Journal of Food and Nutrition Research, 2016, Vol. 4, No. 11, 729-735
Available online at http://pubs.sciepub.com/jfnr/4/11/5

DOI:10.12691/jfnr-4-11-5

Same Dietary but Different Physical Activity Pattern in Normal-weight and Overweight Mexican Subjects

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Abstract The prevalence of overweight and obesity has increased significantly in Westernized countries including Mexico. In general, unbalanced diets and physical inactivity have been identified as environmental factors that contribute to the obesity epidemic. The aim of this study was to compare the patterns of dietary intake and physical activity between Mexican individuals with normal-weight and overweight. In a cross-sectional and analytical study, 500 subjects were included. A 3-day food record and a food frequency questionnaire were used to evaluate dietary intake. In general, both groups had a higher intake of total fatty acids (36.9 ± 7.1%), saturated fatty acids (12.2 ± 3.5%), simple carbohydrates (19.2 ± 6.9%), dietary cholesterol (338.1 ± 253.8 mg/d) and a high n-6:n-3 PUFA ratio (12:1). In contrast, an insufficient daily consumption of PUFA (6.7 ± 5.7%), vitamins A and E, magnesium and zinc were found. The main foods that contributed to these dietary characteristics were an overconsumption of sugars, fats, and meat as well as an insufficient consumption of fruits and vegetables. Additionally, the normal-weight group had a higher prevalence of physical activity than the overweight group (56.7% *vs.* 33.3%, $p<0.05$). In conclusion both normal-weight and overweight groups had an inadequate dietary pattern, which could lead to the development of obesity, type 2 diabetes, and metabolic disease. Our work highlights the importance of dietary guidance and lifestyle intervention in both normal-weight and overweight groups.

Keywords: *Diet, PUFA, normal-weight, overweight, physical activity*

Cite This Article: Wendy Campos-Pérez, Karina González-Becerra, Omar Ramos-López, Jorge A Silva-Gómez, Elisa Barrón-Cabrera, Sonia Roman, Arturo Panduro, and Erika Martínez-López, "Same Dietary but Different Physical Activity Pattern in Normal-weight and Overweight Mexican Subjects." *Journal of Food and Nutrition Research*, vol. 4, no. 11 (2016): 729-735. doi: 10.12691/jfnr-4-11-5.

1. Introduction

In the last decades, the prevalence of overweight and obesity has increased significantly in Westernized countries including Mexico [1]. Currently more than 70% of the Mexican population presents overweight and obesity [2,3]. Obesity is considered as an important risk factor for the development of type 2 diabetes mellitus (T2DM), cardiovascular diseases (CVD) and liver diseases [4,5], in which cultural, environmental, behavioral and genetic factors are involved [6]. Moreover, unbalanced diets and physical inactivity have been identified as the main environmental factors that contribute to the obesity epidemic in Mexico [7].

In this context, a frequent consumption of industrially processed foods in West Mexico including sweetened beverages, fast food, sausages and confectionery products, increase the proportional amounts of calories, simple carbohydrates, saturated fat and cholesterol [8,9]. In contrast, reductions in the inputs of essential micronutrients and dietary fiber were documented as the result of a low consumption of vegetables and fruits [9]. On the other hand, a recent study showed more than 65% of the general population in West Mexico were physically inactive [9]. Moreover, the ENSANUT reported a 47% increase in the prevalence of physical inactivity in Mexican adults from 2006 to 2012 [10]. These trends are similar to the global physical activity levels in adults and are explained by sedentary behaviors [11].

To date, there are no intervention strategies with enough effectiveness in the reduction of obesity rates in our population, despite the high prevalence of obesity in Mexico and its impact on health [12,13]. Most studies have described dietary habits and physical activity in overweight and obese individuals [14,15]; whereas the analysis of these factors in normal-weight individuals remains less explored. The aim of this study was to compare the patterns of dietary intake and physical activity between normal-weight, and overweight Mexican subjects.

2. Materials and Methods

2.1. Study Population

In this study, 500 subjects between the age of 18 and 65 years were enrolled from April 2011 to May 2013. These subjects went through a general medical screening at the Nutrigenomic and Nutrigenetic Clinic at the Civil Hospital “Fray Antonio Alcalde” in Guadalajara, Jalisco, Mexico. Subjects were selected using a stratified cluster random sampling frame. Exclusion criteria included a history of cardiovascular, liver, kidney or pancreas disease and history of malabsorption or alcoholism (consumption ≥ 40g and ≥20g of alcohol per day for man and woman, respectively).

2.2. Dietary Intake

Each subject was interviewed with a medical history questionnaire to obtain sociodemographic data which included the assessment of physical activity and dietetic habits. Habitual dietary intake was estimated by a validated food frequency questionnaire and a 3-day food consumption record, including a weekend day. Food scales and models were used to enhance the accuracy of the portions sizes based on Mexican food composition tables as a reference [16]. All subjects were instructed to write the dietary history questionnaire. Then, completed questionnaires were analyzed using the Nutritionist Pro™ Diet Analysis software, (Axxya Systems, USA) by a professional nutritionist.

Data were interpreted and contrasted according to the ranges expressed as percentage of total kilocalories (Kcal) recommended by the Official Mexican Norms: NOM-037-SSA2-2012 [15], NOM-015-SSA2-2010 [17], and ATPIII [18].

