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Consumption of ultra-processed foods and relationship with sodium and potassium excretion: a cross-sectional study

Consumo de alimentos ultraprocesados y relación con la excreción de sodio y potasio: un estudio transversal

Alimentos ultraprocesados y excreción de sodio y potasio

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HIGHLIGHTS

- Individuals who consume more fresh and minimally processed foods had higher average potassium intake values.
- A sample of adult university workers shows a high consumption of ultra-processed foods.
- Sample of adult university workers does not meet WHO recommendations for sodium (in excess) and potassium (in deficit) intake.

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ABSTRACT

Introduction: Higher consumption of ultra-processed foods (UPF) had been associated with higher risk of non-communicable diseases (NCD) and NCD-promoting nutrient profile such as high sodium content and low potassium content. The objective of the study was to evaluate the level of food processing according to the NOVA classification and its relationship with sodium and potassium intake estimated by 24-hour urinary excretion.

Methods: This is a cross-sectional study. Data collection included 107 workers from a public university (51.4% female; mean age 47 years) participating in an iMC Salt clinical trial). A 24-hour urinary collection was used to estimate sodium and potassium intake, validated by the creatinine coefficient. The corresponding 24-hour dietary recall was used to assess food intake and foods were categorized using the NOVA classification according to the degree and purpose of processing, into four groups. Nutri-score was also used to categorize UPF and provide more information about the nutritional quality of products.

Results: The largest energy contribution came from the group of unprocessed or minimally processed foods (51.6%), followed by UPF (24%), processed foods (21.8%) and processed culinary ingredients (2.6%). Individuals with the lowest caloric contribution of the consumption of UPF had higher average values of potassium (K) intake (1438 vs 1136 mg/1000kcal; p=0.007), as individuals with the highest weight contribution of the consumption of unprocessed or minimally processed foods (1434 vs 1109 mg/1000kcal; p=0.010). For sodium (Na) intake no significant results were found between individuals with the lowest and the highest consumption of each NOVA group.

Conclusions: Higher consumption of fresh or minimally processed foods and lower UPF intake were associated with higher K intake values. On the other hand, higher UPF intake was not associated with higher Na intake values.

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Keywords: Food processed; Sodium; Potassium

RESUMEN

Introducción: Un mayor consumo de alimentos ultraprocesados (UPF) se ha asociado con un mayor riesgo de enfermedades no transmisibles (ENT) y un perfil de nutrientes que promueve las

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ENT, como un alto contenido de sodio y un bajo contenido de potasio. El objetivo del estudio fue evaluar el nivel de procesamiento de los alimentos según la clasificación NOVA y su relación con la ingesta de sodio y potasio estimada por la excreción urinaria de 24 horas.

Metodología: Este es un estudio transversal. La recopilación de datos incluyó a 107 trabajadores de una universidad pública (51,4% mujeres; edad media 47 años) que participaron en un ensayo clínico iMC Salt NCT03974477). Se utilizó una muestra de orina de 24 horas para estimar la ingesta de sodio y potasio, validada por el coeficiente de creatinina. Se utilizó el correspondiente recordatorio dietético de 24 horas para evaluar la ingesta de alimentos y los alimentos se clasificaron mediante la clasificación NOVA según el grado y finalidad de procesamiento, en cuatro grupos. Nutri-score también se utilizó para categorizar UPF y proporcionar más información sobre la calidad nutricional de los productos.

Resultados: El mayor aporte energético provino del grupo de alimentos no procesados o mínimamente procesados (51,6%), seguido de UPF (24%), alimentos procesados (21,8%) e ingredientes culinarios procesados (2,6%). Los individuos con menor aporte calórico del consumo de UPF tuvieron mayores valores promedio de ingesta de potasio (K) (1438 vs 1136 mg/1000kcal; p=0,007), que los individuos con mayor aporte de peso del consumo de alimentos no procesados o mínimamente procesados. (1434 vs 1109 mg/1000kcal; p=0,010). Para la ingesta de sodio (Na) no se encontraron resultados significativos entre los individuos con el consumo más bajo y alto de cada grupo NOVA.

