HHS Public Access

Author manuscript

Ann Rheum Dis. Author manuscript; available in PMC 2024 July 16.

Published in final edited form as:

Ann Rheum Dis. ; 83(8): 1072–1081. doi:10.1136/ard-2023-225389.

Changes in alcohol intake and serum urate changes: longitudinal analyses of annual medical examination database

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Abstract

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Author contributions: SF, MO, and DHS contributed to the original conception and design of this study, which TS, TA, TN, HT, MK, HH, TM, JM, ST, and HC reviewed and corrected. SF collected data with support from MO, TS, TA, TN, HT, MK, HH, and TM. SF performed data analysis with support from TS, JM, ST, HC, and DHS. SF, JM, ST, and DHS initially interpreted the data, and other authors advised on the interpretation. SF drafted the original manuscript, which was critically reviewed and revised by all other authors. All authors have read and approved the final version of the manuscript. SF had full access to all the data in the study and took responsibility for the integrity of the data and the accuracy of the data analysis.

Declaration of competing interest:
HT reports personal fees from Chugai Pharmaceutical, AbbVie, Ono Pharmaceutical, Kyowa-Kirin, Takeda Pharmaceutical, Astellas Pharma, Tanabe-Mitsubishi, GSK, Pfizer, Dai-ichi-Sankyo, Eisai, Illy-lily and Ayumi, outside the submitted work.
MK reports consulting fees and honoraria from AbbVie, Amgen, Asahi-Kasei Pharma, Astellas, Ayumi Pharma, BMS, Celgene, Chugai, Daiichi-Sankyo, Eisai, Eli Lilly, Gilead, Janssen, Kyowa Kirin, Novartis, Ono Pharma, Pfizer, Tanabe-Mitsubishi, Teijin Pharma, and UCB Pharma, outside the submitted work.
ST reports consulting fees from Novartis.
DS reports salary support through research contracts to his institution from CorEvitas, Janssen, and Novartis, and royalties from UpToDate.
All other authors have no conflict of interest.

Ethical approval information: This study was approved by the St Luke's International University Institutional Review Board (22R095, 098, and 099). Written informed consent was waived by offering options for opting out.

Patient and public involvement: Patients and/or the public were not involved in the design, conduct, reporting, or dissemination of this research.

Introduction: Despite the strong cross-sectional association between alcohol intake and serum urate (SU), its longitudinal association remains unknown. This study aimed to determine whether changes in alcohol intake have a clinically relevant association with SU change.

Method: We conducted retrospective analyses using systematically collected annual medical examination data from October 2012 to October 2022 in a Japanese preventive medicine center. The exposure was changes in alcohol intake between two consecutive visits. The association of SU changes with alcohol intake changes was estimated by mixed-effect linear regression with adjustment for relevant covariates.

Results: We analyzed 63,486 participants (median age, 47.0 years; 55% women; 58.6% regular alcohol drinkers with a median of 1.4 drinks/day) with 370,572 visits. The median SU level was 5.3 mg/dL, and 506 (0.8%) participants had diagnoses of gout or hyperuricemia without medication use during the study period. Decreasing one daily alcohol intake had a clinically small association with SU changes (−0.019 [95%CI: −0.021, −0.017] mg/dL). Beer had the largest association with SU (−0.036 [95%CI: −0.039, −0.032] mg/dL for one beer decrease). Complete discontinuation of any alcohol from a mean of 0.8 drinks/day was associated with −0.056 mg/dl [95%CI −0.068, −0.043] decrease in SU; the association became larger in hyperuricemic participants (−0.110 mg/dl [95%CI −0.154, - 0.066] for alcohol discontinuation from a mean of 1.0 drinks/day).

Conclusions: This study revealed changes in alcohol intake had small associations with SU change at the general Japanese population level. Complete discontinuation of alcohol in hyperuricemic participants had only modest improvement in SU.

Keywords

alcohol; serum urate; uric acid; gout; urolithiasis; crystal nephropathy

INTRODUCTION

Hyperuricemia is an abnormal laboratory condition typically defined as serum urate (SU) level ≥6.8 mg/dL [1], which has greatly increased in prevalence [2-5]. High SU levels can lead to monosodium urate crystals causing gout [6], crystal nephropathy [7], and urolithiasis [8]. Hyperuricemia is the most important risk factor for gout. A concentration-dependent relationship is observed between SU levels and the risk of incident gout. While the 15-year cumulative incidence of gout is 1.1% in patients with SU <6 mg/dL, it increases to 9.0% in those with SU between 7.0 to 7.9 mg/dL, and 48.6% for SU ≥10.0 mg/dL [9].

Cross-sectional epidemiologic studies have shown a direct relationship between alcohol intake and SU level [10-16], such that alcohol intake has the strongest association with SU level among dietary factors [16]. Beer has consistently shown the largest association with SU among alcoholic beverages. One unit increase in daily beer intake was associated with up to 0.5 mg/dL increase in SU level [10-16]. This association forms a part of the rationale for recommending alcohol reduction in gout and/or hyperuricemic patients [17, 18]. Furthermore, the association of alcohol with SU is well-recognized among both the general public and healthcare professionals.

In recent years, studies revealed that there are various genetic alleles associated with SU level [19], and the relative contributions of diet and genetics to SU and gout have been debated [16, 20, 21]. In addition, obesity has been reported to have more impact on SU compared with specific diets [20-22]. Different comprehensive dietary modifications resulted in weight reduction and improvement in SU level. However, the overall effects in average participants were modest compared to urate-lowering medications [23, 24].

While the cross-sectional association between alcohol and SU is clear, it has remained unknown whether increasing or reducing alcohol intake results in changes to SU levels. This study aimed to determine if altering daily alcohol intake would have a clinically relevant association with SU levels by using data from annual longitudinal medical examinations.

