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Research Article

Dietary Patterns and Economic and Geographic Risk Factors for the Burden of Diabetes Mellitus (Observational Study)

Lyudmila Alexandrovna Radkevich[1]* and Dariya Andreyevna Radkevich[2]

[1]*Doctor of Biological Sciences, Chief Researcher, Center for Theoretical Problems of Physicochemical Pharmacology of the Russian Academy of Sciences, Russia*

[2]*Specialist (Physicist), Analyst, Center for Theoretical Problems of Physicochemical Pharmacology of the Russian Academy of Sciences, Russia*

***Corresponding Author:** Lyudmila Alexandrovna Radkevich, Doctor of Biological Sciences, Chief Researcher, Center for Theoretical Problems of Physicochemical Pharmacology of the Russian Academy of Sciences, Russia.

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Abstract

Purpose: To analyze quality of life, dietary patterns, and metabolic syndrome in countries with the lowest and highest burden of diabetes mellitus (DM2).

Methods and Results: Using the Mann-Whitney U-criterion, we found that the minimum (25 countries) and maximum (25 countries) of 158 countries with DM2 burden was 4-fold different for men in 2004: 186 ± 33 versus 650 ± 122 DALYs ($p \leq 0.0001$). There was no difference between country groups in terms of per capita income in 2000. But countries of Group 1 were located in northern latitudes, 49° ± 11°; countries of Group 2 were located in southern latitudes, 14° ± 12° ($p \leq 0.001$).

The MS predictors - overweight, obesity, hyperglycemia, and LPA - had no statistical differences between Groups 1 and 2. However, overweight and obesity combined accounted for 80% of the population in both groups 1 and 2.

Hyperlipidemia and BP were 2-fold higher in group 1 ($p \leq 0.0001$).

In group 1, there was 1.5 to 4-fold higher consumption: TDC, AP; CV, FS and AB ($p \leq 0.0001$).

Conclusion: DM2 burden was 4 times higher in group 2 than in group 1. However, food consumption levels, quality of life and hyperlipidemia were on average 2 times higher in group 1. Obesity and overweight did not differ between country groups, but reached 80% of the populations in both group 1 and 2. Thus, the DM2 burden was 4-fold higher in countries with low quality of life, low food consumption, and low hyperlipidemia.

Keywords: *Food Consumption Levels; Dietary Patterns; Predictors of Metabolic Syndrome; Burden of Cardiovascular Diseases; Diabetes and Liver Cirrhosis*

Abbreviations

AB: Alcoholic Beverage; AP: Animal Products; BMI: Body Mass Index; BP: Blood Pressure; CVD: Cardiovascular Disease; CD: Communicable, Maternal, Perinatal Diseases; Chol: Blood Cholesterol; CL: Consumption Level of Selected Foods; DM2: Diabetes Mellitus; EEI: Eco-

logical Efficiency Index; FAO: Food and Agriculture Organization of the United Nations; COPD: Chronic Obstructive Pulmonary Disease; FS: Fruits and Sweeteners; GDP: Domestic Gross Product; Glu: Blood Glucose; HPI: Happiness Index; IHD: Index of Human Development; LPA: Low Physical Activity; m: Male; NCD: Non-Communicable Diseases; p: Person; CV: Cereals and Vegetables; RE: Rating Educations; TCL: Total Daily Consumption; UV: Ultraviolet Level

Introduction

The incidence of type 2 diabetes (DM2) is progressing and is a consequence of the global obesity epidemic [1]. Low-income countries are the epicenter of cardio-metabolic diseases (CMD) regardless of genetic predisposition [2]. DM2 accounts for 1.5 million deaths worldwide [3]. Not all obese patients have CMD. The heterogeneity of obesity contributed to the discovery of the cannabinoid receptor type 1 system, a regulator of energy metabolism and obesity [1].

DM2 begins with impaired pancreatic islet Langerhans β-cell function to respond to chronic excess of energy. Excess of energy causes glycemic load, insulin resistance, and leads to obesity [2]. Obesity, high cholesterol level, and high blood pressure are considered major risk factors for DM2 and CVD [3-7]. World obesity rates are estimated at 1.4 billion and are increasing year by year. Obesity affects socioeconomic and ethnic groups and is a prerequisite for metabolic syndrome (MS). MS increases five-fold the risk of DM2 and three-fold the risk of CVD [8-10]. Multiple regression analysis showed that mortality from CVD and DM2 is concentrated in middle- and low-income countries and negatively associated with GDP, GINI and Western diet [11-13]. Vitamin D deficiency has a direct impact on DM2 mechanisms, beta-cell dysfunction, insulin efficacy, and systemic inflammation [14-19].

