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Mealtime habits and risk of developing the metabolic syndrome or insulin resistance among Mexican adults

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Abstract

Meals are an important source of food intake, contributing to body weight and health status. Previous studies have examined the relationship between isolated mealtime behaviours and the metabolic syndrome (MetS). The aim of this study was to examine the influence over time of ten interrelated mealtime habits on the risk of developing the MetS and insulin resistance (IR) among Mexican adults. We conducted a prospective cohort study with a sample of 956 health workers. The Mealtime Habits Quality (MHQ) scale is based on four mealtime situations (availability of time to eat, distractions while eating, environmental and social context of eating, and familiar or cultural eating habits), which were used to assess the participants' MHQ at the baseline (2004–2006) and follow-up (2010–2012) evaluations. The MetS was assessed using criteria from the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) and the International Diabetes Federation (IDF). IR was defined using the homoeostasis model assessment. Crude and adjusted relative risks were calculated to estimate the relationship between MHQ and the risk of developing the MetS or IR. Participants classified in the lower MHQ category had an 8·8 (95 % CI 3·1, 25) and 11·1 (95 % CI 3·4, 36·1) times greater risk of developing the MetS (using the NCEP-ATP III and IDF criteria, respectively), and an 11·2 times (95 % CI 3·9, 31·5) greater likelihood of developing IR, compared with those in the higher MHQ group. This prospective study reveals that individuals who engaged in more undesirable than recommended mealtime behaviours had a >10-fold risk of developing the MetS or IR.

Key words: Mealtime habits; Metabolic syndrome; Insulin resistance; Abdominal obesity; Mexican adults

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Abbreviations: DP, dietary patterns; HWCS, Health Worker Cohort Study; IDF, International Diabetes Federation; IR, insulin resistance; MetS, metabolic syndrome; MHQ, Mealtime Habits Quality; NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; TV, television.

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The metabolic syndrome (MetS) is a cluster of interconnected physiological, biochemical, clinical and metabolic factors that directly increase the risk of atherosclerotic cardiovascular disease (CVD), type 2 diabetes mellitus and all-cause mortality[1]. The prevalence of the MetS is increasing worldwide along with obesity, sedentary behaviours, population ageing and unhealthy dietary habits, which include a high intake of simple carbohydrates and foods with high saturated fat along with a low intake of fibre[2].

Nutrition research has traditionally focused on examining specific foods, nutrients and dietary components, without taking into account the context of food consumption. Since most foods are consumed as part of a meal, the social and environmental circumstances at mealtime have become key issues to better understand food intake[3] and its influence on body weight and health status[4,5]. Some studies have shown that what people do while eating and the environmental context at mealtime can influence what people eat and their body weight[4–6]. For example, eating while distracted by watching television (TV), reading, working, listening to a detective story or music, or playing video games has been linked to increased food consumption, a higher intake of fat, fast foods and soft drinks, and a lower intake of fruits and vegetables, which can lead to a greater likelihood of becoming overweight[7–12]. Social interactions such as eating with friends and colleagues can also be important distractions that put individuals at risk of mindless eating, increasing energy intake and weight gain[13–15]. Eating with family, however, has been shown to have potential benefits because families frequently have healthier eating habits[16,17].

Eating out and not having enough time to eat are mealtime habits that affect food intake and body weight. For instance, rushing meals has been associated with a higher consumption of soft drinks, fast food and fat as well as with a lower intake of healthy foods[18]. Skipping breakfast has been shown to increase obesity, fasting blood insulin, and cholesterol levels[19,20], whereas eating out has been linked with an unhealthy diet, high fat intake[21], low fruit and vegetable consumption[22] and high risk of obesity[23]. One's eating environment, which includes the general atmosphere, social context and the presence of distractors, is also related to diet and body weight, because it can inhibit the monitoring of food intake[13], regardless of the hunger or energy needs of the individual[7,24,25].

Recent studies have demonstrated that some mealtime behaviours can predict risk of MetS and its components. A longitudinal study of Japanese adults found that eating speed was significantly correlated with the MetS, abdominal obesity, and low levels of HDL-cholesterol[26], whereas a cross-sectional study reported that eating quickly was associated with the MetS and abdominal obesity in Japanese people[27]. A population-based, cross-sectional study of Australian adults showed that eating distractions such as extensive TV watching and consuming a large amount of snack foods were associated with the MetS[10].

Mealtime habits are of interest because they may help elucidate how familiar, social and environmental factors can influence energy intake, and consequently the development of metabolic diseases[5]. For example, a systematic review of intervention trials that examined the association between overall European dietary patterns and their relationship with the MetS showed that westernised dietary patterns were linked to a higher risk of the MetS while traditional patterns were inversely related[28]. The Mealtime Habits Quality (MHQ) scale is based on four mealtime situations (availability of time to eat, distractions while eating, environmental and social contexts of eating, and familiar or cultural eating habits). Studies conducted with the Health Worker Cohort Study (HWCS) participants in Mexico using the MHQ scale have demonstrated that certain mealtime habits can influence food intake[4], dietary patterns, obesity, and risk of weight gain[5]. However, few studies have prospectively evaluated the influence of specific mealtime habits on key metabolic health indicators[5,10]. The aim of this study was to investigate the relationship between the MHQ scale and risk of developing the MetS or insulin resistance (IR) among the HWCS participants at the baseline (2004–2006) and follow-up (2010–2012) evaluations.

