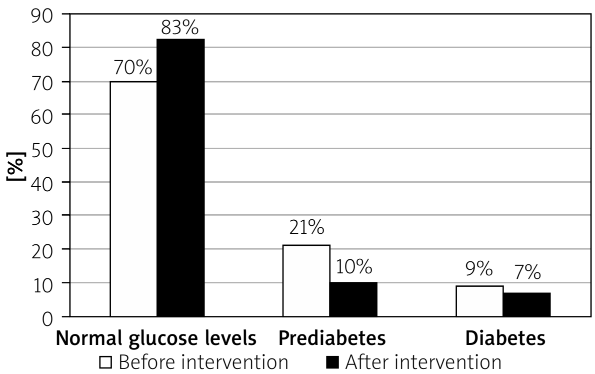

Figure 3. Dynamics of serum glucose indicators after 3 months

than 10,000 and 28% of patients started running. After 3 months, only 10% described their physical activity as a "sedentary lifestyle", while those reporting "moderate physical activity" increased by 7%. The study found an average correlation between minimal activity and overweight (r = 0.48, p < 0.05) and a strong correlation with I–II degree of obesity (r = 0.66, p < 0.01).

Discussion

Social factors and the negative impact of globalisation, such as the increase in supermarket chains and the active popularisation of fast food, large-scale urbanisation, sedentary lifestyle, and economic and social aspects, are the main behavioural risk factors for the development of metabolic disorders. Overweight and insulin resistance are among the main components and continue to be a serious problem for world health and increase the likelihood of 4 major "lifestyle diseases": cardiovascular events, oncological processes, carbohydrate metabolism disorders (type II diabetes mellitus), and chronic lung diseases. The burden of this pathology is extremely high, especially in low–middle-income countries [10]. The prevalence rates of patients with overweight and obesity in this study correspond to the general figures of world statistics and amounted to 34% and 14%, respectively, while the number of patients with stage I obesity is the largest. But there were significantly more patients with abdominal obesity than according to the BMI classification. This important fact should be considered during the initial assessment of the patient's anthropometric data. Because the average age of the subjects was 45 ±11.3 years, the above risk factors take place in this population group (workers of an industrial facility).

In recent years, the amount of shift work at industrial facilities has increased significantly, especially in industrially developed regions, which account for more than 20% of the total able-bodied population of the planet. In Europe and North America, this figure is estimated at 15% of the workforce. Shift work is associated with several health problems (for example, gastrointestinal disorders, some types of cancer, cardiovascular events, mental disorders, and workplace accidents), including obesity and impaired carbohydrate metabolism [11]. Some studies show that being overweight is more common in shift work than in daily work [12, 13]. For example, Liu *et al.* [12] established that workers on shift schedules had a higher prevalence of overweight than a control group (46.2% vs. 42.1%), and, as specified by logistic regression analysis, such work schedules significantly increase the risk of weight gain and obesity (risk ratio (RR) = 1.2; 95% confidence interval (CI): 1.04–1.4, p < 0.05). It can be assumed that circadian rhythm disturbances and lack of sleep have a primary negative effect on metabolism and hunger, which can lead to excessive energy consumption, especially in the evening. Insufficient sleep reduces leptin levels and increases ghrelin levels, which certainly increases appetite.

The problems associated with being overweight are the main cause not only of health problems but also of economic costs for the population and the state. It is quite difficult to calculate the specific amount of costs for the consequences of these diseases because they vary significantly in each country. But despite this, the authors of the book "Obesity: Health and Economic Consequences of an Impending Global Challenge", Shekar and Popkin [13], suggest that the total costs in the United States are estimated in the range of 89 to 212 billion USD, in China – at 3.58% and 8.73% of gross domestic product (GDP) in 2020 and 2025, respectively, and Brazil predicts a doubling of obesity-related health care costs from 5.8 billion USD in 2010 to 10.1 billion USD in 2050. It is important to note the impact of obesity on industry workers, because it negatively affects productivity and early retirement, and increases the risk of disability, which is reflected in the financial component of the country's economy [13].