2.3. Anthropometric Measurements

Height and weight were measured after a 12 hour fast wearing light clothes. Waist circumference was measured at the narrowest diameter between the xiphoid and iliac crest. Tetrapolar body electrical bioimpedance was used to determine the body composition (InBody 3.0, Biospace CO., Korea). Body mass index (BMI) was calculated as weight in kilograms divided by height squared in meters (kg/m2). All subjects were classified by BMI to assess the nutrition status according to criteria established by the World Health Organization (WHO) in 2012 [19]. Subjects were classified into two groups: normal-weight (NW: BMI 18.5 to < 25 Kg/m^2) and overweight (OW: BMI ≥25Kg/m^2). We used the cut-off points of the International Diabetes Federation to determine abdominal obesity [20].

2.4. Physical Activity Assessment

The physical activity information was obtained through a questionnaire. The information included the type of exercise, number, duration and frequency of sessions per week. Subjects were classified as sedentary if they did not perform any kind of physical activity or less than 2 times per week. Subjects who exercised 3 times or more a week for a minimum of 30 minutes each, were classified as physically active according to WHO recommendations 2010 [21]. Besides, physical activity was classified according to Rapid Assessment of Physical Activity (RAPA) for the Latin population [22].

2.5. Definitions

For purposes of comparison, the following cut-off points were established: total energy intake >1200kcal, of these: 15% Ps, TFA <30%, SFA <7%, MUFA >10%, PUFA >10%, CH consumption <55%, of these <10% of sCH and at least 20g of fiber [15,16]; and the cutoff for the n-6:n-3 PUFA ratio was 5:1 [23]. Micronutrients intake were compared with the daily recommended intake established by the National Institute of Medical Sciences and Nutrition “Salvador Zubirán” for the Mexican population [24]. Portions intake were compared with the National Mexican Academy of Medicine recommendations [25].

2.6. Statistical Analysis

All quantitative variables are shown as mean ± SD, whereas qualitative variables are expressed as absolute frequency (n) and percentage (%). For comparative purposes, subjects were grouped as NW and OW. The distribution of variables was analyzed by Kolmogorov-Smirnov test. Quantitative variables with normal distribution were analyzed with a two-tailed Student’s t-test. Nonparametric variables were analyzed with the U Mann–Whitney test. The differences in average intake *versus* recommended dietary references were statistically analyzed using the one-sample t-test. All analyses were done using the SPSS statistical package (Version 19, SPSS Inc, Chicago IL). A $p<0.05$ value was considered statistically significant.

2.7. Ethical Guidelines

Subjects were informed about the procedures of the study and signed a consent form before their inclusion. All practices were performed according to the Helsinki´s Declaration 2013. This study was approved by the Committee of Ethics for Human Research of the University of Guadalajara, Jalisco, Mexico (Register number: CI/019/2010).

3. Results

3.1. Population Description

Demographic and anthropometric characteristics of the study participants are showed in Table 1. The mean of age of the study population was 37.6±10.8 years, 71% (n=355) were women and 29% (n=145) were men. Among the study group, 27% (n=137) had normal-weight (NW) and 73% (n=363) had overweight (OW). The mean of waist circumference was 91.6 ± 14.3 cm and by gender was: 97.6 ± 12.8cm and 89.2 ± 14.2 cm in males and females, respectively. According to these data, the 60.8% (n=304) of the total study population had abdominal obesity. No significant differences in gender and age between NW and OW group were found.

3.2. Physical Activity

Regarding physical activity, 58.2% of total subjects did not perform physical activity. The NW subjects had a higher prevalence of physical activity (56.7%) compared with OW subjects (33.3%), $p<0.0001$. The type of mild-intensity physical activity were walking, yoga and housework; moderate-intensity physical activity was fast walking, aerobics classes, dancing and weightlifting and in vigorous-intensity physical activity were jogging or running, soccer and swimming. The significant differences are showed in Table 1.

Table 1. Demographic, anthropometric and physical activity characteristics of study participants

Variable	General population	NW Group	OW Group	P value
Number of subjects	500	137	363	---
Age (years)	37.6±10.9	36.5±11.1	38±10.9	0.166
Gender (F/M)	355/145	94/43	261/102	0.573
Waist circumference (cm)	91.6 ± 14.3	77.6±8.5	97.0±12.3	**<0.0001**
Weight (kg)	75.7±16.1	61.5±8.9	81±14.9	**<0.0001**
BMI (Kg/m^2)	28.5±5.4	22.2±1.7	31.2±5.1	**<0.0001**
Physical Activity Frequency (%)	41.8	56.7	33.3	**<0.0001**
Mild (%)	15.6	9.7	27.9	**0.016**
Moderate (%)	76.3	79.2	69.1	**0.045**
Vigorous (%)	8.1	11.1	3.9	0.054

The p-value are significant differences between the groups (Normal-weight *vs* overweight).

3.3. Macronutrients Intake

According to the 3-day food consumption record, the average of total energy intake in the subjects was 2570 ± 817.2 kcal/day. The mean value of macronutrients in the study subjects in comparison with the recommendations showed an excessive intake of TFA, SFA, cholesterol, and sCH, but deficient intake of PUFA (Table 2). Overall, both groups had an inadequate pattern of macronutrients intake (excessive in TFA, SFA, cholesterol, sCH, and insufficient PUFA). However, the analysis of the pattern of macronutrients intake showed that the NW group had a significantly higher intake of maltose and galactose ($p<0.05$), while OW group showed a higher intake of MUFA ($p<0.01$) (Table 2).