Methods

Study population

The HWCS is a prospective cohort study composed of 1640 active and retired health workers aged 20–70 years, from the Instituto Mexicano del Seguro Social (IMSS) and the Instituto Nacional de Salud Pública, both located in Cuernavaca, Morelos. Participants were initially enrolled in a baseline assessment that occurred during 2004–2006 and were followed-up from 2010 to 2012[29]. We excluded individuals who did not complete all the mealtime habits questions in both data collection periods (*n* 588), participants without clinical or anthropometric assessments (*n* 30) and those with diseases or health conditions that could be related to weight change or mealtime habits in either data collection period, such as CVD (*n* 13), cancer (*n* 31), kidney failure (*n* 13) and pregnancy (*n* 9). The remaining 956 participants (239 men and 717 women) were included in the analysis. This study was conducted in accordance with the Helsinki declaration on human studies[30], and each participant signed an informed consent form before enrollment. The IMSS ethics committee approved the study protocol and informed consent form.

Assessment of Mealtime Habits Quality

The MHQ scale was used to assess the quality of mealtime habits among the HWCS participants by obtaining information about structured meals at any given time of the day, on any day of the week, without accounting for snacking. Mealtime items were categorised into two groups, recommended and undesirable for good health, on the basis of previously published studies[4,5]. At the baseline assessment, participants were asked 'When you eat, what do you generally do?', and they responded about their mealtime habits with the specific binary choices: 'yes' or 'no'. For the follow-up evaluation, the MHQ scale was changed to a multiple-choice response format, in order to capture a wider range of mealtime habits[31]. The two formats of the MHQ scale were constructed using the same domain content, and the consistency of the results of the two versions was measured through parallel-form reliability, which is reported elsewhere[5].

For this study, mealtime behaviours were classified into four specific situations: (a) availability of time to eat, (b) distractions while eating, (c) environmental and social context of eating, and (d) familiar or cultural eating habits. Availability of time to eat was measured with four items at the baseline assessment ('I take my time to finish my meal', 'I rush my meals to avoid exceeding the available time to eat', 'I eat in huge mouthfuls' and 'I eat slowly'). For the follow-up assessment, these items were replaced with two questions: 'How fast do you eat your meals?' and 'Did you skip any meal?', since these questions have previously been associated with a lack of time to eat[32]. Distractions while eating were determined using two items at the baseline assessment ('I'm distracted: I talk, watch TV or read' and 'I take advantage of mealtimes to accomplish work activities'). These two items were combined into one question for the follow-up assessment: 'Are you distracted when you eat, either by watching TV, working, reading, talking, or solving everyday problems?'. The environmental and social context of eating was measured with two items at the follow-up assessment: 'Do you eat with friends, family, or colleges?' and 'How many times per week do you eat your main meal at home?'. Familiar or cultural eating habits were assessed at baseline with the item 'I eat all my food, without leaving anything on the plate', which at follow-up was changed to 'Do you eat all your food without leaving anything on the plate?'. Moreover, food selection is a mealtime situation that has been closely related to energy intake and BMI. In this study, it was measured at baseline with the item 'I choose what I eat'; however, in order to be more specific about the type and amount of food selected by participants, this item became two questions for the follow-up assessment: 'Do you choose the food you eat with your health in mind?' and 'Do you choose the amount of food that you eat?'. Finally, the question 'Do you enjoy eating?' was added at the follow-up assessment, because greater pleasure with food has been associated with fewer food anxieties, fewer dieting behaviours, and a lower BMI[5].

Exploratory factor analysis was used for both assessments to uncover underlying factors and factor loadings. During both evaluations (2004–2006 and 2010–2012), factor solution was composed of one factor, recommended mealtime habits were correlated positively and undesirable habits had a negative correlation. The scale was constructed by summing the contribution of each item, weighted by its factor loading. As the indicators had negative values, five was added to the total summarised score in order to obtain a positive score. Each participant received an individual score representing the quality of their mealtime habits, with higher scores reflecting a better quality of mealtime habits. At baseline, the MHQ scale had a mean of 5·28 points, ranging from 2·24 to 8·08 (SD 1·17), and the internal consistency was 0·84[4]. During the follow-up assessment, the MHQ scale had a mean of 3·84 points with a range from 0·87 to 7·19 (SD 0·96), and the internal consistency was 0·60 (online supplementary Appendix: MHQ questionnaire form)[5]. A panel of data for longitudinal analysis that included the two MHQ scores was created in order to derive a personal-level data set. Next, participants were classified into tertiles (with the highest tertile reflecting the recommended MHQ), and were designated a MHQ status for baseline and another one for follow-up, so we could relate MHQ status with its corresponding MetS and IR status at baseline or follow-up.

Metabolic syndrome assessment

The MetS was determined using criteria from the National Cholesterol Education Program Adult Treatment Panel III (NCEP-ATP III) and the International Diabetes Federation (IDF). The NCEP-ATP III defines the MetS as having at least three of the following five components: (1) abdominal obesity (waist circumference ≥102 cm for men and ≥88 cm for women), (2) elevated TAG (≥150 mg/dl or 1·7 mmol/l) or specific treatment for this lipid abnormality, (3) reduced HDL-cholesterol (<40 mg/dl or 1·03 mmol/l for men and <50 mg/dl or 1·29 mmol/l for women) or taking medication for this condition, (4) elevated blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg) or taking medication for hypertension, or (5) elevated fasting plasma glucose (≥110 mg/dl or 6.1 mmol/l) or previously diagnosed type 2 diabetes[33].