Purpose of the Study

To assess the impact of dietary patterns, quality of life, and metabolic syndrome (MS) in countries of the world with the lowest and highest burden of type 2 diabetes (DM2) in 2004.

Materials and Methods

Research design: Observation statistical analysis.

For the purpose of this work, a database of the total burden of communicable diseases (CD), non-communicable diseases (NCD), and diabetes mellitus was formed. As premorbid conditions for diabetes mellitus were investigated: endocrine, cardiovascular diseases and liver cirrhosis (ICD-10 codes). Two groups were formed for 25 countries with a minimum incidence and for 25 countries with a maximum incidence.

Disease burden (DALY) data for men (all ages) in 25 countries, standardized by sex and age per 100,000 population, were selected from the GBD 2004 database [20].

A number of indicators were used to characterize quality of life (QOL) in countries: per capita income, or gross domestic product (GDP) in 2008 (US dollars per person per day) [21]; geographical location of countries by latitude and the level of ultraviolet radiation in the capital (UV) (J/m^2 2004) [22]; life expectancy for men (LE) [23]; access to good health care, clean water and clean air [24]; Index of Happiness (IH), or the Internal Gross Happiness in 2016 [25]. Body Mass Index (BMI) ≥ 25 kg/m^2 and ≥ 30 kg/m^2 have been studied as predictors of metabolic syndrome (MSP) - the percentage of men in the country with overweight and obesity; and the percentage of men with blood cholesterol (Chol ≥ 5.0 mmol/l and ≥ 6.2 mmol/l); blood glucose (Glu ≥ 7.0 mmol/l); blood pressure (BP ≥ 140/90 mmHg); with low physical activity (LPA) ≤ 60 min/day walking [26]. Daily Food Consumption Level (TDC) (g/person/day) (47 types of products) for each country was selected from the FAO database for 2003 - 2005 [27].

The nutrition structure (NS) of the countries is presented in the form of 4 blocks in absolute and in percentage of (NS): 1 - products of animal origin (AP); 2 - cereals and vegetables (CV); 3 - fruits and sweeteners (FS); 4 - alcoholic beverages (AB); 5 - vegetable oils (VO); 6 - fish (F). The composition of macro-elements was also analyzed [27].

Statistical analysis of the study results was performed using Mann-Whitney-Wilcoxon U-criterion and Multiple Linear Regression Analysis for Independent Samples (MRA). U is the numerical value of the Mann-Whitney Criterion. The central trend in data distribution in the sample was represented by the mediana.

The dispersion of data in the samples was estimated by means of the quartile range (QR) between the first and the third quartiles, that is between the 25^{th} and 75^{th} percentiles. Level of statistical significance that reflects the degree of confidence in the conclusion about the differences between indicators of 1 and 2 groups of countries. Two levels of accuracy were assessed: (1) $p \leq 0.01$ - error probability 1%; (2) $p \leq 0.05$ - error probability 5%.

All calculations were performed using StatSoft software (version 13).

Results

Quality of life

Per capita income was 3.4 times higher in group 1 compared to group 2 in 2000, but not statistically significant ($p \geq 0.06$). In 2008 per capita income in group 1 was 3.5 times higher than in group 2 ($p \leq 0.03$). There was a statistically significant difference between group 1 and group 2 in geographic latitude: 49° vs. 14° ($p \leq 0.0001$), longitude: 16° vs. 59° ($p \leq 0.001$) and ultraviolet (UV) levels of 1907 J/m^2 vs. 4931 J/m^2 ($p \leq 0.0001$) (Table 1).

