Table S1: The risk of bias within individual studies for RCTs

M. Abidov et al. 2009

Methods	RCT, (Carotenoids vs. placebo) 16 weeks Summary risk of bias: low
Participants	NLF group: People with obesity (BMI>30kg/m^2) N: 19 intervention, 19 control Mean age in years (SE): 35.7(3.20) intervention, 34.7(3.50) control Gender: 0 males/19females intervention, 0 males /19 females control NAFLD group: People with obesity (BMI>30kg/m^2) N: 36 intervention, 36 control Mean age in years (SE): 36.1(2.10) intervention, 37.4(2.80) control Gender: 0 males/36females intervention, 0 males /36 females control Location: Russia
Interventions	Type: Carotenoid supplement (Xanthigen, containing fucoxanthin) Comparison: Xanthigen supplementation vs. control Intervention: Participants in intervention group received Xanthigen, 2.4mg fucoxanthin one three times a day 15–30 min before meals. Control: a placebo capsule was given one three times a day 15–30 min before meals. Compliance: Participants were required to visit the hospital three times a week for anthropometrical, physiological and biochemical analyses Length of intervention: 16 weeks
Outcomes	Main study outcome: Body weight, body fat, waist circumference, liver fat, TG, AST, ALT, GGT, CRP, Systolic blood pressure and Diastolic blood pressure in the study groups at the beginning and the end of the study and intergroup comparison Dropouts:0 intervention, 0 control Available outcomes: Body weight, body fat, waist circumference, liver fat, TG, AST, ALT, GGT, CRP, Systolic blood pressure and Diastolic blood pressure in the study group at the beginning and the end of the study and control group.
Notes	The body weight, body fat, waist circumference, liver fat and TG of intervention group and control group, the beginning and the end of the intervention group were compared.

Risk of bias

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	This was a double-blind, placebo-controlled, randomized clinical trial
Allocation concealment (selection bias)	Unclear risk of bias	The method of random assignment was not mentioned in the article
Blinding of participants and personnel (performance bias)	Low risk	double-blinded

All outcomes		
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk of bias	Not mentioned
Incomplete outcome data (attrition bias) All outcomes	Low risk	Participant flow well described.
Selective reporting (reporting bias)	Low risk	The published report contains all the expected results.
Attention	Low risk	All participants appear to have had similar frequency and quantity of attention and follow-up.
Compliance	Low risk	Participants were required to visit the hospital three times a week for anthropometrical, physiological and biochemical analyses
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S1: The risk of bias within individual studies for RCTs (continued)

Ryo et al. 2018

Methods	RCT, (Carotenoids vs. placebo) 12 weeks Summary risk of bias: low
Participants	patients with overweight (BMI from 25 to < 30 kg/m^2) and aged > 20 years N: 41 intervention, 39 control Mean age in years (SE): 48.90(1.38) intervention, 50.8(1.39) control Location: Japan
Interventions	Type: supplement (Paprika xanthophyll capsules) Comparison: Paprika xanthophyll capsules supplementation vs. control Intervention: supplemented with 9mg of carotenoids every night after meal for 12 weeks Control: supplemented with placebo every night after meal for 12 weeks Compliance: In week 0 (before starting administration) and week 12 of the treatment period, subjects underwent computed tomography (CT), interview by a site investigator, measurement of anthropometric, physical, blood, and urine parameters, and the confirmation of the dairy record. On the day before each set of tests, subjects were prohibited from drinking alcohol and performing excessive exercise, and had to finish the evening meal by 22:00. After that, only intake of water was allowed until the tests were completed on the following day. Length of intervention: 12 weeks
Outcomes	Main study outcome: Anthropometric measurements, measurements of the abdominal fat area and biochemical parameters in the study group at the beginning and the end of the study and control group. Dropouts: 2 subjects dropped out for personal reasons unrelated to ingestion of the study capsules Available outcomes: all of the results were available and was expressed as actual values or as the changes from week 0 in the study group at the beginning and the end of the study and control group.
Notes	The parameters of intervention group and control group, the beginning and the end of the intervention group were compared.

Risk of bias

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	randomized double-blind placebo-controlled clinical trial. The controller randomized the subjects to each group at a 1:1 ratio using a table of random numbers, and stored the assignment list in a sealed container until completion of all analyses.

