Supplementary table 1 Characteristics of the individual studies included in this meta-analysis

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| First authoryear ofpublication | Location | Ageyears | Gender | Sample Size | Study design | Adjustments | Exposure | Category of exposure  | Effect Estimates(RR or SMD) | Diagnostic criteria of MetS | NOS |
| Ford 2003 [8] | US | >20 | Both | 8808 | Cross-sectional | NA | FFQ | Control subjects MetS subjectsControl subjects MetS subjects | Dietary vitamin C 106.3 (100.8, 111.8)106.4 (96.0, 116.8)Circulating vitamin C 42.9 (41.3, 44.6)36.4 (34.2, 38.6) | NCEP-ATP III | 8 |
| Kim 2007 [9] | Korea | >60 | Both | 404 | Cross-sectional | Age, BMI, energy intake, smoking status, alcohol, physical activity, vitamin, and mineral supplements | 24 hours recall | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsDietary vitamin CMaleQuartiles 1Quartiles 2Quartiles 3Quartiles 4FemaleQuartiles 1Quartiles 2Quartiles 3Quartiles 4Control subjects MetS subjectsCirculating vitamin CMaleTertiles 1 Tertiles 2Tertiles 3FemaleTertiles 1Tertiles 2Tertiles 3 | Dietary vitamin C124.2 (101.1, 147.3)144.4 (102.0, 186.8)Dietary vitamin C107.8 (94.6, 121.0)101.4 (88.2, 114.6)RR1.01.2 (0.4, 3.6)1.5 (0.54, 4.5)0.58 (0.19, 1.8)RR1.01.1 (0.60, 2.3)1.0 (0.53, 1.98)0.84 (0.44, 1.63)Circulating vitamin C514.7 (454.2, 575.2)481.7 (431.8, 531.6)RR1.00.66 (0.13, 3.20)0.45 (0.10, 2.40)RR1.01.40 (0.59, 3.30)1.40 (0.62, 3.50) | NCEP-ATP III | 7 |
| Kim 2008 [10] | Korea | Middle-aged | Both | 688 | Cross-sectional | NA | FFQ | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjects | Dietary vitamin C56.6 (52.8, 60.4)59.7 (55.0, 64.4)Dietary vitamin C70.0 (64.8, 75.2)73.9 (69.0, 78.8) | NCEP-ATP III | 6 |
| Czernichow 2009 [29] | France | 49 | Both | 5520 | Cohort | Age, sex, intervention group, educational level, smoking status, physical activity and alcohol consumption | NA | Circulating vitamin CTertiles 1Tertiles 2Tertiles 3 | RR1.00.76 (0.53, 1.09)0.53 (0.35, 0.80) | NCEP-ATP III | 5 |
| Moon 2010 [11] | Korea | 40-64 | Both | 2382 | Cross-sectional | NA | 24 hours recall | Control subjects MetS subjects | Dietary vitamin C111.8 (107.4, 116.2)103.3 (97.6, 109.0) | NCEP-ATP III | 7 |
| Bruscate 2010 [34] | Brazil | 69.3 | Female | 284 | Cross-sectional | Age, smoking, education, physical activity and dietary fiber | 24 hours recall | Control subjects MetS subjectsDietary vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C135.0 (121.9, 148.1)133.0 (112.8, 153.2)RR1.00.69 (0.33, 1.46)0.55 (0.26, 1.18)0.70 (0.33, 1.47) | IDF | 6 |
| Beydoun 2011 [12] | US | 20-85 | Both | 3202 | Cross-sectional | Age, sex, race/ethnicity, marital status, educational level, PIR, smoking status, total energy intake, alcohol, caffeine, b-carotene, vitamin C, vitamin E, and dietary supplement use, serum levels of folate, tHcy, vitamin B-12, 25(OH)D, total cholesterol, and TG | 24 hours recall | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsMaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsCirculating vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C96.5 (90.0, 103.0)95.3 (83.7, 106.9)Dietary vitamin C85.4 (79.9, 90.9)81.2 (73.5, 88.9)Circulating vitamin C50.9 (47.3, 54.5)43.7 (39.7, 47.7)Circulating vitamin C57.7 (54.5, 60.9)52.1 (45.2, 59.0)RR1.00.98 (0.62, 1.53)0.52 (0.28, 0.98)0.52 (0.25, 1.10) | NCEP-ATP III | 8 |
