Nutr Hosp. 2017; 34(3):654-660 ISSN 0212-1611 - CODEN NUHOEQ S.V.R. 318

Nutrición Hospitalaria

Trabajo Original

Epidemiología y dietética

Association between meal intake behavior and blood pressure in Spanish adults

Asociación entre conductas relacionadas con la ingesta de alimentos y tensión arterial en adultos españoles

Kristin Keller[1], Santiago Rodríguez-López[2] and María Margarita Carmenate-Moreno[1]

[1]*Department of Biology. Universidad Autónoma de Madrid. Madrid, Spain.* [2]*Centre for Research and Studies on Culture and Society. National Scientific and Technical Research Council (CIECS, CONICET-UNC). Córdoba, Argentina*

Abstract

Introduction and objectives: Eating frequency has been suggested to modify blood pressure. Yet, the results are inconclusive, possibly because eating frequency, particularly meal intake behavior (MIB), does not differentiate between meals and snacks. Hence, the aim of this study was to examine the association between more specific MIBs, like the consumption of the three main meals, the intake of forenoon and afternoon meals and snacking between the regular meals, and systolic/diastolic blood pressure (SBP/DBP).

Methods: This cross-sectional study includes 1,314 Spanish adults aged 20-79 years. Data collection occurred during cardiovascular health day events organized in four Spanish cities (Madrid, Las Palmas, Seville and Valencia) in 2008. Linear regression analysis was performed to assess the independent association between the mentioned MIBs and SBP/DBP, controlling for several confounders in multiples models.

Results: After adjusting for sex, age and individual risk factors, having an afternoon meal was associated with lower SBP (ß -3.91, 95% CI [-6.33, -1.49]) and DBP (ß -2.35, 95% CI [-3.76, -0.94]). This association was attenuated when introducing dietary intake and waist circumference in the predictive models (SBP: ß -2.83, 95% CI [-5.25, -0.40]; DBP: ß -1.67, 95% CI [-3.04, -0.31]), although it still remained significant. None of the other investigated MIBs showed any associations with SBP/DBP.

Conclusions: This study suggests that SBP/DBP might be reduced by the intake of an afternoon meal. However, population-based prospective studies are needed in order to confirm the consequences of the investigated associations on health.

Key words:

Systolic and diastolic blood pressure. Waist circumference. Forenoon meal. Afternoon meal. Snacking.

Resumen

Introducción y objetivos: evidencias sugieren que el número de ingestas alimentarias modifican la presión arterial. Sin embargo, los resultados encontrados no son concluyentes, probablemente debido a que esta conducta relacionada con la ingesta de alimentos (CRIA) no diferencia entre comidas y *snacks*. Este estudio examina la asociación entre CRIA más específicas como la realización de las tres comidas principales, de la media mañana, de la merienda y picar entre las comidas regulares, y la tensión arterial sistólica y diastólica (TAS y TAD).

Métodos: es un estudio transversal, en el cual fueron incluidos 1.314 españoles (20-79 años). Los datos fueron recogidos en las Jornadas de Salud Cardiovascular en Madrid, Las Palmas, Sevilla y Valencia, durante el año 2008. Se aplicaron análisis de regresión lineal, controlando el efecto de diversos factores de confusión en múltiples modelos.

Resultados: después de ajustar por sexo, edad y factores de riesgo individual, tomar la merienda se asoció directamente a menor TAS (ß -3,91, 95% CI [-6,33, -1,49]) y TAD (ß -2,35, 95% CI [-3,76, -0,94]). La introducción del consumo alimentario y la circunferencia de cintura en los modelos predictivos atenuó esta asociación (TAS: ß -2,83, 95% CI [-5,25, -0,40]; TAD: ß -1,67, 95% CI [-3,04, -0,31]). Ninguna de las otras CRIA investigadas mostró asociaciones con TAS y TAD.

Conclusiones: el estudio sugiere que tanto la TAS como la TAD podrían verse reducidas mediante la ingesta de la merienda, aunque se requieren estudios adicionales para confirmar y profundizar en las consecuencias sobre la salud de las asociaciones investigadas.

Palabras clave:

Tensión arterial sistólica y diastólica. Circunferencia de cintura. Media mañana. Merienda. Picar.