According to the IDF definition of the MetS, a person must have abdominal obesity (≥90 cm for men and ≥80 cm for women, these cut-offs may vary based on ethnicity-specific values) or a BMI >30 kg/m^2 and any two of the following four factors: (1) elevated TAG (≥150 mg/dl or 1·7 mmol/l) or specific treatment for this lipid abnormality, (2) reduced HDL-cholesterol (<40 mg/dl or 1·03 mmol/l for men and <50 mg/dl or 1·29 mmol/l for women) or specific treatment for this lipid abnormality, (3) elevated blood pressure (systolic ≥130 mmHg or diastolic ≥85 mmHg, or treatment for hypertension, or (4) elevated fasting plasma glucose (≥100 mg/dl or 5·6 mmol/l) or previously diagnosed type 2 diabetes[34].

Anthropometric and clinical evaluation

Waist circumference was obtained using a steel measuring tape at the high point of the iliac crest at the end of normal expiration, to the nearest 0·1 cm. Weight was assessed with participants wearing minimal clothing with a previously calibrated electronic total body composition analyser, TANITA scale, model TBF-300A. Height was measured with a conventional stadiometer. BMI was calculated as a ratio of weight (kg):height squared (m^2). One blood pressure measurement was taken with an electronic digital blood pressure monitor. Participants were seated with their right arm resting at heart level. The anthropometric and blood pressure measures were obtained by nurses trained in these standardised procedures, and reproducibility of the values was evaluated (resulting in a concordance coefficient of 0·83–0·90).

Biochemical assessment

Fasting venous blood samples were collected and glucose levels were assessed by the oxidised glucose method. TAG were determined by the colorimetric method after enzymatic hydrolysis with lipases technique, HDL-cholesterol was measured by the elimination of chylomicron and subsequent catalase, and insulin sensitivity was measured using the homoeostasis model assessment and calculated from the fasting insulin and glucose measurements using the standard formula: (glucose (mmol/l) × insulin (μU/ml))/22·5[35]. All biomedical assays were performed at the IMSS laboratory in Cuernavaca, Mexico, in compliance with the procedures of the International Federation of Clinical Chemistry and Laboratory Medicine[36].

Demographic characteristics, smoking, energy content, and dietary patterns assessment

Demographic data were obtained through self-administered questionnaires. Smoking status was assessed using the categories proposed by the World Health Organization[37]: current, past and never.

Dietary patterns (DP) and energy intake were obtained using a semi-quantitative FFQ validated in a Mexican population[38]. This questionnaire included data on the consumption of 116 food items commonly consumed over the past year, ranging from never to ≥6 times/d. For this study, we used three major DP that were previously identified in a cross-sectional study of 9467 Mexican adults who participated in the HWCS[39]. Briefly, in both assessments, food items were classified into twenty-eight food groups on the basis of similarity in nutrients, lipid content profile, sugar content, proportion of dietary fibre and commonly consumed foods. Three DP were derived: the prudent or balanced diet is represented by a greater intake of processed vegetable juices, potatoes, fresh fruits, fresh vegetables and legumes and a lower intake of pastries; the Western diet is characterised by a higher intake of pastries, refined cereals, corn tortillas and soft drinks and a lower intake of wholegrain cereals, sea food and full-fat dairy products; and the high-animal protein/high-fat diet is typified by a greater intake of red meat, processed meat, margarine and eggs and a lower intake of fruits and wholegrain cereals. The factor score for each dietary pattern was constructed by summing the standardised percentage of energy intake of food groups, weighted by their factor loading. Next, a panel of data for longitudinal analysis was created, obtaining a personal-level data set of the three DP for both assessments. Individuals were classified into tertiles, with the highest tertile reflecting greater adherence to each DP. We then determined whether there were any differences in the participant's adherence to each DP between the baseline and follow-up assessments, and the associated risk of developing the MetS or IR over time.

Depression evaluation

Depressive symptoms were assessed using a Spanish-language depression scale, derived from a twenty-item questionnaire created by the Center for Epidemiologic Studies[40]. We defined probable clinical depression using the mean plus one standard deviation as a cut-off, which has previously been used to identify depressive symptoms in a Mexican population[29]. A continuous scale from 0 to 60 points was generated, and a score of 16 or more was used to identify participants who had depressive symptoms at the baseline or follow-up assessments[40].

Physical activity

Recreational physical activity (PA) was assessed using a PA questionnaire[41] that has been validated in Spanish[42] and adapted for the HWCS population in Mexico[43]. We determined PA levels on the basis of the public health recommendations regarding the type and amount of PA needed to improve and maintain health benefits among adults: <30 and ≥30 min/d[44].

Statistical analysis

The differences observed between the 2004–2006 and 2010–2012 assessments, with regard to demographics, lifestyle and anthropometric measures, prevalence of the MetS and its components as well as the prevalence of IR, were obtained using the McNemar test for assessing differences in two paired proportions and the t test for assessing differences in two paired means (Table 1).

The MHQ scale was constructed by summing the factor loadings of each mealtime habits item, and participants were assigned an individual MHQ score at baseline and another for the follow-up assessment. A panel of data for longitudinal analysis was then created, which included the two MHQ scores for obtaining a personal-level data set[45]. Participants were classified into tertiles (with the highest tertile reflecting the recommended MHQ), obtaining one MHQ status for baseline and another for follow-up, so we could relate MHQ status with its corresponding MetS and IR status at baseline or follow-up. Adherence to each DP across the MHQ categories was assessed using the Cochran's Q test to determine whether there was a difference between the means of the three groups (Table 2). The Cochran's Q test was also used to identify any differences in the percentage of new cases of the MetS, components of the MetS, and IR across the three MHQ categories. For this analysis, we only included participants who did not have the MetS or its components or IR at the baseline evaluation, as defined by NCEP-ATP III or IDF criteria (Table 3).

