Herbal Medicines Journal
DOI: 10.22087/hmj.v8i2.975
2023; 8(2):113-22
ISSN: 2538-2144

Review Article

Effects of Sour Tea (*Hibiscus Sabdariffa L.*) Consumption on Anthropometric Indices: A Systematic Review and Meta-Analysis

Salman Mohammadi[1], Mahboobe Hosseinikia[2], Naseh Pahlavani[3], Ali Ghaffarian-Bahraman[4], Esmaeil Yousefi Rad[1*], Somayeh Saboori[1*]

[1]Nutritional Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran
[2]Department of Nutrition and Food Sciences, Yasuj University of Medical Sciences, Yasuj, Iran
[3]Health Sciences Research Center, Torbat Heydariyeh University of Medical Sciences, Torbat Heydariyeh, Iran
[4]Occupational Environment Research Center, Rafsanjan University of Medical Sciences, Rafsanjan, Iran

Received: 29.10.2022; Accepted: 11.03.2023

Abstract

Beverages of *Hibiscus Sabdariffa L.* (sour tea) are widely used for improving liver diseases, hypertension cardio-metabolic indices, and body composition. Nevertheless, little is known about the impacts of sour tea on body composition and anthropometric indices. This study aimed to systematically review and perform a meta-analysis on the evidence evaluating the effects of sour tea on body composition and anthropometric indices. International databases, including PubMed, Scopus, and Web of Science, were searched to find clinical trial studies published up to February 2022. The response variables examined in the present study included body weight, body mass index, waist circumference, body fat mass, and hip circumference. Pooled effect size of mean difference (95% CI) between the treatment and placebo interventions was estimated for body weight (-0.51 kg, -3.35, 2.32), body mass index (-0.09 kg/m2, -0.98, 0.80), waist circumference (-0.26 cm, -2.86, 2.35), hip circumference (-0.07 cm, -2.87, 2.74), and body fat mass (-1.85 %, -4.90, 1.19). This meta-analysis showed that despite the reducing effect of sour tea consumption on body composition and anthropometric indices, this effect was not statistically significant. However, there are several determinant factors that probably affected our findings, including the type, dosage, and duration of the intervention as well as the heterogeneity of the target population. Thus, future well-designed clinical trials are suggested to establish a definitive conclusion in this regard.

Keywords: Sour tea, Body weight, Body composition, Anthropometric Indices, Meta-analysis

***Corresponding Authors:** Dr. Somayeh Saboori, and Dr. Esmaeil Yousefi Rad, Nutritional Health Research Center, School of Health and Nutrition, Lorestan University of Medical Sciences, Khorramabad, Iran. Email: saburi_somaye@yahoo.com, and esyussefirad2@yahoo.com.

Please cite this article as: Mohammadi S, Hosseinikia M, Pahlavani N, Ghaffarian-Bahraman A, Yousefi Rad E, Saboori S. Effects of Sour Tea (*Hibiscus Sabdariffa L.*) Consumption on Anthropometric Indices: A Systematic Review and Meta-Analysis. Herb. Med. J. 2023;8(2):113-22.

Introduction

In the 21st century, obesity and overweight are recognized as major epidemic health problems with progressive prevalence throughout the world (1, 2). According to predictions, approximately 85% and 50% of American adults will meet the criteria of overweight and obesity by 2030, respectively. Previous studies have suggested a remarkable correlation between obesity and the incidence of metabolic syndrome,

Table 1: Characteristics of the included studies.

First Author (Year)	Country	Design	Population	Gender	Sample size Sour Tea/Placebo	Duration	Outcome	Intervention dosage
Kuriyan (2010)	India	DB-RCT	Hyperlipidemia	F/M	28/29	12 weeks	Weight/BMI/WC/BF/MAC/HC	500 mg twice a day
Chang (2014)	Taiwan	DB-RCT	Fatty Liver	F/M	19/17	12 weeks	Weight/BMI/WC/WHR/BF/HC	mg 450 three times a day
Asgary (2016)	Iran	DB-RCT	Metsy	F/M	18/17	4 weeks	BMI	500 mg daily
Sari (2018)	Indonesia	QE	Overweight/obesity	M	14/11	6 weeks	Weight/BMI/WC	480 ml daily
Izadi (2020)	Iran	DB-RCT	NAFLD	F/M	30/31	8 weeks	Weight/BMI/WC	450 mg daily
Yusni (2020)	Indonesia	QE	Metsy	F	8/8	3 weeks	Weight	2 gr twice a day

DB-RCT: Double-Blind Randomized Controlled Trial, QE: Quasi-experimental study, Mesty; metabolic syndrome, non-alcoholic fatty liver disease, F; female, M; Male, BMI; body mass index, WC; waist circumference, BF; body fat, MAC; mid arm circumference, HC; hip circumference, WHR; waist to hip ratio

diabetes mellitus, cancer, coronary heart disease, hypertension, and mental disorders (3).

Many factors play key roles in raising the incidence of obesity and metabolic syndrome, including increased energy intake, decreased energy expenditure, genetic predisposition and some environmental factors (4, 5). Although some strategies have been proposed to prevent and control obesity and its complications, they are difficult to perform correctly and have limited success over the time (6). Thus, a large number of researchers have focused on more traditional procedures in response to the energy imbalance caused by obesity. Accordingly, complementary medicine and natural supplements have been increasingly used as popular and practical solutions in recent years (7, 8).