| Sempértegui 2011 [28] | Ecuador | >65 | Both | 352 | Cross-sectional | Age and sex | NA | Circulating vitamin C< 0.2 mg/dL> 0.2 mg/dL | RR1.00.16 (0.03, 0.81) | IDF | 7 |
| Kouki 2011 [13] | Finland | 57-78 | Both | 1334 | Cross-sectional | Age, alcohol consumption, smoking, education and VO2 max | 4-day food record | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsDietary vitamin CMale< 10mg/d> 10mg/dFemale< 10mg/d> 10mg/d | Dietary vitamin C 112.0 (105.7, 118.3)90.0 (80.6, 99.4)Dietary vitamin C 115.0 (110.0, 120.1)107.0 (98.3, 115.7)RR1.00.97 (0.94, 1.01)RR1.00.99 (0.96, 1.02) | NCEP-ATP III | 7 |
| Beydoun 2012 [14] | US | 12-19 | Both | 1339 | Cross-sectional | NA | 24 hours recall | Control subjects MetS subjectsControl subjects MetS subjects | Dietary vitamin C83.8 (76.5, 91.1)67.3 (41.7, 92.9)Circulating vitamin C54.9 (51.8, 58.0)32.6 (22.5, 42.7) | IDF | 7 |
| de Oliveira Otto 2012 [15] | US | 45-84 | Both | 3828 | Cohort | Energy intake, age, sex, race-ethnicity, education, study center, alcohol intake, physical activity, BMI, fiber intake, cigarette smoking, dietary supplement use, the ratio of polyunsaturated fat intake and saturated fat intake, Mg, Zn, heme iron, nonheme iron, and antioxidant intake | FFQ | Dietary vitamin CQuintiles 1Quintiles 2Quintiles 3Quintiles 4Quintiles 5 | RR1.01.07 (0.85, 1.34)1.04 (0.82, 1.32)1.01 (0.79, 1.29)1.18 (0.90, 1.54) | AHA | 8 |
| Odum 2012 [30] | Nigeria | 50 | Both | 192 | Case-control | NA | NA | Control subjects MetS subjects | Circulating vitamin C43.9 (42.5, 45.4)29.1 (27.6, 30.5) | NCEP-ATP III | 6 |
| Al-Daghri 2013 [16] | Saudi Arabia | 19-60 | Both | 185 | Cross-sectional | Age, BMI and physical activity | 24 hours recall | Control subjects MetS subjectsDietary vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C61.2 (49.9, 72.5)50.2 (42.0, 58.4)RR1.00.44 (0.21, 0.66)0.24 (0.15, 0.32)0.24 (0.09, 0.49) | IDF | 7 |
| Motamed 2013 [33] | Iran | 35-65 | Both | 3800 | Cross-sectional | Sex, age, physical activity level, smoking, past medical history, energy intake, and BMI | 24 hours recall | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsDietary vitamin CQuintiles 1Quintiles 2Quintiles 3Quintiles 4Quintiles 5 | Dietary vitamin C84.9 (78.5, 90.7)97.4 (89.7, 105.1)Dietary vitamin C80.4 (76.3, 84.6)84.2 (79.5, 88.9)RR1.01.01 (0.80, 1.20)0.89 (0.70, 1.10)1.02 (0.80, 1.20)1.08 (0.80, 1.30) | IDF | 8 |
| Bian 2013 [17] | China | 30-70 | Both | 258 | Cross-sectional | NA | 24 hours recall | Control subjects MetS subjects | Dietary vitamin C106.0 (98.1, 113.9)101.9 (94.5, 109.3) | NCEP-ATP III | 9 |
| Li 2013 [18] | China | 18-65 | Both | 550 | Cross-sectional | Age and sex | 3-day food record | Control subjects MetS subjectsDietary vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C62.0 (56.8, 67.2)53.2 (47.7, 58.7)RR1.0 0.77 (0.46,1.30)  0.63 (0.37-1.06) 0.63 (0.37-1.06) | NCEP-ATP III | 7 |
| Park 2015 [19] | Korea | >20 | Both | 27656 | Cross-sectional | NA | 24 hours recall | Control subjects MetS subjects | Dietary vitamin C80.1 (78.7, 81.5)73.4 (71.0, 75.8) | NCEP-ATP III | 8 |
| Wei 2015 [20] | China | 18-84 | Both | 2069 | Cross-sectional | Age, sex, cigarette smoking, alcohol, drinking, nutritional supplementary, activity level, dietary energy intake, fiber intake and protein intake. | FFQ | Control subjects MetS subjectsDietary vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C108.8 (104.8, 112.8)104.2 (95.9, 112.5)RR1.00.65 (0.47, 0.90) 0.79 (0.57, 1.10)0.64 (0.43, 0.94) | AHA | 7 |