Finally, in order to estimate the independent effect of MHQ on the risk of developing the MetS, components of the MetS, or IR over the study period, we used generalised linear models to calculate the adjusted relative risks with binomial log-linear regression[46], as well as their respective 95 % CI. Relative risks were adjusted by sex, depression, dietary patterns, PA and education level as categorical variables, while age and energy intake were continuous variables. Analyses were performed using STATA software, version 12.0.

Results

Table 1 compares the demographic, anthropometric, and lifestyle characteristics of the HWCS participants from the baseline and follow-up assessments. Participants were mainly women (75 %) and middle-aged, with a mean age of 46 years at baseline and 53 years at follow-up. Some anthropometric indicators and the MetS components significantly changed from 2004–2006 to 2010–2012, for example, the percentage of participants with normal BMI decreased from 38 to 33 %, whereas abdominal obesity increased from 48 to 58 % (using the NCEP-ATP III criteria) and from 80 to 88 % (using the IDF criteria).

Table 1. Demographic, anthropometric, and lifestyle characteristics of the HWCS participants at the baseline and follow-up evaluations (*n* 956: female 717, male 239)
(Mean values and standard deviations)

	Baseline		Follow-up		
Characteristics of the study population	Mean	SD	Mean	SD	*P**
Age (years)	46·3	11·5	53·3	11·5	0·000
Weight (kg)	67·4	13·4	68·4	13·8	0·000
Waist circumference in men (cm)	95·6	9·6	98·4	10·5	0·002
Waist circumference in women (cm)	90·5	12·4	92·4	11·3	0·000
BMI (kg/m²)†	26·7	4·4	27·3	4·5	0·004
Normal (%)	38·2		33·3		0·000
Overweight (%)	41·5		43·7		0·176
Obesity (%)	20·2		23·0		0·005
Abdominal obesity (NCEP-ATP III definition)					
>102 cm in men and >88 cm in women (%)	48·0		58·4		0·000
Abdominal obesity (IDF definition)					
>90 cm in men and >80 cm in women (%)	80·3		88·2		0·000
Glucose (≥100 mg/dl) (%)	23·1		43·1		0·000
TAG (≥150 mg/dl) (%)	42·9		55·5		0·000
Reduced HDL (<40 mg/dl men and <50 mg/dl women) (%)	88·2		61·8		0·000
Blood pressure (≥130/85 mmHg) (%)	29·7		48·9		0·000
MetS (NCEP-ATP III definition) (%)	54·2		56·1		0·192
MetS (IDF definition) (%)	62·7		63·0		0·941
Insulin resistance (HOMA)	2·3	4·2	2·54	3·5	0·174
Insulin resistance (>3·2 HOMA) (%)	21·2	23·4	0·230		
Energy content (kJ)	9064·3	5098	7922·9	4081	
Energy content (kcal)	2165·5	1218	1892·8	975	0·000
Dietary patterns‡					
Balanced, greater adherence (%)	36·2		33·8		0·219
High fat/protein, greater adherence (%)	33·9		31·4		0·152
Western, greater adherence (%)	36·7		33·4		0·133
MHQ score§	5·28	1·17	3·84	0·96	0·000
Lower MHQ category (%)	14·9		52·4		0·000
Middle MHQ category (%)	26·9		39·3		0·001
Higher MHQ category (%)	58·2		8·3		0·000
Recreational physical activity (min/d)	25·4	30·5	22·2	27·9	0·035
Active (>30 min/d) (%)	36·7		31·3		0·006
Depression (%)	20·5		20·2		1·000
Current smoker (%)	15·9		10·8		0·000

NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Federation; MetS, metabolic syndrome; HOMA, homoeostasis model assessment; MHQ, Mealtime Habits Quality.
* *P* value was calculated using the McNemar test for difference in two paired proportions, and the *t* test (for paired data) to assess difference of two means, both comparing baseline and follow-up assessments. Proportions and means were adjusted by age and sex. A *P* value ≤0·05 was considered as significant.
† BMI: ratio of weight (kg):height squared (m²); normal weight 18·5–24·9 kg/m², overweight 25–29·9 kg/m², obesity ≥30 kg/m².
‡ Dietary pattern adherence: balanced dietary pattern was typified by greater intake of processed vegetable juices, potatoes, fresh fruits, fresh vegetables and legumes and a lower intake of pastries; the Western dietary pattern was characterised by a higher intake of pastries, refined cereals, corn tortillas and soft drinks and a lower intake of wholegrain cereals, sea food and full-fat dairy products; and the high- protein/high-fat dietary pattern was typified by a greater intake of red meat, processed meat, margarine and eggs and a lower intake of fruits and wholegrain cereals. Dietary patterns were categorised in tertiles; tertile 3 represents greater adherence[39].
§ The MHQ score was created by summing factor loadings of each mealtime habits item, assigning each participant an individual MHQ score at baseline and another at the follow-up assessment. Categories of the MHQ: lower MHQ category (from 0·87 to 3·86 points score), middle MHQ category (from 3·87 to 5·19 score) and higher MHQ category (5·20 to 8·08 score).

