Clinical Nutrition xxx (2012) 1–8

Contents lists available at SciVerse ScienceDirect

Clinical Nutrition

journal homepage: http://www.elsevier.com/locate/clnu

Original article

Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort☆

Maria T. Barrio-Lopez [a,b], Maira Bes-Rastrollo [a], Carmen Sayon-Orea [a], Martin Garcia-Lopez [a,b], Alejandro Fernandez-Montero [a], Alfredo Gea [a], Miguel A. Martinez-Gonzalez [a,*]

[a] Department of Preventive Medicine and Public Health, School of Medicine, University of Navarra, C/Irunlarrea, 1, 31008 Pamplona, Navarra, Spain
[b] Department of Cardiology and Cardiac Surgery, University Clinic of Navarra, Avenida Pio XII, 36, 31008 Pamplona, Navarra, Spain

ARTICLE INFO

Article history:
Received 9 August 2012
Accepted 5 December 2012

Keywords:
Metabolic syndrome
Alcohol consumption
Incidence
Cohort

SUMMARY

Background & aims: We prospectively assessed the association between alcohol consumption and the incidence of Metabolic Syndrome (MS) in a Mediterranean cohort.
Methods: We included 8103 (mean age: 35.4 years) University graduates free of any MS criteria and followed-up during ≥6 years. Alcohol consumption was collected with a validated 136-item food frequency questionnaire. New-onset cases of MS were defined according to the updated harmonizing criteria.
Results: We observed 341 incident cases of MS. Consumers of ≥7 drinks/wk presented a significantly higher risk of developing MS (aOR: 1.80; 95% CI: 1.22–2.66; $p < 0.001$) compared with non-drinkers. In addition, alcohol drinkers (≥7 drinks/wk) had higher risk of hypertriglyceridemia (aOR: 2.07; 95% CI: 1.46–2.93) and impaired fasting glucose (aOR: 1.54; 95% CI: 1.16–2.04). Beer consumption was associated with higher risk for MS (p for trend = 0.027) and higher risk of hypertriglyceridemia (aOR: 1.81; 95% CI: 1.02–3.20), but with lower risk of low HDL-cholesterol criterion (aOR: 0.21; 95% CI: 0.05–0.89) for ≥7 drinks/wk versus no consumption. Non-significant association was observed between wine or liquor consumption and MS.
Conclusions: Consumption of at least seven alcoholic drinks per week was associated with a higher risk of developing MS among subjects initially free of any MS criteria.

1. Introduction

The metabolic syndrome (MS) is a clustering of metabolic abnormalities associated with a high risk of developing type 2 diabetes mellitus, cardiovascular disease, as well as an increased cardiovascular mortality and all-cause mortality.[1] The prevalence of MS is increasing worldwide.[2] Hence, it has become a major problem in public health.

Alcohol consumption is one of the most prevalent lifestyle habits worldwide. In the published literature there is an inconsistent relationship between alcohol consumption and MS. Mild to moderate alcohol consumption may have a favorable influence on lipids metabolism, and glucose regulation.[3] On the other hand, alcohol consumption represents an additional source of calories and contributes to a positive energy balance because alcohol consumers usually add alcohol to their customary daily energy intake rather than substituting it for food. Accordingly, some studies have found an association between alcohol consumption and a higher risk of hypertension[4,5] and hypertriglyceridemia.[4] There is not a complete agreement in the literature about the association between alcohol consumption and obesity. Some prospective studies reported a positive association[6] whereas others reported no association.[7] A recently review of the literature concluded that in most studies the relation between alcohol consumption and weight gain were found in heavy drinkers and

Abreviations: MS, metabolic syndrome; CVD, cardiovascular disease; SUN, Seguimiento Universidad de Navarra. Follow-up University of Navarra; Q6, questionnaire after 6 years of follow-up; Q0, baseline questionnaire; IDF, International Diabetes Federation; AHA/NHLBI, America Heart Association/National Heart, Lung, and Blood Institute; FFQ, food frequency questionnaire; ATP-III, Adult treatment panel III; aOR, adjusted odds ratio; BMI, body mass index; CI, confidence interval; TG, triglycerides; SBP, systolic blood pressure; DBP, diastolic blood pressure.

☆ Conference presentation: Part of this work was presented in the Euroepi 2012 Conference. 5–8 September 2012. Porto, Portugal.

* Corresponding author. Dept of Preventive Medicine and Public Health, School of Medicine, University of Navarra, C/Irunlarrea, 1, 31008 Pamplona, Navarra, Spain. Tel.: +34 948 425600x6463; fax: +34 948 455649.
E-mail address: mamartinez@unav.es (M.A. Martinez-Gonzalez).

0261-5614/$ – see front matter © 2012 Elsevier Ltd and European Society for Clinical Nutrition and Metabolism. All rights reserved.
http://dx.doi.org/10.1016/j.clnu.2012.12.002

light to moderate alcohol intake, specially of wine, was not associated with obesity.[8]

In relation to the complete syndrome, several cross-sectional studies have reported inconsistent findings between alcohol consumption and the prevalence of MS.[9–11] Some reported that the relationship was inversely linear,[9] J-shaped,[10] or positively linear.[11]

In the same way some prospective studies have evaluated the association between alcohol consumption and the incidence of MS with different results. One of them found that alcohol intake was not related to MS.[12] Two studies found that alcohol intake was inversely associated with MS.[13,14] Finally, two other studies conducted in Korea showed a positive association between alcohol consumption and the incidence of MS.[15,16] Both studies showed that consumption of more than 30 g alcohol per day was associated with a significantly increased risk of MS, one in 3833 Korean adults and the other in 4505 men. Beyond these studies, there is scarce information on the relationship between alcohol consumption and the long-term risk of developing MS.

Our aim was to prospectively assess the association between alcohol consumption (and different types of alcoholic beverages) and the incidence of MS (and each specific definition criterion) in a cohort of Spanish university graduates followed-up for at least 6 years.

2. Material and methods

2.1. Study participants

The SUN (Seguimiento Universidad de Navarra) Project is a dynamic prospective cohort study conducted in Spain with permanently open recruitment and whose participants are university graduates. It was patterned after the models of the large cohort studies conducted at the Harvard School of Public Health (Nurses' Health Study and Health Professionals Follow-up Study). A detailed description of the study methods has been previously published.[17] Briefly, beginning in December 1999, all graduates of the University of Navarra, registered nurses from some Spanish provinces, and university graduates from other universities and associations received a mailed questionnaire and a letter of invitation to participate in the SUN Project. A response to the initial questionnaire was assumed to be a surrogate of detailed informed consent that it implied the willingness to participate in the study. The project protocol was approved by the Institutional Review Board of the University of Navarra. The estimated response rate is around 20–25%, however this data is difficult to quantify for us because invitation to participate is done through different institutions. This response rate is in line with other similar cohorts, such as the Nurses' Health Study.[18] In large epidemiologic cohorts projected for the long-term follow-up of initially healthy volunteers the priority is to have a good retention rate. It has even been recommended that several hurdles to participation such as a long first baseline questionnaire may help to select collaborative participants, so only subjects with a strong personal motivation to participate enter in the cohort. These procedures may low the initial response rate, but would lead to a good retention rate in the long run.[19] After baseline assessment, participants received follow-up questionnaires every two years that contained a wide variety of questions on diet, lifestyle, risk factors and medical conditions.