Variable	U	Z	p-value	Median 1	Quartile 1	Median 2	Quartile 2
The quality of life							
IPC 2000 $	15,00	1,88	0,0598	21,509	23,259	6,312	10,188
IPC 2008 $	198,00	2,21	0,0270	28,500	30,600	8,900	16,200
IPC 2016 $	155,00	2,89	0,0039	40,262	33,842	13,225	16,827
lat°	21,00	5,65	0,0000	49	11	14	12
UV rad. J/m^2	27,00	- 5,53	0,0000	1907	844	4931	593
lon°	146,50	- 3,21	0,0013	16	37	59	46
Prosperity Rating	128,00	- 3,43	0,0006	22	49	72	15
Rating Educations	99,00	- 4,01	0,0001	28	42	72	13
RPF - Personal freedom	218,00	- 1,63	0,1031	33	80	71	18
RPC - Personal capital security	143,00	- 3,13	0,0017	29	56	72	26
CR - Corruption Rank	141,50	- 2,47	0,0136	26	71	90	67
PR - Peacefulness Rank	54,00	- 2,90	0,0037	26	54	88	47
IHD - Happiness index 2006	206,00	- 2,06	0,0397	42	8	52	21
IHD - Happiness index 2016	126,00	2,05	0,0403	6,537	2,115	5,956	1,604
HDI - Human Development Index	145,50	3,23	0,0012	0,947	0,164	0,772	0,144
IE - Environmental Performance Index	139,00	2,90	0,0037	64	25	52	14

ASM 1990	113,00	3,17	0,0015	100	15	84	18
ACW 1990	90,50	3,40	0,0007	100	21	76	41
ACA 2004	185,50	- 1,90	0,0578	0	6	15	64
male life expectancy	156,50	3,02	0,0026	75	5	69	8
female life expectancy	116,00	3,80	0,0001	81	8	74	7
IPD - Burden of Infectious Disease (DALY)	98,00	- 4,15	0,0000	179	1289	2202	2233
NCD - Burden of noncommunicable diseases (DALYs)	151,00	- 3,12	0,0018	10057	3306	13792	2750
Diabetes mellitus	-	- 6,05	0,0000	186	33	650	122
Endocrine disorders	103,00	- 4,06	0,0001	120	75	342	287
Cardiovascular diseases	188,00	- 2,41	0,0161	2079	2553	3970	1969
Ischaemic heart disease	219,00	- 1,80	0,0712	1047	1062	1519	897
Cerebrovascular disease	208,00	- 2,02	0,0436	451	879	1181	845
Hypertensive heart disease	93,00	- 4,25	0,0000	39	129	328	178
Cirrhosis of the liver	277,00	- 0,68	0,4971	223	280	255	311
Metabolic syndrome - MS (predictors) % in the population							
Male BMI ≥ 25	282,00	0,58	0,5605	59	14	58	20
Male BMI ≥ 30	291,00	0,41	0,6837	20	9	20	12
Male Chol. ≥ 5.0	106,00	4,00	0,0001	57	21	35	19
Male Chol. ≥ 6.2	108,00	3,96	0,0001	15	11	7	7
Male Glu. ≥ 7.0	306,00	0,12	0,9073	11	2	11	4
Male BP2 ≥ 140/90	105,00	4,02	0,0001	47	5	42	7
Male LPA ≤ 60 min	93,00	- 1,34	0,1787	31	20	38	20

Table 1: *Comparative analysis of quality of life and MS predictors and for the burden of diabetes mellitus in groups 1 and 2 of countries with different levels of TDC (Manna Whitney U-criterion) (Manna Whitney U-criterion).*

Legend: The quality of life

IPC: Per Capita Income; UV rad.: Ultraviolet Radiation; RE: Education Rating; RPF: Personal Freedom; RPC: Personal Capital Security; CR: Corruption Rank; PR: Peacefulness Rank; HDI: Human Development Index; IE: Environmental Performance Index; ASM: Availability of Medicine; ACW: Clean Water; ACA: Clean Air; IHD: Happiness Index; IPD: Burden of Infectious Disease (DALY); NCD: Burden of Noncommunicable Diseases (DALYs); MS: Metabolic Syndrome (predictors)% in the Population; BMI: Body Mass Index; Chol.: Hyperlipidemia; Glu.: Hyperglycemia; LPA: Low Physical Activity.