Conclusiones: Un mayor consumo de alimentos frescos o mínimamente procesados y una menor ingesta de UPF se asociaron con mayores valores de ingesta de K. Por otro lado, una mayor ingesta de UPF no se asoció con mayores valores de ingesta de Na.

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Palabras clave: Alimentos procesados; Sodio; Potasio

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INTRODUCTION

The consumption of ultra-processed food (UPF) has increased globally during the last decades[1,2]. These products are displacing healthy dietary patterns based on meals prepared from unprocessed or minimally processed foods and culinary ingredients[1].

A food classification according to level and extent of processing is a complement to current food classifications systems and gives us new insight into current dietary patterns. Several methods to group foods according to their processing level have been proposed[3]. The NOVA classification developed by researchers from the University of São Paulo[1] was already studied to explore the relation between food processing and health[4]. The NOVA classification categorizes food and food products into four distinct groups (unprocessed or minimally processed foods, processed culinary ingredients, processed foods and UPF and drink products) according to the nature, extent and purpose of the industrial processing[1].

A great part of actual diets includes UPF, which are associated with unbalanced nutritional intakes, strongly associated with non-communicable diseases (NCD)-promoting nutrients: a higher content of total fat, saturated fat, added sugar, energy density, and sodium and lower in NCD-protective nutrients: fibre and potassium[5,6].

The consumption of UPF is a matter of concern in the nutritional quality of the diet and long-term health impacts. The evidence has shown that a high dietary intake of UFP is associated with multiple adverse health outcomes and NCD[7]. It is particularly significant, since the prevalence of diet-related chronic NCD, such as obesity, type II diabetes, hypertension and cancer, is increasing worldwide[8].

Several observational studies have showed that higher proportions of UPF in the diet is associated with higher incidences of coronary heart and cerebrovascular diseases[9] as well as with a higher risk of hypertension[10].

Globally sodium intakes are commonly in excess. High levels of dietary sodium are highly associated with increased blood pressure and total CVD mortality Hypertension-related CVD is a leading cause of mortality and morbidity worldwide[11]. In addition, potassium intake may have some cardiovascular protective effect. The evidence has shown that increasing current potassium to recommended levels may lower blood pressure[12]. The urine sodium-potassium ratio (Na/K ratio) is also considered an important measure as it has been shown to be more strongly associated with blood pressure outcomes than sodium or potassium alone[13].

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The objective of the study was to evaluate the level of food processing according to the NOVA classification and its relationship with sodium and potassium intake estimated by 24-hour urinary excretion.

METHODS

Study Population

Cross-sectional study, carried out with the convenience sample from the baseline assessment of the iMC SALT study, a clinical study that began in 2019 and ended in September 2020. The study methodology has already been published in a protocol[14].

Participants were recruited from the staff of one public Portuguese university in annual occupational health appointment carried out by the doctor responsible for the appointment.

The same eligibility criteria as the clinical study were used in this study. The following were the eligibility criteria used by the doctor responsible for the occupational health appointment: adult (>18 years), frequently eats home- cooked meals (more than 4 days a week and at least 3 Sundays per month), one annual occupational health appointment at the hospital and reports motivation to control dietary salt consumption. The following were the exclusion criteria: pregnant, with hypotension, kidney disease, active infection that impacts renal function, urinary incontinence, acute coronary syndrome, severe liver disease or heart failure, not using salt for cooking, and staff member of the faculty that promotes the study[14].

Baseline data collection included 114 participants, however the sample used for this study has 107 participants (female 51.4%; mean age 47 years), since 7 participants were excluded due to invalid urine collection.

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Ethics Committee of Centro Hospitalar de São João (Approval Code: 11/2019, Approval Date: 15 February 2019).

Sociodemographic and anthropometric variables

Sociodemographic characteristics (gender, age and education) were assessed using the sociodemographic questionnaire based on the WHO STEPS questionnaire and participant then undergoes anthropometric measurements.