Furthermore, the percentage of participants with elevated glucose increased from 23 to 43 %, elevated TAG rose from nearly 43 to 55 %, the percentage of participants with low HDL-cholesterol decreased from 88 % to almost 62 % and high blood pressure increased from nearly 30 % to almost 49 %. Our findings regarding the MHQ reported at baseline and during the follow-up assessment indicate that the mean score decreased significantly from 5·28 to 3·84 points. Additionally, the percentage of participants categorised in the lower MHQ category increased significantly from nearly 15 to 52 %, and the percentage of participants in the higher MHQ category decreased from 58 to 8 % ($P<0·000$, for both). In terms of lifestyle characteristics, the percentage of physically active participants decreased from almost 37 to 31 %, and the prevalence of current smokers decreased from nearly 16 % to almost 11 % (Table 1).

The participants' adherence to the three DP that were identified in the HWCS population[39] was examined for each of the MHQ categories over the 7 years of follow-up, and is presented in Table 2. A higher percentage of participants with greater adherence to the balanced dietary pattern were classified in the higher MHQ category than in the lower MHQ category (40·2 *v.* 24·6 % respectively, $P\leq0·000$), whereas a greater percentage of participants adhering to the Western dietary pattern were categorised in the lower MHQ than in the higher MHQ category (37·4 *v* 30·2 %, respectively, $P\leq0·025$). A greater percentage of participants with lower adherence to the high-protein/high-fat dietary pattern were classified in the higher MHQ than in the lower MHQ category (35·3 *v* 29·4 %, respectively, $P\leq0·040$).

Table 3 shows that a larger percentage of participants who reported more undesirable than recommended mealtime habits

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Table 2. Dietary pattern adherence across Mealtime Habits Quality (MHQ) categories, at baseline and follow-up evaluations, among Mexican adult participants*

	MHQ categories†			
Dietary pattern adherence‡	Low (*n* 321)	Middle (*n* 317)	High (*n* 318)	*P*§
Balanced dietary pattern (%)				
Tertile 1	35·9	33·3	31·0	0·192
Tertile 2	39·5	31·9	28·8	0·000
Tertile 3	24·6	34·8	40·2	0·000
Western dietary pattern (%)				
Tertile 1	31·0	35·0	34·0	0·319
Tertile 2	31·6	32·5	35·8	0·257
Tertile 3	37·4	32·5	30·2	0·025
High-protein/high-fat dietary pattern (%)				
Tertile 1	29·4	35·3	35·3	0·040
Tertile 2	35·0	33·5	31·5	0·409
Tertile 3	35·6	31·2	33·2	0·274

* Categories: lower MHQ category (from 0·87 to 3·86 points score), middle MHQ category (from 3·87 to 5·19 score) and higher MHQ category (from 5·20 to 8·08 score).

† The MHQ category was constructed by summing the factor loadings of each mealtime habit item, assigning each participant an individual MHQ score at baseline and another at the follow-up assessment. Individuals were classified in tertiles (highest tertile reflecting more advisable MHQ), obtaining one MHQ status for baseline and another for follow-up.

‡ Dietary pattern adherence: balanced dietary pattern (typified by a greater intake of processed vegetable juices, potatoes, fresh fruits, fresh vegetables and legumes and a lower intake of pastries; Western dietary pattern (higher intake of pastries, refined cereals, corn tortillas and soft drinks, and a lower intake of wholegrain cereals, sea food, and full-fat dairy products); and high-protein/high-fat dietary pattern (greater intake of red meat, processed meat, margarine, and eggs and a lower intake of fruits and wholegrain cereals). Dietary patterns were categorised into tertiles; tertile 3 represents greater adherence[39].

§ In order to relate the MHQ status to the respective baseline or follow-up dietary pattern adherence, the Cochran's *Q* test was performed to assess the difference of three probabilities. Proportions were adjusted by sex and age. A *P* value <0·05 was considered statistically significant.

during the study period developed the MetS and its components, as well as IR. During the 7-year follow-up period, 25·8 and 48·3 % of individuals in the lower MHQ category developed abdominal obesity (according to NCEP-ATP III and IDF criteria, respectively), whereas only 2·5 and 5·4 % of those in the higher MHQ category developed abdominal obesity (according to NCEP-ATP III and IDF criteria, respectively). Furthermore, a greater percentage of participants in the lower MHQ category as compared with the higher MHQ category developed impaired fasting glucose (25·7 *v.* 3·4 %), elevated TAG (30·9 *v.* 2·6 %), decreased HDL-cholesterol (15·1 *v.* 0 %) and high blood pressure (28·5 *v.* 4·3 %). More participants categorised in the lower MHQ developed the MetS, 17·4 % according to the NCEP-ATP III and 20·5 % according to the IDF criteria, compared with only 1·6 and 1·8 % of those categorised in the higher MHQ, respectively. In addition, 12·5 % of the participants who were classified in the lower MHQ developed IR during the study period, compared with only 1·2 % of those categorised in the higher MHQ category.