For our study, a subsample of the SUN cohort was selected. To warrant a minimum follow-up of 6 years, we included only those participants who at the beginning of 2012 had completed the 6-year and/or the 8-year follow-up questionnaire. All included participants had therefore repeatedly answered questionnaires inquiring on demographic information, medical history, health conditions, dietary intake, and lifestyle.

Fifteen thousand three hundred and fifty participants were candidates to be included (SUN participants who had responded to the baseline questionnaire (Q0) before March 2005). We excluded 3905 of them who met at least one MS criterion at baseline because we wanted to assess the association between alcohol consumption and MS in healthy participants. The effect of alcohol consumption could be different in hypertensive participants or patients with diabetes mellitus than in healthy people. Moreover, there is a possibility that participants with baseline elevated values of blood pressure, glucose or triglycerides may feel an incentive or receive an advice to not consume alcohol. In this context, we feel that the exclusion of participants with any MS criteria at baseline might better protect our study against reverse causality bias. Therefore this procedure strengthens the validity of our analysis because it allays the possibility of reverse causality bias.

We excluded 1117 participants whose baseline total energy intake was out of predefined limits to avoid information bias. It is recommended to include only participants within the range of 500 to 3500 kcal/day for women and 800 to 4000 kcal/day for men because intakes outside these ranges are more likely to be incorrect or to be associated with a misinterpretation of the FFQ.[20]

We also excluded 799 who had not answered the 6-year and 8-year follow-up questionnaires and other 784 participants who had not answered any of the follow-up questionnaires. We considered these two last groups as participants lost to follow-up. Finally we excluded 576 participants without information on alcohol intake. These 576 participants have answered a 6-year or/and 8-year follow up questionnaire but they have not answered the specific questions on alcohol. After these exclusions, 8103 participants (2687 men and 5416 women) were included in final analyses.

2.2. Assessment of MS

We defined MS according to the harmonizing criteria of the International Diabetes Federation (IDF) and American Heart Association (AHA)/National Heart, Lung, and Blood Institute (NHLBI).[21] According to this definition, the diagnosis of MS needs the presence of at least 3 out of 5 defining criteria: elevated waist circumference (WC) according to the population and country specific definition (in our study: $\geq$94 cm in males and $\geq$80 cm in females), elevated triglycerides ($\geq$150 mg/dL) or presence of drug treatment for elevated triglycerides, reduced HDL-cholesterol ($<$40 mg/dL in males and $<$50 mg/dL in females) or presence of drug treatment for reduced HDL-cholesterol, elevated blood pressure (systolic $\geq$130 and/or diastolic $\geq$ 85 mm Hg) or presence of antihypertensive drug treatment in a patient with history of hypertension, and elevated fasting glucose $\geq$ 100 mg/dL or drug treatment of elevated glucose.

In the 6-year and 8-year follow-up questionnaires, self-reported data about these specific MS criteria were collected. A measuring tape was sent including explanations about how to measure their own waist. Validation of the self-reported criteria for the MS was assessed in a subsample of the cohort comparing self-reported MS with MS diagnosed by medical records of our participants.[22] We found a sensitivity of 66% and a specificity of 98%. Incident cases of MS were defined as those participants who did not have MS at baseline and reported criteria of MS in either the 6-year or 8-year follow-up questionnaire.

2.3. Assessment of dietary and non-dietary exposures

Dietary habits at baseline were assessed using a semi-quantitative food-frequency questionnaire (FFQ) with 136 items, previously validated in Spain and recently re-evaluated.[23] As an "a priori" definition of the Mediterranean dietary pattern we used the score proposed by Trichopoulou,[24] but excluding alcohol. The

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002

baseline questionnaire also included different questions related to lifestyle, sociodemographic variables (sex, age, and years of university education), anthropometric data, health-related habits (e.g., smoking status and physical activity), and medical history information (medication use, cholesterol level, and blood pressure). The reproducibility and validity of the self-reported anthropometrics,[25] physical activity questionnaire,[26] and the diagnosis of hypertension[27] were assessed in sub-samples of the cohort. Self-reported BMI for the diagnosis of overweight and obesity (BMI $\geq$25 kg/m^2) presented a sensitivity of 90%, a specificity of 100% and a positive and negative predictive value of 100% and 93% respectively. Kappa index was 0.91 (95% CI: 0.81–0.99). The correlation coefficient between the measured weight and the self-reported weight was 0.991 (95% CI: 0.986–0.994) and between de measured BMI and the self-reported BMI was 0.944 (95% CI: 0.911–0.965).[25]The self-reported physical activity presented a Spearman coefficient of 0.451 (95% CI 0.162, 0.669) compared with the gold standard (triaxial accelerometer measurements).[26] For the self reported diagnosis of hypertension the intraclass correlation coefficient, was 0.35 and the sensitivity, specificity and kappa coefficient were 0.23, 0.99, and 0.31, respectively. Hypertension was confirmed in 82.3% (95% CI 72.8–92.8%) of participants and the absence of hypertension confirmed in 85.4% (95% CI 72.4–89.1%).[27]

2.4. Assessment of alcohol intake

Questions on alcohol intake included the type of alcoholic drinks: red wine (one glass = 100 mL), other wines (one glass = 100 mL), beer (330 mL), and spirits (50 mL); the frequency of consumption (in a month, in a week, per day) and the consumption habits like drinking during the week or the weekend. We described two alcohol consumption patterns. One of them was defined by high alcohol consumption during the weekend (more than 5 drinks). The other alcohol consumption pattern was defined by high alcohol consumption during the week (consumption of alcohol only 1 or 2 days per week and more than 30 g of alcohol in one day). We analyzed the association between each pattern of consumption and the incidence of MS.

A dietitian updated the nutrient databank using recently available information on food composition tables for Spain.[28] In the validation study for this questionnaire, the correlation coefficient for alcohol consumption was 0.90 between the results of the FFQ and the average of four repeated 4-day food records during one year time.[23]

Alcohol intake was categorized in 5 groups: non-drinkers, <1 drink/wk, 1 to <2 drinks/wk, 2 to <7 drinks/wk, and $\geq$7 drinks/wk.