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All measurements were performed with participants wearing light clothing and without shoes, body composition (body mass index (BMI) and weight) were assessed using Tanita MC180MA body composition analyser (Tanita, Illinois, USA).

Sodium and potassium variables

Sodium and potassium were assessed trough a 24h urinary collection (by indirect potentiometry), validated by the coefficient of creatinine. Samples were excluded when creatinine (mg/day/kg) was <10.8 and >25.2 in women and <14.4 and >33.6 in men[15].

Participants received instructions to start the 24-h urinary collection the day before the baseline assessment and maintain their usual dietary and physical activity patterns. The first morning urine was discarded and afterwards all the urine were collected in an appropriated container during the entire day, during the night and including the first morning urine when getting up on the following day.

Dietary variables

Dietary intakes referring to the day of urine collection were collected using one 24-hour dietary recall administrated by trained researchers using a photographic book and household measures to quantify portion sizes[16].

The nutritional composition of the 24-h dietary recall was assessed using an adapted Portuguese version of the nutritional analysis software Food Processor Plus (ESHA Research Inc., Salem, OR, USA). Then the food and beverage items were categorized using the NOVA classification according to degree and purpose of processing, into four groups: unprocessed and minimally processed foods, processed culinary ingredients, processed foods and UPF[1,4].

The first NOVA group is of unprocessed or minimally processed foods include the natural edible food parts of plants, animals, fungi, algae and water. The processes they normally undergo have the main purpose of preservation[1].

The second NOVA group is of processed culinary ingredients derived directly from nature or from group 1 food by pressing, refining, grinding, milling, and spray drying. They are typically used to prepare, cook or season unprocessed or minimally processed foods[1]. Generally, in these group quantities are underestimated due to the difficulties that participants have in estimating the amounts used for cooking and most often report meals without specifying the ingredients of the recipe or report the consumption of ready-to-eat meals and away from home meals. The culinary ingredients included in this category were mainly sugar and butter. Discretionary salt was not included since it was not reported.

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The third NOVA group is of processed foods, these are usually made by adding ingredients from the second group to foods from the first group to increase the durability or palatability[1]. Some foods included in this group were breads, cheeses, canned fish, beer, cider and wine.

The fourth NOVA group is of UPF and drink products, these are industrial formulations made from processed substances extracted or refined from whole foods and additives, with a small proportion or even no group 1 foods[1,2,4]. These products are attractive, convenient, hyper-palatable, cheap, ready-to-consume or to heat, have a long shelf-life, and are highly competitive with foods that are naturally ready to consume and freshly prepared meals[1,2,4]. Ingredients only found in UPF include additives whose purpose is to imitate sensory qualities (e.g. ice-cream, chocolate, candies margarines and spreads, cookies).

Whenever possible, the standardised recipes from Portuguese table of food composition[17] were used to identify and disaggregate homemade food preparations and applied the NOVA classification to the ingredients. In case of doubt, the food preparation was categorised according to the main constituent ingredient.

The Nutri-score a five colour (from green/A to red/E) front-of-pack labelling system, was used to categorize UPF to provide more information on the nutritional quality of products. Participants without consumption of UPF and with the consumption of alcoholic beverages (more than 1.2% alcohol) were excluded from this classification, since Nutri-score does not apply to alcoholic drinks containing more than 1.2% alcohol[18].

Nutri-score converts the nutritional value of the food and beverages into a score, which represents the balance between the content in nutrients to limit (calories, saturated fat, sugars and sodium) and the content in nutrients to encourage (fibre, proteins, nuts, fruit and vegetables). The Open Food Facts[19] (a collaborative and open database of food products) was used to categorize food and beverages from green/A (better profile) to red/E(worst profile). When it was not possible to have access to the food or beverage brand, products were categorised according to most common classification for that group food. Artisanal preparations that were UPF, were categorized using a Nutri-score calculation tool[20,21].