The crude and adjusted relative risks for developing the MetS, its components or IR for each of the MHQ categories are presented in Table 4. Compared with participants in the higher MHQ category, those in the middle and lower MHQ categories had a 3·8 and 7·9 times greater risk of developing elevated glucose, respectively; 8·9 and 12·9 times higher risk of developing elevated TAG, respectively; were 6·0 and 9·5 times more likely to develop hypertension, respectively; had a 7·6 and 10·2 greater likelihood of developing abdominal obesity, respectively (considering the NCEP-ATP III criteria); an 8·5 and 9·8 higher risk of abdominal obesity, respectively (considering the IDF criteria); 7·3 and 8·8 times larger risk of developing the MetS, respectively

Table 3. Change in the percentage of participants with the metabolic syndrome (MetS) components, the MetS, and insulin resistance (IR) across Mealtime Habits Quality (MHQ) categories, after 7 years of follow-up, among the HWCS participants

	MHQ scale categories*			
MetS and its components, and IR	Low (0·87–3·86 score)	Middle (3·87–5·19 score)	High (5·20–8·08 score)	*P*†
Normal WC at baseline (*n* 497)				
Raised WC after follow-up (*n* 150) (%) (NCEP-ATP III definition: >102 cm in men and >88 cm in women)	25·8	18·2	2·5	0·000
Normal WC at baseline (*n* 188)				
Raised WC after follow-up (*n* 114) (%) (IDF definition: >90 cm in men and >80 cm in women)	48·3	43·9	5·4	0·000
Normal glucose at baseline (*n* 735)				
Raised glucose at follow-up (*n* 220) (≥100 mg/dl) (%)	25·7	15·8	3·4	0·000
Normal TAG at baseline (*n* 545)				
Raised TAG at follow-up (*n* 196) (%) (≥150 mg/dl)	30·9	20·8	2·6	0·000
Normal HDL at baseline (*n* 113)				
Reduced HDL at follow-up (*n* 29) (%) (<40 mg/dl in men and <50 mg/dl in women)	15·1	22·1	0·0	0·000
Normal blood pressure at baseline (*n* 672)				
Raised blood pressure at follow-up (*n* 237) (%) (≥130/85 mmHg)	28·5	20·5	4·3	0·000
Free MetS at baseline (*n* 438)				
Developed MetS at follow-up (*n* 150) (%) (NCEP-ATP III definition)	17·4	14·4	1·6	0·000
Free MetS at baseline (*n* 356)				
Developed MetS at follow-up (*n* 93) (%) (IDF definition)	20·5	17·2	1·8	0·000
Free IR at baseline (*n* 738)				
Developed IR at follow-up (*n* 100) (%) (HOMA >3·2)	12·5	5·3	1·2	0·000

WC, waist circumference; NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; IDF, International Diabetes Federation; HOMA, homoeostasis model assessment.

* The MHQ score was created by summing factor loadings of each mealtime habits item, assigning each participant an individual MHQ score at the baseline and another at the follow-up assessment. Categories of the MHQ: lower MHQ category (from 0·87 to 3·86 points score), middle MHQ category (from 3·87 to 5·19 score) and higher MHQ category (5·20 to 8·08 score).

† To assess the difference for developing MetS components, MetS and IR across MHQ categories, Cochran's *Q* test was performed to assess the difference of three probabilities. Proportions were adjusted by sex and age. A *P* value <0·05 was considered as statistically significant.

Table 4. Developing the metabolic syndrome (MetS) and insulin resistance (IR) across the Mealtime Habits Quality (MHQ) categories, after 7 years follow-up, among Mexican adults
(Relative risks (RR) and 95 % confidence intervals)

				MHQ scale categories†				
				High	Middle		Low	
The MetS and its components, and IR	Participants with normal values at baseline (n)	Abnormal values of the MetS and its components, and IR after follow-up (n)	Analysis	RR	RR	95 % CI	RR	95 % CI
Elevated glucose (≥100 mg/dl)	735	220	Crude	1	4·6***	2·8, 7·7	7·6***	4·6, 12·3
			Adjusted	1	3·8***	2·0, 7·1	7·9***	4·4, 14·3
Elevated TAG (≥150 mg/dl)	545	196	Crude	1	7·8***	4·1, 14·8	11·5***	6·1, 21·7
			Adjusted	1	8·9***	3·9, 20·3	12·9***	5·8, 29·1
Reduced HDL (<40 mg/dl in men and <50 mg/ dl in women)	113	29	Crude	–	–	–	–	–
			Adjusted	–	–	–	–	–
Hypertension (≥130/85 mmHg)	672	237	Crude	1	4·7***	2·9, 7·5	6·5***	4·1, 10·3
			Adjusted	1	6·0***	3·1, 11·6	9·5***	5·1, 18·0
Abdominal obesity (NCEP-ATP III definition) (>102 cm in men and >88 cm in women)	497	150	Crude	1	8·1***	3·9, 16·7	11·4***	5·6, 3·2
			Adjusted	1	7·6***	3·2, 17·7	10·2***	4·5, 23·4
Abdominal obesity (IDF definition) (≥90 cm in men and ≥80 cm in women)	188	114	Crude	1	7·8***	4·0, 15·1	8·5***	4·4, 16·5
			Adjusted	1	8·5***	3·9, 18·6	9·8***	4·5, 20·9
MetS (NCEP-ATP III definition)	438	150	Crude	1	9·1	3·7, 22·8	11·0***	4·5, 27·4
			Adjusted	1	7·3***	2·6, 20·8	8·8	3·1, 25·0
MetS (IDF definition)	356	93	Crude	1	10·0***	2·1, 11·8	11·2***	4·7, 24·6
			Adjusted	1	10·9***	3·3, 35·4	11·1***	3·4, 36·1
IR (HOMA >3·2)	738	100	Crude	1	4·9***	2·1, 11·8	10·8***	4·7, 24·6
			Adjusted	1	4·7*	1·6, 14·1	11·2***	3·9, 31·5

NCEP-ATP III, National Cholesterol Education Program Adult Treatment Panel III; MetS, metabolic syndrome; IDF, International Diabetes Federation; HOMA, homoeostasis model assessment.
P values and CI of the RR were calculated by using generalised linear models, which were adjusted by sex, depression, dietary patterns (balanced, Western and high protein/fat), with recreational physical activity and level education as categorical variables and age and energy content as continues variables. * $P<0·05$, *** $P<0·001$.
† The MHQ score was created by summing factor loadings of each mealtime habits item, assigning each participant an individual MHQ score at the baseline and another at the follow-up assessment. Categories of the MHQ: lower MHQ category (from 0·87 to 3·86 points score), middle MHQ category (from 3·87 to 5·19 score) and higher MHQ category (5·20 to 8·08 score).