Herbal remedies and supplements have been used for centuries to treat a variety of ailments (9). Previous studies have suggested that sour tea consumption as a cheap and affordable complementary therapy may be effective in improving cardio-metabolic indices and body composition (10, 11). Sour tea is a plant species with the scientific name *Hibiscus Sabdariffa L.* from the

Table 2: Methodological quality score of included studies calculated using Cochrane Quality Assessment tool.

First Author (Year)	Random sequence generation	Allocation concealment	Selective reporting	Incomplete outcome data	Blinding (participants and personnel)	Blinding (outcome assessment)	Other sources of bias	Overall
Kuriyan (2010)	L	U	L	H	L	U	L	High risk
Chang (2014)	L	U	L	L	L	U	H	High risk
Asgary (2016)	L	U	L	L	L	L	L	Moderate risk
Sari (2018)	L	U	L	U	U	H	H	High risk
Izadi (2020)	L	L	L	L	L	L	L	Low risk
Yusni (2020)	L	L	L	H	U	H	H	High risk

L; Low, H; High, U; Unclear

Table 3: Meta-analysis results of sour tea effects on anthropometric indices.

Outcome [a]	Number of studies (Pooled sample size)	Effect size [b] MD (95% CI)	p-value	I^2 (%)	Heterogeneity P-value
BW (kg)	5 (195)	-0.51 (-3.35, 2.32)	0.72	0.00	0.999
BMI (kg/m^{2})	5 (214)	-0.09 (-0.98, 0.80)	0.84	0.00	0.999
WC (cm)	4 (179)	-0.26 (-2.86, 2.35)	0.84	0.00	0.983
HC (cm)	2 (93)	-0.07 (-2.87, 2.74)	0.23	0.00	0.889
BF (%)	2 (93)	-1.85 (-4.90, 1.19)	0.96	0.00	0.819

BW: Body Weight, BMI: Body Mass Index, WC: Waist circumference, HC: Hip circumference, BF: Body Fat Mass, MD: Mean difference.

[a] All meta-analyses were conducted in a random effects model due to the significant between-study heterogeneities.

[b] MD effect size was calculated by subtracting the mean changes of the control group from that of the treatment group

Malvaceae family, which grows mostly in tropical and subtropical regions such as African and Asian countries. This herb is also known by different local names, including Roselle, Red Sorrel or Karkade or Jamaica flower (12, 13). In the past, sour tea was commonly prescribed to control high blood pressure (14), while some other effects have been reported for it, including anti-inflammatory, anti-carcinogenesis, anti-bacterial and anti-diabetic, Antipyretic, and anti-nociceptive properties (15-19). Seemingly, the clinical effects of sour tea can be attributed to its active compounds, the most important of which are anthocyanins, phenolic acids, polysaccharides, and flavonoids (20).

Although several meta-analysis studies have been conducted to evaluate the impacts of sour tea consumption on diabetes, hypertension, hyperlipidemia, and cardio-metabolic disorders(14, 21-26), as far as we know no meta-analysis study has investigated the effects of sour tea on anthropometric indices. Hence, this study aimed to systematically review the evidence on the effects of *Hibiscus Sabdariffa L.* on body composition and anthropometric indices, including body weight, waist and hip circumferences, and body mass index.

Methods

Search Strategy

Inclusive literature searches in the online databases of PubMed, Scopus, and Web of Science were conducted from inception up to May 2022. The following keywords were used in the search strategy: ("sour tea" or "red tea" or "Hibiscus sabdariffa" or Roselle or Roselles or Bissap or "Hibiscus cannabinus") and ("Weight" or obese or obesity or overweight or adiposity or "body mass index" or BMI or waist or WC or "waist-to-hip ratio" or WHR or "fat mass" or FM or "fat free mass" or FFM or "lean body mass" or LBM or "body fat" or BF or "body composition" or "body fat percentage" or "hip circumference"). We did not consider any restriction with regard to language and publication time. Moreover, the reference lists of the included articles were reviewed to avoid missing any records. All the searched studies were imported in the Endnote software for screening. Duplicate citations were removed afterwards. We also excluded unpublished records. This study was conducted according to PRISMA protocol for reporting systematic reviews and meta-analyses (27).

Inclusion and Exclusion Criteria

Selection of the studies was based on the following criteria: randomized controlled clinical trials, the target population of adult subjects (≥ 18 years), administration of various forms of sour tea, providing necessary information for variables of interest at the baseline and end of the trial for both the intervention and control groups or their attributed mean changes and standard deviations. Study qualification was mainly performed on the basis of the PICO framework (28). Experimental and ecological studies, observational papers, and review articles were excluded in the present meta-analysis. We also excluded open-label trials, papers with insufficient data, and those that used a combination of supplements or were conducted on children or adolescents.