But despite some international differences, the main reasons for the increase in body weight comprise 2 main factors: lack of mobility and unsustainable eating habits. As claimed by Yusefzadeh *et al.* [14], in the modern civilised world, the food consumed becomes much more accessible, and its caloric content increases significantly. Similarly, this study revealed that most patients consumed insufficient fibre in the form of vegetables/fruit (69% consumed them less than 2–3 times a week) and excessively digestible carbohydrates (73% more often than 3 times a week). This fact is confirmed by several international publications. Thus, in 2019, Sugihiro *et al.* [15] published the results of their study, which included 765 patients and a follow-up period of more than 10 years. In line with their results, patients with obesity developed diabetes, which is associated with increased consumption of total protein (RR = 1.22, 95% CI: 1.03–1.45, p = 0.025), animal proteins (RR = 1.20, 95%, CI: 1.04–1.38, p = 0.011), animal fats (RR = 1.09, 95%, CI: 1.02–1.17, p = 0.010), and saturated fatty acids (RR = 1.14, 95%, CI: 1.00–1.30, p = 0.047) [15]. These associations did not depend on baseline values of age, gender, BMI, systolic blood pressure, triglyceride levels, and serum glucose levels (mean follow-up period 10.7 ±6.3 years). At the same time, the development of obesity without concomitant carbohydrate metabolism disorders is presumably positively associated with the consumption of simple carbohydrates (RR = 1.07, 95% CI: 1.04–1.10, p < 0.001), sugar (RR = 1.09, 95% CI: 1.04–1.14, $p < 0.001$), and fructose (RR = 1.05, 95% CI: 1.01–1.08, $p = 0.011$). In contrast, an inverse relationship was found: the use of vegetable protein (RR = 0.82, 95% CI: 0.68–0.99, $p = 0.049$) and complex carbohydrates (RR = 0.97, 95% CI: 0.93–0.99, $p = 0.047$) has a positive effect on weight (mean follow-up period 10.4 ±6.5 years) [15]. The presence of such persistent associations of weight with specific foods indicates that the correction of eating behaviour and eating habits will have a positive effect on reducing not only body weight but also improving carbohydrate metabolism.

In recent decades, the widespread adoption of a sedentary lifestyle has been a leading social paradigm. According to the findings of this study, most respondents characterise their physical activity as moderate (60%). Simultaneously, a direct correlation was established between overweight and low physical activity ($r = 0.42$, $p < 0.05$), which once again confirms the unconditional association of these parameters. Insufficient daily physical activity may be associated with the growth of industrialisation, the development of technology, and the urbanisation of cities. That is why leading medical organisations and communities (National Institutes of Health of different countries, the North American Association for the Study of Obesity, and the WHO) in their manuals recommend not only mandatory physical exercise, but also clearly define their intensity, duration, type, and frequency of performance. In the opinion of Mehrabani and Ganjifar [16], it is important to consider the fact that even losing 5–10% of weight significantly improves lipoprotein indices and insulin resistance, lowers blood pressure, and reduces the risks of cardiovascular events. Thus, 3 months later, after an increase in physical activity, it was found that there was a statistically significant reduction in patients with overweight and obesity. It is important to note that the waist size also significantly decreased and the number of patients with abdominal type obesity decreased by 19.5%.

A similar positive association was found in foreign studies. The authors C.H. Lee *et al.* [17] found statistically significant weight reductions 3 months after intervention for moderate (–2.5 ±3.81 vs. –0.3 ±2.24), satisfactory (–1.6 ±3.03 vs. –0.1 ±1.94 kg), and health-enhancing physical activity (HEPA) has a positive effect even on visceral obesity in patients (–1.6 ±3.69% vs. –0.1 ±3.15%). However, the level of glycosylated haemoglobin significantly decreased in patients after HEPA compared to the control group (–0.2 ±0.67 vs. 0.0 ±0.34 mg/dl) [17]. These results suggest it can be assumed that not only the amount of sport is critically important, but also the very fact of having any physical activity on a regular basis. Due to their huge and increasing prevalence in the population, diabetes mellitus and obesity have been recognised by the World Health Organization as non-infectious epidemics of the 21st century. A growing body of scientific evidence also points to the role of overweight in the development of both type 1 and type 2 diabetes [18]. On the one hand, weight gain can be considered as a complication of insulin treatment, and on the other hand, it has a significant pathophysiological effect on the occurrence and progression of diabetes stages. Overweight and obesity are the most important factors in the occurrence of insulin resistance and are primarily compensated by hyperinsulinaemia [18].

The problem of diabetes mellitus is especially acute in people who have a shift work schedule, which aggravates the already existing metabolic changes in this group of patients. Thus, Shan *et al.* [19] published a study in which 143,410 patients took part, assessing the relationship between the duration of shift work on a night shift and lifestyle factors with the risk of diabetes. During about 24 years of follow-up, 10,915 cases of diabetes mellitus were established, while the multivariate risk coefficients of 5-year night shift work before were 1.31 (95% CI: 1.19–1.44), and unhealthy lifestyle (constant smoking, poor nutrition quality, low physical activity, overweight or obesity) – 2.30 (95% CI: 1.88–2.83) [19]. Thus, both night shift work and an unhealthy lifestyle were associated with a higher risk of developing diabetes. These results show that most cases of this disease can be averted with early prevention. In addition to being overweight, the patients also had some carbohydrate metabolism disorders: 21% had elevated glucose levels and another 9% had diabetes mellitus. Moreover, a correlation was found between patients with obesity and diabetes mellitus ($r = 0.54$, $p < 0.001$), and the fact that patients with normal body weight have significantly lower levels of glycosylated haemoglobin ($p < 0.05$) than patients with overweight and obesity.