(based on the NCEP-ATP III criteria); 10·9 and 11·1 times higher risk of developing the MetS, respectively (using the IDF criteria); and a 4·7 and 11·2 times greater risk of developing IR, respectively.

Discussion

The results of this prospective study indicate that certain habitual mealtime behaviours can predict the development of metabolic diseases. We found that participants who reported more undesirable mealtime habits (low MHQ) than recommended mealtime habits (high MHQ) had a >11-fold higher risk of developing the MetS or IR. Recent nutrition studies have indicated that isolated mealtime behaviours such as distractions while eating[7–12], not having enough time to eat[18], skipping breakfast[19,20], rushing meals, eating out[21], eating quickly, and certain eating environments or social interactions during meals[13–15] can promote unhealthy diets and a higher BMI. These undesirable mealtime behaviours are also associated with a prolonged inflammatory state, as well as the development of IR, dyslipidemia, and the MetS[47].

This study demonstrates that several inter-related recommended and undesirable mealtime habits can influence dietary intake, anthropometric status and the development of metabolic diseases. However, as the set of mealtime habits we examined cannot be disaggregated, it is difficult to directly compare our results with other studies that have evaluated the influence of isolated mealtime behaviours on risk of the MetS and its components. To better understand the impact of specific mealtime habits on anthropometric indicators and the subsequent development of metabolic diseases, we situate our results in a comprehensive theoretical framework to help explain how four mealtime situations – availability of time to eat, distractions while eating, environmental and social context of eating, and familiar or cultural eating habits – can affect food intake and risk of the MetS.

We evaluated availability of time to eat through the following four items: taking time to eat, rushing meals, skipping meals, and eating in huge mouthfuls. Other researchers have also studied the effects of eating quickly on risk of developing the MetS. For example, a longitudinal study with Japanese adults found that compared with the slow-eating group, the fast-eating group had a multivariate-adjusted hazard ratio that was 1·30 times greater for incidence of the MetS, 1·35 times higher for abdominal obesity, and 1·37 times greater for low HDL-cholesterol[26]. In a cross-sectional study of Japanese adults, the likelihood of having the MetS was inversely related to eating speed – 0·79 for slow and 1·61 for fast eating among men ($P<0·001$) and 0·74 for slow and 1·27 for fast eating among women ($P<0·001$) – and eating rate was also associated with abdominal obesity[27]. Lack of time to eat is a frequent trend in many countries, for example, among young adults in the USA, 35 % of males and 42 % of females reported not having enough time to sit down and eat a meal. Eating on the run is associated with a higher intake of soft drinks, fast food and fat, as well as a lower intake of healthy foods among females[18]. Among a sample of university employees in central Mexico, 39 % reported a lack of time to eat breakfast at home and 13 % indicated that they eat street food. In some urban environments and

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workplaces in Mexico, it may be difficult to find healthy food options because many restaurants mostly offer fatty foods, sweetened soft drinks and, meals that lack fruits and vegetables[48].

We analysed two items that relate to distractions while eating: watching TV or reading while eating and doing office work while eating. Distractions while eating have received much attention as they have been associated with ignoring satiety signals that trigger feelings of fullness[49], which impairs the ability to monitor food consu mption, leading to an unintentional excess of energy intake[50]. Other studies have evaluated the impact of eating distractions on the MetS risk, including a cross-sectional study of 5682 Australian adults over the age of 35 years. They found that participants who spent ≥2 h/d watching TV and consumed three or more snack food servings per day were 1·5 and 3·6 times more likely to have the MetS, respectively, compared with those who reported low levels of TV viewing and low snack intake[10]. Poor dietary habits are potential mediators associated with high levels of TV viewing that can be triggered by advertising[51,52] and increased intake of energy-dense and nutrient-poor snack foods[53]. TV viewing has also been shown to have an impact on subsequent meals because individuals who eat while watching TV report less vivid memories of their previous meals and consequently consume more food at the subsequent meals[7]. A meta-analysis of twenty-four experimental studies provided additional evidence that watching TV reduces attention during eating, which increases food intake at the next meal[9]. In the present study, we also examined other distractions such as reading, doing office work or engaging in tasks, which have been demonstrated to be associated with a greater likelihood of becoming overweight/obese[8–12,50]. Other sources of distractions examined by the scientific literature are listening to stories or music, playing video games, social interactions, and eating environment, which can all lead to impaired awareness of food consumption, mindless eating, increased energy intake, and risk of weight gain[8,13–15]. The environmental and social contexts of eating were also assessed as part of the current study by taking into account the number of times participants ate with friends, family or colleagues, and the number of times they ate their main meal at home. One's eating environment, which includes social interactions and distractions, can make people more vulnerable to mindless eating, resulting in increased meal size and energy intake[13], regardless of hunger[7,24,25]. Other studies have shown that meals eaten with others tend to be larger and longer in duration compared with meals eaten alone, regardless of the relationship of the eating companion or the time of day, with similar effects occurring at morning, noontime and evening meals[25]. Furthermore, a systematic review of twenty-nine nationally representative studies or large cohorts reported that eating away from home is associated with a higher total energy intake, energy content from fat and lower intake of micronutrients, particularly vitamin C, Ca and Fe[21].