Data Extraction

Two independent investigators (MH &SS) carried out data extraction. Discrepancies were resolved by discussion or referral to a third investigator. We

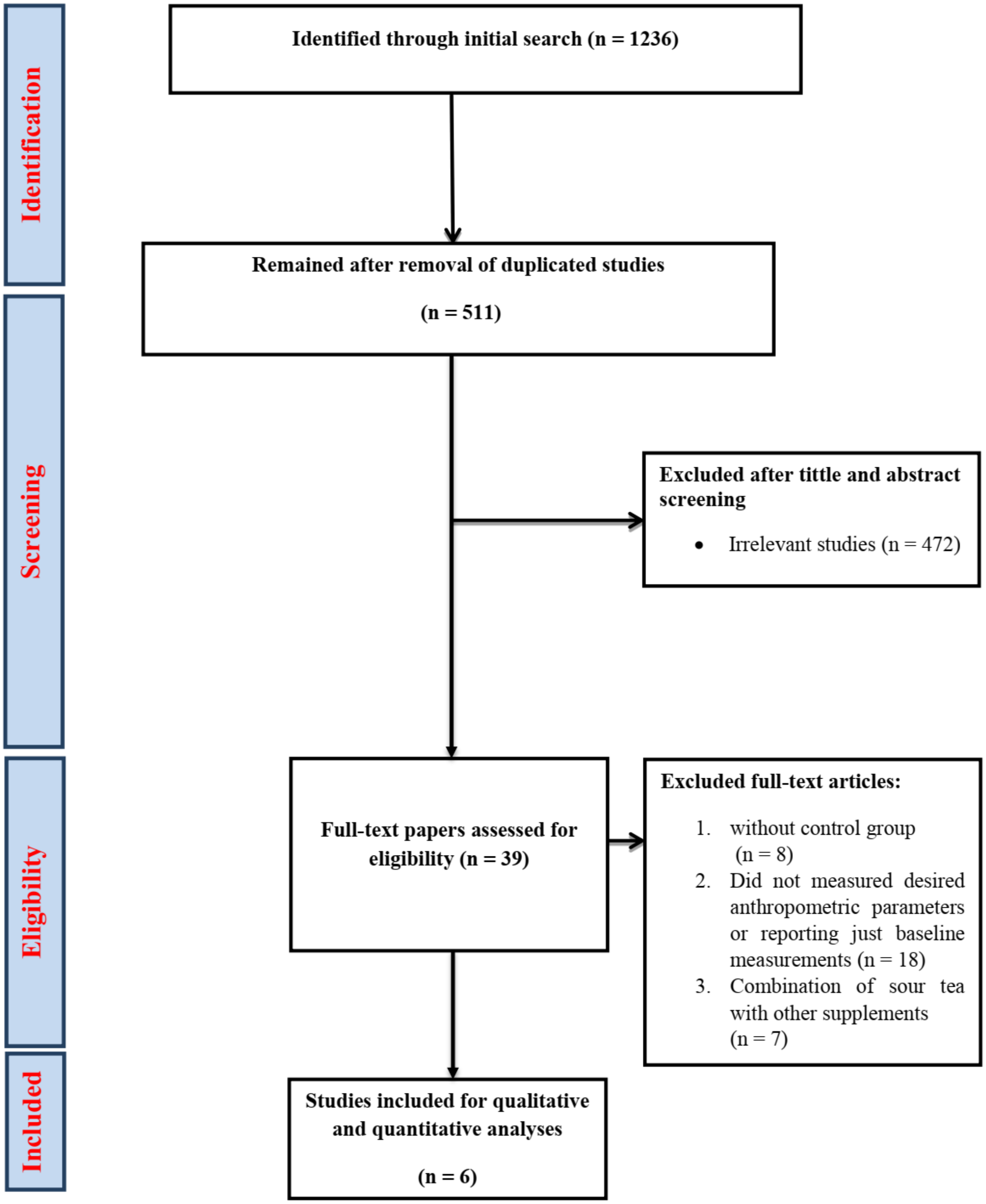

Figure 1: Flowchart of study selection

extracted the following data separately for the control and intervention groups as the main response variables: mean changes and SDs of body weight, body mass index, waist circumference, body fat mass, and hip circumference. The following information was also

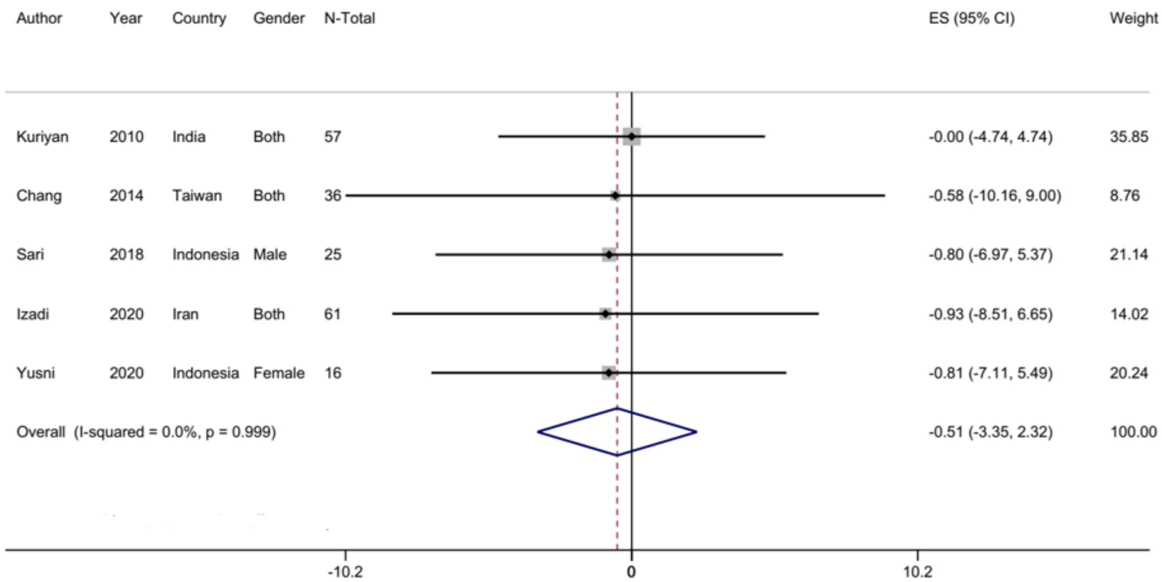

Figure 2. Pooled effect size of sour tea consumption on body weight (kg).

extracted into an excel sheet: the name of the first author, publication year, participants' basic characteristics (mean age and sex), study design, country of origin, sample size, the dosage of sour tea, type of intervention in the control group, any co-interventions, duration of intervention, the health status of the studied population, outcome assessment methods, and the confounding variables adjusted in the analyses.