Statistical analysis

For each participant, the proportion of unprocessed and minimally processed foods, processed culinary ingredients, processed foods and UPF in total energy (%Kcal/day) and in total weight (%g/day) of food and beverages consumed was calculated. The use of these proportion of caloric and weight contribution of each NOVA group allows us to assess the quality of the diet, since it reduces the differences in the total energy and weight consumed between individuals. Additionally, participants for each NOVA group were split into two groups (lowest and highest intakes) by the median. For each participant, the proportion of each Nutri-score group in total energy of UFP was calculated.

The Kolmogorov-Smirnov test was used to assess the assumption of normality. Independent Sample T-test or Mann–Whitney U test were performed to compare continuous variables.

To analyse the association between sodium and potassium excretion and the NOVA classification, multiple linear regression was performed, with 95% confidence intervals.

Data were analysed using IBM SPSS Statistics, Version 27. A p-value <0.05 was considered to indicate statistical significance.

RESULTS

Descriptive characteristics of the sample (n=107) are presented in Table 1, 51.4% were women, mean age was 47.4 (10.4) (range 24–69) years, mean BMI was 25.9 (3.9) kg/m^2, mean energy consumption was 2196±756 kcal and mean weight consumption 2903 (948) g.

The education level was similar in both sexes, 90.4% of male and 83.6% female have university level of education.

On average, 24h urinary sodium excretion was 3244 (1329) mg/day (corresponding to average 8.25 g of salt), 24h urinary potassium excretion was 2654 (760) mg/day and Na/K ratio was 2.2 (1.0).

The largest energy and weight contribution came from the minimally processed foods group (51.6% and 81%, respectively), followed by UPF (24% and 10.1%, respectively), processed foods (21.8% and 8.6%, respectively) and processed culinary ingredients (2.6% and 0.3%, respectively).

Table 1. Characterization of participants by gender (age, body mass index, dietary intake, and urinary excretion).

	All (n= 107)	*Male (n= 52)*	*Female (n= 55)*	*p*
Age (y) [a,c]	47.4 (10.4)	49.2 (11.0)	45.8 (9.6)	0.091
BMI (kg/m^2) [a,c]	25.9 (3.9)	27.0 (3.6)	24.9 (4.0)	0.006
Energy consumption (kcal) [a,c]	2196 (756)	2430 (761)	1976 (688)	0.002

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Weight consumption (g) [b,d]	2800 (2324, 3365)	2960 (2443, 3554)	2743 (2300, 3090)	0.191
Na (mg/day) [a,c]	3244 (1329)	3876 (1340)	2646 (1012)	<0.001
Na (mg/1000kcal) [b,d]	1472 (1019, 2146)	1498 (1153, 2363)	1410 (815, 1970)	0.100
K (mg/day) [a,c]	2654 (760)	2957.3 (789.0)	2368.4 (613.0)	<0.001
K (mg/1000kcal) [b,d]	1308 (914, 1585)	1287 (890, 1645)	1324 (922, 1497)	0.980
Na/K ratio [b,d]	2.0 (1.5, 2.6)	2.1 (1.6, 3.1)	1.8 (1.4, 2.4)	0.028
NOVA1 (%kcal/day)[a,c]	51.6 (19.7)	53.8 (18.8)	49.5 (20.5)	0.256
NOVA2 (%kcal/day)[b,d]	1.6 (0.0, 2.9)	0.4 (0.0, 2.3)	2.1 (0.0, 4.3)	0.008
NOVA3 (%kcal/day)[b,d]	20.2 (10.8, 31.6)	21.7 (9.6, 36.7)	16.5 (11.1, 26.8)	0.273
NOVA4 (%kcal/day)[b,d]	19.1 (12.3, 35.4)	16.9 (11.6, 29.4)	24.0 (12.3, 39.4)	0.216
NOVA1 (%g/day) [b,d]	84.5 (76.3, 90.4)	84.5 (71.9, 89.9)	84.5 (78.9, 90.8)	0.229
NOVA2 (%g/day) [b,d]	0.2 (0.0, 0.4)	0.1 (0.0, 0.3)	0.3 (0.0, 0.4)	0.017
NOVA3 (%g/day) [b,d]	5.9 (3.0, 10.8)	7.8 (3.2, 18.3)	5.3 (2.9, 9.5)	0.063
NOVA4 (%g/day) [b,d]	7.0 (2.9, 14.2)	6.9 (2.7, 13.2)	7.1 (2.9, 14.8)	0.879
	(n=97)	(n=48)	(n=49)	
Nutri-score A (%kcal/day) [b,d]	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	0.0 (0.0, 3.5)	0.281
Nutri-score B (%kcal/day) [b,d]	0.0 (0.0, 9.8)	0.0 (0.0, 0.0)	0.0 (0.0, 42.5)	0.059
Nutri-score C (%kcal/day) [b,d]	0.0 (0.0, 41.6)	0.0 (0.0, 42.4)	0.0 (0.0, 42.5)	0.753
Nutri-score D (%kcal/day) [b,d]	33.4 (0.8, 67.1)	51.0 (20.3, 86.6)	19.4 (0.0, 44.8)	0.005
Nutri-score E (%kcal/day) [b,d]	0.0 (0.0, 33.4)	0.0 (0.0, 20.3)	0.0 (0.0, 42.7)	0.644