The levels of prosperity and peacefulness were 3 times higher in group 1 ($p \leq 0.001$) and ($p \leq 0.004$), respectively. The level of corruption was 1.2 times lower in group 1 ($p \leq 0.04$). Group 1 had 1.2 times higher human development index (HDI) and environmental efficiency (EE) ($p \leq 0.002$). Group 1 had on 16% more efficient health care, 25% higher access to clean water ($p \leq 0.001$) and clean air, but not significantly ($p \geq 0.1$) (Table 1). Group 1 had 6 years higher life expectancy (LE) for men and 7 years higher for women ($p \leq 0.002$). The

Happiness Index was 10% higher in group 1 than in group 2 ($p \leq 0.04$) The GINI coefficient was not statistically different between groups 1 and 2 ($p \geq 0.1$). However, Group 2 had 1.03 times higher GINI (Table 1).

Thus, the residents of group 1 were generally more successful than of group 2. Countries of group 2 had a higher UV level of 3,000 J/m^2, as Group 2 was 35 ° closer to the equator than group 1.

The burden of diabetes mellitus and premorbid conditions

Group 1 had a 12-fold lower overall burden of infectious disease (CD) ($p \leq 0.0001$) and a 1.4-fold lower overall burden of non-communicable disease (NCD) ($p \leq 0.002$) (Table 1).

Group 1 had 4.0 times lower burden of diabetes mellitus ($p \leq 0.0001$); 3.0 times lower burden of endocrine diseases ($p \leq 0.0001$); 3.0 times lower burden of cerebrovascular diseases ($p \leq 0.04$); 8.0 times lower burden of hypertension ($p \leq 0.0001$); difference in burden of cirrhosis was statistically insignificant ($p \geq 0.5$) between groups (Table 1).

Thus, the burden of diabetes mellitus was 4.0 times lower in group 1 compared to group 2. The burden of premorbid diseases was also more associated with countries of group 2.

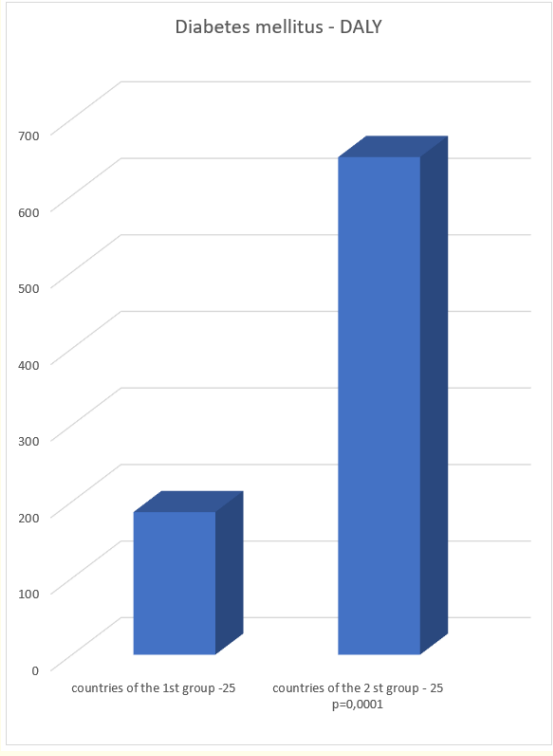

Figure 1: *Burden of diabetes mellitus in groups 1 and 2 countries.*

Metabolic syndrome

The proportions (%) of men who were overweight (BMI ≥ 25) and obese (BMI ≥ 30)) in group 1 compared to group 2 were not statistically different between country groups (p ≥ 0.6) and (p ≥ 0.7), respectively. At the same time, in both group 1 and 2, the percentages in the populations of overweight and obese men cumulatively reached 80% (Table 1).

There were 2.0 times higher proportions (%) of men with hyperlipidemia in group 1: (Chol. ≥ 5.0) (p ≤ 0.0001) and (Chol. ≥ 6.2) (p ≤ 0.0001); 1.1-fold higher proportion (%) of men with high blood pressure: (BP ≥ 140/90 mm/Hg) (p ≤ 0.0001) (Table 1).

There were no statistical differences in the proportion (%) of men with hyperglycemia (Glu. ≥ 7.0) (p ≥ 0.9) and low physical activity (LPA ≤ 60 min) (p ≥ 0.2) in groups 1 and 2 (Table 1).

Thus, overweight, obesity, hyperglycemia, and LPA did not have statistical differences between groups 1 and 2. However, the cumulative proportion of overweight and obese men was as high as 80% in both groups 1 and 2.