We sent additional questionnaires to participants who reported in the main questionnaire that they did not consume alcohol to double-check if they were actually abstainers (or were in fact sporadic social drinkers) and to inquire whether they were former drinkers and, in that case, what were the reasons for giving up alcohol consumption. In sensitivity analyses, we excluded the former drinkers from the category of non-drinkers and included only the actual abstainers as the reference group.

2.5. Statistical analysis

The cumulative incidence of MS was computed for each category of alcohol consumption and stratified by different types of alcoholic beverage. To avoid the confounding effect of other variables simultaneously associated with the outcome and the main exposure, we used non-conditional logistic regression models.

We fitted three multivariable-adjusted models controlling for: (a) age (continuous) and sex, (b) baseline total energy intake (continuous), adherence to the Mediterranean food pattern (Score proposed by Trichopoulou et al.[24]) excluding alcohol consumption (tertiles), baseline BMI (kg/m^2, continuous), smoking status (never smoker, ex-smoker and current smoker), physical activity during leisure time (MET-h/week as continuous), snacking between meals (yes or not) and change in sugared-sweetened soft drinks consumption (continuous) and (c) alcohol consumption pattern defined by high alcohol consumption during the week (consumption of alcohol only 1 or 2 days per week and more than 30 g of alcohol in one day).

We also assessed the association between categories of alcohol consumption and each of the individual criterion for the MS. Linear trend tests were calculated using the median alcohol consumption of each category and introducing this new variable as a continuous one in the models. We evaluated the effect modification of age and sex with alcohol consumption through likelihood ratio tests for the product-term introduced in fully-adjusted models. p values were based on two-tailed test and p values < 0.05 were considered statistically significant.

As sensitivity analyses, we estimated the fully-adjusted odds ratios for the category of highest alcohol consumption after modifying several assumptions: (a) using ATP-III criteria for MS, (b) using IDF criteria for MS, (c) adopting different limits for allowable total energy intake, (d) imputing missing alcohol questions, (e) excluding participants with diabetes, cancer and cardiovascular disease at baseline, (e) excluding former drinkers from the category of non-drinkers and including in it only lifetime abstainers, (f) including MS criteria at baseline and excluding only prevalent MS. We imputed the missing values for alcohol consumption with STATA (with random components and 6 predictors: age, sex, body mass index, smoking, total energy intake and Mediterranean diet adherence). We also calculated the relative risk (RR) from the odds ratio (OR) for alcohol consumption using the mean method.[29]

3. Results

The baseline characteristics of participants lost to follow-up did not substantially differ from those who completed the follow-up (data not shown). Table 1 shows the baseline characteristics of the 8103 participants according to their alcohol consumption.

Participants with the highest alcohol consumption were more likely to be men, older, more physically active, smoke more, drink more sugar-sweetened soft beverages and have better adherence to the Mediterranean diet. This greater Mediterranean diet adherence could be due to the fact that moderate alcohol consumption is an important component of the Mediterranean diet and most drinkers in this cohort consumed only moderate amounts of alcohol. No important differences in baseline BMI or in time spent watching television were observed according to alcohol consumption.

3.1. Incidence of MS

During an average follow-up of 6-year, 341 cases of MS were newly identified among 8103 participants initially free of any MS criteria.

Table 2 shows the incidence of MS at least of 6 years of follow-up according to baseline alcohol consumption and to baseline consumption of the different types of alcoholic beverage. After adjusting for age and sex, participants who consumed $\geq$7 drinks/wk presented a significantly higher risk of developing MS (OR: 1.99; 95% CI: 1.37–2.88; p for trend <0.001) compared with those who never consumed alcohol. This association persisted (adjusted odds ratio (OR): 1.80; 95% CI: 1.22–2.66; p for trend<0.001) even after accounting for other potential confounding factors. If we calculated the relative risk using de odds ratio by the mean method we found a similar relative risk (RR: 1.76; 95% CI: 1.33–2.72).

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002

Table 1
Baseline characteristics of participants according to number of baseline drinks consumption per week. SUN project 1999–2011.

	Drinks/week				
	0	<1	1–<2	2–<7	≥7
Alcohol (g/day)	0 (0)	1.1 (0.3)	2.7 (0.6)	8.1 (2.6)	23.4 (11.3)
N (%)	1794 (22.1%)	1506 (18.6%)	1559 (19.2%)	2294 (28.3%)	950 (11.7%)
Red wine (%)	3821 (47.2%)	1649 (20.4%)	922 (11.4%)	1111 (13.7%)	600 (7.4%)
Other wine (%)	5782 (71.4%)	1426 (17.6%)	437 (5.4%)	401 (4.9%)	57 (0.7%)
Beer (%)	3485 (43.0%)	1863 (23.0%)	1238 (15.3%)	1290 (15.9%)	227 (2.8%)
Liquor (%)	4860 (60%)	1640 (20.2%)	944 (11.7%)	617 (7.6%)	42 (0.5%)
Age (y)	35.1 (10.3)	35.2 (10.1)	33.4 (9.9)	35.5 (9.9)	39.5 (10.6)
Women (%)	83.2	78.6	72.4	55.8	34.7
BMI	22.1 (2.7)	22.3 (2.7)	22.4 (2.7)	22.9 (2.7)	23.8 (2.7)
Physical activity (MET-h/wk)	19.6 (25.8)	18.2 (19.2)	18.8 (20.8)	22.9 (23.3)	23.1 (21.9)
Current smokers (%)	15.8	20.5	26.0	28.0	33.3
Former smokers (%)	18.3	24.2	24.7	27.9	34.7
Total energy intake (kcal/d)	2316 (609)	2311 (585)	2326 (571)	2421 (606)	2540 (624)
Soft drinks (mL/d)	39.99 (91.81)	33.70 (67.73)	40.74 (59.89)	50.40 (84.83)	55.76 (95.06)
Mediterranean diet adherence[a]	3.7 (1.7)	3.7 (1.7)	3.7 (1.7)	4.4 (1.8)	4.7 (1.7)
Snacking between meals (%)	37.8	34.7	37.3	33.6	32.6
Television watching (h/week)	1.7 (1.3)	1.7 (1.3)	1.7 (1.2)	1.6 (1.2)	1.7 (1.1)

Values are mean (SD) unless otherwise stated.
[a] Score proposed by Trichopoulou et al.[24]

When we studied the incidence of MS according to different alcoholic beverages a non-significant association between wine consumption and the incidence of MS was observed (p for trend = 0.14 for red wine and $p = 0.90$ for other wines). We did not find any significant association for the highest levels of wine consumption (versus non-drinkers) after adjusting for potential confounders and for the consumption of other alcoholic beverages. However, a significant linear increase in the risk of MS was associated with beer consumption (p for trend = 0.027) or to the sum of beer and spirits ($p = 0.025$) in the analyses that did not adjust for other alcoholic beverages. These direct linear trends for beer or beer + spirits remained significant after additional adjustment for other beverages ($p = 0.043$ and 0.047, respectively). We did not observe any significant interaction between alcohol consumption and age ($p = 0.61$) or sex ($p = 0.67$).