Note: Nutri-Score is a front-of-pack nutritional label based on a scale of letters A the best nutritional quality to E the lowest. BMI, Body mass index; Na, Sodium; K, Potassium. [a] Analysis by Student t test for continuous variables. [b] Analysis by Mann-Whitney U test. [c] Values are mean (standard deviation). [d] Values are median (P25, P75).

As shown in Table 2 individuals with the lowest caloric contribution of UFP to daily intake had higher average values of potassium excretion (mg/1000kcal) (p=0.007). To sodium and ratio sodium-potassium was not found significant differences between the UPF bigger and lower eaters.

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Table 2. Characterization of the study participants.

Estimated intake	Ultra-processed foods (% kcal/ day)		
	Lower intake (0.0% to 19%)[e]	Higher intake (19% to 71%)[e]	p
Na mg/day [a,c]	3279 (1236)	3210 (1426)	0.788
Na mg/1000kcal [b,d]	1605 (1026, 2398)	1318 (981, 1897)	0.100
Na/K ratio [b,d]	1.9 (1.4, 2.6)	2.0 (1.5, 2.9)	0.485
K mg/day [a,c]	2800 (853)	2512 (634)	0.051
K mg/1000kcal [b,d]	1438 (1053, 1765)	1136 (845, 1419)	0.007

Na, Sodium; K, Potassium. [a] Analysis by Student t test for continuous variables. [b] Analysis by Mann-Whitney U test. [c] Values are mean (standard deviation). [d] Values are median (P25, P75). [e] Median: 19.12; Minimum: 0.00; Maximum: 70.71.

In Table 3 are presented the contribution of NOVA groups in weight, individuals with the highest weight contribution of the consumption of unprocessed or minimally processed foods had higher average values of potassium excretion (mg/1000kcal) (p=0.010) and individuals with the lowest weight contribution of the consumption of processed culinary ingredients had higher average values of potassium excretion (mg/day) (p=0.009).

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Table 3. Urinary data on sodium and potassium excretion by lowest or highest intakes of minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods (%g/day).

Estimated intake	Unprocessed or minimally processed foods (%g/day)			Processed culinary ingredients (%g/day)			Processed foods (%g/day)			Ultra-processed foods (%g/day)		
	LI	HI	*p*	LI	HI	*p*	LI	HI	*p*	LI	HI	*p*
Na mg/day [a,c]	3181	3307	0.625	3454	3039	0.106	3115	3372	0.320	3268	3221	0.855
Na mg/1000kcal [b,d]	1316	1586	0.080	1605	1391	0.631	1484	1391	0.789	1561	1359	0.298
Na/K ratio [b,d]	2.0	1.9	0.667	1.8	2.0	0.337	1.8	2.0	0.083	1.9	2.0	0.535
K mg/day [a,c]	2562	2746	0.211	2848	2465	0.009	2662	2648	0.925	2738	2573	0.262
K mg/1000kcal [b,d]	1109	1434	0.010	1308	1310	0.363	1359	1086	0.058	1359	1284	0.132

LI, Lowest intakes; HI, Highest intakes; Na, Sodium; K, Potassium. [a] Analysis by Student t test for continuous variables. [b] Analysis by Mann-Whitney U test. [c] Values are mean. [d] Values are median.