Received: 26/08/2016
Accepted: 27/11/2016

Keller K, Rodríguez-López S, Carmenate-Moreno MM. Association between meal intake behavior and blood pressure in Spanish adults. Nutr Hosp 2017;34:654-660

DOI: http://dx.doi.org/10.20960/nh.487

Correspondence:

Kristin Keller. Departament of Biology. School of Science. Universidad Autónoma de Madrid. Edificio de Biología. C/ Darwin, 2. Ciudad Universitaria de Cantoblanco. 28049 Madrid, Spain
e-mail: biol.kristin.keller@gmail.com

INTRODUCTION

Hypertension is a known risk factor for cardiovascular diseases. Therefore, its high prevalence worldwide is a concern. Prevention is reached through lifestyle modifications (1,2). Hence, decreasing sodium chloride and cholesterol intake and increasing fruit and vegetable consumption are recommended by the European Society of Cardiology (3), alongside with weight reduction, regular physical activity, restricted alcohol consumption and smoking cessation. However, the intake of nutrients and specific food groups is only one aspect of dietary behavior. Another aspect are meal intake behaviors (MIBs) like eating frequency (EF), irregular eating, snacking or skipping meals. These are related to specific lifestyles and dietary patterns and, therefore, might contribute to the development of cardiovascular risk factors (4-8). However, only a few studies have explored the associations between MIB and blood pressure (BP) (9-17).

In the case of EF, a systematic review of weight-loss and maintenance intervention studies carried out by Palmer et al. (15) suggested no associations between EF and BP. Moreover, different cross-sectional studies did not find any associations (16,17) with EF. By contrast, Edelstein et al. (9) showed that systolic blood pressure (SBP) was lower in those subjects who ate more frequently. This was confirmed by Kim et al. (12), who observed an inverse association between EF and BP. Furthermore, a longitudinal study (10) evaluating 115 non-diabetic men and women found that a high eating frequency was associated with decreased systolic (SBP) and diastolic BP (DBP).

Altogether, the results are inconclusive, suggesting either no associations or negative associations between EF and SBP/DBP. This might be due to different methodological limitations: a) EF does not differentiate between meals and snacks; and b) the definition of meals, snacks or even eating occasions is inconsistent across the literature (18,19). For example, most studies consider only breakfast, lunch and dinner to be meals, coding the rest of the eating occasions as snacks (4,6). However, most traditional meal patterns consist of more than three meals per day (18,20). In Spain, for example, in addition to the three main meals, two smaller eating occasions occur, and they are perceived as meals rather than snacks (20). They occur between breakfast and lunch (a forenoon meal, *"media mañana"*) and between lunch and dinner (an afternoon meal, *"merienda"*).

Based on the above mentioned, the present study aims to determine the associations of several MIBs, such as the intake of the three main meals, a forenoon meal, an afternoon meal and snacking between regular meals, with SBP and DBP in a sample of Spanish adults.

MATERIALS AND METHODS

PARTICIPANTS

Data from 1,314 adults (63.2% women and 36.8% men) aged 20-79 years (mean age 57.8 ± 14.9 years) were examined in a cross-sectional study. The survey was carried out in 2008 in four Spanish cities (Madrid, Las Palmas, Seville and Valencia) during a cardiovascular health event organized by the Fundación Española del Corazón and the Sociedad Española de Cardiología. A random sampling of participants was not carried out since the main purpose of these events was to promote the prevention of cardiovascular diseases and to screen for cardiovascular risk factors. Hence, all the volunteers were accepted. Participants were included in the study after completing a guided questionnaire, as well as measurements of waist circumference (WC) and BP. Technicians used standardized anthropometric instruments during measurements, following the recommendations of the International Biological Program (21). The study was approved by the Ethics Committee of the Fundación Española del Corazón, and conducted according to the guidelines in the Declaration of Helsinki (22). Signed consent forms were obtained from all participants.

MEASUREMENTS

A digital tensiometer (Visomat® Comfort 20/40) was used to assess SBP (mmHg) and DBP (mmHg). Participants were measured while sitting and after having completed the questionnaire, the intention of which was to achieve a calm state. These measurements were repeated when values were beyond the normal range: from < 90/60 mmHg or > 140/90 mmHg for SBP/DBP (23). WC (cm) was measured midway between the last rib and the upper edge of the iliac crest, using a non-stretchable tape.

MEAL INTAKE BEHAVIORS

The four MIBs investigated (the intake of all three main meals, having a forenoon meal, having an afternoon meal and snacking) were assessed by means of short self-reported questions. Participants were asked about the meals consumed during the day, given the following meals to choose from: breakfast, forenoon meal, lunch, afternoon meal and dinner (1 = yes/0 = no). The intake of all three main meals was confirmed when the three questions on breakfast, lunch and dinner were answered positively. The habit of snacking between their regular meals was estimated by the question "Do you snack between meals?" (1 = yes/0 = no), immediately after asking about their meal intake.