In a study by Apovian *et al.* [20] conducted in the United States and Europe, which compared people with obesity and people with normal weight, men with obesity had a 7-fold higher risk, and women with obesity had a 12-fold higher risk of diabetes mellitus. It is important to note not only the commonality in the occurrence of these diseases, but also the increased risk of serious complications. Cardiovascular diseases, apnoea, and peripheral blood flow disorders are especially associated with obesity and diabetes. All patients with metabolic disorders (overweight, elevated glucose levels), regardless of the severity and age of occurrence, are recommended to optimise their diet and change eating habits. As indicated in the recommendations of the

American Diabetes Association [21], there is no single universal approach to nutrition for such patients, and the selection of a diet should be individual, considering the current diet model, preferences, and specific glycometabolic goals. Based on studies by nutritionists, for the prevention of obesity-related diseases, the Mediterranean diet is one of the best diets of 2023 [22]. It involves the use of seasonal dishes, the use of extra virgin olive oil, an increase in the amount of legumes, vegetables, fruit, nuts, whole grains, and fish in the daily diet with a restriction on the consumption of sweets, red meat, and dairy products. Such nutrition, like other plant-based approaches, is associated with positive changes in laboratory parameters, and may even reduce the need for high doses of pharmacological drugs [23]. In particular, Mirabelli *et al.* [24] demonstrated important health benefits of the Mediterranean diet model, which can significantly improve fasting glucose, glycosylated haemoglobin, and insulin levels in obese diabetic patients compared to low-fat diets. These glyco-metabolic benefits appear to persist over time, regardless of changes in body weight, because they are not apparent in other successful nutritional interventions for weight loss [24]. Milenkovic *et al.* [25] published data that such a diet compared to other diets showed a decrease in HbA_{1c} by 0.47%, a faster decrease in body weight, and retention for 6 months (weighted mean difference (WMD): –1.84 kg), a significant decrease in triglyceride levels (WMD: –0.21 mmol/l), and an improvement in the level of lipoproteins of high density (WMD: +0.05 mmol/l). The Mediterranean diet in this review has proven to be the best diet for patients with diabetes and overweight. It helps reduce glycosylated haemoglobin, thereby improving glycaemic control, causing weight loss, and improving lipid exchange [25].

Along with foreign publications, this study also found positive changes in the parameters of carbohydrate metabolism: the number of patients with borderline glucose levels decreased statistically significantly (21% vs. 10%, $p < 0.05$), and the number of patients with optimal sugar levels increased significantly. At the same time, there was no significant difference between the number of patients with diabetes at the beginning and at the end of the study (9% vs. 7%, $p > 0.05$). Along with this, HbA_{1c} significantly decreased in patients with overweight and obesity (5.98 ±1.23% and 6.12 ±1.32%, $p < 0.05$, respectively). Jannasch *et al.* [26] investigated the relationship between certain dietary habits and type 2 diabetes. Their systematic review found that the Mediterranean diet demonstrates the potential for early prevention of diabetes and its possible complications. This indicator ranged from 9% to 20%, and the results showed that the longer the adherence to the Mediterranean diet, the lower the risk of carbohydrate metabolism disorders (risk ratio for comparison of extreme quantiles: 0.87, 95% CI: 0.82, 0.93) [26]. This can be explained by the fact that the intake of macronutrient-balanced foods in the long term positively affects both the already existing elevated glucose levels and metabolic changes, and prevents them in the future.

Conclusions

The study of the early prevention of overweight, obesity, and carbohydrate metabolism disorders in workers of an industrial facility in Kazakhstan has led to the following conclusions. It was revealed that in the study group, one-third were overweight, 14% were obese, while abdominal obesity was diagnosed in a statistically larger number. The prevalence of diabetes mellitus was significantly lower (in 9%), while a correlation between it and obesity was confirmed ($r = 0.54$, $p < 0.001$). The level of glycosylated haemoglobin in those with normal weight was significantly lower ($p < 0.05$) than in patients with overweight.

During statistical processing of the results, the following behavioural features of overweight and obese subjects were reliably established: insufficient physical activity, dinner as the main meal, insufficient consumption of vegetables/fruit, and excessive consumption of simple carbohydrates. The use of such methods of early prevention as walking more than 10,000 steps per day, dosed physical activity in the form of cardio and swimming, and nutrition correction (Mediterranean diet with alcohol restriction) significantly reduces body weight and optimises carbohydrate metabolism.

Conflict of interest

The author declares no conflict of interest.

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Received: 22.12.2022
Accepted: 24.02.2023