Quality Assessment

As demonstrated in Table 2, Cochrane quality assessment tool was used to evaluate the risk of bias for every study included in the present meta-analysis (29). This tool consists of seven domains, including random sequence generation, allocation concealment, and different sources of bias (reporting, performance, detection, attrition etc.). A "high risk" score was considered for every domain if the study contained

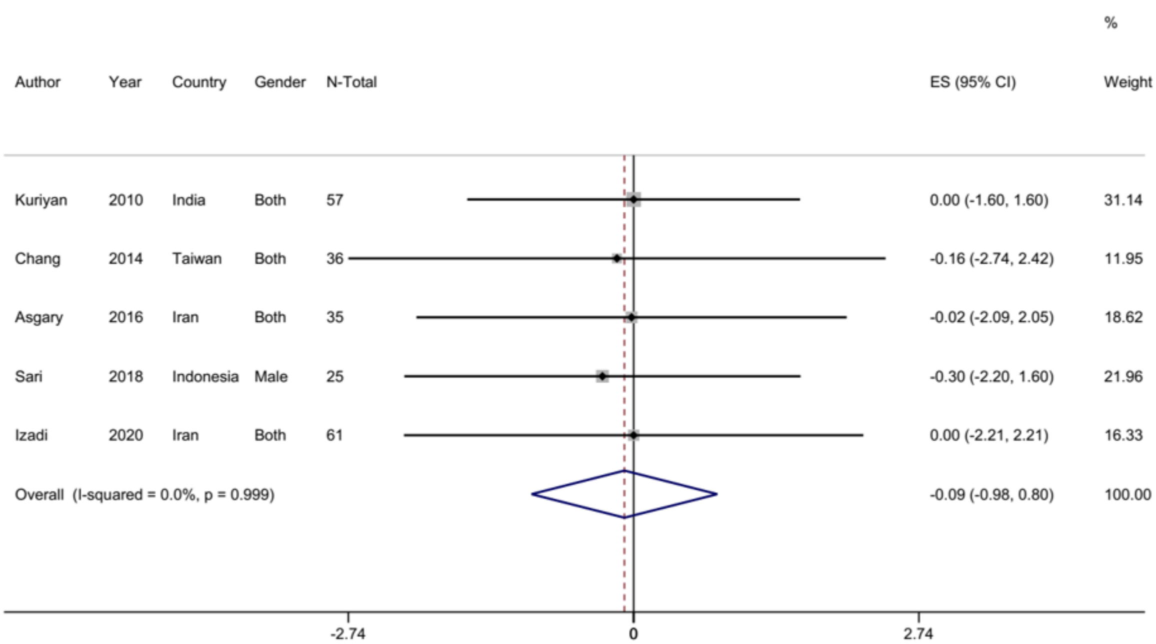

Figure 3. Pooled effect size of sour tea consumption on BMI (kg/m^2).

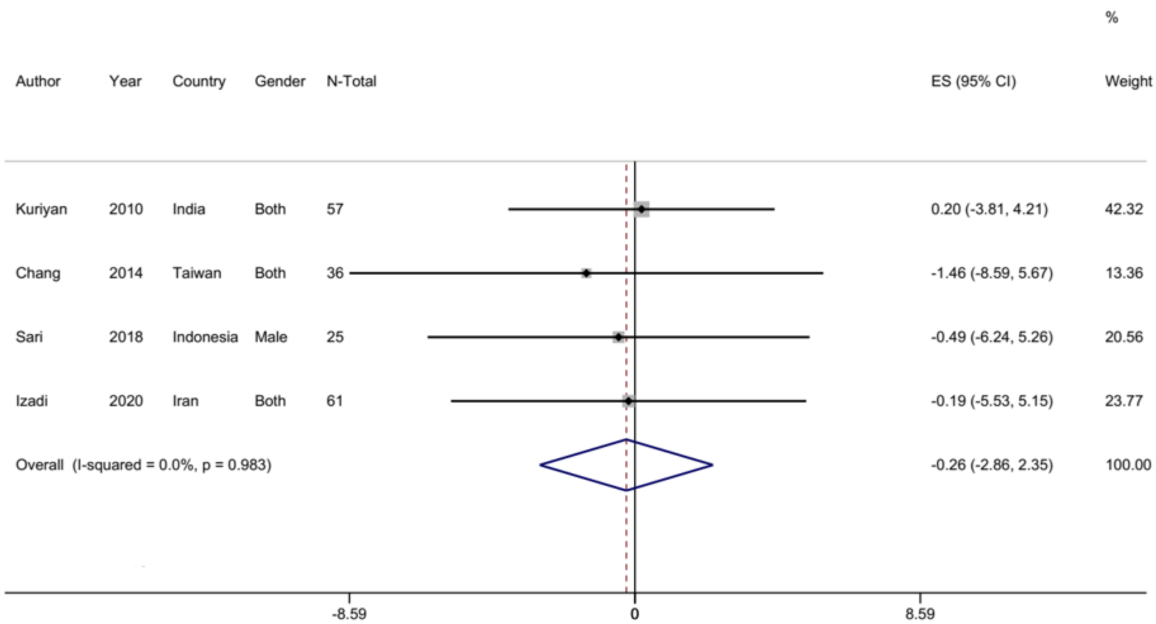

Figure 4. Pooled effect size of sour tea consumption on waist circumference (cm).

methodological errors that might have been influential on its findings, a "low risk" score was given if no deficiency was observed, and an "unclear risk" score was considered if the information was not enough to determine the effect. The general risk of bias for an RCT was considered: (1) low if all domains had "low risk", (2) moderate if one or more domains had "unclear risk", and (3) high if one or more domains had "high risk". The risk of bias assessment was carried out separately by two reviewers.