The direct association between alcohol consumption and the risk of MS was robust and remained statistically significant in all but one sensitivity analyses (Table 3). The only exception was the p for trend when we considered the ATP-III definition of MS, a more stringent definition.

When we analyzed the influence of alcohol consumption pattern, we observed that high alcohol consumption during the weekend was associated with a higher risk of developing MS although it was not statistically significant (OR: 1.88; 95% CI: 0.99–3.60) compared with participants who drank less that 5 drinks during the weekend. High alcohol consumption during the whole week was also associated with a higher risk of developing MS (OR: 2.00; 95% CI: 1.16–3.45) compared with participants who did not meet this consumption pattern. Total alcohol consumption adjusted by each alcohol consumption pattern was still significant associated with MS (OR: 1.76; 95% CI: 1.19–2.61) and (OR: 1.71; 95% CI: 1.15–2.57) respectively, even when we adjusted for both alcohol consumption patterns (OR: 1.68; 95% CI: 1.12–2.51). We only presented the results adjusting for the pattern of consumption during the week because this pattern was most significantly associated with MS (Table 2). We did not adjust for the two pattern of consumption to avoid excessive adjustment.

3.2. Incidence of individual components of MS

Fig. 1 shows the relative odds of developing each individual component of the MS (OR and 95% CI) at least of 6 years of follow-up for the category of consumption of 7 or more drinks per week as compared with non-alcohol consumers.

Participants who consumed 7 or more drinks per week presented a 19% higher risk of developing the blood pressure criterion of MS (adjusted OR: 1.19; 95% CI: 0.95–1.48; p for trend 0.031), a 107% higher risk of developing the triglyceride criterion of MS (adjusted OR: 2.07; 95% CI: 1.46–2.93; p for trend < 0.001) and a 54% higher risk of developing the fasting glucose criterion of MS (adjusted OR: 1.54; 95% CI: 1.16–2.04; p for trend 0.001) than did those who never consumed alcohol after adjusting for potential confounding factors. We did not find any significant increase in the risk for the other criteria of the MS (waist circumference and HDL cholesterol criteria) associated with high (≥7 drinks/wk) alcohol consumption.

The analyses according to different types of alcoholic beverages showed that red wine consumption (≥7 glasses/wk) was associated with a higher risk of meeting the impaired fasting glucose criterion for MS, but it did not exhibit any association with other defining criteria; consumption of other types of wine was associated with a higher risk of elevated blood pressure (aOR: 2.60; 95% CI: 1.39–4.88) for drinkers of ≥7 glasses/wk compared with non-drinkers; finally, beer consumption (≥7 drinks/wk) was associated with higher risk of developing hypertriglyceridemia (aOR: 1.81; 95% CI: 1.02–3.20) but it was associated with lower risk of meeting the low HDL-cholesterol criterion (aOR: 0.21; 95% CI: 0.05–0.89) compared with non-drinkers. Spirits consumption had a very low prevalence in this cohort and exhibited no apparent association with any individual defining criteria.

4. Discussion

In this prospective study of initially healthy young-middle-aged Mediterranean university graduates, alcohol consumption was associated with a higher risk of developing MS during at least 6-year follow up and with higher risk of developing three of the five MS defining criteria: high blood pressure, hypertriglyceridemia, and impaired fasting glucose.

We observed 341 new cases of MS among 8103 subjects, representing an incidence of around 4.2%. This incidence rate is inferior to that described in the general Spanish population[29] as it is to be expected in a cohort of young and active adults with a low baseline BMI and a high educational level and, specially, after selecting only participants without any criteria for MS at baseline.[2] Alcohol

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002

Table 2
Odds ratios (OR) (95% CI) of incident metabolic syndrome (MS) according to baseline alcohol consumption and stratified by type of alcohol. The SUN project 1999–2011.