Table 2. Comparison of nutrients intake between normal-weight and overweight subjects

Nutrients	Dietary references[a]	General intake	NW group	OW group	P value
Energy (Kcal/d)	------	2570 ± 817.2	2651.7 ± 977.6	2522.1 ± 1094	0.439
Ps (%)	15	17.2 ± 3.7	16.8 ± 3.1	17.4 ± 4.0	0.309
TFA (%)	<30	36.9 ± 7.1*	36.0 ± 8.0	37.4 ± 6.5	0.222
SFA (%)	<7	12.2 ± 3.5 *	12.2 ± 3.58	12.2 ± 3.5	0.991
MUFA (%)	>10	11.0 ± 3.5	9.6 ± 3.5	11.1 ± 3.3	0.007
PUFA (%)	10	6.7 ± 3.0†	6.21 ± 3.2	6.9 ± 2.7	0.125
n-6:n-3 PUFA ratio	<5:1	12:1	11.4:1	11.6:1	0.812
CH (%)	55	47.5 ± 8†	46.26 ± 8.6	44.7 ± 7.1	0.203
sCH %	<10	19.2 ± 6.9*	19.3 ± 8.07	19.1 ± 6.1	0.812
sCH (g/d)	<50	119.3 ± 58.1*	120±49	118.9±63.1	0.907
Glucose (g/d)		17.2 ± 13.9	16.05 ± 13.2	17.9 ± 14.3	0.405
Fructose (g/d)		20.0 ± 15.3	18.9 ± 14.2	20.7 ± 15.9	0.475
Galactose (g/d)		0.10 ± 0.3	0.21± 0.6	0.04 ± 0.1	0.033
Sucrose (g/d)		23.9 ± 18.3	22.7 ± 19.0	24.5 ± 18.0	0.534
Lactose (g/d)		10.8 ± 12.2	10.2 ± 13.2	11.2 ± 11.6	0.587
Maltose (g/d)		1.8 ± 1.9	1.19 ± 0.9	0.96 ± 2.3	<0.001
Cholesterol (mg/d)	<200	338.1 ± 253.8*	369.2 ± 311.2	319.6 ± 212.5	0.219
Fiber (g)	20-30	26.7 ± 13.5	27.46 ± 10.6	26.2 ± 15.0	0.580

Ps: proteins, TFA: total fatty acids, SFA: saturated fatty acids, MUFA: monounsaturated fatty acids, PUFA: polyunsaturated fatty acids, CH: carbohydrates, and sCH: simple carbohydrates. [a] Dietary references adapted according to NOM-015-SSA2-2010, NOM-037-SSA2-2012 and ATP III. *Excessive or †Insufficient intake according to the dietary reference values. The p-value are significant differences between the groups (Normal-weight *vs* overweight).

The fatty acid intake profile is provided in Table 3. The main saturated fatty acids consumed were palmitic (SFA 16:0) and stearic acid (SFA 18:0). Oleic acid (MUFA 18:1) was the main monounsaturated fatty acid consumed; while linoleic acid (PUFA 18:2) and linolenic acid (PUFA 18:3) were the most common polyunsaturated omega-6 and omega-3 fatty acids consumed, respectively. However, no significant differences between groups were found except for the intake of arachidic acid, which was higher in OW group ($p<0.05$).

In regards to the n-6:n-3 PUFA ratio intake, the study population had a ratio of 12:1 which indicates an imbalance between the intake of n-6 and n-3 according to recommendations. No statistically significant differences in the n-6:n-3 PUFA ratio (11.4:1 *versus* 11.6:1) between the NW and OW group were recorded.