Statistical Analysis

The pooled effect sizes were estimated using meta-analysis forest plots conducted in a random-effects model. To evaluate the between-study heterogeneity, we used Cochran Q-test and I-squared index(I^2). Furthermore, the Egger's regression statistical test was used to evaluate the publication bias of the included studies which was visually verified by drawing their funnel plot. Stata software (Stata Corp, version 13.0, College Station, TX, USA) was used for conducting statistical analyses.

This work was supported by Lorestan University of Medical Sciences (Grant number: 1397-1-99-2546 and Ethics Committee number: ID: IR.LUMS.REC.1401.027).

Results and Discussion

As it has been shown in the study flowchart (Figure 1), our initial databases search led to finding a total of 1236 articles reduced to 39 articles after removing duplicates and unrelated articles. After the full text reviewing, a number of studies were removed for different reasons, including the lack of control group, failure to measure the desired parameters, or simultaneous use of several interventions so that we finally recognized 6 eligible studies to be included in the meta-analysis. As it has been indicated in Table 1, four out of the 6 the eligible articles were double-blind randomized clinical trials (10, 30-32) and the other two articles had a quasi-experimental design (33, 34). The included articles were scored based on their methodological quality, the results of which have been presented in Table 2.

Meta-Analysis

The effect size estimated in the present study was the mean difference anthropometric parameter changes reported for the intervention and control groups. Our meta-analysis estimates showed trivial mean differences between the treatment and placebo interventions in terms of anthropometric indices (Table 3). Considering the 95% confidence interval of overall effect sizes which ranged from negative to positive values in all the analyses, no meaningful statistical