Hyperlipidemia and BP were statistically higher in group 1 compared to group 2 (Table 1).

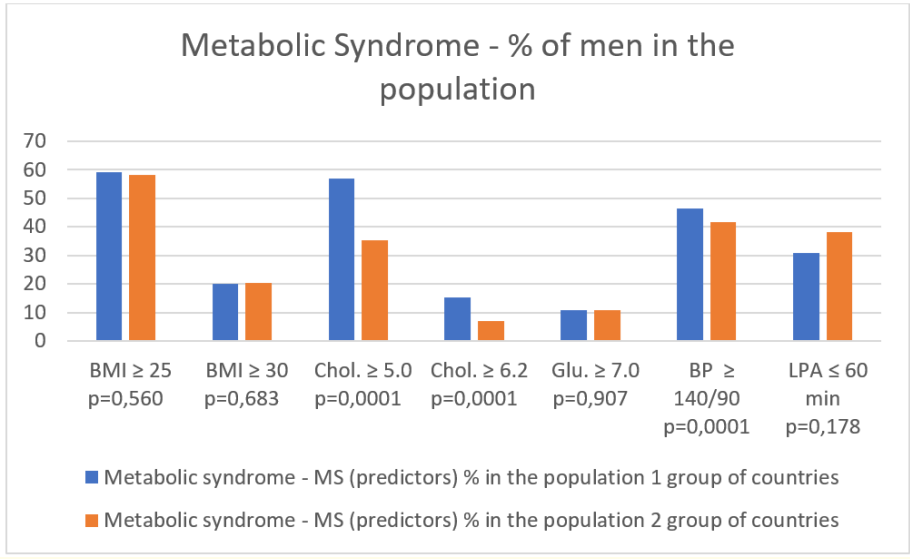

Figure 2: *Metabolic syndrome - MS (predictors) % of men in the population.*

Dietary patterns

Consumption levels

In group 1, compared to group 2, the daily food consumption (TDC) was 1.6 times higher (p ≤ 0.0001) (Table 2 and 3).

Variable	U	Z	p-value	Median 1	Quartile 1	Median 2	Quartile 2
Dietary Patterns - Food Structure							
Total Daily food consumption -TDC							
TDC gram/person/day	53,50	5,02	0,0000	2109	405	1334	459
Components of TDC							
AP - Animal products	89,50	4,32	0,0000	731	274	434	202
CV - Grains vegetables	103,50	4,05	0,0001	835	338	546	234
FS - Fruit, sweeteners	165,00	2,85	0,0043	231	157	143	75
AB - Alcoholic beverages	116,00	3,80	0,0001	204	217	58	63
VO - Vegetable oils	179,50	2,57	0,0101	16	12	8	18
F - Fish	310,50	- 0,03	0,9768	47	36	43	55
Percentage structure of TDC							
% AP	256,50	1,08	0,2815	35	7	32	13
% CV	240,00	- 1,40	0,1624	42	17	48	12
% FS	307,50	- 0,09	0,9304	12	5	12	5
% AB	174,00	2,68	0,0074	10	10	5	7
% Oil	260,00	1,01	0,3130	0,8	0,6	0,6	1,4
% Fish	205,00	- 2,08	0,0379	2,3	1,7	3,4	4,8
Community Nutrients							
Energy kcal/person/day	119,50	3,74	0,0002	3190	410	2820	410
Carboh% E	121,00	- 3,71	0,0002	56	11	64	8
Proteins%E	119,50	3,74	0,0002	12	2	11	1
Fats%E	135,50	3,42	0,0006	32	10	25	6
Nutrients in animal products							
AP Energy %	96,00	4,19	0,0000	31	12	16	6
AP Protein %	156,00	3,03	0,0025	57	13	42	11
AP Fat %	131,50	3,50	0,0005	59	9	38	17
Micronutrients							
Animal origin	180,00	2,56	0,0104	3,4	1,2	2,1	1,6
Vit A	307,00	- 0,10	0,9227	6	1	7	1
Vegetal origin	231,50	- 1,56	0,1183	10	3	11	4
Diversification of nutrients							
DEnergy%	176,50	2,63	0,0086	67	20	52	13
DProteins%	204,50	2,09	0,0370	68	17	58	13
DFats%	166,00	2,83	0,0046	96	3	94	5
mDailyAge	101,50	1,56	0,1177	32	19	22	26
Nutritional deficiencies	141,00	- 3,32	0,0009	67	245	329	344
Protein-energy malnutrition	100,00	- 4,11	0,0000	15	63	135	198
Iodine deficiency	285,00	0,52	0,6004	0	6	0	21
Vitamin A deficiency	179,50	- 2,57	0,0101	0	0	0	1
Iron-deficiency anaemia	114,00	- 3,84	0,0001	50	62	112	160