Allocation concealment (selection bias)	Low risk	stored the assignment list in a sealed container until completion of all analyses.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	double-blinded
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Apart from the controller, all of the investigators and data processors, as well as all of the subjects, were blinded to the treatment assigned until the end of this trial
Incomplete outcome data (attrition bias) All outcomes	Low risk	Participant flow well described.
Selective reporting (reporting bias)	Low risk	registration of clinical trials: UMIN000021529
Attention	Low risk	All participants appear to have had similar frequency and quantity of attention and follow-up.
Compliance	Low risk	On the day before each set of tests, subjects were prohibited from drinking alcohol and performing excessive exercise, and had to finish the evening meal by 22:00. After that, only intake of water was allowed until the tests were completed on the following day.
Other bias	Low risk	The authors are employees of Ezaki Glico Co., Ltd., but this did not influence the author's adherence to the journal's policy.

Table S1: The risk of bias within individual studies for RCTs (continued)

Zohre et al. 2014

Methods	RCT, (Carotenoids vs. placebo) 20 days Summary risk of bias: Unclear
Participants	All patients with BMI of 25 kg/m^2 or higher. N: 40 intervention vs 35 controls age: all patients in this study were aged between 20 and 30 years. Gender: 0 males/40 females intervention group, 0 males /35 females placebo group. Location: Iran
Interventions	Comparison: Carotenoids (tomato juice) vs. placebo(water) Intervention: The intervention group received 330 ml (two cups) of tomato juice (Takdaneh Company), and the control group (n = 40) received two cups of water daily for 20 days, respectively. This amount of tomato juice provided 60 mg of lycopene. Participants were asked to consume the juice two times a day (morning and afternoon) Compliance: The strategy for monitoring adherence to the protocol was by using phone calls to participants every 3 days. To minimize loss of juice due to other family members consuming and/or spilling the study tomato juice, three additional packets were given to participants. Length of intervention: 20 days
Outcomes	Main study outcome: Antioxidant and anthropometric indicators of intervention and control groups pre- and postintervention intervention Dropouts: 5 drop out due to unwillingness to continue with sample collection procedures. Available outcomes: Weight and BMI at the beginning and the end of the intervention group.
Notes	Weight and BMI at the beginning and the end of the intervention group were compared.

Risk of bias

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	Subjects were randomly allocated to the intervention or control group using a computer-generated program by an independent statistician
Allocation concealment (selection bias)	Low risk	Initial diet allocation was concealed from the clinical recruitment staff until each woman had entered the trial and received a randomization code. This clinical trial was carried out as a double blinded procedure

Blinding of participants and personnel (performance bias) All outcomes	High risk	Obviously not used
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned
Incomplete outcome data (attrition bias) All outcomes	Low risk	Participant flow well described
Selective reporting (reporting bias)	Unclear risk	The clinical registration number was lacked.
Attention	Low risk	No problem with attention bias.
Compliance	Low risk	The strategy for monitoring adherence to the protocol was by using phone calls to participants every 3 days. To minimize loss of juice due to other family members consuming and/or spilling the study tomato juice, three additional packets were given to participants
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S1: The risk of bias within individual studies for RCTs (continued)

Maria et al. 2019

Methods	RCT, (Carotenoids vs. placebo) 4 weeks Summary risk of bias: low
Participants	volunteers with moderate obesity, 30 < BMI < 35 kg/m^2 Mean age in years (SD): 56.2(5.9) intervention group, 56.1(5.8) control group. N: 6 intervention, 6 control Gender:2 males/4 females intervention, 4 males /2 females control Location: Denmark
Interventions	Type: supplement (capsule of 7mg GA lycopene formulated with medium saturated fatty acids, GAL-MSFA) Comparison: Carotenoids vs. placebo Intervention: lycopene formulated with GAL-MSFA (7mg GA lycopene/d, capsules were advised to be taken once a day after the main meal.) Control: GAL-MSFA (capsules were advised to be taken once a day after the main meal) Compliance: Both capsule and chocolate products were advised to be taken once a day after the main meal. All patients were informed of the purpose and goals of the study and had signed a consent form before enrolment and participation in the study. Length of intervention: 4 weeks
Outcomes	Main study outcome: blood and tissue parameters, such LDL and HDL, of intervention and control groups pre- and postintervention intervention Dropouts: 0 Available outcomes: TG, LDL and HDL in the intervention group at the beginning and the end of the study and control group.
Notes	TG, LDL and HDL of intervention group and control group, the beginning and the end of the intervention group were compared.