	Drinks/week					*p* for trend
	0	<1	1–<2	2–<7	≥7	
Alcohol						
N	1794	1506	1559	2294	950	
MS incidence, *n* (%)	55 (3.1%)	47 (3.1%)	47 (3.0%)	90 (3.9%)	102 (10.7%)	
Crude OR	1 (Ref.)	1.02 (0.69–1.51)	0.98 (0.66–1.46)	1.29 (0.92–1.82)	3.80 (2.71–5.33)	<0.001
Age-sex adjusted OR	1 (Ref.)	0.96 (0.64–1.44)	0.97 (0.64–1.46)	1.01 (0.70–1.45)	1.99 (1.37–2.88)	<0.001
Multivariate adjusted OR[a]	1 (Ref.)	0.95 (0.63–1.44)	0.92 (0.61–1.40)	0.97 (0.67–1.41)	1.80 (1.22–2.66)	<0.001
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	0.94 (0.62–1.41)	0.91 (0.60–1.38)	0.98 (0.68–1.43)	1.72 (1.15–2.57)	<0.001
Red wine (1 drink = 100 mL)						
N	3821	1649	922	1111	600	
MS incidence, *n* (%)	116 (3.0%)	57 (3.5%)	38 (4.1%)	68 (6.1%)	62 (10.3%)	
Crude OR	1 (Ref.)	1.14 (0.83–1.58)	1.37 (0.94–1.99)	2.08 (1.53–2.83)	3.68 (2.67–5.08)	<0.001
Age-sex adjusted OR	1 (Ref.)	1.05 (0.75–1.47)	1.15 (0.78–1.69)	1.27 (0.92–1.75)	1.56 (1.10–2.20)	0.062
Multivariate adjusted OR[a]	1 (Ref.)	1.07 (0.76–1.50)	1.10 (0.74–1.63)	1.16 (0.83–1.61)	1.46 (1.02–2.09)	0.141
Additionally adjusted for other types of alcohol OR	1 (Ref.)	1.05 (0.75–1.48)	1.07 (0.72–1.59)	1.11 (0.79–1.55)	1.40 (0.97–2.01)	0.207
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	1.04 (0.74–1.46)	1.09 (0.74–1.61)	1.12 (0.80–1.56)	1.31 (0.91–1.91)	0.327
Other wine (1 drink = 100 mL)						
N	5782	1426	437	401	57	
MS incidence, *n* (%)	219 (3.8%)	62 (4.3%)	21 (4.8%)	33 (8.2%)	6 (10.5%)	
Crude OR	1 (Ref.)	1.15 (0.87–1.54)	1.28 (0.81–2.03)	2.28 (1.56–3.33)	2.99 (1.27–7.04)	0.001
Age-sex adjusted OR	1 (Ref.)	1.15 (0.85–1.55)	1.01 (0.63–1.63)	1.29 (0.86–1.92)	1.34 (0.53–3.35)	0.569
Multivariate adjusted OR[a]	1 (Ref.)	1.14 (0.84–1.55)	0.88 (0.54–1.42)	1.08 (0.72–1.64)	1.32 (0.52–3.36)	0.896
Additionally adjusted for other types of alcohol OR	1 (Ref.)	1.13 (0.83–1.53)	0.82 (0.51–1.34)	0.95 (0.63–1.45)	1.15 (0.45–2.95)	0.834
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	1.14 (0.84–1.55)	0.82 (0.50–1.33)	0.96 (0.63–1.46)	1.08 (0.41–2.84)	0.802
Beer (1 drink = 330 mL)						
N	3485	1863	1238	1290	227	
MS incidence, *n* (%)	118 (3.4%)	73 (3.9%)	54 (4.4%)	72 (5.6%)	24 (10.6%)	
Crude OR	1 (Ref.)	1.16 (0.86–1.57)	1.30 (0.94–1.80)	1.69 (1.25–2.28)	3.37 (2.13–5.35)	<0.001
Age-sex adjusted OR	1 (Ref.)	0.93 (0.68–1.27)	1.11 (0.79–1.57)	1.26 (0.91–1.73)	1.68 (1.03–2.75)	0.016
Multivariate adjusted OR[a]	1 (Ref.)	0.91 (0.66–1.26)	1.07 (0.75–1.52)	1.21 (0.87–1.69)	1.56 (0.94–2.62)	0.027
Additionally adjusted for other types of alcohol OR	1 (Ref.)	0.91 (0.66–1.25)	1.04 (0.73–1.48)	1.15 (0.82–1.62)	1.47 (0.88–2.46)	0.043
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	0.88 (0.64–1.21)	1.04 (0.73–1.49)	1.18 (0.84–1.65)	1.35 (0.79–2.31)	0.068
Spirits (1 drink = 50 mL)						
N	4860	1640	944	617	42	
MS incidence, *n* (%)	199 (4.1%)	71 (4.3%)	35 (3.7%)	31 (5%)	5 (11.9%)	
Crude OR	1 (Ref.)	1.06 (0.80–1.40)	0.90 (0.62–1.30)	1.24 (0.84–1.83)	3.16(1.23–8.14)	0.068
Age-sex adjusted OR	1 (Ref.)	1.16(0.86–1.55)	1.16 (0.79–1.72)	1.52 (1.00–2.32)	1.46 (0.53–4.01)	0.463
Multivariate adjusted OR[a]	1 (Ref.)	1.05 (0.77–1.42)	0.98 (0.66–1.47)	1.45 (0.93–2.25)	1.20 (0.43–3.36)	0.358
Additionally adjusted for other types of alcohol OR	1 (Ref.)	0.97 (0.72–1.33)	0.90 (0.60–1.36)	1.27 (0.81–1.99)	0.98 (0.35–2.79)	0.593
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	0.96 (0.71–1.31)	0.89 (0.59–1.34)	1.24 (0.79–1.95)	0.93 (0.32–2.68)	0.559
Spirits + beer						
N	2594	2911	712	1625	261	
MS incidence, *n* (%)	95(3.7%)	104 (3.6%)	27 (3.8%)	88(5.4%)	27 (10.3%)	
Crude OR	1 (Ref.)	0.97 (0.73–1.29)	1.04 (0.67–1.60)	1.51 (1.12–2.03)	3.03 (1.94–4.75)	<0.001
Age-sex adjusted OR	1 (Ref.)	0.91 (0.67–1.22)	1.08 (0.68–1.72)	1.29 (0.93–1.77)	1.83 (1.12–2.99)	0.004
Multivariate adjusted OR[a]	1 (Ref.)	0.86 (0.63–1.17)	0.92 (0.57–1.49)	1.24 (0.89–1.73)	1.60 (0.96–2.69)	0.025
Additionally adjusted for other types of alcohol OR	1 (Ref.)	0.84 (0.62–1.15)	0.85 (0.53–1.39)	1.16 (0.83–1.64)	1.53 (0.91–2.56)	0.047
Additionally adjusted for alcohol consumption pattern OR[b]	1 (Ref.)	0.85 (0.63–1.16)	0.86 (0.53–1.39)	1.17 (0.84–1.65)	1.48 (0.86–2.52)	0.093

SUN: "Seguimiento Universidad de Navarra" (Follow-up Study University of Navarra).
[a] Adjusted for age, sex, baseline body mass index, smoking, physical activity, total energy intake, adherence to the Mediterranean dietary pattern (Score proposed by Trichopoulou et al.[24] excluding alcohol consumption) snacking between meals and change in soft drinks consumption.
[b] Alcohol consumption pattern: alcohol consumption only 1 or 2 days per week and more than 30 g of alcohol in one day.

consumption was associated with a higher risk of developing MS in a population free of any MS criteria. It is possible that in other populations with hypertension or obesity the prevalence may be even higher. In fact, when we included participants with any MS criteria the incidence of MS was nearly twice (8.0%) but the risk was similar in participants with the highest alcohol consumption (OR: 1.72; 95% CI: 1.15–2.57) (Table 3). This similar association could be affected by the reverse causality bias, because hypertensive or obese participants at baseline may feel an incentive or receive an advice to not consume alcohol.

Our study is consistent with a previous cross-sectional study conducted in 27,030 healthy Korean men reporting that higher alcohol intake was linearly associated with increasing BMI, blood pressure and higher levels of triglycerides and fasting glucose (but also with higher levels of HDL).[4] However the cross-sectional design and the lack of assessment of the actual prevalence of MS in that study render their results difficult to be compared with ours. More importantly, results found in another previous prospective cohort with a smaller sample size ($n = 3833$) also provide consistency with our findings.[15] They found that higher levels of alcohol consumption (>30 g/day) were associated with a 63% higher risk of MS, compared with non-drinkers. When they stratified by BMI and type of alcohol beverage the association remained significant only among overweight/obese person and among liquor drinkers. In our analyses, obese participants were excluded to obtain a population initially free of any prevalent MS criteria. In addition in our sample liquor consumption was very low and this probably impeded us to be able to identify such an association.