METHODS

Study Design and Setting

We conducted analyses of a systematically collected longitudinal medical examination database (St. Luke's Health Check-up Database: SLHCD), from Oct 2012 to Oct 2022. In Japan, medical insurers or employers mandate all insured people or full-time employees to undergo medical examinations annually [25]. During the medical examination, participants typically received height and weight measurements, physical examination, blood tests, electrocardiogram, and chest radiography. Participants were required to answer a questionnaire about their medical histories and lifestyles. Participants subsequently received advice on lifestyle modification from the physicians based on the results of examinations and questionnaires. All these data were recorded in SLHCD.

This study was approved by the St Luke’s International University Institutional Review Board. Written informed consent was waived by offering options for opting out. The study was conducted based on the Declaration of Helsinki and relevant ethical guidelines for medical research in Japan. The study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Study Participants

We enrolled consecutive participants undergoing medical examinations at the Center for Preventive Medicine in St. Luke’s International Hospital, tertiary care center, Tokyo, Japan. Participants who underwent systematic medical examinations at least twice during the study period were included. We excluded the following participants from our primary cohort: 1) participants who received pharmacological treatment for hyperuricemia or gout during the study period (these participants were analyzed in the sensitivity analysis); 2) participants younger than age 20 years, as Japanese law prohibits those under 20 from drinking alcohol; 3) participants who made errors in the questionnaire (e.g., contradictory answers); 4) those underwent hemodialysis; and 5) participants who did not consent to use their data for research.

Outcome and Exposure of Interest

The outcome of this study was the change in SU level (mg/dL) between two consecutive visits. SU was routinely measured at each visit as a part of the systematic annual medical examination by uricase oxidization method (Clinical Chemistry Analyzers, JCA-BM2250/6070, JEOL Ltd, Tokyo, Japan). Exposures of interest were changes in daily intake (drinks/day) of total alcohol and specific alcoholic beverages. The specific alcoholic beverages included beer, wine, whiskey, sake (Japanese rice wine), shochu (Japanese common spirits), and other alcoholic beverages (spirits-based cocktails were assumed based on the National Survey of Alcoholic Beverages [26]). The annual medical examination collected information on current daily alcohol intake using a standardized questionnaire. Participants were asked whether they were regular alcoholic drinkers (at least 1 drink per week). If yes, they were asked how many days of the week they currently drank alcohol and the average daily consumption for each type of alcoholic beverage. The unit of alcoholic beverage was converted to a standard drink that included 10g of pure ethanol. The change in alcohol intake between two consecutive visits was calculated. The details of the questionnaire and calculation of ethanol amounts are described in Supplemental Methods.

Covariates

We collected data from the SLHCD including age, sex, body mass index (BMI), estimated glomerular filtration rate (eGFR) calculated by Japanese-specific eGFR formula [27], results of questionnaires about medical conditions with treatment status, and the contents of lifestyle questionnaires. Given that major medications that potentially change SU included aspirin, diuretics, calcium blockers, angiotensin receptor blockers, sodium-glucose cotransporter 2 inhibitors, and statins [28], we utilized data on the status of medication use for hypertension, diabetes, dyslipidemia, angina, myocardial infarction, transient ischemic attack, and cerebral infarction. We used the following results of the food frequency questionnaire as covariates: carbohydrates (e.g., rice, bread, noodles); meat and eggs; seafood; vegetables; fruits; milk and dairy products; soy; fat-rich diet (fried foods, animal fat, and other fatty meal); and sweets. Reported dietary habits (frequency of eating until full, eating out, and snacks between meals) as well as other lifestyles such as smoking (never, previous, current), daily physical activity (very low, low, moderate, high), and exercise level (the number of days with at least 20 minutes of light and sweaty exercise: less than 1 day/week, 1-2 days/week, 3-5 days/week, more than 5 days/week) were also collected. These results from the questionnaire were utilized as categorical covariates in all analyses.

Statistical analyses

We described the baseline characteristics of the participants. Categorical variables were summarized as numbers (percentages), and continuous variables were presented as median (interquartile range [IQR]). To reduce the influence of outliers, we imputed a 99.9 percentile value of daily alcohol intake for reported alcohol consumption above this threshold. Complete case analyses were performed because the number of observations that had at least one missing value was only 0.3% (980 out of 370,572 visits).

Participants contributed multiple consecutive visits, thus a linear mixed-effect model with random intercepts was used to account for longitudinal within-person correlations. Since the

primary exposure was change in alcohol use and the primary outcome was change in SU, two consecutive visits were considered in all analyses; the first visit was described as the "prior visit" and the latter visit as "concurrent visit".

We used two analytic models with different covariates for adjustment. Age, sex, and prior history of gout or hyperuricemia as well as alcohol intake and SU at prior visits were adjusted in all analyses. In addition, the primary analytic models adjusted only for lifestyle covariates and medication use measured at prior visits to avoid conditioning mediators. The alternative analytic models additionally adjusted for these covariates measured at concurrent visits.

The primary analyses evaluated the association of continuous changes in total alcohol intake with SU changes. The results were presented as SU changes associated with one daily alcohol decrease. Then, we conducted a series of sensitivity analyses as described below (details were described in Supplemental methods).

First, we conducted several analyses while maintaining "continuous" alcohol changes as an exposure. Initially, intake of specific alcoholic beverages was used as exposure, instead of total alcohol intake. Then, the alternative analytic model was applied to the association of SU changes with changes in total or specific alcohol intake. Stratified subgroup analyses (categorized age, BMI, eGFR, prior alcohol intake, prior SU, and previous history of gout or hyperuricemia) were performed separately by sex. Other additional sensitivity analyses included excluding heavy drinkers (daily alcohol intake ≥ 99.9 percentile); excluding participants with several medical conditions (e.g., cardio-cerebrovascular events, cancers) that might have impacted alcohol use; and removing SU at prior visits from the analytic models. Furthermore, we also considered the exposure of interest as the change in alcohol use from the baseline visit to the concurrent visit.

Second, analyses with "categorical" alcohol changes were performed to minimize the influence of minor variations in alcohol consumption; changes in alcohol intake were categorized as increase or decrease by 3 drinks or more, by 2 to 3 drinks, by 1 to 2 drinks, by up to 1 drink, and no change. Both total and specific alcohol intakes were evaluated.