| Kim 2016 [22] | Korea | >20 | Both | 22671 | Cross-sectional | Age, sex, BMI, smoking, education level, household income, energy intake, total fat intake, dietary fiber intake and alcohol consumption | 24 hours recall | Control subjects MetS subjectsDietary vitamin C<85 mg/day≥85 mg/day | Dietary vitamin C111.8 (109.4, 114.2)109.4 (105.7, 113.1)RR1.00.89 (0.80, 0.99) | JIS | 8 |
| Godala 2016 [21] | Poland | 30-65 | Both | 182 | Cross-sectional | NA | 3-day food record | Control subjects MetS subjectsControl subjects MetS subjects | Dietary vitamin C93.3 (66.7, 120.0)104.0 (83.6, 124.3)Circulating vitamin C58.4 (54.7, 62.2)31.2 (29.8, 32.5) | IDF | 6 |
| Lim 2017 [24] | Korea | Middle-aged | Both | 143 | Cross-sectional | Not mentioned | 3-day food record | Control subjects MetS subjectsDietary vitamin CLow-consumerHigh-consumer | Dietary vitamin C92.7 (88.3, 97.1)63.1 (53.3, 72.9)RR1.00.89 (0.84, 0.94) | NCEP-ATP III | 6 |
| Ahn 2017 [23] | Korea | 30-60 | Both | 614 | Cross-sectional | Age, smoking status, alcohol consumption and physical activity | 3-day food record | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjectsDietary vitamin CMaleTertile 1Tertile 2Tertile 3FemaleTertile 1Tertile 2Tertile 3 | Dietary vitamin C41.1 (36.4, 45.8)39.4 (35.0, 43.8)Dietary vitamin C52.4 (47.0, 57.8)60.4 (52.7, 68.1)RR1.01.12 (0.64, 1.97) 0.87 (0.49, 1.53)RR1.00.76 (0.42, 1.36) 1.24 (0.69, 2.21) | NCEP-ATP III | 7 |
| Ahn 2017-2 [35] | Korea | 20-65 | Both | 10286 | Cross-sectional | NA | 24 hours recall | MaleControl subjects MetS subjectsFemaleControl subjects MetS subjects | Dietary vitamin C106.7 (102.0, 115.5)105.1 (91.5, 118.7)Dietary vitamin C112.1 (107.0, 117.3)99.6 (89.0, 110.1) | NCEP-ATP III | 8 |
| Kanagasabai 2018 [32] | Canada | >20 | Both | 2049 | Cross-sectional | Age, ethnicity, education, income, smoking, alcohol intake, recreational PA, and BMI | NA | Circulating vitamin CMaleLowerNormalFemaleLowerNormal | RR1.00.58 (0.39, 0.98)RR1.00.52 (0.28, 0.98) | JIS | 7 |
| Ahn 2019 [25] | Korea | 19-64 | Both | 10351 | Cross-sectional | Age, BMI, alcohol consumption, smoking, physical activity, household income, education level and energy intake | 24 hours recall | Dietary vitamin CMaleTertile 1Tertile 2Tertile 3FemaleTertile 1Tertile 2Tertile 3 | RR1.00.88 (0.70, 1.09) 0.75 (0.58, 0.95)RR1.01.24 (0.96, 1.61) 0.81 (0.62, 1.06) | NCEP-ATP III | 7 |
| Suriyaprom 2019 [31] | Thailand | 30-59 | Both | 300 | Case-control | Age, gender, and BMI | NA | Control subjects MetS subjectsCirculating vitamin C< 5mg/L> 5mg/L | Circulating vitamin C6.70 (6.00, 7.50)5.90 (4.80, 6.70)RR1.00.43 (0.24, 0.75) | NCEP-ATP III | 7 |
| Godala 2020 [26] | Poland | 57 | Both | 332 | Cross-sectional | NA | 24 hours recall | Control subjects MetS subjectsControl subjects MetS subjects | Dietary vitamin C127.9 (108.0, 147.8)113.1 (100.3, 125.8)Circulating vitamin C64.2 (61.4, 67.0)35.3 (33.7, 36.9) | IDF | 7 |
| Peng 2021 [27] | China | >99 | Both | 992 | Cohort | Aex, marital status, physical activity, smoking status, alcohol intake, family history of chronic diseases and daily total energy intake | 24 hours recall | Control subjects MetS subjectsDietary vitamin CQuartiles 1Quartiles 2Quartiles 3Quartiles 4 | Dietary vitamin C88.5 (56.0, 121.0)79.7 (53.1, 106.3)RR1.01.28 (0.79, 2.02) 0.81 (0.47, 1.37)0.91 (0.53, 1.84) | NCEP-ATP III | 6 |