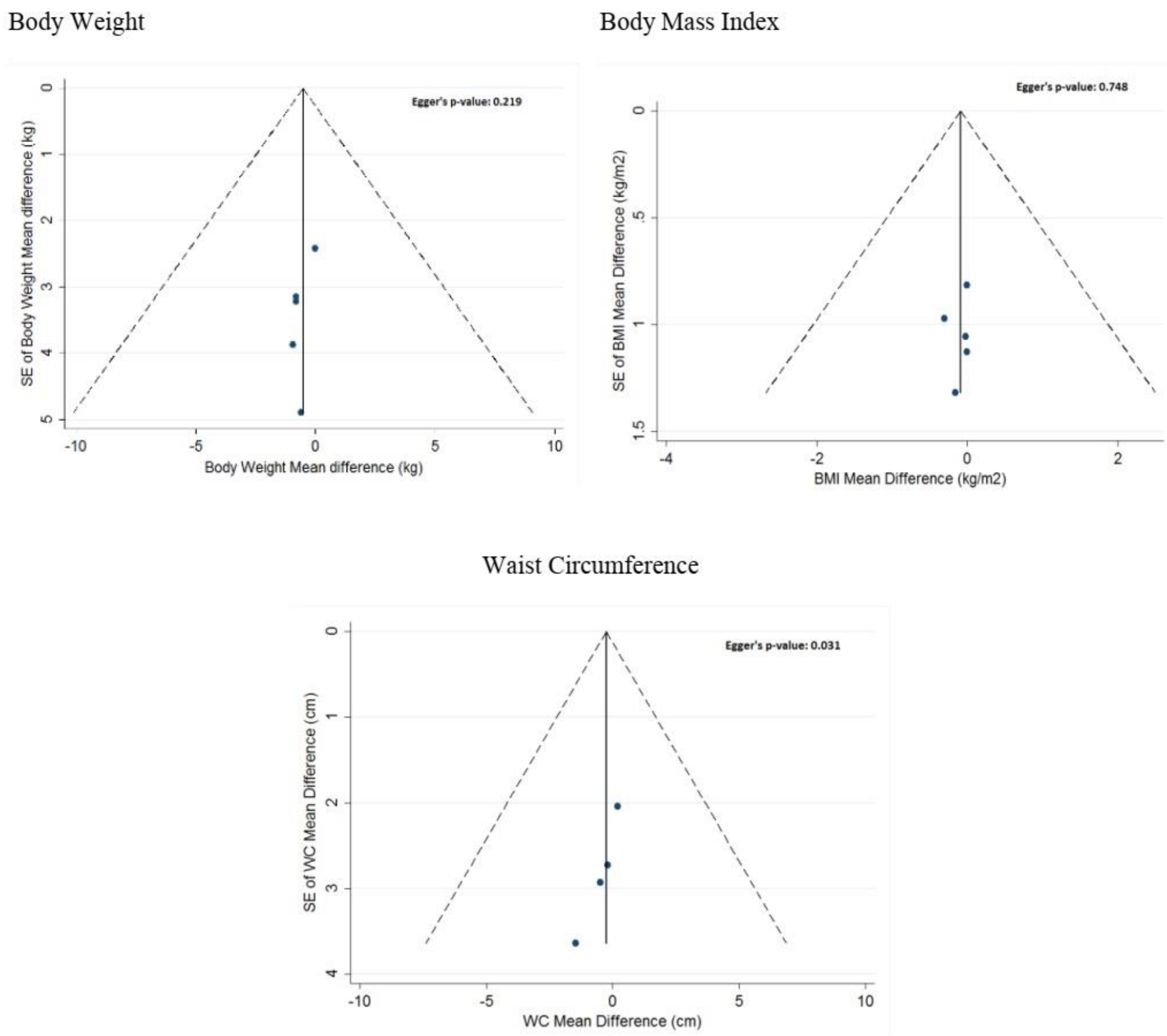

Figure 5. Funnel plots of standard errors for the assessment of publication bias.

difference was observed between the intervention and control groups in terms of body weight (Figure 2), body mass index (Figure 3), waist circumference (Figure 4), hip circumference and body fat mass percentage.

Publication Bias

Egger's statistical test revealed a significant publication bias for the studies evaluating waist circumference (p-value = 0.031), while there was no significant publication bias among the studies reporting the anthropometric parameters of body weight and body mass index (Eggers p-value> 0.05). We also assessed publication bias using the Funnel plot visual test, the results of which have been presented in Figure 5.

Although accompanied by contradictions, anti-obesity effects of sour tea consumption have been scientifically confirmed. Most of these effects have been attributed to the compounds present in this herbal supplement, including phytochemicals and antioxidants (polyphenols, flavonoids, terpenoids, and saponins) (35, 36). The results of the present meta-analysis showed that sour tea supplementation has reducing effects, though not significant, on body composition and anthropometric indices. These findings were consistent with the results of previous studies (31, 37). However, other human and animal investigations have indicated significant effects of sour tea consumption on anthropometric indices. According to a previous clinical trial study, daily consumption of a 450-mg capsule of sour tea extract for 12 weeks resulted in the significant reduction of body weight and BMI compared with the control group (10)

Furthermore, an animal-model experiment indicated that sour tea administration led to weight loss in transgenic obese rats probably through suppressing PI3-K/Akt-mediated and ERK-mediated adipogenesis, blocking the intestinal absorption of sugar, and decreasing the activity of enzyme α-amylase (38).

There are various factors that play roles in the effectiveness of sour tea supplementation on the alteration of anthropometric indices. Duration of intervention seems to be one of the most important determinants in this regard. All the studies included in this meta-analysis had an intervention period of less than 12 weeks, and half of them were finished within 6 weeks. Furthermore, the type and dosage of intervention could be considered as other effective factors. The main reason for the achievement of insignificant changes caused by the intervention in one of our included studies was claimed to be the use of non-extracted sour tea powder. It is believed that sour tea extraction can increase the bioactive compounds' concentration and bioavailability (30). Moreover, other beneficial properties have been reported for sour tea consumption to date. Recently, two meta-analysis studies have suggested improving impacts of sour tea supplementation on blood pressure and biochemical glycemic indices (14, 17). These effects might be mediated through the inhibition of the α-amylase, α-glucosidase, and angiotensin-converting enzyme (ACE), stimulation of nitric oxide secretion and diuretic agents' production, and activity enhancement of catalase and glutathione peroxidase(38-40).

It is also shown that consumption of sour tea could improve serum triglyceride levels, liver enzymes, and total antioxidant capacity in NAFLD patients (31). Seemingly, the polyphenol content of this herbal agent can increase the clearance of hepatic fat by inhibiting lipogenesis in the liver, and reduce hyperlipidemia (41, 42). Recently, it has been shown that sour tea supplementation can prevent the collection of fat in the liver by down-regulating the reduction of sterol regulatory element-binding protein 1 (SREBP-1c) and peroxisome proliferator-activated receptor gamma (PPAR-γ), which plays a key role in obesity-related inflammation (43, 44).

Limitations

This study had some limitations. The study population was heterogeneous among the included studies. Obviously, the effectiveness of sour tea consumption on anthropometric indices varies in different populations depending on their baseline characteristics. In meta-analysis studies, subgroup analysis is recommended to eliminate the effect of this confounding variables. However, the small number of studies in each subgroup prevented us to utilize this strategy. Nonetheless, we performed all the meta-analyses in a random-effects model to nullify the between-study heterogeneities. Moreover, the publication bias in the present meta-analysis was evaluated as a potential source of heterogeneity by Egger's statistical test and the funnel plot visual test. As another limitation, the quality evaluation of studies showed that most of the included studies had a poor methodology probably influencing the findings

Conclusion

The present evidence is insufficient to establish the effects of sour tea on the improvement of anthropometric indices. To provide a comprehensive conclusion, conducting long-term and well-designed clinical trials with adequate sample sizes using an appropriate type and dosage of sour tea supplementation is recommended in future.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

None.