Third, we evaluated the effect of initiating or fully discontinuing regular alcohol intake. Finally, we analyzed the participants who were excluded from our primary cohort due to receiving pharmacological treatment for gout or hyperuricemia during the study period (see Supplemental Methods).

We conducted all statistical analyses with Stata (Version 17.1, Stata Corp LLC, TX, USA). Point estimates and 95% confidence intervals were reported for all analyses.

RESULTS

Characteristics of study participants

67,467 people participated in systematic annual medical examinations at least twice from October 2012 to October 2022. A total of 3981 participants were excluded from our primary cohort, most of whom received treatment for hyperuricemia or gout during the period.

Our analyses included 63,486 participants with 370,572 visits (307,086 consecutive two visits) and 347,236 person-year follow-ups (Supplemental Figure 1). On the first visit, the median age (IQR) was 47 (39, 56) years, and 28,578 (45.0%) were male; 37,199 (58.6%) were regular alcohol drinkers with a median alcohol intake of 1.4 (0.6, 2.9) drinks/day. The median (IQR) SU level was 5.3 (4.4, 6.3) mg/dL, and 8,385 (13.2%) participants had hyperuricemia (SU ≥7 mg/dL). The median interval between visits was 1.0 (1.0, 1.2) years. There were 149,441 episodes of changing alcohol intake in 41,661 participants (Table 1). When changes in alcohol intake were categorized, many episodes were small changes (increase or decrease by up to 1 drink/day) (Supplemental Table 1). Supplemental Table 2 shows the results of the lifestyle and dietary questionnaire. Participants were well-distributed in each category of the questionnaire items.

Association between serum urate level and continuous changes in daily alcohol intake

The primary analysis showed that one drink decrease in daily alcohol intake was associated with SU change of −0.019 mg/dL (95% CI −0.021, −0.017) (Figure 1). The secondary analytic model, which additionally adjusted for covariates at concurrent visits, produced similar results as the primary analyses. In the analyses for specific alcoholic beverages, decreases in beer intake demonstrated the largest yet clinically small change in SU of −0.036 mg/dl (95% CI −0.039, −0.032) (Figure 1).

In stratified sub-group analyses, younger participants, lighter drinkers, and those with higher initial SU levels had larger changes in SU with alcohol intake (Figure 2). The results of additional sensitivity analyses using the exposure of continuous alcohol use demonstrated no clinically relevant differences from the primary analyses (Supplemental Table 3).

Association of serum urate change with categorical changes in daily alcohol intake

When alcohol intake was categorized, the primary analytic model revealed the increases in SU were 0.021mg/dl for a < 1 drink increase; 0.037 for a 1–2 drink increase; 0.041 for a 2–3 drinks increase; and 0.059 for ≥ 3 drinks increase. Decreases in SU were −0.018 for a < 1 drink decrease; −0.029 mg/dl for a 1–2 drink decrease; −0.051 for a 2–3 drinks decrease; and −0.105 for ≥ 3 drinks decrease (Figure 3). Among alcoholic beverages, beer, wine, and shochu showed clear dose-response relationships. Beer intake had the strongest association with SU while the magnitude of the association was modest (Figure 4).

Alcohol initiation and serum urate level

10,726 participants initiated regular alcohol intake at 12,798 visits. Initiating one daily alcoholic beverage was associated with a mean increase of 0.038 mg/dl (95% CI 0.029, 0.047) in SU. When alcohol intakes were categorized, we observed increased SU by 0.026 mg/dL for < 1 drink/day, 0.079 for 1–2 drinks/day, 0.081 for 2–3 drinks/day, and 0.156 for ≥ 3 drinks/day of alcohol initiation. Compared with other types of alcohol, beer initiation was associated with the largest SU increase (SU change 0.054 mg/dL [95% CI 0.038, 0.070] for one beer initiation) (see Supplemental Figure 2).

Alcohol discontinuation and serum urate level

12,528 participants discontinued regular alcohol intake at 15,085 visits. When compared to maintaining the same alcohol intake, complete discontinuation of any alcohol (from a mean of 0.8 drinks/day) was associated with −0.056 mg/dl [95% CI −0.068, −0.043] decrease in SU. This association became larger in hyperuricemic participants (−0.110 mg/dl [95% CI −0.154, −0.066] for alcohol discontinuation from a mean of 1.0 drinks/day). One drink discontinuation was associated with a SU change of −0.047 mg/dl (95% CI −0.055, −0.039) in all eligible participants and −0.071 mg/dl (95% CI −0.091, −0.050) in hyperuricemic participants (see Figure 5). Discontinuation of beer was associated with a SU reduction of −0.067 mg/dl (95 CI −0.082, −0.053) per one drink. The association became larger in hyperuricemic participants, presenting a SU change of −0.115 mg/dl (95% CI −0.156, −0.074) per one beer discontinuation. (Supplemental Figures 3 and 4).

Analyses of participants who received pharmacological treatment for hyperuricemia or gout

3,478 participants reported medication use for their hyperuricemia or gout during the study visits, and they contributed to 23,185 visits in total. In this secondary cohort, one drink decrease in daily alcohol intake was associated with SU change of −0.08 mg/dL (95% CI −0.017, 0.000). The association between categorial alcohol changes and SU changes in this population and in those with SU ≥7.0 mg/dL was similar to the relationships observed in the primary study cohort (Supplemental Figure 5).

Discussion

Previous cross-sectional studies have demonstrated the associations of alcohol intake with SU level [10-16]. The association between one daily beer intake and SU varied depending on studies but ranged up to 0.5 mg/dL (Supplemental Table 4). The strength of this cross-sectional association formed a part of the basis for recommending alcohol reduction for controlling SU [17, 18].