Table 2: *Comparative analysis of dietary patterns, including nutrients in groups 1 and 2 of countries differing in TDC levels (Manna Whitney U-criterion).*

Legends: Food Structure

TDC: Total Daily Food Consumption; AP: Animal Products; GV: Grains Vegetables; FS: Fruit, Sweeteners; AB: Alcoholic Beverages; VO: Vegetable Oils; F: Fish. Nutrients in animal products, Community Nutrients, Total energy, Total carbohydrates, Total proteins, Micronutrients, Diversification of nutrients, Smoking - number of cigarettes per day, Components of TDC, Percentage structure of TDC, gram/person/day, kcal/person/day.

Variable	U	Z	p-value	Median 1	Quartile 1	Median 2	Quartile 2
Food consumption levels - gram/person/day							
TDC - Total Daily food consumption -TDC	53,50	5,02	0,0000	2109	405	1334	459
AP - Animal products							
Bovine Meat	120,50	3,72	0,0002	49	34	21	13
Poultry Meat	206,00	- 2,06	0,0397	39	33	74	61
Mutton and Goat Meat	260,50	1,00	0,3177	8	13	5	13
Pigmeat	114,50	3,83	0,0001	59	61	11	18
Meat, Other	139,00	3,36	0,0008	46	14	33	10
Offals, Edible	203,50	2,11	0,0353	8	10	5	5
Milk, Whole	122,00	3,69	0,0002	275	174	144	121
Milk, Skimmed	205,00	2,08	0,0379	36	73	13	50
Eggs	134,50	3,44	0,0006	28	14	11	7
Cheese	149,00	3,16	0,0016	19	39	4	7
Butter, Ghee	143,50	3,12	0,0018	7	9	2	3
Fats, Animals,	154,50	2,90	0,0037	7	7	4	5
Freshwater Fish	193,00	2,31	0,0209	5	10	2	4
Demersal Fish	222,50	1,74	0,0825	12	19	5	12
Pelagic Fish	283,00	- 0,56	0,5737	13	14	16	32
Marine Fish, Other	176,50	- 2,63	0,0086	3	5	7	12
Molluscs, Other	213,00	1,73	0,0836	2	11	1	1
Fish amount	310,50	- 0,03	0,9768	47	36	43	55
% Fish	205,00	- 2,08	0,0379	2	2	3	5
AP amount	89,50	4,32	0,0000	731	274	434	202
% AP	256,50	1,08	0,2815	35	7	32	13
GV - Grains vegetables							
Wheat	98,50	4,14	0,0000	274	118	151	155
Rice	86,00	- 4,39	0,0000	13	10	116	122
Maize	176,50	- 1,31	0,1895	9	30	23	51
Barley	213,00	1,92	0,0547	3	8	0	3
Beans	236,00	- 1,47	0,1403	2	3	3	6
Rye	80,00	2,96	0,0031	2	18	0	1
Nuts	179,50	2,57	0,0101	6	6	2	5
Potatoes	53,00	4,93	0,0000	179	115	42	52
Tomatoes	168,50	2,45	0,0145	55	39	20	43
Onions	240,00	1,40	0,1624	22	23	13	21
Vegetables, Other	139,50	3,35	0,0008	179	111	108	100
Soyabean Oil	283,00	0,56	0,5737	9	10	5	11