Table 3. Fatty acid profile intake in the study population

Fatty Acid	General population	NW Group	OW Group	P value
Saturated Fat (g)	36.77 ± 25.14	37.86 ± 25.77	36.13 ± 24.86	0.668
Monounsaturated Fat (g)	31.06 ± 20.65	28.45 ± 14.71	32.60 ± 23.39	0.207
Polyunsaturated Fat (g)	19.42 ± 11.75	18.49 ± 12.25	19.97 ± 11.46	0.439
SFA 4:0 Butyric acid (g)	0.50 ± 0.73	0.51 ± 0.62	0.50 ± 0.79	0.943
SFA 6:0 Caproic acid (g)	0.37 ± 0.58	0.35 ± 0.48	0.38 ± 0.63	0.730
SFA 8:0 Caprylic acid (g)	0.30 ± 0.40	0.29 ± 0.36	0.31 ± 0.42	0.791
SFA 10:0 Capric acid (g)	0.51 ± 0.83	0.51 ± 0.70	0.52 ±0.90	0.929
SFA 12:0 Lauric acid (g)	0.77 ± 1.28	0.80 ± 1.46	0.75 ± 1.17	0.791
SFA 14:0 Myristic acid (g)	2.29 ± 3.15	2.32 ± 2.64	2.28 ± 2.43	0.936
SFA 16:0 Palmitic acid (g)	13.70 ± 10.17	12.9 ± 8.29	14.1 ± 11.14	0.422
SFA 17:0 Margaric acid (g)	0.08 ± 0.08	0.06 ± 0.08	0.09 ± 0.08	0.127
SFA 18:0 Stearic acid (g)	5.95 ± 4.28	5.71 ± 3.77	6.08 ± 4.56	0.569
SFA 20:0 Arachidic acid (g)	0.07 ± 0.06	0.06 ± 0.06	0.08 ±0.06	0.023
SFA 22:0 Behenic acid (g)	0.04 ± 0.07	0.04 ± 0.08	0.05 ±0.06	0.668
MUFA 14:1 Myristoleic acid (g)	0.05 ± 0.07	0.04 ± 0.07	0.06 ±0.06	0.098
MUFA 16:1 Palmitoleic acid (g)	1.17 ± 1.20	1.16 ± 0.77	1.18 ± 0.40	0.893
MUFA 18:1 Oleic acid (g)	24.40 ± 18.11	22.69 ± 13.22	25.41 ± 20.45	0.294
MUFA 20:1 Gadoleic acid (g)	0.21 ± 0.15	0.19 ± 0.14	0.22 ± 0.15	0.298
MUFA 22:1 Erucic acid (g)	0.01 ± 0.05	0.02 ± 0.06	0.01 ± 0.04	0.329
PUFA 18:2 (N-6) Linoleic acid (g)	15.80 ± 10.66	14.80 ± 11.53	16.38 ± 10.13	0.367
PUFA 18:3 (N-3) Linolenic acid (g)	1.32 ± 0.76	1.18 ± 0.52	1.41 ± 0.86	0.056
PUFA 18:4 (N-3) Stearidonic acid (g)	0.00 ± 0.02	0.01 ± 0.03	0.006 ± 0.02	0.130
PUFA 20:4 (N-6) Arachidonic acid (g)	0.15 ± 0.13	0.17 ± 0.16	0.14 ± 0.10	0.120
PUFA 20:5 (N-3) Eicosapentaenoic acid EPA (g)	0.03 ± 0.09	0.05 ± 0.13	0.02 ± 0.06	0.103
PUFA 22:5 Docosapentaenoic acid DPA (g)	0.02 ± 0.04	0.03 ± 0.06	0.02 ± 0.03	0.132
PUFA 22:6 (N-3) Docosahexaenoic acid DHA (g)	0.09 ± 0.25	0.12 ± 0.34	0.06 ± 0.16	0.127
Trans Fatty Acid (g)	1.31 ± 1.30	1.22 ± 1.68	1.36 ± 1.03	0.424

SFA: Saturated fatty acids, MUFA: Monounsaturated fatty acids, PUFA: Polyunsaturated fatty acids.

3.4. Micronutrients Intake

The comparative micronutrients intake between NW and OW subjects are shown in Table 4. The intake of vitamins A and E, magnesium, and zinc were insufficient in comparison with the recommendations in all study subjects. In contrast, other micronutrients intake were above the recommendations, except pyridoxine. No significant differences between groups were found.

Table 4. Comparison of micronutrients intake between normal-weight and overweight subjects

Nutrients	Dietary references[a]	General intake	NW group	OW group	P value
Vitamin A (µg/d)	900	599 ± 651.8†	646.1 ± 571.3	571.3 ± 613.0	0.471
Thiamin (mg/d)	1.5	1.85 ± 1.2*	1.7 ± 1.3	1.9 ± 1.2	0.402
Riboflavin(mg/d)	1.7	1.85 ± 0.7*	1.7 ± 0.7	1.8 ± 0.79	0.401
Pyridoxine (mg/d)	2	2.05 ± 0.9	2.0 ± 0.8	2.0 ± 0.9	0.622
Cobalamin (µg/d)	2	5.5 ± 5.2*	6.1 ± 6.9	5.1 ± 3.8	0.298
Vitamin C (mg/d)	60	133 ± 97.1*	139.6 ± 94.9	129.2 ± 98.7	0.503
Vitamin E (mg/d)	10	1.4 ± 1.8†	1.3 ± 1.9	1.5 ± 1.7	0.646
Folate (µg/d)	200	366 ± 191.3*	355.2 ± 145.7	372.4 ± 214.0	0.573
Calcium (mg/d)	800	1044.6 ± 877.2*	1072.5 ± 742.7	1028.2 ± 950.5	0.752
Iron (mg/d)	10	18.0 ± 9.9*	17.7 ± 9.8	18.2 ± 10.0	0.758
Potassium (mg/d)	1800	2953.5 ± 1282.2*	2989 ± 1103.2	2932.7 ± 1381.0	0.783
Magnesium (mg/d)	350	323.5 ± 128.7†	323.8 ± 127.0	323.3 ± 130.2	0.983
Sodium (mg/d)	2200	3578.5 ± 1884.4*	3808.5 ± 1854.2	3443 ± 1897.5	0.223
Phosphorus (mg/d)	800	1563 ± 788.4*	1525.7 ± 707.1	1585 ± 835.1	0.637
Selenium (µg/d)	62.5	106.8 ± 55.0*	101.9 ± 54.6	109.7 ± 55.2	0.372
Zinc (mg/d)	15	12.6 ± 6.4†	12.5 ± 6.7	12.7 ± 6.3	0.866

Variables are expressed as mean ± standard deviation. [a] Dietary references values according to the daily recommend intake by National Institute of Medical Sciences and Nutrition Salvador Zubirán. * Excessive or † insufficient intake compared to dietary references. The p-value are significant differences between the groups (Normal-weight vs overweight).