References

1. Ayatollahi S, Ghoreshizadeh Z. Prevalence of obesity and overweight among adults in Iran. Obesity reviews. 2010;11(5):335-7.
2. Janghorbani M, Amini M, Willett WC, Gouya MM, Delavari A, Alikhani S, et al. First nationwide survey of prevalence of overweight, underweight, and abdominal obesity in Iranian adults. Obesity. 2007;15(11):2797-808.
3. Mohammadi S, Rastmanesh R, Jahangir F, Amiri Z, Djafarian K, Mohsenpour MA, et al. Melatonin supplementation and anthropometric indices: A randomized double-blind controlled

clinical trial. BioMed Research International. 2021;2021.
4. Kumar S, Kelly AS, editors. Review of childhood obesity: from epidemiology, etiology, and comorbidities to clinical assessment and treatment. Mayo Clinic Proceedings; 2017: Elsevier.
5. Saboori S, Rad EY, Mardani M, Khosroshahi MZ, Nouri Y, Falahi E. Effect of Q10 supplementation on body weight and body mass index: A systematic review and meta-analysis of randomized controlled clinical trials. Diabetes & Metabolic Syndrome: Clinical Research & Reviews. 2019;13(2):1179-85.
6. Tong TJ, Mohammadnezhad M, Alqahtani NS. Determinants of overweight and obesity and preventive strategies in Pacific countries: a systematic review. Global Health Journal. 2022.
7. Katz DL, O'Connell M, Njike VY, Yeh M-C, Nawaz H. Strategies for the prevention and control of obesity in the school setting: systematic review and meta-analysis. International journal of obesity. 2008;32(12):1780-9.
8. Kidambi S, Batsis JA, Donahoo WT, Jastreboff AM, Kahan S, Saunders KH, et al. Dietary supplements and alternative therapies for obesity: A Perspective from The Obesity Society's Clinical Committee. Obesity. 2021;29(7):1095-8.
9. Haghani F, Arabnezhad M-R, Mohammadi S, Ghaffarian-Bahraman A. Aloe vera and Streptozotocin-Induced Diabetes Mellitus. Revista Brasileira de Farmacognosia. 2022:1-14.
10. Chang H-C, Peng C-H, Yeh D-M, Kao E-S, Wang C-J. Hibiscus sabdariffa extract inhibits obesity and fat accumulation, and improves liver steatosis in humans. Food & function. 2014;5(4):734-9.
11. Herrera-Arellano A, Flores-Romero S, Chavez-Soto M, Tortoriello J. Effectiveness and tolerability of a standardized extract from Hibiscus sabdariffa in patients with mild to moderate hypertension: a controlled and randomized clinical trial. Phytomedicine. 2004;11(5):375-82.
12. Mozaffari-Khosravi H, Jalali-Khanabadi B, Afkhami-Ardekani M, Fatehi F, Noori-Shadkam M. The effects of sour tea (Hibiscus sabdariffa) on hypertension in patients with type II diabetes. Journal of human hypertension. 2009;23(1):48-54.
13. Aurelio DL, Edgardo RG, Navarro-Galindo S. Thermal kinetic degradation of anthocyanins in a roselle (Hibiscus sabdariffa L. cv.'Criollo') infusion. International journal of food science & technology. 2008;43(2):322-5.
14. Serban C, Sahebkar A, Ursoniu S, Andrica F, Banach M. Effect of sour tea (Hibiscus sabdariffa L.) on arterial hypertension: a systematic review and meta-analysis of randomized controlled trials. Journal of hypertension. 2015;33(6):1119-27.
15. Pérez-Torres I, Ruiz-Ramírez A, Baños G, El-Hafidi M. Hibiscus sabdariffa Linnaeus (Malvaceae), curcumin and resveratrol as alternative medicinal agents against metabolic syndrome. Cardiovascular & Hematological Agents in Medicinal Chemistry (Formerly Current Medicinal Chemistry-Cardiovascular & Hematological Agents). 2013;11(1):25-37.
16. Liu Ks, Tsao Sm, Yin Mc. In vitro antibacterial activity of roselle calyx and protocatechuic acid. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2005;19(11):942-5.
17. Najafpour Boushehri S, Karimbeiki R, Ghasempour S, Ghalishourani SS, Pourmasoumi M, Hadi A, et al. The efficacy of sour tea (Hibiscus sabdariffa L.) on selected cardiovascular disease risk factors: A systematic review and meta-analysis of randomized clinical trials. Phytotherapy Research. 2020;34(2):329-39.
18. Lin H-H, Chen J-H, Wang C-J. Chemopreventive properties and molecular mechanisms of the bioactive compounds in Hibiscus sabdariffa Linne. Current medicinal chemistry. 2011;18(8):1245-54.
19. Ali BH, Wabel NA, Blunden G. Phytochemical, pharmacological and toxicological aspects of Hibiscus sabdariffa L.: a review. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation of Natural Product Derivatives. 2005;19(5):369-75.
20. Tsai P-J, McIntosh J, Pearce P, Camden B, Jordan BR. Anthocyanin and antioxidant capacity in Roselle (Hibiscus sabdariffa L.) extract. Food research international. 2002;35(4):351-6.
21. Bule M, Albelbeisi AH, Nikfar S, Amini M, Abdollahi M. The antidiabetic and antilipidemic effects of Hibiscus sabdariffa: A systematic review and meta-analysis of randomized clinical trials. Food Research International. 2020;130:108980.
22. Aziz Z, Wong SY, Chong NJ. Effects of Hibiscus sabdariffa L. on serum lipids: A systematic review and meta-analysis. Journal of ethnopharmacology. 2013;150(2):442-50.
23. Ellis LR, Zulfiqar S, Holmes M, Marshall L, Dye L, Boesch C. A systematic review and meta-analysis of the effects of Hibiscus sabdariffa on blood pressure and cardiometabolic markers. Nutrition reviews. 2021.
24. Zhang B, Yue R, Wang Y, Wang L, Chin J, Huang X, et al. Effect of Hibiscus sabdariffa (Roselle) supplementation in regulating blood lipids among patients with metabolic syndrome and related disorders: A systematic review and meta-analysis. Phytotherapy Research. 2020;34(5):1083-95.
25. Shafiee M, Mohammadi V, Kazemi A, Davarpanah H, Tabibzadeh SM, Babajafari S, et al. The effect of Hibiscus sabdariffa (sour tea) compared to other herbal teas and antihypertension drugs on cardiometabolic risk factors: Result from a systematic review and meta-analysis. Journal of Herbal Medicine. 2021;29:100471.
26. Abdelmonem M, Ebada MA, Diab S, Ahmed MM, Zaazouee MS, Essa TM, et al. Efficacy of Hibiscus sabdariffa on Reducing Blood Pressure in Patients With Mild-to-Moderate Hypertension: A Systematic Review and Meta-Analysis of Published Randomized Controlled Trials. Journal of Cardiovascular Pharmacology. 2022;79(1):e64-e74.
27. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Bmj. 2021;372.
28. Higgins JP. green S. Cochrane handbook for systematic reviews of interventions version. 2011;5(0):3.
29. Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. Bmj. 2011;343.
30. Asgary S, Soltani R, Zolghadr M, Keshvari M, Sarrafzadegan N. Evaluation of the effects of roselle (Hibiscus sabdariffa L.) on oxidative stress and serum levels of lipids, insulin and hs-CRP in adult patients with metabolic syndrome: a double-blind placebo-controlled clinical trial. Journal of Complementary and Integrative Medicine. 2016;13(2):175-80.
31. Izadi F, Farrokhzad A, Tamizifar B, Tarrahi MJ, Entezari MH. Effect of sour tea supplementation on liver enzymes, lipid profile, blood pressure, and antioxidant status in patients with non-alcoholic fatty liver disease: A double-blind randomized controlled clinical trial. Phytotherapy Research. 2021;35(1):477-85.
32. Kuriyan R, Kumar DR, Kurpad AV. An evaluation of the hypolipidemic effect of an extract of Hibiscus Sabdariffa leaves in hyperlipidemic Indians: a double blind, placebo controlled trial. BMC complementary and alternative medicine. 2010;10(1):1-8.
33. Sari C, Damayanthi E, Kustiyah L. The effect of rosella beverage intervention on lipid profiles and antropometric in obese adult men. EXECUTIVE EDITOR. 2018;9(12):12654.
34. Yusni Y, Meutia F. Action mechanism of Rosella (Hibiscus sabdariffa L.) used to treat metabolic syndrome in elderly women. Evidence-Based Complementary and Alternative Medicine. 2020;2020.
35. Guardiola S, Mach N. Potencial terapéutico del Hibiscus sabdariffa: una revisión de las evidencias científicas. Endocrinología y Nutrición. 2014;61(5):274-95.