Table 4 presents the possible degrees of processing of the NOVA classification associated with the excretion of sodium and potassium.

Potassium excretion was associated with the consumption of fresh or minimally processed foods (B=0.205, 95% CI =0.012-0.327).

Multiple linear regression analyzes indicated that all other possible degrees of processing of the NOVA classification were not significantly associated with potassium excretion. There was no association between sodium excretion and the degree of processing according to the NOVA classification.

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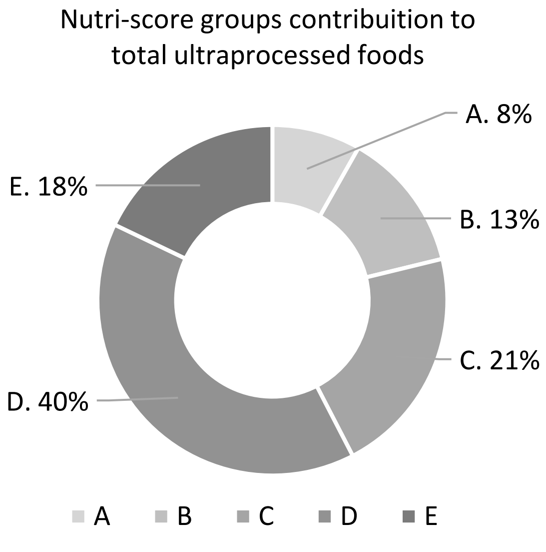
Table 4. Analysis of the association between sodium and potassium excretion and the nova classification according to its degree of processing.

		B	95% CI
Sodium (mg/day)	Model 1		
	NOVA1 (%g/day)	-0.018	[-0.311; 0.260]
	NOVA2 (%g/day)	-0.108	[-44.582; 12.990]
	NOVA3 (%g/day)	0.083	[-0.653; 1.608]
	NOVA4 (%g/day)	0.024	[-0.716; 0.913]
Potassium (mg/day)	Model 1		
	NOVA1 (%g/day)	0.205	[0.012; 0.327]
	NOVA2 (%g/day)	-0.137	[-27.406; 4.325]
	NOVA3 (%g/day)	0.169	[-0.066; 1.180]
	NOVA4 (%g/day)	0.002	[-0.444; 0.453]

B, Standardized Coefficients Beta; 95% CI, 95,0% Confidence Interval for B

Finally, UPF (n=97 participants) were categorized by Nutri-score (Figure 1) and the largest energy contribution came from group D (39.7%), followed by C (21.2%), E (17.9%), B (13%) and A (8.2%).

Figure 1. Relative contribution (%) of each Nutri-score group to consumption of ultra-processed food in diet.



DISCUSSION

The purpose of this study was to better understand the contribution of foods according to their level of processing and the relationship with the subjects' sodium and potassium excretion.

In this sample from the staff of one public Portuguese university, 77.6% of the participants exceed the WHO recommendations for daily sodium intake (2000 mg/day), 84.1% did not meet WHO recommendations for daily potassium intake (3510 mg/day) and 98.1% were largely above the Na/K ratio recommended. A previous study in the Portuguese population[22] also shown that averages intakes of sodium and potassium were far from meeting the daily WHO recommendations.

Our results show that in this sample about one-quarter of daily energy intake came from UPF. The NOVA group that contributed the most to the total energy and weight was unprocessed and minimally processed foods, followed by UPF, processed foods and processed culinary ingredients. These pattern is consistent with the previous reported in studies Belgium[23], Canada[24] and Brazil[25].