The current study uniquely centered on how changes in alcohol intake might alter SU levels, a clinically relevant topic not yet explored in depth. Unlike prior cross-sectional analyses, this large longitudinal study demonstrated that changes in alcohol intake led to significant but small changes in SU. A series of secondary analyses showed consistent results. The longitudinal design can enhance accurate estimation of how changes in exposure impact changes in outcome [29]. As shown in the causal diagram (Supplemental Figure 6), prior serum urate may work as a confounder.

Conditioning prior alcohol and SU may reduce the influence of fixed unmeasured confounders which was related to prior alcohol and SU association and likely influential in cross-sectional analyses [29]. Moreover, the unadjusted association between alcohol intake and SU changes was notably weaker than the cross-sectional associations of alcohol with SU in Supplemental Figures 7 and 8, suggesting other factors potentially confounded the association between alcohol intake and SU. In this study, persons who were greater alcohol consumers showed distinct characteristics, being more obese and having more

comorbidities; dietary content and habits were also different (Supplemental Table 5). Confounding by these different patient characteristics and genetic factors made it difficult to estimate the association between alcohol and SU. Our study results were in line with recent genetic studies revealing a small contribution of dietary factors to SU variation [16, 20].

Furthermore, previous randomized controlled or interventional trials, examining the effect of alcohol reduction on blood pressure, supported our results; these studies showed alcohol reduction did not decrease SU levels [30, 31] (Supplemental Table 6).

Various factors contributed to the extent of the association between alcohol change and SU change. As with previous studies[10, 11, 13-15], beer intake was most strongly associated with SU level changes in this study. Beer includes more purine bodies compared to other alcohols [32]. Moreover, guanine, a purine body relatively abundant in beer, is more likely to be readily metabolized and therefore affects SU levels [33]. Dietary habits also vary depending on the type of alcoholic beverages [34, 35], which might confound the association. The association became larger in hyperuricemic participants. In these participants, SU levels might change more easily in response to diet because of having predisposing genetic factors. Genetically altered metabolism of purines from diet and decreased elimination of uric acid into urine and intestines might potentially affect SU changes after diet [36-39]. Fully discontinuing alcohol was associated with a larger and modest SU decrease. This association might be mediated or confounded by other exposures, as such people might experience other lifestyle changes. Given the modest association of alcohol reduction or discontinuation with SU change, even in participants with gout or hyperuricemia, simply decreasing alcohol would often be insufficient to achieve target SU. Our study highlighted the importance of prioritizing the appropriate introduction of ULT when patients need to control their SU. Medication compliance is a serious problem in gout management [40]. If patients are aware that the average association between changes in alcohol consumption and SU levels is modest, their compliance may improve by understanding the importance of taking medications.

Alcohol intake is an established risk factor for gout [41], and acute gout attacks are known to occur after alcohol intake [42]. Moreover, physiological experimental studies revealed that alcohol intake, particularly beer, caused acute increases in SU [32, 43-45]. However, such acute increases in SU may not be captured in the research or in clinical practice. Therefore, alcohol intake as a trigger for acute gout flares may be more important rather than its association with stable SU levels. Alcohol restriction should continue to be recommended in gout management even though its long-term effects on stable SU are likely small.

Strengths and Limitations

This study had several strengths and limitations. In addition to the longitudinal design, this study included a large number of participants, with a broad range of covariates, who were evaluated regularly by a standardized protocol. Thus, there were only a few missing values in our database because these data were required for daily practice. This was not a study of gout, but rather SU; SU is important as an established target in gout management [46]. While we included various dietary questionnaire information, the questionnaire was not

robustly validated like the food frequency questionnaire [47]; this might potentially lead to biased estimates. There might be potential reporting biases of underreporting alcohol intake, especially when patients did not adhere to physicians' recommendations to reduce alcohol consumption. The study database lacked detailed information about medications, while we adjusted for medication use status for diseases treated with medications that potentially change SU level. To minimize this limitation, we also excluded participants with comorbidities related to medications affecting SU in sensitivity analyses. Finally, the majority of participants in this study were healthy Japanese without hyperuricemia. While undergoing annual health examinations is a duty in Japan, the participants might be healthier or more compliant than the general Japanese population. In addition, several important characteristics associated with SU, such as obesity and comorbidities [21, 22, 48], differed from those in previous study populations. For instance, the mean BMI in this study was 22.2 kg/m^2 at baseline, which was much lower than 27.0 kg/m^2 in a previous study in the United States [11]; hypertension was less frequent (8.8% in this study vs 24% in the US study [11]). Our study population may also have different genetic backgrounds affecting SU levels. For instance, decreased aldehyde dehydrogenase activity, which is more prevalent in East Asia, might alleviate the SU changes [49]. Therefore, our result should be carefully applied to other populations and need to be replicated in other study populations.

Conclusions

In conclusion, we conducted longitudinal analyses of the association between changes in alcohol intake and SU changes. The current analyses found that changes in daily alcohol consumption did not result in clinically relevant changes in SU levels in the study population. Complete discontinuation of alcohol, particularly in hyperuricemic participants, had a modest association with lowering SU. Reducing alcohol intake alone is unlikely to be a major driver of reductions in stable SU. The appropriate introduction of ULT should be prioritized when patients need to control their SU.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments:

We thank the contributions of physicians and other staff who examined the medical checkup participants. We appreciate Mr. Nakajima and the Information System Unit in St. Luke’s International Hospital for supporting data collection, and Dr. Kimura for his advice on the analyzing data of SLHCD.

Source of Funding:

This study was supported by NIH funding P30 AR072577 (PI: DHS)

Data sharing statement:

Data is not available publicly because of the regulations in our institution. Data were analyzed using STATA software (version 17.1, StataCorp, College Station, TX). The codes used in this study are available upon reasonable request from the corresponding author (SF).

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Key Messages

What is already known on this topic

■ Cross-sectional studies suggest a strong association between alcohol intake and serum urate (SU) levels. However, it remains unknown whether increasing or reducing alcohol intake results in changes to SU levels

What this study adds

■ In this longitudinal study using a large database of annual medical examinations, changes in alcohol intake had small associations with SU change at the general Japanese population level.