CONFOUNDERS

Known risk factors for hypertension, such as sex, age, individual risk factors and dietary intake, were considered as potential confounders of the MIB-BP association. Individual risk factors were assessed using self-report questions. Participants were asked whether they currently drank alcohol (1 = yes/0 = no) or smoked (1 = yes/0 = no). Additionally, they had to indicate their level of physical activity during spare time. They could select from the following options: sedentary (reading, watching television), light exercise (minimum effort: yoga, walking, fishing), moderate exercise (minimum four hours a week: hiking, cycling, gardening) and intensive exercise (high heart rate: running, football, swimming). For the analysis, moderate and intensive exercises were grouped into one category.

Furthermore, the data from a short food habits questionnaire was used to create two scores that reflect dietary intake. First, the Achievement of the Dietary Guideline Score (ADGS) was based on five short questions about the usual daily intake of: a) meat, fish and eggs (responsive options: zero to five or more servings); b) milk and dairy products (zero to three servings); c) fruit (zero to five or more servings); d) vegetables (zero to three servings); and e) bread, pasta, rice and cereals (zero to five or more servings). One point was obtained for each food group when the serving recommendations of the Spanish dietary guidelines, as presented by Salvador et al. (24), were reached: a) meat, fish and eggs (less than three servings); b) milk and dairy products (more than one serving); c) fruit (more than one serving); d) vegetables (more than one serving); and e) bread, pasta, rice and cereals (more than three servings). By adding up the points obtained, the score ranges from 0 to 5 points, and it is categorized into 1 = very low (0-1 points), 2 = low (2 points), 3 = middle (3 points), and 4 = high (4-5 points). The second score (Unhealthy Habit Score [UHS]) was based on the regular consumption of: a) fatty foods; b) ready-made meals; c) salty foods; d) adding salt to already prepared meals; and e) intake of sugary drinks during a meal. It was assessed by the results of a short question about whether or not each habit was performed regularly (1 = yes/0 = no). The UHS was determined by totaling the points obtained for each question answered with yes (the range is 0 to 5 points), and then recoding them into 1 = very low (0 points), 2 = low (1 point), 3 = medium (2 points) and 4 = high (3-5 points).

STATISTICAL ANALYSIS

Continuous variables were tested for normality and described using means and standard deviation, whereas categorical variables were represented by frequencies. First, the association between the confounders and the dependent variables (SBP and DBP) was assessed by means of linear regression, and adjusted for the investigated MIB. Second, multiple linear regression models were used to examine the associations between the MIBs (the intake of the three main meals, having a forenoon meal, having an afternoon meal and snacking) and SBP/DBP. Model 1 described the analysis adjusted by sex, age, smoking, alcohol consumption, and physical activity during leisure time. Additionally, this model included the MIBs not considered as the main independent variable in each regression, controlling for the mutual effect between them. To examine whether the associations were mediated by dietary intake, represented by ADGS and UHS, or WC, they were introduced in the second (Model 2) and third (Model 3) model, respectively. Finally, Model 4 included all the confounders in the regression. Statistical analysis was conducted using the software package SPSS 17, considering p-value < 0.05 as statistically significant.

RESULTS

Table I presents the sample characteristics according to the investigated MIBs: the intake of all three main meals, having a forenoon meal, having an afternoon meal and snacking. The majority of the sample consumed all three main meals. More than one third of the participants took a forenoon meal and nearly half of them an afternoon meal, whereas only a fourth of the individuals snacked between their regular meals. SBP was significantly lower among the participants who usually had a forenoon meal, an afternoon meal and those who snacked between the regular meals. In contrast, subjects who had all three main meals showed a significantly higher SBP. Additionally, those who had a forenoon meal and an afternoon meal also presented lower DBP.

Table II shows the associations between SBP/DBP and the confounders (sex, age, smoking, drinking alcohol, physical activity during spare time, the ADGS and UHS). Subjects with an increased WC had significantly higher BP. SBP was lower among men and individuals with moderate to intense physical activity, whereas SBP increased with age. In contrast, DBP did not show any associations with the confounders.

Finally, table III shows the associations between the MIBs and SBP/DBP. After adjusting for the confounders, MIB not being considered to be the main independent variable, having an afternoon meal was directly associated with SBP and DBP. The participants who had an afternoon meal had significantly lower SBP and DBP. Those associations were attenuated when the ADGS, UHS and WC were included in the regression models, yet, the association remained significant. In contrast, making all three main meals, the intake of a forenoon meal and snacking did not show associations with SBP and DBP.