Table 5. Comparison of food portions intake between normal-weight and overweight

Food Group	Recommended Portions[a]	General intake	NW group	OW group	P value
Fruits	3.0	1.5 ± 1.5†	1.6 ± 1.3	1.4 ± 1.6	0.612
Vegetables	3.0	1.6 ± 1.3†	1.5 ± 1.3	1.6 ± 1.2	0.288
Cereals	8.0	11.2 ± 3.5*	11.5 ± 2.7	11.0 ± 3.7	0.822
Sugar	2.0	5.8 ± 4.4*	6.1 ± 2.6	5.5 ± 4.7	0.492
Meat	3.5	8.0 ± 3.3*	8.3 ± 3.1	7.8 ± 3.4	0.709
Fat	5.0	10.1 ± 3.5*	9.8 ± 3.9	10.5 ± 3.6	0.530
Dairy products	2.0	0.9 ± 1.1	1.1 ± 1.2	0.8 ± 1.1	0.639

Portions of food intake by groups are expressed as mean ± standard deviation. [a] Recommendations values per day. * Excessive or † insufficient intake according to National Mexican Academy of Medicine recommendations. The p-value are significant differences between the groups (Normal-weight vs overweight).

3.5. Food Portion Intakes by Groups.

Study subjects in both groups indicated an excessive intake of sugar, fat, and meat, and an insufficient intake of fruits and vegetables (Table 5), no significant differences were found.

4. Discussion

The relationship between dietary intake and health status has been extensively studied. Diets with adequate fat intake (<30% of the total energy consumed) contribute to optimal function of essential physiological processes such normal growth, tissue repair, and structural function [26]. However, high-fat diets are strongly associated with overweight and obesity [15]. In addition, it has been reported that the excessive intake of SFA and cholesterol induce lipid and lipoprotein alterations, inflammation and insulin resistance (IR) increasing the risk of CVD, T2DM, liver disease and other metabolic diseases [27,28]. In this study, a high intake of total fat, SFA and cholesterol was found among the studied population, with no differences between NW and OW groups. The most important foods that contributed to total fat intake were meat, over fried foods and pastry products. These observations are consistent with previous studies in West Mexico and reflect the current pattern of dietary intake of the Mexican population [8,9]. Recently, we also reported the association of the high frequency of the A allele of *CD36* polymorphism (rs1761667) with a higher fat intake among the population of West Mexico [29].

It has been documented that n-6:n-3 PUFA ratios equal or greater that 10:1 are related to the development of chronic diseases such as CVD, nonalcoholic steatohepatitis (NASH), and some types of cancer [23,30,31]. In this study, an imbalance in the n-6:n-3 PUFA ratio intake was detected. In general, subjects had a low intake of n-3 PUFA with an n-6:n-3 PUFA ratio of 12:1, which exceeded the optimal ranges recommended (2:1 to 5:1). Dietary n-6 PUFA such as arachidonic acid that was found in higher amounts in OW group may promote the oxidation of low-density lipoprotein particles, which in turn leads to atherosclerosis and CVD [32]. Moreover, decreased n-3 PUFA induces fat accumulation in the liver and the production of proinflammatory eicosanoids such as prostaglandins, thromboxanes, leukotrienes, hydroxy fatty acids, and lipoxins, all resulting in lipotoxicity that triggers IR, obesity, NASH, T2DM, depresion and some types of cancer [33,34,35,36]. Our results demonstrate a high intake of SFA and low in PUFA and MUFA; this feature is different to some European countries, where the Mediterranean diet is high in PUFA and MUFA and where the prevalence of obesity is minor. Also, it has been suggested that the epidemic of obesity is due in part to a diet low in PUFAs [37].

On the other hand, Nelson G et al demonstrated that low-fat diets *versus* high-fat diets with similar fatty acid composition at constant caloric intake: identical ratios of PUFA:SFA (1:0), n-6:n-3 PUFA ratio and MUFA:TFA ratio had similar effects on total cholesterol and LDL levels in healthy man; therefore this demonstrates that the main problem is the composition of the consumed total FA, where quality has a major impact than quantity [38].

In regards to dietary carbohydrates, an excessive intake of sCH was observed among the subjects which are widely related to the elevated consumption of sugared beverages and other refined foods. Consistent with these data, is the fact that Mexico is one of the countries with the highest consumption of these food items worldwide [8]. In this context, more than 70% of the Mexicans consume sugared beverages daily or almost daily leading to an average consumption of 160 liters per year [8]. These dietary trends have increased the input of fructose in the Mexicans which is positively associated with the increasing occurrence of multiple metabolic disorders including IR, dyslipidemia, vascular disease, inflammation and liver steatosis [39,40,41]. Recently, the high frequency of Val191Val variant of sweet taste *TAS1R2* receptor among the Mexican population has been associated to the overconsumption of carbohydrates which may play a major role in this condition [42].