■ Complete discontinuation of alcohol in hyperuricemic participants had only modest improvement in SU.

How this study might affect research, practice, policy

■ Simply decreasing or discontinuing alcohol may have small impacts on the SU level, likely insufficient to achieve target SU levels.

■ The appropriate introduction of urate-lowering treatment should be prioritized for improving SU level.

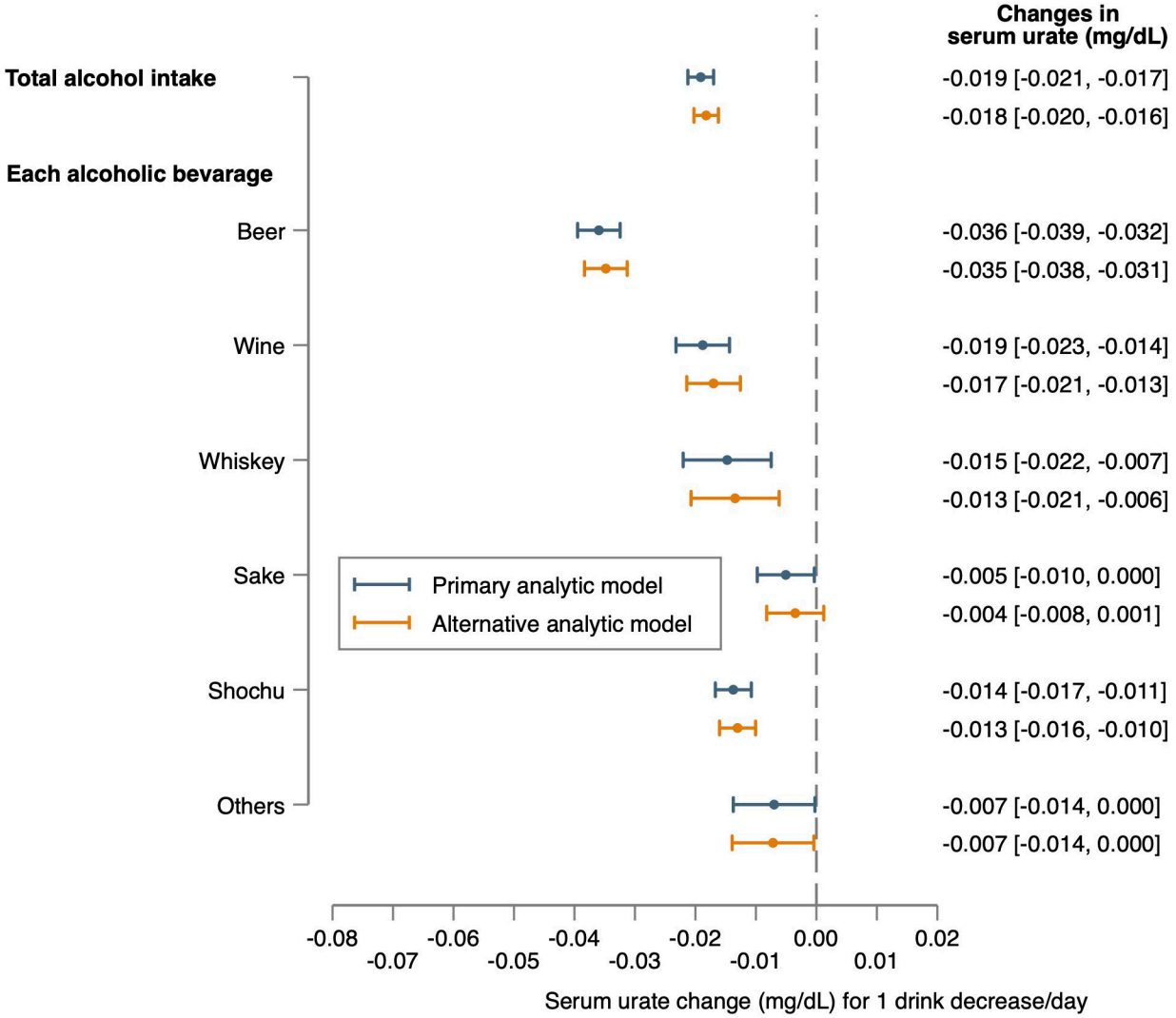

Figure 1. The association of changes in serum urate levels (mg/dL) with one unit decrease in daily alcohol intake (standard drink/day).

Points and bars represented point estimates and 95% confidence intervals. Total alcohol included beer, wine, whiskey, sake, shochu, and other alcoholic beverages. Sake, Japanese rice wine; Shochu, Japanese spirit.

63,486 participants with 307,086 consecutive two visits were analyzed. Results were adjusted for age, sex, history of hyperuricemia or gout, serum urate, and alcohol consumption at a prior visit in all analyses. In the primary analytic model, we adjusted for lifestyle covariates measured at prior visits. In the alternative analytic model, we additionally adjusted for the lifestyle covariates measured at concurrent visits. These lifestyle covariates included body mass index; estimated glomerular filtration rate; medication use for hypertension, diabetes, dyslipidemia, and cardiovascular and cerebrovascular diseases; smoking status; daily activity level; exercise level; and results of dietary questionnaires. Amounts of other alcohol intake were adjusted for analyses using each alcoholic beverage intake.