DISCUSSION

In this study, we used linear regression models to assess associations between the MIBs (intake of the three main meals, forenoon meal, afternoon meal and snacking between the regular meals) and SBP/DBP. Our findings showed that subjects who consumed an afternoon meal seemed to have lower BP independently of other variables such as sex, age and individual risk factors. However, the association was attenuated through dietary intake, represented by ADGS and UHS, and WC. On the other hand, the rest of the investigated MIBs were not related to SBP/DBP.

To the best of our knowledge, the negative direct association between the afternoon meal and SBP/DBP is a unique result, as meals in addition to breakfast, lunch and dinner are underexplored for several reasons. First, in previous studies extra meals or small meals are usually examined as snacks, and therefore are considered the same as snacking in general (4,6). For example, Kim et al. (12) found snack frequency, but not meal frequency, to be inversely associated with BP. However, the used meal definition included only breakfast, lunch and dinner, whereas other eating occasions were considered as snacks. Second, an afternoon and a forenoon meal are meals traditionally taken in Spain.

Table I. Study sample characteristics according to meal intake behaviors: intake of all three main meals, having a forenoon meal, having an afternoon meal and snacking

	Intake of all three main meals					Having a forenoon meal					Having an afternoon meal					Snacking					Total	
	Yes		No		p-value	Yes		No		p-value	Yes		No		p-value	Yes		No		p-value		
	Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD	Mean	SD		Mean	SD
SBP	132.3	21.5	127.1	20.9	< 0.05	129.2	20.9	133.6	21.6	< 0.001	128.9	20.1	134.6	22.2	< 0.001	129.7	22.4	132.7	21.1	< 0.01	132.0	21.5
DBP	77.5	11.9	76.5	11.3	0.765	75.8	11.3	78.3	12.0	< 0.001	75.7	10.8	78.9	12.4	< 0.001	77.4	12.1	77.4	11.7	0.917	77.4	11.8
WC (cm)	93	12.0	91.3	11.1	0.206	91.9	11.3	93.5	12.3	< 0.05	91.1	11.2	94.4	12.4	0.641	93.2	12.4	92.8	11.8	0.641	92.9	12.0
	n	%	n	%		n	%	n	%		n	%	n	%		n	%	n	%		n	%
Men	448	36.6	35	44.3	0.151	158	32.6	325	39.2	< 0.05	166	27.8	317	44.3	< 0.001	109	33.1	374	39.0	0.115	483	36.8
Women	787	63.7	44	55.7		326	67.4	505	60.8		432	72.2	399	55.7		220	66.9	611	62.0		831	63.2
Age (years)																						
20-44 years	239	90.5	25	9.5	< 0.05	103	39.0	161	61.0	0.057	117	44.3	147	55.7	0.633	92	34.8	172	65.2	< 0.001	264	20.1
45-64 years	491	94.1	31	5.9		207	39.7	315	60.3		246	47.1	276	52.9		131	25.1	391	74.9		522	39.7
> 64 years	505	95.6	23	4.4		174	33.0	354	67.0		235	44.5	293	40.9		106	20.1	422	79.9		528	40.2
Smoking (yes)	165	13.4	25	3.6	< 0.001	69	14.3	121	14.6	0.873	77	12.9	113	15.8	0.136	60	18.2	130	13.2	< 0.05	190	14.5
Drinking alcohol (yes)	592	47.9	42	53.2	0.367	223	46.1	411	49.5	0.228	257	43.0	377	52.7	< 0.001	155	47.1	479	48.6	0.634	634	48.2
Physical activity during spare time																						
Sedentary	249	20,2	32	40.5	< 0.001	96	19.8	185	22.3	0.463	128	21.4	153	21.4	0.363	97	29.5	184	18.7	< 0.001	281	21.4
Light	419	33,9	20	25.3		170	35.1	269	32.4		211	35.3	228	31.8		101	30.7	338	34.3		439	33.4
Moderate + intensive	567	45.9	27	34.2		218	45.0	376	45.3		259	43.3	335	46.8		131	39.8	463	47.0		594	45.2
Achievement Dietary Guideline Score																						
Very low (0-1)	123	10.0	26	32.9	< 0.001	33	22.1	116	14.0	< 0.001	30	5.0	119	16.6	< 0.001	38	11.6	111	11.3	0.625	149	11.3
Low (2)	323	26.2	26	32.9		112	23.1	237	28.6		137	22.9	212	29.6		96	29.2	253	25.7		349	26.6
Middle (3)	539	43.6	18	22.8		199	41.1	358	43.1		284	47.5	273	38.1		132	40.1	425	43.1		557	42.4
High (4-5)	250	20.2	9	11.4		140	28.9	119	14.3		147	24.6	112	15.6		63	19.1	196	19.9		259	19.7
Unhealthy Habit Score																						
Very low (0)	534	43.2	17	21.5	< 0.001	199	41.1	352	42.4	0.577	269	45.0	282	39.4	0.065	77	23.4	474	48.1	< 0.001	551	41.9
Low (1)	353	28.6	24	30.4		132	27.3	245	29.5		157	26.3	220	30.7		99	30.1	278	28.2		377	28.7
Middle (2)	204	16.5	17	21.5		87	18.0	134	16.1		91	15.2	130	18.2		73	22.2	148	15.0		221	16.8
High (3-5)	144	11.7	21	26.6		66	13.6	99	11.9		81	13.5	84	11.7		801	24.3	85	8.6		165	12.6
Meal intake behaviors (yes)																						
Having three main meals						448	92.6	787	94.8	0.097	558	93.3	677	94.6	0.346	304	92.5	931	94.5	0.162	1,235	94.0
Having																						
Breakfast	1235	100.0	30	38.0	< 0.001	461	95.2	804	96.9	0.135	579	96.8	686	95.8	0.335	312	94.8	953	96.8	0.112	1,265	96.3
Forenoon meal	448	36.6	36	45.6	0.097						345	57.7	139	19.4	< 0.001	138	41.9	346	35.1	< 0.05	484	36,8
Lunch	1235	100.0	68	86.1	< 0.001	477	98.6	826	99.5	0.064	591	98.8	712	99.4	0.225	325	98.8	978	99.3	0.384	1,303	99.2
Afternoon meal	558	45.2	40	50.6	0.346	345	71.3	253	30.5	< 0.001						168	51.1	430	43.7	< 0.05	598	45.5
Dinner	1235	100.0	51	64.6	< 0.001	473	97.7	813	98.0	0.786	579	96.8	707	98.7	< 0.05	320	97.3	966	98.1	0.380	1,286	97.9
Snacking	304	24.6	25	31.6	0.162	138	28.5	191	23.0	< 0.05	168	28.1	161	22.5	< 0.05						329	25.0