The UPF and beverages are usually recognized as products with a lower nutritional quality[4,6]. As predictable in our results the largest energy and weight contribution of UPF came from the Nutri-score groups with the lowest nutritional quality (C, D and E).

The participants that ingest more unprocessed and minimally processed foods had higher average values of potassium (mg/1000kcal) excretion (in g). These results can be explained by the dietary food sources of potassium, since national data shows that fruits, vegetables and pulses were the main sources of population's potassium intake (19,9%)[26]. Previous studies in Japan[27] shown that individuals with a higher dietary potassium intake consumed more vegetables, fruits, fish, and milk. Another study in Poland[28], shows that around 82% of dietary potassium intake mostly came from unprocessed or minimally processed foods.

In the line with main sources of potassium be fruits, vegetables and pulses, the results also shows that participants that showed lowest energy contributions of UPF had higher average values of potassium intake (mg/1000kcal). These results are consistent with a previous study in Canada that shown that potassium intake (mg/1000kcal) decreased with the increase of dietary share of UPF[6], similar results were found in a sample of USA adults[29], in SUN prospective cohort study[30], in Brazil[5,31] and in UK[32].

The results shown that individuals with the lowest weight contribution of the consumption of processed culinary ingredients had higher average values of potassium (mg/day). This finding may be explained by the fact that the quantification of foods from the second group of NOVA (e.g. discretionary salt and olive oil) cannot be estimated accurately and the foods included in this group aren't used in food preparation and cooking (e.g. butter and sugar).

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UPF are usually products with higher content in sodium, so it was expected that participants high dietary share of UPF presented high intake of sodium. However, our results shown no significant differences in average intakes of sodium between highest and lowest consumptions of UPF. This pattern of results is also found in other studies[25,29,33]. One interpretation of these findings is that dietary sodium derives from three sources: the sodium found naturally in food, the salt added to processed and UPF by food industry and the salt added to food during cooking and food preparations (discretionary salt), since in our study discretionary dietary salt cannot be correctly estimated this could affect the results. This fact could be relevant, since data from Portuguese population shown that the main source of salt consumption is the salt added during food preparation and cooking (29.2%)[26].

Our data suggest that highest dietary intakes of foods from NOVA group 1 could have higher intakes of sodium (p=0.080) and a possible explanation is that cooked meals (already seasoned) was included in the group 1 of unprocessed and minimally processed food and in that way discretionary salt was not accounted for in group 2 of processed culinary ingredients.

Our study was the first study in occupational set that explore the association between UPF and sodium and potassium intake and is strengthened by the 24-hour urine collection, considered the clinical gold standard, to assess sodium and potassium intake. Conversely, the use of a 24-h dietary recall can be a limitation in our study, the success of the recall depends on the memory, cooperation and communication ability of the participants and also a single recall cannot describe a typical diet. Although, 24-hour recalls were administered by trained researchers using a photographic book and household measures to quantify portion sizes, which minimized this potential limitation. Additionally, salt added to food and food preparations cannot be accurately estimated since it was not reported and was not included in the second NOVA group. Furthermore, our sample is small, recruited from university staff and the majority of sample has superior education and consequently our results are of limited generalizability.

Our results show that in our sample the consumption of ultra-processed foods is not associated with sodium consumption. In the future, it will be important to carry out more studies on this relationship to direct efforts towards the strategy to be used to reduce targeted sodium consumption according to the population.

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CONCLUSIONS

It is concluded that individuals who eat more fresh and minimally processed foods had higher average potassium intake values. No differences were found between UPF consumption and sodium.

Reducing the dietary consumption of UPF and increasing the consumption of unprocessed or minimally processed foods can be an effective way to significantly improve the nutritional quality of diets and contribute to the prevention of CVD and other chronic diet related NCDs.

AUTHORS' CONTRIBUTIONS

Study Design: CG, PM and OP; Data analysis and drafting of the manuscript: IA, TS-S and CG; Critical revision of the manuscript: CG, OP, PP, PM and TS-S; Approval of the final version for publication: all coauthors.

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CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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