Risk of bias

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	randomized clinical trial
Allocation concealment (selection bias)	Unclear risk	Not mentioned
Blinding of participants and personnel (performance bias) All outcomes	Low risk	double-blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not mentioned

Incomplete outcome data (attrition bias) All outcomes	Low risk	There was no dropout.
Selective reporting (reporting bias)	Low risk	registration of clinical trials: ACTRN12618000715279.
Attention	Low risk	No problem with attention bias.
Compliance	Low risk	Both capsule and chocolate products were advised to be taken once a day after the main meal. All patients were informed of the purpose and goals of the study and had signed a consent form before enrolment and participation in the study.
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S1: The risk of bias within individual studies for RCTs (continued)

Hye et al. 2011

Methods	RCT, (Carotenoids vs. placebo) 12 weeks Summary risk of bias: low
Participants	All patients were overweight (body mass index (BMI) >25.0 kg/m^2) N: 14 intervention vs 13 control Mean age in years (SD): 30.1(9.5) intervention group, 31.1(9.4) control group. Gender: 12 males/2females intervention group, 11 males /2 females control group Location: South Korea
Interventions	Type: supplement (capsule of astaxanthin) Comparison: Carotenoids vs. placebo Intervention: The subjects in the astaxanthin group were instructed to take one 20 mg astaxanthin capsule (Marine. Product Tech. Inc., Seongnam, South Korea) once daily after breakfast for 12 weeks. Compliance: All subjects visited for blood sampling every four weeks and body weight, height, and waist circumference were measured at baseline and at 12 weeks. During the study, the subjects were asked to maintain their usual lifestyle and to refrain from taking any vitamins or nutritional supplements. At the end of the study, all subjects were asked to bring back their remaining astaxanthin or placebo capsules and administration reports to assess adherence and adverse drug reactions All subjects in the two intervention groups completed the study. Length of intervention: 12 weeks
Outcomes	Main study outcome: Blood Lipid Profiles, oxidative Stress Biomarkers in intervention and control groups pre- and postintervention intervention. Dropouts: 0 Available outcomes: The indicators of body weight, BMI, waist circumference, TC, HDL and LDL at the beginning and the end of the intervention group.
Notes	The body weight, BMI, waist circumference, TC, HDL and LDL at the beginning and the end of the intervention group were compared.

Risk of bias

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	randomized, double-blind, placebo-controlled trial
Allocation concealment (selection bias)	Unclear risk	Not described
Blinding of participants and personnel (performance bias) All outcomes	Low risk	double-blinded

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described
Incomplete outcome data (attrition bias) All outcomes	Low risk	There was no dropout.
Selective reporting (reporting bias)	Unclear risk	The clinical registration number was lacked.
Attention	Low risk	No problem with attention bias.
Compliance	Low risk	All subjects visited for blood sampling every four weeks and body weight, height, and waist circumference were measured at baseline and at 12 weeks. During the study, the subjects were asked to maintain their usual lifestyle and to refrain from taking any vitamins or nutritional supplements. At the end of the study, all subjects were asked to bring back their remaining astaxanthin or placebo capsules and administration reports to assess adherence and adverse drug reactions
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S1: The risk of bias within individual studies for RCTs (continued)

Fatemeh et al. 2019

Methods	RCT, (Carotenoids vs. placebo) 12 weeks Summary risk of bias: low
Participants	Patients were overweight or obese with 25 ≤ BMI <40 kg aged 25–70 years. N: 23 intervention, 23 control Mean age in years (SD): 38.1(7.6) intervention, 35.6(9.1) control Location: Iran
Interventions	Type: supplement (BCX powder) Comparison: carotenoids vs. control Intervention: supplemented with 6 mg of BCX every day for 12 weeks Control: supplemented with placebo every day for 12 weeks Compliance: Apart from scheduled follow-up visits at weeks 6 and 12 of the intervention period, weekly phone follow-ups were carried out to minimize the attrition rate. Compliance, defined as taking ≥90% of the prescribed capsules, was evaluated at every scheduled follow-up visit. To assess the blinding of the study, each subject was asked to guess his/her allocated intervention at study end point. Length of intervention: 12 weeks
Outcomes	Main study outcome: Subjects' anthropometrics, dietary intakes, physical activity, and serum BCX at baseline and study end point. Dropouts: 0 Available outcomes: Body weight, BMI and WC at the beginning and the end of the study in the intervention group and control group.
Notes	Data of body weight, BMI and WC intervention group and control group, the beginning and the end of the intervention group were compared.