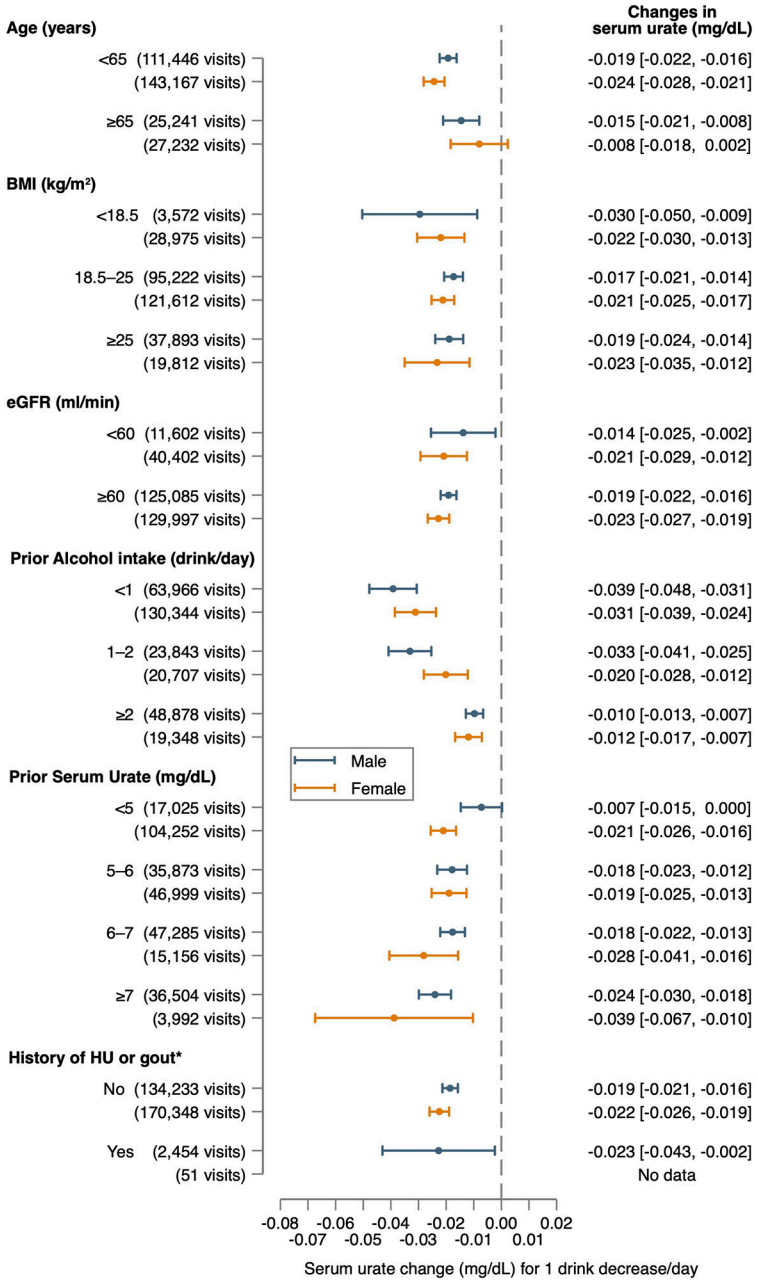

Figure 2. Results of subgroup analyses for the association of changes in serum urate levels (mg/dL) with one unit decrease in daily alcohol intake (standard drink/day).

Points and bars represented point estimates and 95% confidence intervals.

BMI, body mass index; eGFR, estimated glomerular filtration rate; HU, hyperuricemia

63,486 participants with 307,086 consecutive two visits were analyzed. The visit numbers for each category of participants characteristics were the number of consecutive two visits. Results were adjusted for history of hyperuricemia or gout; serum urate; alcohol consumption; age; body mass index; estimated glomerular filtration rate; medication use for hypertension, diabetes, dyslipidemia, and cardiovascular and cerebrovascular diseases;

smoking status; daily activity level; exercise level; and results of dietary questionnaires at prior visits (primary analyses model).

* Participants who had a history of gout or hyperuricemia but did not receive treatment during the study period. We did not analyze female participants in this subgroup because there were only 11 eligible female participants with 52 concurrent visits.