n: Number; SD: Standard derivation; DBP: Diastolic blood pressure; SBP: Systolic blood pressure; WC: Waist circumference.

Table II. Unstandardized regression coefficients (ß) and 95% CI for linear regression of SBP, and DBP with WC, sex, age, smoking, drinking alcohol, physical activity during spare time, the Achievement of the Dietary Guideline Score and Unhealthy Habit Score adjusted for the investigated meal intake behavior

	SBP		DBP	
	Coef.	**95% CI**	**Coef.**	**95% CI**
WC	0.398	0.290, 0.505[b]	0.253	0.197, 0.318[b]
Sex (women)[a]	-3.396	-5.879, -0.914[b]	-0.297	-1.733, 1.140
Age (years)	0.339	0.255, 0.423[b]	-0.004	-0.053, 0.045
Smoking (yes)[a]	-2.808	-6.050, 0.434	-1.024	-2.900, 0.852
Drinking alcohol (yes)[a]	0.298	-1.926, 2.522	-0.058	-1.345, 1.229
Physical activity during spare time[a]				
Light	-2.621	-5.374, 2.334	-1.075	-2.905, 0.755
Moderate + intensive	-0.654	-3.690, - 2.382[b]	0.191	-1.556, 1.948
Achievement of the Dietary Guideline Score[a]				
Low (2)	-1.034	-4.930, 2.862	-1.526	-3.781, 0.728
Middle (3)	-1.520	-5.374, 2,334	-1.231	-3.461, 0.999
High (4-5)	-2.529	-6.832, 1.774	-1.679	-4.169, 0.811
Unhealthy Diet Score[a]				
0	2. 393	-1.485, 6.271	2.041	-0.203, 4.285
Low (1)	1.552	-2.300, 5.405	1.937	-0.292, 4.285
Middle (2)	1.385	-2.747, 5.517	0.511	-1.880, 2.902

DBP: Diastolic blood pressure; SBP: Systolic blood pressure; WC: Waist circumference; [a]Reference categories: Sex (men), smoking (no), alcohol consumption (no), physical activity during spare time (sedentary), Achievement of the Dietary Guideline Score (very low), Unhealthy Diet Score (very low). [b]Significant association p ≤ 0.05.