Sunflowerseed Oil	155,50	3,04	0,0024	3	12	0	3
Olive Oil	143,50	3,27	0,0011	2	3	0	1
Oil amount	179,50	2,57	0,0101	16	12	8	18
% Oil	260,00	1,01	0,3130	1	1	1	1
CV amount	103,50	4,05	0,0001	835	338	546	234
% CV	240,00	- 1,40	0,1624	42	17	48	12
FS - Fruit, sweeteners							
Oranges	172,00	1,77	0,0767	36	71	24	47
Lemons, Limes	270,50	0,58	0,5619	4	3	4	5
Apples	41,50	5,25	0,0000	43	40	9	18
Honey	182,50	2,51	0,0120	1	0	0	1
Sugar	258,50	1,04	0,2992	105	29	93	53
Coffee	194,00	2,29	0,0220	9	16	4	5
Tea	265,50	- 0,90	0,3669	2	2	3	1
FS amount	165,00	2,85	0,0043	231	157	143	75
% FS	307,50	- 0,09	0,9304	12	5	12	5
AB - Alcoholic beverages							
Beverages, Alcoholic	178,00	2,60	0,0093	9	11	2	10
Wine	66,00	4,67	0,0000	26	46	1	4
Beer	129,50	3,54	0,0004	152	166	50	57
AB amount	116,00	3,80	0,0001	204	217	58	63
% AB	174,00	2,68	0,0074	10	10	5	7

Table 3: *Comparative analysis of the structure of food - levels of consumption of individual products with different levels of TDC (Manna Whitney U-criterion).*

TDC: Total Daily Food Consumption; AP: Animal Products; GV: Grains Vegetables; FS: Fruit, Sweeteners; AB: Alcoholic Beverages; VO: Vegetable Oils; F: Fish.

Group 1 had 1.8 times higher consumption of animal products (AP) ($p \leq 0.0001$); 1.5 times higher consumption of cereals and vegetables (CV); 1.6 times higher consumption of fruits and sweeteners (FS) ($p \leq 0.004$); 3.5 times higher consumption of alcoholic beverages (AB) ($p \leq 0.0001$); 2 times higher consumption of vegetable oils (VO) ($p \leq 0.01$) and there were no statistical differences in fish consumption (F) ($p \geq 0.9$) (Table 2 and 3).

Thus, both TDC and its components AP, CV, FS, AB and VO were higher in group 1.

At the same time, the percentages of AP, CV, FS and VO in TDC were not statistically different in groups 1 and 2. However, % of AB was 2 times higher in group 1 ($p \leq 0.007$), and % of F was 1.5 times higher in group 2 ($p \leq 0.04$).

We can conclude that the levels of food consumption in group 1 differ from group 2 in terms of volume and percentage.

Nutrients

Group 1 had 1.13 times higher total energy ($p \leq 0.001$); 1.14 times lower total carbohydrates ($p \leq 0.0002$), 1.09 times higher total proteins ($p \leq 0.0002$), and 1.28 times higher total fats ($p \leq 0.0006$) (Table 2).

Group 1 compared with group 2 had 2.0 times higher levels of energy from animal products, AP ($p \leq 0.0001$); 1.4 times higher levels of animal proteins, AP ($p \leq 0.003$), and 1.6 times higher levels of animal fats, AP ($p \leq 0.0005$).

Group 1 had 1.6 times higher levels of iron from animal products ($p \leq 0.01$).

Group 1 had a 1.2-fold higher diversification of total energy, proteins, and fats ($p \leq 0.004$) (Table 2).

Thus, group 1 had higher levels of total and animal nutrients, except for carbohydrates, which were higher in group 2.

Discussion

DM2 is a rapidly growing and most pressing health problem of the 21st century. Countries in the Arab world have the highest incidence of DM2 [28,29]. Globalization plays an important role in the increase of DM2 worldwide [30-32]. The total cost of DM2 and its consequences will rise from 0.4% to 62.5% of countries' GDP per capita by 2030 [33-35]. Insulin resistance is a major factor in the development of DM2 and a major cause of morbidity and mortality [36].

Diets such as "stop hypertension", Mediterranean, intermittent fasting can reduce CVD risk and improve control of body weight, arterial hypertension, dyslipidemia, and DM2 through multiple pathways, including reducing oxidative stress and ketogenesis [37].

Weight changes are accompanied by an imbalance between caloric intake and expenditure. It is assumed that the different components of the energy balance are dynamically interrelated, and weight loss is counteracted by balancing physiological processes. Low-carbohydrate diets have been proposed to partially undermine these processes by increasing energy expenditure and promoting fat loss [38].

Circadian rhythms and sleep and wakefulness disorders have been shown to be associated with DM2 [39].

Endogenous, 24-hour circadian rhythms in the brain, autonomic nervous system, heart, and vessels tune the cardiovascular system for optimal functioning during expected cycles [40].