Chronic inflammation and oxidative stress contribute significantly to the development of highly prevalent chronic diseases such as CVD and cancer [43,44], these conditions are commonly related to low plasma levels of antioxidants, vitamins, and minerals [45]. In this study, we found substantial deficiencies in the intake of vitamin A, vitamin E, magnesium and zinc which are micronutrients recognized by their antioxidant and anti-inflammatory properties [46,47,48]. Similar data were reported in a previous study in West Mexico and is linked to a poor consumption of fruits, vegetables and oilseeds among our population [8]. In contrast, an excessive intake of sodium and iron was observed, which have been considered for impaired fasting glucose and T2DM [49,50]. The overconsumption of meat and processed products could be contributing to these dietary characteristics.

On the other hand, numerous studies have shown that physical inactivity is a risk factor for multiple adverse health outcomes and all-cause mortality [51,52,53]. The main detrimental effects of physical inactivity include increases in adiposity, IR, dyslipidemia and liver steatosis [54,55,56]. In this study, 58% of the population analyzed was physically inactive which is consistent with the current trends of physical inactivity in Mexico [10]. NW subjects were more active than those with OW, which could explain why these study subjects did not present excess of weight. However, if NW subjects become physically inactive and continue with the same unhealthy dietary pattern, they would increase the medium or long-term risk to develop obesity and metabolic disorders. This observation highlights the importance of dietary counseling and lifestyle intervention in both NW and OW groups. Furthermore, it is evident that dietary patterns (amount and type fat, meat, dairy products and diversity of season's fruits and vegetables) differ by population due to genetics, geographic locality, and food cultures [57], thus warranting the implementation of individualized-diets based on the genetic and environmental characteristics of the population [13,58].

5. Conclusion

In conclusion, an unhealthy dietary pattern and high frequencies of physical inactivity were observed among Mexican population. Overall, the diet was characterized by excessive intakes of saturated fat and simple carbohydrates as well as unbalanced n-6:n-3 PUFA ratio and deficiencies in micronutrients with antioxidant and anti-inflammatory properties. Intervention strategies should be directed to the whole population including normal-weight subjects.

Acknowledgments

The authors thank all the participants included in this study.

Financial Support

This work was funded by CONACYT Salud-202540 to EM.

Conflict of Interest

The authors declare no conflict of interest related to this study

List of Abbreviations

ENSANUT: National Health and Nutrition survey 2012
NW: normal-weight
OW: overweight
T2DM: type 2 diabetes mellitus
CVD: cardiovascular diseases
Kcal: kilocalories
Ps: proteins
TFA: fatty acids
SFA: saturated fatty acids
MUFA: monounsaturated fatty acids
PUFA: polyunsaturated fatty acids
CH: carbohydrates
sCH: simple carbohydrates
BMI: Body mass index
WHO: World Health Organization
RAPA: Rapid Assessment of Physical Activity
IR: insulin resistance
NASH: nonalcoholic steatohepatitis

References

[1] Malik, V.S., Willett, W.C., Hu, F.B. Global obesity: trends, risk factors and policy implications. *Nat Rev Endocrinol,* 9. 13-27. 2013.

[2] Gutiérrez, J.P., Rivera-Dommarco, J., Shamah-Levy, T. et al. Encuesta Nacional de Salud y Nutrición 2012: Resultados Nacionales. Available: http://ensanut.insp.mx/informes/ENSANUT2012 ResultadosNacionales.pdf. (Accessed June 2016). 2012.

[3] Rtveladze, K., Marsh, T., Barquera, S. et al. Obesity prevalence in Mexico: impact on health and economic burden. *Public Health Nutr*, 17. 233-239. 2014.

[4] Mitchell, N.S., Catenacci, V.A., Wyatt, H.R. et al. Obesity: overview of an epidemic. *Psychiatr Clin North Am,* 34. 717-732. 2011.

[5] Gómez-Dantés, O., Sesma, S., Becerril, V.M. et al. Sistema de salud de México. *Salud Publica Mex,* 53. 220-232. 2011.

[6] Hebebrand, J., Hinney, A. Environmental and genetic risk factors in obesity. *Child Adolesc Psychiatr Clin N Am,* 18. 83-94. 2009.

[7] Weinsier, R.L., Hunter, G.R., Heini, A.F. et al. The etiology of obesity: relative contribution of metabolic factors, diet, and physical activity. *Am J Med,* 105. 145-150. 1998.

[8] Ramos-López, O., Ojeda-Granados, C., Román, S. et al. Influencia genética en las preferencias alimentarias. *Rev Endocrinol Nutr,* 21. 74-83. 2013.

[9] Ramos-López, O., Román, S., Ojeda-Granados, C. et al. Patrón de ingesta alimentaria y actividad física en pacientes hepatópatas en el Occidente de México. *Rev Endocrinol Nutr,* 21. 7-15. 2013.

[10] Encuesta Nacional de Salud y Nutrición. Evidencia para la política pública en salud. Resultados de actividad física y sedentarismo en personas de 10 a 69 años. Available: http://ensanut.insp.mx/doctos/analiticos/ActividadFisica.pdf (Accessed June 2016). 2012.

[11] Hallal, P.C., Andersen, L.B., Bull, F.C. et al. Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. *Lancet* 380, 247-257. 2012.

[12] Panduro, A., Zacarias-Castillo, R. ¿Estamos incidiendo en el manejo médico-nutricional del paciente obeso en Mexico? *Rev Mex Endocrinol Metabol Nutr,* 1. 189-192. 2014.