Table III. Unstandardized regression coefficients (ß) and 95% CI for the associations between meal intake behaviors and SBP/DBP

	SBP							
	Model 1[a]		**Model 2[b]**		**Model 3[c]**		**Model 4[d]**	
	Coef.	**95% CI**	**Coef.**	**95% CI**	**Coef.**	**95% CI**	**Coef.**	**95% CI**
Intake of all three main meals[e]	2.47	-2.16, 7.10	2.96	-1.75, 7.66	1.98	-2.55, 6.50	2.14	-2.46, 6.74
Having a forenoon meal[e]	-1.62	-4.10, 0,85	-1.32	-3.83, 1.19	-1.65	-4.06, 0.77	-1.43	-3.88, 1.02
Having an afternoon meal[e]	-3.91	-6.33, -1.49[f]	-3.60	-6.07, -1.13[f]	-2.99	-5.37, -0.62[f]	-2.83	-5.25, -0.41[f]
Snacking[e]	-0.38	-2.93, 2.17	-0.08	-2.71, 2.55	-1.10	-3.60, 1.40	-0.72	-3.29, 1.86
	DBP							
	Model 1[a]		**Model 2[b]**		**Model 3[c]**		**Model 4[d]**	
	Coef.	**95% CI**	**Coef.**	**95% CI**	**Coef.**	**95% CI**	**Coef.**	**95% CI**
Intake of all three main meals[e]	0.42	-2.28, 3.11	0.68	-2.05, 3.41	0.10	-2.52, 2.72	0,16	-2.50, 2.83
Having a forenoon meal[e]	1.37	-2.81, 0.08	1.18	-2.64, 0.28	-1.38	-2.78, 0.20	-1.25	-2.67, 0.17
Having an afternoon meal[e]	-2.35	-3.76, -0.94[f]	-2.16	-3.60, -0.73[f]	-1.77	-3.15, -0.39[f]	-1.67	-3.07, -0.27[f]
Snacking[e]	0.66	-0.83, 2.14	0.99	-0.54, 2.51	0.20	-1.25, 1.65	0.58	-0.91, 2.07

[a]Model 1: Adjusted for sex, age, individual risk factors (smoking, alcohol consumption, physical activity in leisure time); MIB not considered to be the main independent variable. [b]Model 2: Model 1 and Achievement of the Dietary Guideline Score, Unhealthy Habit Score. [c]Model 3: Model 1 and WC. [d]Model 4: Model 1 and Achievement of the Dietary Guideline Score, Unhealthy Habit Score and WC. DBP: Diastolic blood pressure; SBP: Systolic blood pressure; WC: Waist circumference. [e]Reference category: no. [f]Significant association p ≤ 0.05.

However, they are much less common in other populations. For instance, Barba et al. (25) studied the association between EF and BP in children from southern Italy. When defining EF, they included, in addition to the three main meals, a forenoon meal, an afternoon meal and milk before bed.

The possible mechanisms by which the intake of an afternoon meal might reduce SBP and DBP are unclear, especially, as there was no observed association with the forenoon meal. However, we believe that the afternoon meal might somehow affect the intake of the subsequent meal. In the case of the forenoon meal this is lunch, whereas for the afternoon meal it is dinner. The amount of energy consumed during dinner might be one of the highest of the day, as observed by several studies from different countries. Additionally, previous investigations showed a decline in insulin sensitivity throughout the day, reaching its lowest point in the evening (27). Hence, the intake of an afternoon meal may result in a decreased energy intake during dinner and thus, perhaps, it improves insulin metabolism. Yet, given the observational nature of the study, we were not able to test this assumption. However, an intervention study carried out by Chapelot et al. (18) showed a lower dinner intake in those participants who usually had a traditional French mid-afternoon eating occasion. This occurred even though the participants who never make such a small meal in the afternoon ate a snack out of the same food items as provided for this afternoon meal. However, after a five-year follow-up, Karatzi et al. (10) found a direct link between high EF and a lower rate of SBP and DBP, independently of the homeostatic model assessment-insulin resistance (HOMA-IR). Nevertheless, they suggest that over the long term a reduced insulin concentration might benefit cardiovascular health. As the afternoon meal is part of a traditional Spanish meal pattern, the long-term effect postulated might have acted over metabolism. Additionally, it is important to mention that in the study by Karatzi et al. (8) participants were screened to have no conditions, such as diabetes mellitus, liver or endocrine diseases, that may impact blood pressure. In our study, participants were enrolled regardless of the diseases they had.