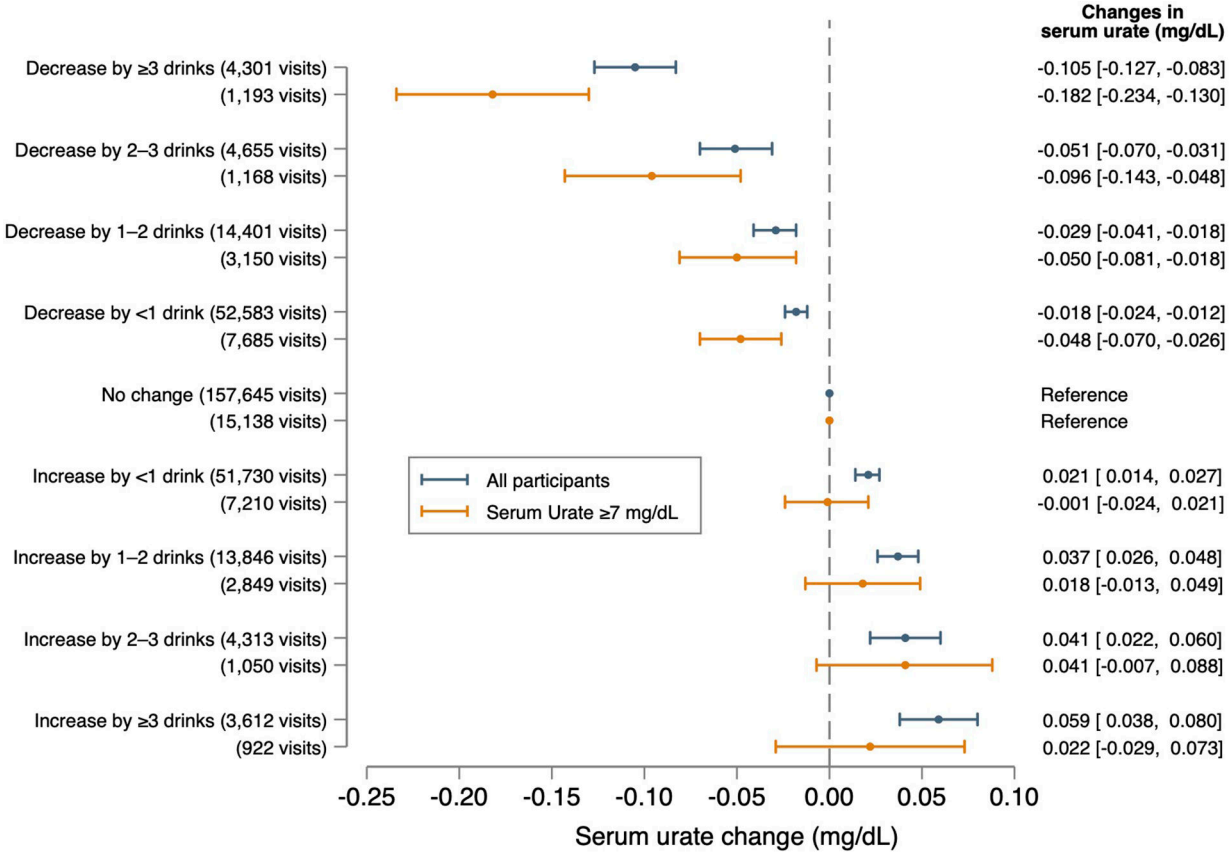

Figure 3. The association of changes in serum urate levels (mg/dL) with categorical changes in daily alcohol intake (drink/day).

Points and bars represented point estimates and 95% confidence intervals.

63,486 participants with 307,086 consecutive two visits were analyzed. The visit numbers for each categorical alcohol intake were the number of consecutive two visits.

Results were adjusted for serum urate, alcohol consumption, age, sex, body mass index, eGFR, history of hyperuricemia or gout, relevant medication use, smoking status, daily activity level, exercise level, and results of dietary questionnaires measured at prior visits (primary analytic model).

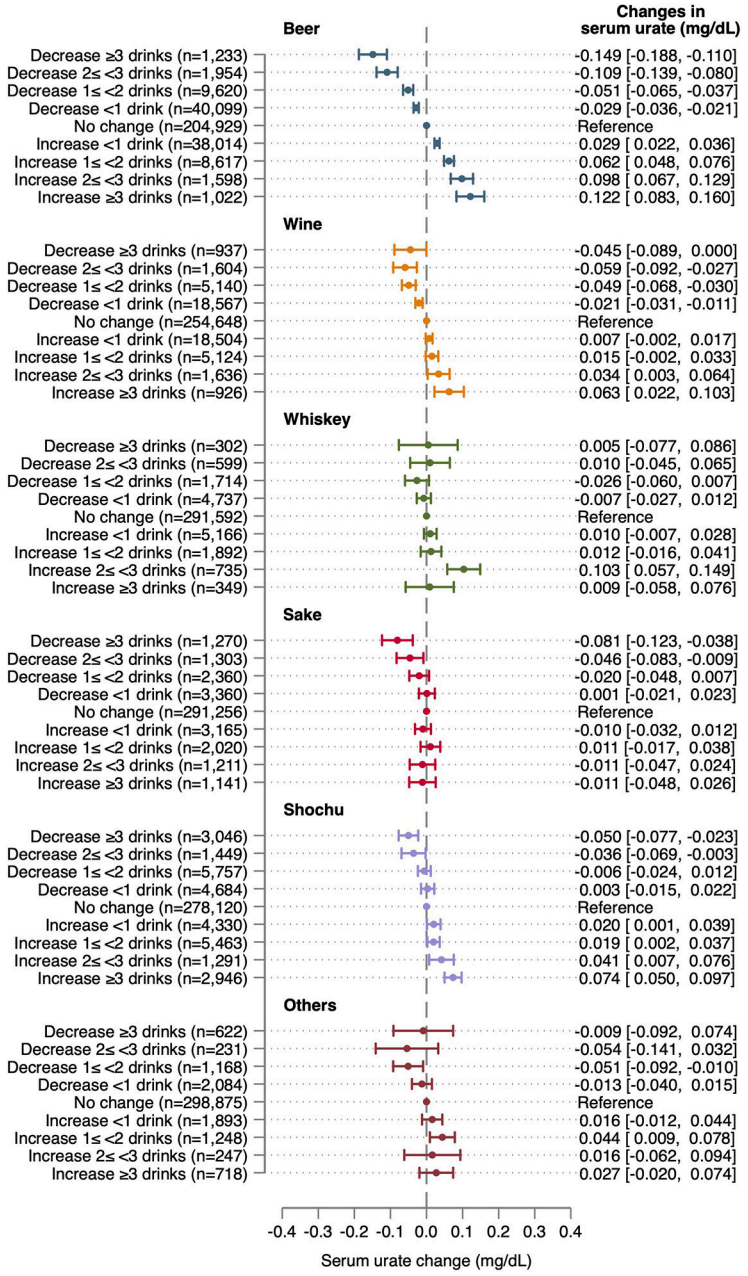

Figure 4. The association of changes in serum urate levels (mg/dL) with categorical changes in each alcoholic beverage intake (drink/day)

Points and bars represented point estimates and 95% confidence intervals. 63,486 participants with 307,086 consecutive two visits were analyzed. The visit numbers for each categorical alcohol intake were the number of consecutive two visits.

Results were adjusted for serum urate, alcohol consumption, age, sex, body mass index, eGFR, history of hyperuricemia or gout, relevant medication use, smoking status, daily activity level, exercise level, and results of dietary questionnaires measured at prior visits (primary analytic model). For the results of each alcoholic beverage, changes in other alcoholic beverages were additionally adjusted.