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Random sequence generation (selection bias)	Low risk	randomized double-blind placebo-controlled clinical trial by software
Allocation concealment (selection bias)	Low risk	An experienced independent biostatistician generated the random allocation sequence at the AJUMS School of Health and gave it in sequentially numbered, opaque, and sealed envelopes to a trained clinician responsible for evaluation and enrollment of subjects at the Golestan Hospital.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	double-blinded

Blinding of outcome assessment (detection bias) All outcomes	Low risk	The random allocation sequence was concealed, and subjects, health care providers, data collectors, and outcome adjudicators were blinded to the allocated interventions until the last recruited subject attended the final follow-up visit
Incomplete outcome data (attrition bias) All outcomes	Low risk	Participant flow well described.
Selective reporting (reporting bias)	Low risk	registration of clinical trials: IRCT2017060210181N10
Attention	Low risk	All participants appear to have had similar frequency and quantity of attention and follow-up.
Compliance	Low risk	Apart from scheduled follow-up visits at weeks 6 and 12 of the intervention period, weekly phone follow-ups were carried out to minimize the attrition rate. Compliance, defined as taking ≥90% of the prescribed capsules, was evaluated at every scheduled follow-up visit. To assess the blinding of the study, each subject was asked to guess his/her allocated intervention at study end point.
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S1: The risk of bias within individual studies for RCTs (continued)

Akira et al. 2017

Methods	RCT, (Carotenoids vs. placebo) 12 weeks Summary risk of bias: low
Participants	Trial 1 patients with BMI ranging from 25 to 32 kg/m^2 N: 13 intervention, 10 control Mean age in years (SD): 41(9.0) intervention, 44 (9.0) control Location: Japan Trial 2 patients with BMI ranging from 25 to 30 kg/m^2 N: 46 intervention, 45 control Mean age in years (SD): 43(10) intervention, 44 (11) control Location: Japan
Interventions	Trial 1 Type: supplement (β-CX beverage) Comparison: vitamin D supplementation vs. control Intervention: supplemented with 1.2mg β-CX per day after a meal for 12 weeks. Control: supplemented with placebo per day after a meal for 12 weeks. Compliance: Physical and clinical parameters were evaluated at the beginning of the pre-treatment period(baseline), the beginning of the treatment period (Week 0), and the last day of the treatment period (Week 12). Length of intervention: 12 weeks Trial 2 Type: supplement (β-CX beverage) Comparison: vitamin D supplementation vs. control Intervention: supplemented with 2mg β-CX per day (at any time) for 12 weeks. Control: supplemented with placebo per day (at any time) for 12 weeks. Compliance: Subjects underwent evaluation of physical and clinical parameters every 4 weeks during the treatment period (Week 0, Week 4, Week 8, and Week 12; Week 0 represents the beginning of the treatment period) Length of intervention: 12 weeks
Outcomes	Main study outcome: Physical parameters at the beginning and the end of the study in the intervention group and control group. Dropouts: one subject dropped out of the trial for personal reasons in trial 2. Available outcomes: BMI and weight in the intervention group at the beginning and the end of the study and control group.
Notes	The BMI and weight of intervention group and control group, the beginning and the end of the intervention group were compared.
Risk of bias	

Bias	Authors' judgment	Support for judgment
Random sequence generation (selection bias)	Low risk	randomized double-blind placebo-controlled clinical trial
Allocation concealment (selection bias)	Unclear risk	Not described.
Blinding of participants and personnel (performance bias) All outcomes	Low risk	double-blinded
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Not described.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Participant flow well described.
Selective reporting (reporting bias)	Low risk	registration of clinical trials: H21-079
Attention	Low risk	All participants appear to have had similar frequency and quantity of attention and follow-up.
Compliance	Low risk	Trial 1: Physical and clinical parameters were evaluated at the beginning of the pre-treatment period(baseline), the beginning of the treatment period (Week 0), and the last day of the treatment period (Week 12). Trial 2: Subjects underwent evaluation of physical and clinical parameters every 4 weeks during the treatment period (Week 0, Week 4, Week 8, and Week 12; Week 0 represents the beginning of the treatment period)
Other bias	Low risk	No commercial company involved, and no conflict of interest.