[13] Roman, S., Ojeda-Granados, C., Ramos-Lopez, O. et al. Genome based-nutrition: an intervention strategy for the prevention and treatment of obesity and nonalcoholic steatohepatitis. *World J Gastroenterol,* 21. 3449-3461. 2015.

[14] Carrera, P.M., Gao, X., Tucker, K.L. A study of dietary patterns in the Mexican-American population and their association with obesity. *J Am Diet Assoc,* 107. 1735-1742. 2007.

[15] Flores, M., Macias, N., Rivera, M. Dietary patterns in Mexican adults are associated with risk of being overweight or obese. *J Nutr,* 140. 1869-1873. 2010.

[16] Norma Oficial Mexicana NOM-037-SSA2-2012. Para la prevención, tratamiento y control de las dislipidemias. Available: http://www.dof.gob.mx/nota_detalle.php?codigo=5259329&fecha =13/07/2012 (Accessed May 2016). 2012.

[17] Norma Oficial Mexicana NOM-015-SSA2-1994. Para la prevención, tratamiento y control de la diabetes. Available: http://www.salud.gob.mx/unidades/cdi/nom/m015ssa24.html (Accessed June 2016). 2000.

[18] Pasternak, R.C. National Cholesterol Education Program (NCEP) Guidelines on the Detection, Evaluation and Treatment of Elevated Cholesterol in Adults: Adult Treatment Panel III (ATP III). *ACC Curr J Rev,* 11. 37-45. 2002.

[19] World Health Organization. Obesity and overweight. Available: http://www.who.int/mediacentre/factsheets/fs311/en/ (Accessed March 2016). 2015.

[20] International Diabetes Federation. Abdominal Obesity. Available: http://www.idf.org/search/site/ABDOMINAL%20OBESITY?language=es. (Accessed April 2016). 2015.

[21] Organització Mundial de la Salud. Recomendaciones mundiales sobre actividad física para la salud. Available: http://whqlibdoc.who.int/publications/2010/9789243599977_spa.pdf (Accessed June 2016). 2010.

[22] Centro de Investigación para el Fomento de Salud de la Universidad de Washington. Valoración del nivel y la intensidad de actividad física. Available: https://depts.washington.edu/hprc/docs/rapa-european-spanish.pdf (Accessed December 2015). 2006.

[23] Simopoulos, A.P. The Importance of the Omega-6/Omega-3 Fatty Acid Ratio in Cardiovascular Disease and Other Chronic Diseases. *Exp Biol Med,* 233. 674-688. 2008.

[24] Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán. Energía, proteína, vitaminas y minerales para la población Mexicana. Tablas de composición de alimentos mexicanos. Available: http://www.facmed.unam.mx/deptos/salud/censenanza/spi/unidad2/micronut.pdf (Accessed March 2016). 2000.

[25] Bonvecchio, A., Fernández-Gaxiola, A.C., Plazas, M. et al. Guías alimentarias y de actividad física en contexto de sobrepeso y obesidad en la población mexicana. Academia Nacional de Medicina de México. Available: http://www.insp.mx/images/stories/2015/Noticias/Nutricion_y_Salud/Docs/151118_guias_alimentarias.pdf (Accessed March 2016). 2015.

[26] Lichtenstein, A.H., Kennedy, E., Barrier, P. et al. Dietary fat consumption and health. *Nutr Rev,* 56. S19-28. 1998.

[27] Riccardi, G., Giacco, R., Rivellese, A.A. Dietary fat, insulin sensitivity and the metabolic syndrome. *Clin Nut,* 23. 447-456. 2004.

[28] Pino, L.Á., Cediel, G.G., Hirsch, B.S. Ingesta de alimentos de origen animal versus origen vegetal y riesgo cardiovascular. *Rev Chil Nutr,* 36. 210-216. 2009.

[29] Ramos-Lopez, O., Panduro, A., Martinez-Lopez, E. et al. Genetic Variant in the CD36 Gene (rs1761667) is Associated with Higher Fat Intake and High Serum Cholesterol among the Population of West Mexico. *J Nutr Food,* 5. 353. 2015.

[30] Marventano, S., Kolacz, P., Castellano, S. et al. A review of recent evidence in human studies of n-3 and n-6 PUFA intake on cardiovascular disease, cancer, and depressive disorders: does the ratio really matter? *Int J Food Sci Nutr,* 66. 611-622. 2015.

[31] Mansara, P.P., Deshpande, R.A., Vaidya, M.M., Kaul-Ghanekar, R. Differential Ratios of Omega Fatty Acids (AA/EPA+DHA) Modulate Growth, Lipid Peroxidation and Expression of Tumor Regulatory MARBPs in Breast Cancer Cell Lines MCF7 and MDA-MB-231. *PLoS ONE,* 10. e0136542. 2015.

[32] Hersberger, M. Potential role of the lipoxygenase derived lipid mediators in atherosclerosis: leukotrienes, lipoxins and resolvins. *Clin Chem Lab Med,* 48. 1063-1073. 2010.

[33] Scorletti, E., Byrne, C.D. Omega-3 fatty acids, hepatic lipid metabolism, and nonalcoholic fatty liver disease. *Annu Rev Nutr,* 33. 231-248. 2013.