In addition, with the use of regression models we could assess the role of dietary intake, represented by ADGS and UHS, as well as WC on the associations between MIBs and SBP/DBP. In the first place, we observed that the association between the intake of the afternoon meal and BP was unconnected to these two confounders. This is in line with the study carried out by Karatzi et al. (10), who also found that the association of EF with BP after a five-year follow-up remained significant after the adjustment of BMI and energy intake. In contrast, Barba et al. (25) found an association between EF and BP in children from southern Italy that was not independent from BMI, which is also confirmed by Kim et al. (12) in an adult population. Secondly, although the association was still significant, attenuation could be observed when WC and dietary intake were included in the regression models, which may also indicate an indirect pathway of the MIB-BP association. Both confounders are known risk factors of high BP, although the metabolic pathways underlying the mechanism are still under discussion. The mechanisms are possibly multifactorial, such as endothelial dysfunction, alteration of the nervous system and kidney function, and the modification of the balance of specific hormones like insulin and leptin (28,29).

This study had several limitations. First, the sample was neither randomly selected nor representative of the Spanish population. The data were collected during events whose objectives were targeting cardiovascular risk factors among the participants and providing information about current lifestyle. Therefore, the study was biased towards certain risk groups that might be more sensitive to their own health, as observed by the higher participation of women and older people. Second, causal relationships could not be established because of the cross-sectional design of the study, even though the analysis was carefully adjusted. However, residual confounding cannot be ruled out. For example, our results might be biased for not having considered the use of antihypertensive medication. This might have led to underestimation of the MIBs-BP association and the presence of disease with an impact on cardiovascular health, such as diabetes mellitus or kidney diseases. Third, the questionnaire used to assess dietary intake was not previously validated.

In contrast, the study had various strengths. First, the use of linear regression models allowed us to deepen into the nature of the associations. Second, WC was measured directly rather than self- reportedly, thus avoiding response errors and underestimations. Finally, a trained person guided the participants through the questionnaire, guarding against wrong interpretations of questions, as well as memory gaps and inexactness.

In conclusion, we found that the intake of an afternoon meal was directly associated with lower BP. This represents a novel result as MIBs, which had rarely been studied before, were investigated. The results might easily be included in dietary advisories. However, in order to confirm the findings, further population-based studies by means of validated measurements of dietary pattern and confounders are needed.

ACKNOWLEDGEMENTS

We acknowledge the contribution of the Universidad Autónoma de Madrid in terms of a studentship given to one of the authors.

REFERENCES

1. Organización Mundial de la Salud. Información general sobre la hipertensión en el mundo. Una enfermedad que mata en silencio, una crisis de salud pública mundial. Geneva: WHO Document Production Services; 2013.
2. Gabriel R, Brotons C, Tormo JM, Segura A, Rigo F, Elosua R, et al. La ecuación ERICE: la nueva ecuación autóctona de riesgo cardiovascular para una población mediterránea envejecida y de bajo riesgo en España. Rev Española Cardiol 2014;68:205-15.
3. Perk J, De Backer G, Gohlke H, Graham I, Reiner Z, Verschuren M, et al. European Guidelines on cardiovascular disease prevention in clinical practice (version 2012). The Fifth Joint Task Force of the European Society of Cardiology and Other Societies on Cardiovascular Disease Prevention in Clinical Practice. Eur Heart J 2012;33:1635-701.
4. Mesas A, Muñoz-Pareja M, López-García E, Rodríguez-Artalejo F. Selected eating behaviours and excess body weight: A systematic review. Obes Rev 2012;13:106-35.