Beer and spirits consumption are associated with after-hours binges. We did not find any significant association between beer and spirits consumption and MS, except a linear association that disappeared when we adjusted for alcohol consumption pattern. However, when alcohol consumption was high and concentrated in one or two days per week this consumption was significantly

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002

Table 3
Sensitivity analyses. Multivariate-adjusted[a] odds ratio (OR) and 95% confidence intervals (95% CI) of new-onset metabolic syndrome (MS) for the highest alcohol consumption (≥7 drinks/wk) taking as the reference non drinkers under several assumptions. The SUN project 1999–2011.

	n	MS (%)	OR (95% CI)[b]	*p* for trend
Using ATP-III criteria for MS	8103	205 (2.53%)	1.44 (0.88–2.37)	0.089
Using IDF criteria for MS	8103	318 (3.92%)	1.90 (1.27–2.83)	<0.001
Energy limits: percentiles 5 to 95	8203	336 (4.10%)	1.86 (1.25–2.77)	<0.001
Energy limits: percentiles 1 to 99	8851	364 (4.11%)	1.76 (1.21–2.55)	<0.001
Imputing missing alcohol questions	8679	392 (4.50%)	1.80 (1.22–2.65)	<0.001
Excluding participants with diabetes or cardiovascular disease at baseline.	8059	329 (4.08%)	1.84 (1.24–2.73)	<0.001
Excluding former drinkers	7548	307 (4.06%)	1.71 (1.14–2.58)	<0.001
Including participants with any MS criteria at baseline and excluding only prevalent MS.	10,565	850 (8.00%)	1.72 (1.15–2.57)	<0.001

SUN: "Seguimiento Universidad de Navarra" (Follow-up Study University of Navarra).
[a] Adjusted for age, sex, baseline body mass index, smoking, physical activity, total energy intake, adherence to the Mediterranean dietary pattern (Score proposed by Trichopoulou et al.[24] excluding alcohol consumption) snacking between meals and change in soft drinks consumption.
[b] Highest (≥7 drinks/wk) alcohol consumption versus non-drinkers.

associated with higher risk of MS. This pattern of consumption is usually composed by beer and liquor. It is difficult to discriminate if the higher MS incidence was due to the amount of alcohol or to the type of alcohol consumed in this case because they are closely related.

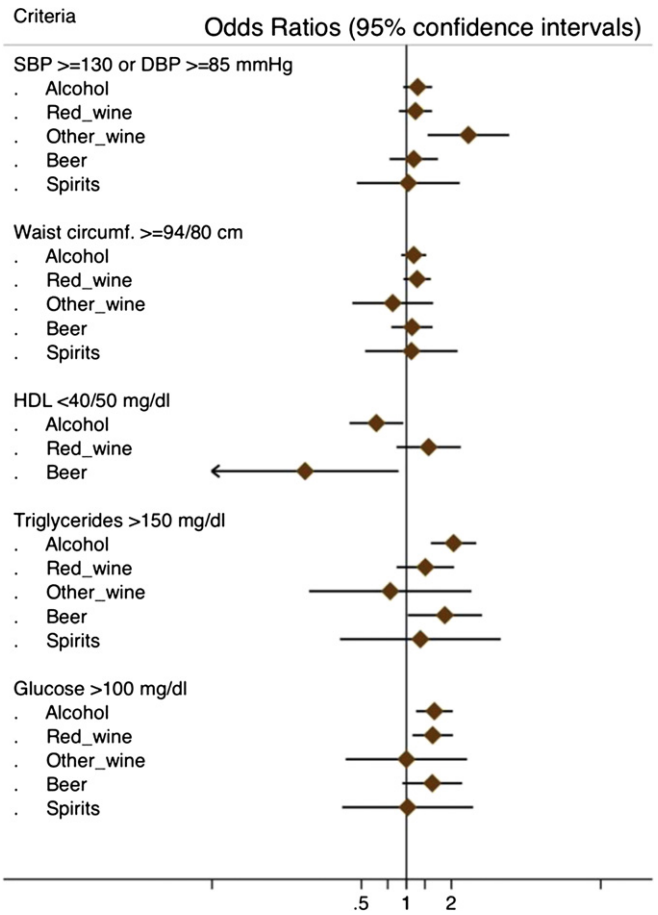

Fig. 1. Odds ratios (OR) (95% CI) of incident metabolic syndrome (MS) criteria for the highest baseline alcohol consumption (≥7 drinks/wk) taking as the reference no alcohol consumption and stratified by type of beverage. The SUN project 1999–2011. SUN: "Seguimiento Universidad de Navarra" (Follow-up Study University of Navarra). Adjusted for age, sex, baseline body mass index, smoking, physical activity, total energy intake, adherence to the Mediterranean dietary pattern (Score proposed by Trichopoulou et al.[24] excluding alcohol consumption), snacking between meals and change in soft drinks consumption. There were no participants who developed HDL criterion of MS in the liquors and other wine consumption categories. Therefore, we cannot present the results for this criterion in liquor and other wine consumption categories.

Some studies have suggested that an U- or J-shaped association exists between alcohol consumption and the prevalence of MS.[10] This phenomenon could be explained by the inclusion of ex-drinkers in the reference group of abstainers. In our sensitivity analyses, after excluding former drinkers, we found similar results.

The mechanisms underlying the relationship of alcohol drinking with MS should be explained by the action of alcohol on each component. Fan et al.[30] observed that the MS components contributing to the increase in the risk of MS were hypertension, elevated concentrations of fasting glucose and triglycerides for both men and women; and central obesity for women. Our analyses, following a longitudinal design and after adjusting for potential confounding factors, found similar results in participants who consumed 7 or more drinks per week.

The association between alcohol consumption and the risk of developing hypertension has been evaluated in some previous studies[5,31] with reported results in accordance with our findings. The association between alcohol consumption and the risk of developing hypertriglyceridemia has been extensively evaluated[4] and there is also consistency with the unfavorable effects suggested by our results. On the other hand, alcohol consumption has been associated with beneficial higher levels of HDL-cholesterol.[3] In our cohort, participants who consumed ≥7 alcoholic beverages per week had a significantly lower risk of meeting during follow-up the criterion for low HDL-cholesterol than non-drinkers (OR: 0.63; 95% CI: 0.42–0.96; p for trend = 0.136).

The association between alcohol consumption and the risk of developing diabetes mellitus have been evaluated in different observational studies and summarized in meta-analyses.[32,33] In those studies[32] alcohol intake was shown to exhibit an U-shaped relationship with diabetes, suggesting a potential benefit of moderate alcohol consumption compared with lifetime abstainers but a deleterious effect in heavy consumers (>60 g/d in men and >50 g/d in women). A similar relationship has been shown in a previous meta-analysis of 15 prospective cohort studies with a 30% lower risk of diabetes mellitus among moderate alcohol consumers (6–47 g/d) compared with heavier drinkers (>48 g/d) or nondrinkers.[33] In our cohort a 54% relatively higher risk to develop the fasting glucose MS criterion (OR: 1.54; 95% CI: 1.16–2.04; p for trend = 0.001) was found for participants in the highest category (≥7 drinks/wk) of alcohol consumption. However, a non-significant inverse association was found for moderate alcohol consumption in the two intermediate categories (<1 drink per week and 1–<2 drinks per week). In addition, red wine consumption was associated with a higher risk of developing fasting glucose criterion of MS. The most important caloric intake from red wine comes from the ethanol. The amount of ethanol from red wine is less than in other types of alcoholic beverages like beer

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002

or liquor. It is possible that other components of red wine can cause this alteration in glucose regulation or it is due to another confounding factor that we have not adjusted for.