[34] Elsner, M., Gehrmann, W., Lenzen, S. Peroxisome-Generated Hydrogen Peroxide as Important Mediator of Lipotoxicity in Insulin-Producing Cells. *Diabetes,* 60. 200-208. 2011.

[35] Grosso, G., Galvano, F., Marventano, S. et al. Omega-3 fatty acids and depression: scientific evidence and biological mechanisms. *Oxid Med Cell Longevity,* 9. 1-16. 2014.

[36] Janakiram, N.B., Mohammed, A., Rao, C.V. Role of lipoxins, resolvins, and other bioactive lipids in colon and pancreatic cancer. *Cancer Metastasis Rev,* 30. 507-523. 2011.

[37] Holman, R.T. The slow discovery of the importance of omega 3 essential fatty acids in human health. *J Nutr,* 128. 427S-433S. 1998.

[38] Nelson, G.J., Schmidt, P.C., Kelley, D.S. Low-fat diets do not lower plasma cholesterol levels in healthy men compared to high-fat diets with similar fatty acid composition at constant caloric intake. *Lipids,* 30. 969-76. 1995.

[39] Johnson, R.J., Segal, M.S., Sautin, Y. et al. Potential role of sugar (fructose) in the epidemic of hypertension, obesity and the metabolic syndrome, diabetes, kidney disease, and cardiovascular disease. *Am J Clin Nutr,* 86. 899-906. 2007.

[40] Moore, J.B., Gunn, P.J., Fielding, B.A. The role of dietary sugars and de novo lipogenesis in non-alcoholic fatty liver disease. *Nutrients,* 6. 5679-5703. 2014.

[41] Abdelmalek, M.F., Suzuki, A., Guy, C. et al. Increased fructose consumption is associated with fibrosis severity in patients with nonalcoholic fatty liver disease. *Hepatology,* 51. 1961-71. 2010.

[42] Ramos-Lopez, O., Panduro, A., Martinez-Lopez, E., et al. Sweet Taste Receptor TAS1R2 Polymorphism (Val191Val) Is Associated with a Higher Carbohydrate Intake and Hypertriglyceridemia among the Population of West Mexico. *Nutrients,* 8. 101. 2016.

[43] Libby, P., Ridker, P.M., Maseri, A. Inflammation and atherosclerosis. *Circulation,* 105. 1135-1143. 2002.

[44] Balkwill, F., Mantovani, A. Inflammation and cancer: back to Virchow? *Lancet,* 357. 539-545. 2001.

[45] Koekkoek, W.A., Van-Zanten, A.R. Antioxidant Vitamins and Trace Elements in Critical Illness. *Nutr Clin Pract,* 20, 1-18. 2016.

[46] Jiang, Q. Natural forms of vitamin E: metabolism, antioxidant, and anti-inflammatory activities and their role in disease prevention and therapy. *Free Radic Biol Med,* 72. 76-90. 2014.

[47] De Baaij, J.H., Hoenderop, J.G., Bindels, R.J. Magnesium in man: implications for health and disease. *Physiol Rev,* 95. 1-46. 2015.

[48] Chasapis, C.T., Loutsidou, A.C., Spiliopoulou, C.A. et al. Zinc and human health: an update. *Arch Toxicol,* 86. 521-534. 2012.

[49] Yin, Y., Han, W., Wang, Y. et al. Identification of Risk Factors Affecting Impaired Fasting Glucose and Diabetes in Adult Patients from Northeast China. *Int J Environ Res Public Health,* 12. 12662-12678. 2015.

[50] Wrede, C.E., Buettner, R., Bollheimer, L.C. et al. Association between serum ferritin and the insulin resistance syndrome in a representative population. *Eur J Endocrinol,* 154. 333-340. 2006.

[51] Paffenbarger, R.S., Hyde, R.T., Wing, A.L. et al. Physical activity, all-cause mortality, and longevity of college alumni. *N Engl J Med,* 314. 605-613. 1986.

[52] Penedo, F.J., Dahn, J.R. et al. Exercise and well-being: a review of mental and physical health benefits associated with physical activity. *Curr Opin Psychiatry,* 18. 189-193. 2005.

[53] Booth, F.W., Roberts, C.K., Laye, M.J. Lack of exercise is a major cause of chronic diseases. *Compr Physiol,* 2. 1143-1211. 2012.

[54] Rector, R.S., Thyfault, J.P. Does physical inactivity cause nonalcoholic fatty liver disease? *J Appl Physiol,* 111. 1828-1835. 1985.

[55] Varì, R., Scazzocchio, B., Amore, A.D. et al. Gender-related differences in lifestyle may affect health status. *Ann Ist Super Sanità,* 52. 158-166. 2016.

[56] Peterson, M.D., Al Snih, S., Serra-Rexach, J.A. et al. Android Adiposity and Lack of Moderate and Vigorous Physical Activity Are Associated With Insulin Resistance and Diabetes in Aging Adults. *J Gerontol A Biol Sci Med Sci,* 70. 1009-17. 2015.

[57] Roman, S., Ojeda-Granados, C., Panduro, A. Genética y evolución de la alimentación de la población en México. *Rev Endocrinol Nutr,* 21. 42-51. 2013.

[58] Ojeda-Granados, G., Panduro, A., Ramos-López, O., Roman, S. Construyendo una dieta correcta con base en el genoma latino. *Rev Endocrinol Nutr,* 21. 84-92. 2013.