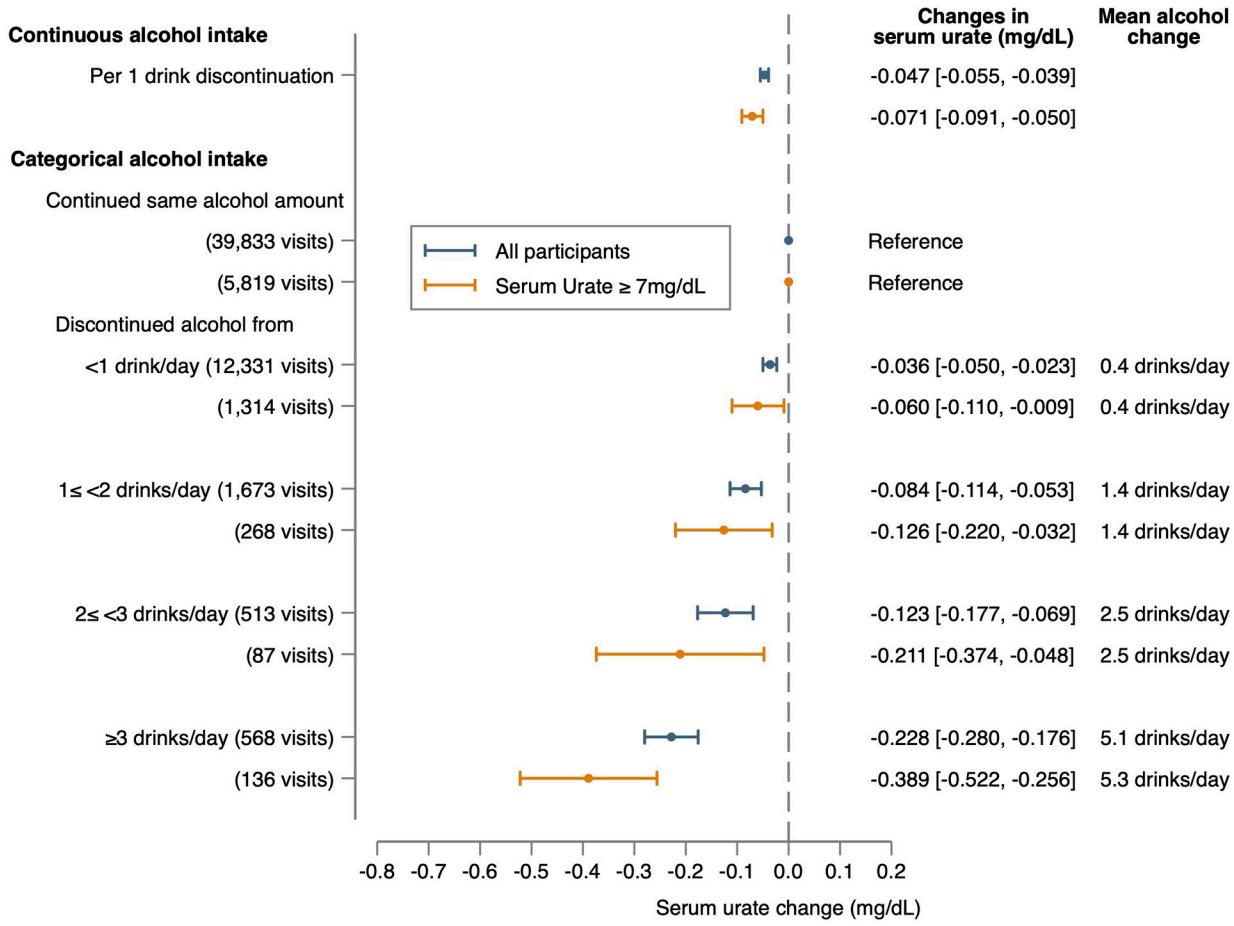

Figure 5. Alcohol discontinuation (drink/day) and serum urate level (mg/dL).

Points and bars represented point estimates and 95% confidence intervals.

Visit data of participants who drank alcohol at prior visits and continued the same alcohol intake or fully discontinued alcohol at concurrent visits were included in the analyses (all participants: 27,416 participants with 54,983 visits, SU ≥ 7 mg/dl: 4,966 participants with 7,624 visits). The visit numbers for each categorical alcohol intake were the number of consecutive two visits.

Results were adjusted for serum urate, alcohol consumption, age, sex, body mass index, eGFR, history of hyperuricemia or gout, relevant medication use, smoking status, daily activity level, exercise level, and results of dietary questionnaires measured at prior visits (primary analytic model).

Table 1.

Baseline characteristics of medical checkup participants

	Total participants N=63,486
Age	47 (39, 56)
Sex, Male	28,578 (45.0%)
Female	34,908 (55.0%)
Body mass index, kg/m^2	21.8 (19.8, 24.1)
Body mass index ≥ 25 kg/m^2	11,335 (17.9%)
Body mass index ≥ 30 kg/m^2	1,601 (2.5%)
Number of visits during follow-up	5.0 (3.0, 9.0)
Total follow up, years	5.5 (2.7, 8.7)
Interval between visits, years	1.0 (1.0, 1.2)
Baseline serum urate, mg/dL	5.3 (4.4, 6.3)
Hyperuricemia (serum urate ≥ 7 mg/dL)	8,385 (13.2%)
eGFR, mL/min/1.73m^2	77.0 (67.0, 88.1)
Medical history of hyperuricemia or gout *	506 (0.8%)
Medication use for the conditions below	9,151 (14.4%)
Hypertension	5,618 (8.8%)
Diabetes	1,426 (2.2%)
Dyslipidemia	4,058 (6.4%)
Ischemic heart disease	499 (0.8%)
Cerebrovascular diseases	294 (0.5%)
Baseline alcohol data (not mutually exclusive)	
Regular Alcohol drinker	37,199 (58.6%)
Total alcohol intake (Standard drink/day)	1.4 (0.6, 2.9)
Beer drinker	26,694 (42.0%)
Daily intake (Standard drink/day)	1.1 (0.6, 1.7)
Wine drinker	10,298 (16.2%)
Daily intake (Standard drink/day)	1.00 (0.5, 2.00)
Whiskey drinker	2,107 (3.3%)
Daily intake (Standard drink/day)	1.1 (0.7, 1.9)
Sake drinker	3,128 (4.9%)
Daily intake (Standard drink/day)	1.9 (1.2, 3.1)
Shochu drinker	5,693 (9.0%)
Daily intake (Standard drink/day)	2.3 (1.4, 4.0)
Others drinker	1,084 (1.7%)
Daily intake (Standard drink/day)	0.8 (0.6, 2.0)

Continuous variables are presented as median (interquartile range) based on their distribution.

* without medication use during the study period