Table S2: The risk of bias within individual studies for observational studies by the NOS.

Rebecca et al. 2019

Study type	Cross-sectional study
Participants	Patients: adolescents Male group N: 40 cases, 49 controls Gender: 40 males/ 0females case, 49 males/0females control Female group N:44 cases, 105 controls Gender: 0 males/ 44females case, 0 males/ 105females control Location: Brazil
Comparison	Comparison: patients with obese or overweight vs. control Case: Patients with obese or overweight Control: normal patients
Outcomes	Main study outcome: the risk of β-carotene insufficiency Available outcomes: the risk of β-carotene insufficiency

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	1	study only controls age between case and control.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Inong R. et al. 2014

Study type	Cross-sectional study
Participants	Patients: Mexica-American children aged 8-15 years N:413 cases, 587 controls Gender: 237 males/230 females case, 283 males /364 females control Location: the U.S.
Comparison	Comparison: patients with obese or overweight vs. control Case: children with obese or overweight Control: children with normal weight.
Outcomes	Main study outcome: the risk for the excess body weight patients in trans-β-carotene, cis-β-carotene, α- carotene sufficiency, the correlation between the obesity and serum Carotenoids levels. Available outcomes: the risk for the excess body weight patients in trans-β-carotene, cis-β-carotene, α- carotene sufficiency.

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Luciane et al. 2007

Study type	Cross-sectional study
Participants	Subjects: children and adolescents aged 7-17 years N:72 cases, 399 controls Gender: 34 males/38 case, 217 males /182 females control. Location: Brazil
Comparison	Comparison: patients with overweight vs. control Case: Subjects with overweight Control: normal weight
Outcomes	Main study outcome: the association between low serum concentrations of carotenoids and overweight (odds ratio) Available outcomes: the risk for the overweight patients of carotenoids insufficiency

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls gender and age between case and control.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Roseli et al. 2005

Study type	Case-control study
Participants	Patients: pre-school children. N:23 cases, 23 controls Gender: 24 males, 22 females Location: Brazil
Comparison	Comparison: patients with obesity vs. control Case: pre-school children with obesity Control: pre-school children with normal weight
Outcomes	Main study outcome: Insufficiency (%) and odds ratio (OR, CI 95%) of retinol and carotenoids in obese and non-obese groups Available outcomes: the risk for the obese patients of carotenoids insufficiency

Risk of bias

Bias	Authors' judgment	Support for judgment
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	0	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Koji et al. 2006

Study type	Cross-sectional study
Participants	Subjects: adults who attended the health examination Male group N:55 cases, 137 controls Mean age in years (SD): 60.0(10.40) case, 60.1(11.1) control. Gender: 55 males/0 females case, 137 males /0 females control. Female group N:119 cases, 279 controls Mean age in years (SD): 58.1(10.20) case, 60.3(9.7) control. Gender: 0 males/119 females case, 0 males /279 females control. Location: Japan
Comparison	Comparison: subjects with high BMI (≥25.0) vs. control Case: subjects with high BMI(≥25.0) Control: normal subjects with BMI<25.0
Outcomes	Main study outcome: Multivariate adjusted odds ratios and 95% confidence intervals of obesity indices for low serum levels of carotenoids Available outcomes: the risk for the high BMI patients of carotenoids (lycopene, astaxanthin; cryptoxanthin, zeaxanthin/lutein, α-carotene and β-carotene) insufficiency.

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	0	hospital controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Allison et al. 2011

Study type	Cross-sectional study
Participants	Patients: urban Indigenous population Medians age in years (25^{th}-75^{th}%): 35 (22-46) male,37(25-48)female Gender: 280 males 617 females Location: Australia
Comparison	Comparison: patients overweight or obesity vs. control Case: overweight or obese patients Control: normal weight control
Outcomes	Main study outcome: Odds ratios and 95% confidence intervals from multivariate models looking at factors associated with being in the top 25% for all plasma carotenoid concentrations Available outcomes: the risk for the excess body weight patients in all carotenoids sufficiency.