36. Puro K, Sunjukta R, Samir S, Ghatak S, Shakuntala I, Sen A. Medicinal uses of Roselle plant (Hibiscus sabdariffa L.): a mini review. Indian Journal of Hill Farming. 2014;27(1):81-90.
37. Kuriyan R, Kumar DR, R R, Kurpad AV. An evaluation of the hypolipidemic effect of an extract of Hibiscus Sabdariffa leaves in hyperlipidemic Indians: a double blind, placebo controlled trial. BMC Complement Altern Med. 2010;10:27.
38. Da-Costa-Rocha I, Bonnlaender B, Sievers H, Pischel I, Heinrich M. Hibiscus sabdariffa L.–A phytochemical and pharmacological review. Food chemistry. 2014;165:424-43.
39. Jiménez-Ferrer E, Alarcón-Alonso J, Aguilar-Rojas A, Zamilpa A, Tortoriello J, Herrera-Ruiz M. Diuretic effect of compounds from Hibiscus sabdariffa by modulation of the aldosterone activity. Planta medica. 2012;78(18):1893-8.
40. Kao E-S, Hsu J-D, Wang C-J, Yang S-H, Cheng S-Y, Lee H-J. Polyphenols extracted from Hibiscus sabdariffa L. inhibited lipopolysaccharide-induced inflammation by improving antioxidative conditions and regulating cyclooxygenase-2 expression. Bioscience, biotechnology, and biochemistry. 2009;73(2):385-90.
41. Peng C-H, Chyau C-C, Chan K-C, Chan T-H, Wang C-J, Huang C-N. Hibiscus sabdariffa polyphenolic extract inhibits hyperglycemia, hyperlipidemia, and glycation-oxidative stress while improving insulin resistance. Journal of agricultural and food chemistry. 2011;59(18):9901-9.
42. Yang M-Y, Peng C-H, Chan K-C, Yang Y-S, Huang C-N, Wang C-J. The hypolipidemic effect of Hibiscus sabdariffa polyphenols via inhibiting lipogenesis and promoting hepatic lipid clearance. Journal of agricultural and food chemistry. 2010;58(2):850-9.
43. Stienstra R, Duval C, Keshtkar S, van der Laak J, Kersten S, Muller M. Peroxisome proliferator-activated receptor γ activation promotes infiltration of alternatively activated macrophages into adipose tissue. Journal of Biological Chemistry. 2008;283(33):22620-7.
44. Zhang W, Sun Q, Zhong W, Sun X, Zhou Z. Hepatic peroxisome proliferator-activated receptor gamma signaling contributes to alcohol-induced hepatic steatosis and inflammation in mice. Alcoholism: Clinical and Experimental Research. 2016;40(5):988-99.