We did not find any association between alcohol consumption and the risk of developing the waist circumference criterion. This result is consistent with a previous study in our cohort about alcohol consumption and the incidence of overweight/obesity[34] that only found an association with the incidence of overweight/obesity for beer plus spirits consumption but not for wine, which is the major source of alcohol in our cohort. Moreover, results reported in the literature are inconsistent because some prospective studies reported a positive association[6] whereas others reported no association.[7] Studies that analyzed each type of alcoholic beverage separately found, for wine drinkers, inverse associations with weight gain or abdominal adiposity, but positive associations for spirits.[35] In our cohort the consumption of spirits was very low as to be able to observe relevant associations.

Average alcohol consumption was very low among our participants (only 950 (1.7%) of the participants included in the analyses consumed $\geq$7 drinks/wk). In spite of this, we found that a consumption that was not specially high ($\geq$7 alcoholic beverages per week) was already associated with a significantly higher risk of developing MS and most of the individual criteria for the MS in comparison with abstainers.

The ethanol content in a serving of wine is similar to that in a serving of beer. If the consumption of one of these two drinks has different effects on metabolism, then other components different from ethanol must confer additional effects. Another explanation might be that wine, beer and liquor have the same physiological effect, but differences in the lifestyle-related risk factors patterns[36] among wine, beer and liquor drinkers might create the appearance of a difference in the risk of MS, and these lifestyle patterns could not be adjusted for in our analyses. Though we admit that residual confounding may exist, we were able to control for a wide array of potential confounders. In most cases the apparent association for specific beverages was only present for the highest category of consumption ($\geq$7 drinks per week). This was consistent with the result observed for the association between total alcohol consumption and the complete syndrome.

Our participants are not representative of the general Spanish population. We restricted our cohort to highly educated participants to obtain a good quality of self-reported information, to improve the retention rate and to prevent confounding by educational level, and therefore, by socio-economic status.[37] It is unlikely that socioeconomic level or educational level could explain in any way our results as this large cohort study is based only on university graduates with similar educational level. It is exactly the opposite: a variable cannot induce confounding if it is prohibited from varying. This feature may have affected the generalizability of those findings, but it could also have actually enhanced the validity of the study because the high level of education and homogeneity of the cohort reduced the potential confounding related to socioeconomic status. In addition, the high educational level of professional participants allowed us to collect high-quality information through self-reported questionnaires. However, their results have not incurred in any substantial bias, because they have used the classical method known as “restriction” in epidemiology to reduce the potential for confounding. Restriction is acknowledged in epidemiologic literature as an excellent technique to reduce confounding by known factors (as educational level).

Inherent to the nutritional epidemiology methods, we admit the possibility of some degree of misclassification (i.e., measurement error) in the dietary assessment. However, we have used an FFQ previously validated in Spain that showed a good estimate of validity specific for the assessment of alcohol consumption.[24,25] The self-reported collection of MS criteria, in spite of our published validation studies, could have also contributed to increase measurement error. In any case, we would expect this misclassification to be non-differential and to introduce some noise in our estimates, therefore, it may drive the associations more likely toward the null value.

Our study has important strengths such as the large number of initially healthy and slim participants, the long follow-up period, the previously published validation studies, the ability to control for potential confounders (including the overall dietary pattern), and the good quality of the self-reported data of our highly-educated volunteers.

In summary, even when we selected a healthy population where both the average alcohol consumption and the incidence of MS were low, relatively small amounts of alcohol were apparently associated with a higher risk of developing MS and three of the five individual metabolic criteria included in its definition. However, further studies in other populations at higher risk should be conducted to confirm these findings.

5. Conclusions

In this prospective cohort study of a Mediterranean population initially free of any MS defining criteria, consumption of at least seven alcoholic drinks per week was associated with a higher risk of developing MS and specific metabolic disorders after at least 6 years of follow-up. However, further studies in other populations are needed to generalize our results and confirm the association between alcohol consumption and the incidence of MS.

Sources of funding

The SUN Study has received funding from the Spanish Government (Grants PI01/0619, PI030678, PI040233, PI042241, PI050976, PI070240, PI070312, PI081943, PI080819, PI1002658, PI1002293, PND2010/87, RD06/0045, and G03/140), the Navarra Regional Government (36/2001, 43/2002, 41/2005, 36/2008, 41/2011) and the University of Navarra. AG is supported by a FPU fellowship from the Spanish Government.

Statement of authorship

MTB-L participated in the study design, statistical analyses, data interpretation and manuscript drafting. MB-R participated in the data interpretation, funding, concept and design of the study. CS-O, MG-L, AF-M and AG participated in the study design and in the data interpretation. MAM-G participated in the study design, statistical analyses, data interpretation, funding, and manuscript drafting. All authors have revised the manuscript for important intellectual content and read and approved the final version of the manuscript.

Conflict of interest

The authors declare that they have no competing interests.

Acknowledgments

The authors thank the collaboration of the participants in the SUN Study.

References

1. Gami AS, Witt BJ, Howard DE, Erwin PJ, Gami LA, Somers VK, et al. Metabolic syndrome and risk of incident cardiovascular events and death: a systematic review and meta-analysis of longitudinal studies. *J Am Coll Cardiol* 2007;**49**: 403–14.