The familiar and cultural customs associated with eating were also examined using the following three items: eating with family, friends or colleagues, eating at home, and eating all the food without leaving anything on the plate. The scientific literature provides evidence that culture is one of the major determinants of what we eat, reflecting unwritten social rules such as eating all the food one is served, which is usually done to show appreciation for the food[49]. However, due to the enormous serving sizes that are offered at restaurants, this custom has become an unhealthy habit that contributes to overeating[54]. Furthermore, the largest contributors to both adult and child BMI seem to include the familiar mealtime habits of the people with whom one eats, as well as the location and duration of the meals[17].

The results of this prospective study suggest that individuals who are engaged in more undesirable than recommended mealtime behaviours have a >10-fold risk of developing the MetS or IR. Other observational studies report an inverse relationship between the MetS and a greater adherence to healthy diets, such as the Mediterranean diet, 'Dietary Approach to Stop Hypertension' or diets based on guidelines such as the 'Healthy Eating Index' in the USA or the 'Programme National Nutrition Santé' in France[13,28,49–51]. A prospective study with 3232 participants from a large European cohort demonstrated that higher adherence to a Mediterranean diet reduced risk of the MetS to 0·47 (95 % CI 0·32, 0·69) and 0·50 (95 % CI 0·32, 0·77) using the updated Mediterranean score and the Mediterranean Diet Score, respectively[55]. A systematic review of intervention trials that focused on European Dietary Patterns and the MetS showed that the Western dietary pattern, which includes high servings of saturated fatty acids and simple carbohydrates, is associated with a higher risk of the MetS. Conversely, more traditional dietary patterns that are characterised by a high intake of vegetables, fruits, wholegrain cereals and fish are associated with a reduced risk of the MetS[28].

Other studies with the HWCS participants have shown that the quality of mealtime habits is associated with dietary patterns[4,5]. A cross-sectional study of 5240 HWCS participants between the ages of 20 and 70 years found that a Western dietary pattern that includes a high intake of pastries, refined cereals, corn tortillas and soft drinks, as well as a lower intake of wholegrain cereals, sea food and full-fat dairy products, is associated with a significantly greater risk of high fasting glucose (OR 1·67), low HDL-cholesterol (OR 1·55) and the MetS (OR 1·56)[39]. A longitudinal study of 837 HWCS participants reported that the healthiest MHQ category is related to a greater adherence to the balanced dietary pattern (higher intake of fresh fruits and vegetables, legumes and a lower intake of pastries), and a lower adherence to the protein/fat dietary pattern (greater intake of red meat, processed meat, margarine and eggs and a lower intake of fruits and wholegrain cereals). In contrast, the least healthy MHQ category is related to a higher adherence to the aforementioned Western dietary pattern[5]. Moreover, a cross-sectional study with 7472 HWCS participants found that individuals who were classified in the healthier MHQ category were more likely to report adherence to a balanced dietary pattern than to the Western pattern[4].

The MHQ scale was constructed with self-reported mealtime behaviours, which might not capture all possible variations at mealtime. Since food intake is affected by the meal of the day, the day of the week, the specific eating context, and the people who are present, we believe that using the MHQ scale to assess mealtime habits has several benefits. First, the MHQ scale is a tool that generalises people's daily life experiences regarding meals, attempting to provide a general picture of mealtime habits. Second, the original MHQ scale was composed of binary response items for the baseline assessment, which were changed to multiple-choice responses for the follow-up assessment, allowing for a wider variety of possible mealtime behaviours to be studied. Third, the MHQ scale has been demonstrated to be a comprehensive, reliable and valid instrument because of its structure, its ability to predict dietary patterns, body weight status and the MetS, as well as its demonstrated consistency with other Mexican populations, including adolescents[4–6].

Conclusions

In previous studies, the quality of mealtime habits has demonstrated the ability to predict dietary patterns, anthropometric status, and risk of gaining weight[4,5]. The present study provides evidence that certain meal situations such as availability of time to eat, distractions while eating, the environmental and social contexts of eating, and familiar or cultural eating habits are associated with the development of the MetS and/or IR. Our results also support the idea that mealtime habits could be a key issue in nutrition research, since most foods are consumed as part of a meal, making the meal an appropriate area of study for concerns about food intake and its consequences on health[3]. Moreover, the MHQ scale could be used as a part of health promotion interventions that target mealtime behaviours, in order to help demonstrate how these strategies could improve diet quality, thus reducing the risk of weight gain and metabolic diseases.

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The contribution of each author to this research study is as follows: P. M.-H. and L. D. D.-C. were involved in the design of the study, statistical analysis and writing of the manuscript. C. S., B. R.-P., L. C.-P., R. P., M. M.-G. and Y. N. F. helped in drafting the manuscript. E. R.-L. and E. S.-M. assisted with the statistical analysis and contributed to writing the manuscript. J. S. helped with the study design, and has led the Health Worker Cohort Study as its Principal Investigator. All authors have approved the final version of this manuscript to be published, have made critical comments during the preparation of the manuscript, and fully accept responsibility for this study.

The authors declare that they have no conflicts of interest.

Supplementary material

For supplementary material/s referred to in this article, please visit http://dx.doi.org/doi:10.1017/S0007114516003329

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