5. Miller R, Benelam B, Stanner SA, Buttriss JL. Is snacking good or bad for health: An overview. Nutr Bull 2013;38:302-22.
6. Leech RM, Worsley A, Timperio A, McNaughton SA. Understanding meal patterns: Definitions, methodology and impact on nutrient intake and diet quality. Nutr Res Rev 2015;28:1-21.
7. Keller K, Rodríguez López S, Carmenate Moreno MM, Acevedo Cantero P. Associations between food consumption habits with meal intake behaviour in Spanish adults. Appetite 2014;83:63-8.
8. Keller K, Rodríguez López S, Carmenate Moreno MM. Association between meal intake behaviour and abdominal obesity in Spanish adults. Appetite 2015;92:1-6.
9. Edelstein SL, Barrett-Connor EL, Wingard DL, Cohn BA. Increased meal frequency associated with decreased cholesterol concentrations; Rancho Bernardo, CA, 1984-1987. Am J Clin Nutr 1992;55:664-9.
10. Karatzi K, Georgiopoulos G, Yannakoulia M, Efthimiou E, Voidonikola P, Mitrakou A, et al. Eating frequency predicts new onset hypertension and the rate of progression of blood pressure, arterial stiffness, and wave reflections. J Hypertens 2016;34:429-37.
11. Karatzi K, Yannakoulia M, Psaltopoulou T, Voidonikola P, Kollias G, Sergentanis TN, et al. Meal patterns in healthy adults: Inverse association of eating frequency with subclinical atherosclerosis indexes. Clin Nutr 2014;1-7.
12. Kim S, Park G-H, Yang JH, Chun SH, Yoon H-J, Park M-S. Eating frequency is inversely associated with blood pressure and hypertension in Korean adults: Analysis of the Third Korean National Health and Nutrition Examination Survey. Eur J Clin Nutr 2014;68:481-9.
13. Nicklas TA, O'Neil CE, Fulgoni III VL. Snacking patterns, diet quality, and cardiovascular risk factors in adults. BMC Public Health 2014;14:388.
14. Ortega R, Redondo M, Zamora M, López-Sobaler A, Quintas M, Andrés P, et al. El número de comidas diarias como condicionante de la ingesta de alimentos, energía y nutrientes en ancianos. Influencia en relación con diversos factores de riesgo cardiovascular. Nutr Hosp 1998;13:186-92.
15. Palmer MA, Capra S, Baines SK. Association between eating frequency, weight, and health. Nutr Rev 2009;67:379-90.
16. Smith KJ, Blizzard L, McNaughton SA, Gall SL, Dwyer T, Venn AJ. Daily eating frequency and cardiometabolic risk factors in young Australian adults: Cross-sectional analyses. Br J Nutr 2012;108:1086-94.
17. Titan S, Bingham S, Welch A, Luben R, Oakes S, Day N, et al. Frequency of eating and concentrations of serum cholesterol in the Norfolk population of the European prospective investigation into cancer (EPIC-Norfolk): Cross sectional study. BMJ 2001;323:1286-8.
18. Chapelot D. The role of snacking in energy balance: A biobehavioral approach. J Nutr 2011;141:158-62.
19. Murakami K, Livingstone MBE. Associations of eating frequency with adiposity measures, blood lipid profiles and blood pressure in British children and adolescents. Br J Nutr 2014;111:2176-83.
20. Bes-Rastrollo M, Sánchez-Villegas A, Basterra-Gortari FJ, Núñez-Córdoba JM, Toledo E, Serrano-Martínez M. Prospective study of self-reported usual snacking and weight gain in a Mediterranean cohort: The SUN project. Clin Nutr 2010;29:323-30.
21. Weiner JS, Lourie JA. Practical Human Biology. Michigan: Academic Press; 1981.
22. WMA (World Medical Association). Declaration of Helsinki. Ethical principles for medical research involving human subjects. 64th ed. Fortaleza, Brazil; 2013.
23. Huch R, Jürgens K, Fessel D. Mensch, Körper, Krankheit. 5th ed. München: Urban & Fischer Verlag; 2007.
24. Salvador Castell G, Mataix Verdú J, Serra-Majem L. Grupos de alimentos. In: Serra-Majem L (ed). Nutrición y salud pública. Métodos, bases científicas y aplicaciones. Barcelona: Masson S.A.; 2006. pp 38-51.
25. Barba G, Troiano E, Russo P, Siani A. Total fat, fat distribution and blood pressure according to eating frequency in children living in southern Italy: The ARCA project. Int J Obes 2006;30:1166-9.
26. Howarth NC, Huang TT-K, Roberts SB, Lin B-H, McCrory MA. Eating patterns and dietary composition in relation to BMI in younger and older adults. Int J Obes 2007;31:675-84.
27. Jakubowicz D, Barnea M, Wainstein J, Froy O. High caloric intake at breakfast vs. dinner differentially influences weight loss of overweight and obese women. Obesity 2013;21:2504-12.
28. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G. Mechanisms of obesity-induced hypertension. Hypertens Res 2010;33:386-93.
29. Neves AL, Coelho J, Couto L, Leite-Moreira A, Roncon-Albuquerque R. Metabolic endotoxemia: A molecular link between obesity and cardiovascular risk. J Mol Endocrinol 2013;51:51-64.