2. Ford ES, Giles WH, Mokdad AH. Increasing prevalence of the metabolic syndrome among US adults. *Diabetes Care* 2004;**27**:2444–9.
3. Koppes LL, Dekker JM, Hendriks HF, Bouter LM, Heine RJ. Moderate alcohol consumption lowers the risk of type 2 diabetes: a meta-analysis of prospective observational studies. *Diabetes Care* 2005;**28**:719–25.
4. Sung KC, Kim SH, Reaven GM. Relationship among alcohol, body weight, and cardiovascular risk factors in 27,030 Korean men. *Diabetes Care* 2007;**30**:2690–4.
5. Halanych JH, Safford MM, Kertesz SG, Pletcher MJ, Kim YI, Person SD, et al. Alcohol consumption in young adults and incident hypertension: 20-year follow-up from the coronary artery risk development in young adults study. *Am J Epidemiol* 2010;**171**:532–9.
6. Wannamethee SG, Field AE, Colditz GA, Rimm EB. Alcohol intake and 8-year weight gain in women: a prospective study. *Obes Res* 2004;**12**:1386–96.
7. Halkjaer J, Tjønneland A, Thomsen BL, Overvad K, Sørensen TI. Intake of macronutrients as predictors of 5-y changes in waist circumference. *Am J Clin Nutr* 2006;**84**:789–97.
8. Sayon-Orea C, Martinez-Gonzalez MA, Bes-Rastrollo M. Alcohol consumption and body weight: a systematic review. *Nutr Rev* 2011;**69**:419–31.
9. Lee KW, Park BJ, Kang HT, Lee YJ. Alcohol-drinking patterns and metabolic syndrome risk: the 2007 Korean national health and nutrition examination survey. *Alcohol* 2011;**45**:499–505.
10. Wakabayashi I. Cross-sectional relationship between alcohol consumption and prevalence of metabolic syndrome in Japanese men and women. *J Atheroscler Thromb* 2010;**17**:695–704.
11. Chen CC, Lin WY, Li CI, Liu CS, Li TC, Chen YT, et al. The association of alcohol consumption with metabolic syndrome and its individual components: the Taichung community health study. *Nutr Res* 2012;**32**:24–9.
12. Wannamethee SG, Shaper AG, Whincup PH. Modifiable lifestyle factors and the metabolic syndrome in older men: effects of lifestyle changes. *J Am Geriatr Soc* 2006;**54**:1909–14.
13. Wilsgaard T, Jacobsen BK. Lifestyle factors and incident metabolic syndrome. The Tromsø study 1979–2001. *Diabetes Res Clin Pract* 2007;**78**:217–24.
14. Buja A, Scafato E, Sergi G, Maggi S, Suhad MA, Rausa G, et al, ILSA Working Group. Alcohol consumption and metabolic syndrome in the elderly: results from the Italian longitudinal study on aging. *Eur J Clin Nutr* 2010;**64**:297–307.
15. Baik I, Shin C. Prospective study of alcohol consumption and metabolic syndrome. *Am J Clin Nutr* 2008;**87**:1455–63.
16. Kim BJ, Kim BS, Kang JH. Alcohol consumption and incidence of metabolic syndrome in Korean men. *Circ J* 2012;**20**.
17. Martínez-González MA. The SUN cohort study (Seguimiento University of Navarra). *Public Health Nutr* 2006;**9**:127–31.
18. The nurses' health study. [Accessed 10.11.12 at: http://www.channing.harvard.edu/nhs/?page_id=70].
19. Willett WC, Colditz GA. Approaches for conducting large cohort studies. *Epidemiol Rev* 1998;**20**:91–9.
20. Willet Walter. *Nutritional epidemiology*. 2nd ed. New York: Oxford University Press; 1998. 322.
21. Alberti KG, Eckel RH, Grundy SM, Zimmet PZ, Cleeman JI, Donato KA, et al, International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; International Association for the Study of Obesity. Harmonizing the metabolic syndrome: a joint interim statement of the International Diabetes Federation Task Force on Epidemiology and Prevention; National Heart, Lung, and Blood Institute; American Heart Association; World Heart Federation; International Atherosclerosis Society; and International Association for the Study of Obesity. *Circulation* 2009;**120**:1640–5.
22. Barrio-Lopez MT, Bes-Rastrollo M, Beunza JJ, Fernandez-Montero A, Garcia-Lopez M, Martínez-González MA. Validation of metabolic syndrome using medical records in the SUN cohort. *BMC Public Health* 2011;**11**:867.
23. de la Fuente-Arrillaga C, Ruiz ZV, Bes-Rastrollo M, Sampson L, Martínez-González MA. Reproducibility of an FFQ validated in Spain. *Public Health Nutr* 2010;**13**:1364–72.
24. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* 2003;**26**(348):2599–608.
25. Bes-Rastrollo M, Pérez Valdivieso JR, Sánchez-Villegas A, Alonso A, Martínez-González MA. Validación del peso e índice de masa corporal auto-declarados de los participantes de una cohorte de graduados universitarios. *Rev Esp Obes* 2005;**3**:183–9.
26. Martínez-González MA, López-Fontana C, Varo JJ, Sánchez-Villegas A, Martínez JA. Validation of the Spanish version of the physical activity questionnaire used in the nurses' health study and the health professionals' follow-up study. *Public Health Nutr* 2005;**8**:920–7.
27. Alonso A, Beunza JJ, Delgado-Rodríguez M, Martínez-González MA. Validation of self reported diagnosis of hypertension in a cohort of University graduates in Spain. *BMC Public Health* 2005;**5**:94.
28. Moreiras O, Carbajal A, Cabrera L, Cuadrado C, editors. *Tabla de composición de alimentos*. 13th ed. Madrid: Pirámide; 2009.
29. Alegría E, Cordero A, Laclaustra M, Grima A, León M, Casasnovas JA, et al, Investigadores del registro MESYAS. Prevalence of metabolic syndrome in the Spanish working population: MESYAS registry. *Rev Esp Cardiol* 2005;**58**:797–806.
30. Fan AZ, Russell M, Dorn J, Freudenheim JL, Nochajski T, Hovey K, et al. Lifetime alcohol drinking pattern is related to the prevalence of metabolic syndrome. The western New York health study (WNYHS). *Eur J Epidemiol* 2006;**21**:129–38.
31. Nuñez-Córdoba JM, Martínez-González MA, Bes-Rastrollo M, Toledo E, Beunza JJ, Alonso A. Alcohol consumption and incidence of hypertension in a Mediterranean cohort: the SUN study. *Rev Esp Cardiol* 2009;**62**:633–41.
32. Rimm EB, Williams P, Fosher K, Criqui M, Stampfer MJ. Moderate alcohol intake and lower risk of coronary heart disease: meta-analysis of effects on lipids and haemostatic factors. *BMJ* 1999;**319**:1523–8.
33. Baliunas DO, Taylor BJ, Irving H, Roerecke M, Patra J, Mohapatra S, et al. Alcohol as a risk factor for type 2 diabetes: a systematic review and meta-analysis. *Diabetes Care* 2009;**32**:2123–32.
34. Sayón-Orea C, Bes-Rastrollo M, Núñez-Córdoba JM, Basterra-Gortari FJ, Beunza JJ, Martínez-González MA. Type of alcoholic beverage and incidence of overweight/obesity in a Mediterranean cohort: the SUN project. *Nutrition* 2010;**27**:802–8.
35. Vadstrup ES, Petersen L, Sørensen TIA, Grønbaek M. Waist circumference in relation to history of amount and type of alcohol: results from the Copenhagen city heart study. *Int J Obes* 2003;**27**:238–46.
36. Gronbaek M, Tjonneland A, Johansen D, Stripp C, Overvad K. Type of alcohol and drinking pattern in 56,970 Danish men and women. *Eur J Clin Nutr* 2000;**54**:174–6.
37. Rothman KJ, Greenland S, Lash TL. Design strategies to improve study accuracy. In: Rothman KJ, Greenland S, Lash TL, editors. *Modern epidemiology*. 3rd ed. , Philadelphia: Lippincott Williams and Wilkins; 2008. p. 168–82.

Please cite this article in press as: Barrio-Lopez MT, et al., Different types of alcoholic beverages and incidence of metabolic syndrome and its components in a Mediterranean cohort, Clinical Nutrition (2012), http://dx.doi.org/10.1016/j.clnu.2012.12.002