Melatonin synchronizes central and peripheral oscillators of the fetal adrenal and pancreatic glands [41]. Melatonin can be used to treat and prevent DM2 and, as a consequence, associated metabolic disorders [42].

The discovery of the genetic basis of circadian rhythms (Nobel Prize 2017) has expanded knowledge about the temporal organization of behavior and physiology of living organisms. The circadian gene network is present in most living organisms from bacteria to humans. New therapeutic options for obesity, DM2 and CVD could arise [43].

The circadian timekeeping system consists of a central clock in the hypothalamic nucleus (suprachiasmatic nucleus) and various clocks in the peripheral organs and tissues. The circadian time system is responsible for coordinating daily processes by incorporating human glucose into the circadian rhythm of metabolism. The central clock regulates food consumption, whole body energy expenditure, and insulin sensitivity [36]. Globally, sleep duration has been steadily decreasing over the past 50 years. It has become clear that larks and owls are genetically determined different chronotypes. Circadian abnormalities are detrimental to human health and can contribute to the risk of DM2 [44-47]. A common variant of the gene encoding melatonin receptor 2 (MTNR1B) has been shown to be associated with impaired glucose homeostasis, decreased insulin secretion and increased risk of DM2 [48].

Our studies showed that the minimum (25 countries) and maximum (25 countries) CD2 burden for men in 158 countries differed by 4 times in 2004: 186 ± 33 versus 650 ± 122 DALYs ($p \leq 0.0001$) and was higher in the Arab countries and the Caribbean countries. There was no difference between country groups in per capita income in 2000. But countries of group 1 were located in northern latitudes, 49° ± 11°; and group 2 in southern latitudes, 14° ± 12° ($p \leq 0.001$) with a high UV of 5000 J/m^2.

	List of countries	2004		
№	1 group of countries	Diabetes mellitus (DALY)	2 group of countries	Diabetes mellitus (DALY)
1	Mongolia	95	Malaysia	547
2	Iceland	97	Honduras	574
3	Ireland	150	Belize	581
4	Luxembourg	154	Nicaragua	583
5	United Kingdom	163	Côte d'Ivoire	588
6	Russian F	166	Kuwait	591
7	Belgium	168	Bahamas	602
8	Norway	178	Angola	605
9	Tunisia	179	Solomon Islands	606
10	Switzerland	182	Barbados	617
11	Albania	185	Samoa	640
12	Croatia	185	Sierra Leone	641
13	France	186	Dominican Republic	650
14	Ukraine	187	Suriname	650
15	Kazakhstan	190	Armenia	669
16	Finland	192	Brunei	685
17	Djibouti	196	Vanuatu	686
18	Japan	198	Saudi Arabia	700
19	Morocco	201	South Africa	724
20	The Netherlands	203	Guyana	769
21	Sweden	204	Fiji	786
22	China	205	Mexico	869
23	New Zealand	208	United Arab E	1023
24	Czech Republic	210	Mauritius	1080
25	Georgia	211	Trinidad and Tobago	1436

Predictors of MS - overweight, obesity, hyperglycemia, and LPF - had no statistical difference between groups 1 and 2. However, overweight and obesity combined accounted for 80% of the population in both groups 1 and 2.

Hyperlipidemia and BP were 2-fold higher in Group 1 ($p \leq 0.0001$).

In group 1 food consumption was 1.5 - 4 times higher, both daily dose (TDC), and its components: AP; CV, FS, and AB ($p \leq 0.0001$). In group 1 the level of macronutrient of animal products (AP) was 2 times higher, and there was a higher diversification of nutrients. The

data we obtained were confirmed by our earlier studies [49-51] and also by other researchers [11-13]. Conflicting data on DM2 risk factors and the threatening growth of DM2 worldwide requires further research on risk factors.

Conclusion

The DM2 burden was 4 times higher in group 2 than in group 1. However, consumption levels, quality of life, and hyperlipidemia were on average 2 times higher in group 1. Obesity and overweight did not differ between country groups but reached 80% of the populations in both group 1 and group 2. Thus, the DM2 burden was 4-fold higher in countries located in southern latitudes, with low quality of life, low food consumption, and low hyperlipidemia.

Conflict of Interest

The authors have no conflict of interest.

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