Risk of bias

Bias	Authors' judgment	Support for judgment
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	not described

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Koji et al. 2003

Study type	Cross-sectional study
Participants	Patients undergoing health examination Male group N:50 cases, 108 controls Mean age in years (SD): 58.3 (10.4) case, 59.3 (10.8) control. Gender: 50 males/0 females case, 108 males /0 females control. Female N:52 cases, 106 controls Mean age in years (SD): 59.4 (10.2) case, 58.7 (10.8) control. Gender: 0 males/52 females case, 0 males /106 females control. Location: Japan
Comparison	Comparison: patients with obese vs. control Case: obese patients Control: normal control
Outcomes	Main study outcome: Odds ratios and 95% confidence intervals for elevated levels of serum CRP, carotenoids, leptin, oxidized LDL, and oxidized LDL antibodies. Available outcomes: the risk for the obese patients of carotenoids insufficiency.

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	0	hospital controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	1	secure record
Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	Not mentioned

Table S2: The risk of bias within individual studies for observational studies by the NOS (continued)

Joel E. et al. 2006

Study type	Cross-sectional study
Participants	Patients: American adults Premenopausal women group N:1320 cases(obese), 1212 cases (overweight),1980 controls Gender: 0 males/1320 females case(obese),0 males/1212females case(overweight), 0 males /1980 females control. Postmenopausal women group N:1267 cases(obese), 1365 cases (overweight), 1239 controls Gender: 0 males/1267 females case(obese),0 males/1365females case(overweight), 0 males /1239 females control. Young male group(19 - < 65 years) N:2285 cases(obese), 1244 cases (overweight),2346 controls Gender: 2285 males/0 females case(obese),1244 males/0females case(overweight), 2346 males /0 females control Old male group(≥65 years) N:363 cases(obese), 854 cases (overweight), 716 controls Gender: 363males/0females case(obese), 854 males/0 females case (overweight), 716males /0 females control Location: the U.S.
Comparison	Comparison: patients with obese or overweight vs. control Case: obese or overweight patients Control: normal weight control
Outcomes	Main study outcome: Odd ratios of low micronutrient levels among US men and women Available outcomes: the risk for the obese or overweight patients of carotenoids insufficiency.

Risk of bias

Bias	**Authors' judgment**	**Support for judgment**
Is the case definition adequate(**Selection**)	1	yes, with independent validation
Representativeness of the cases(**Selection**)	1	consecutive or obviously representative series of cases
Selection of Controls(**Selection**)	1	community controls
Definition of Controls(**Selection**)	1	no history of disease (endpoint)
Comparability of cases and controls on the basis of the design or analysis(**Comparability**)	2	study controls for age, gender and other factors.
Ascertainment of exposure(**Exposure**)	0	self-reported

Same method of ascertainment for cases and controls(**Exposure**)	1	yes
Non-Response rate(**Exposure**)	0	Not mentiond

Table S3. The Summary of Findings (SoF) with GRADE system

The risk of insufficient of carotenoids excess bodyweight compared with normal bodyweight in risk of insufficient of carotenoids			
Population: subjects with overweight or obese vs. normal subjects **Settings:** Two studies (twenty-two data) were conducted in Asia; three studies (four data) were conducted in South America; two studies (forty-four data) were conducted in North America; one study (two data) were conducted in Oceania. **Cases:** subjects with overweight or obese **Controls:** normal subjects			
Outcomes	OR (95% CI)[1]	No. of participants(studies)	Quality of the evidence Comments (GRADE)
The risk of insufficient of carotenoids.	1.731(1.565,1.913)	28446(8 observational studies)	⊕⊕⊕⊖Moderate[2]
Abbreviations: OR: odd ratio; CI: Confidence interval;			
GRADE Working Group grades of evidence **High quality:** We are very confident that the true effect lies close to that of the estimate of the effect **Moderate quality:** We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low quality:** Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect **Very low quality:** We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect			
[1]Results for the risk of insufficient of carotenoids for the subjects with overweight or obese compared with the subjects with normal weight. [2]Upgraded by one level due to all the results of the included studies were almost identical (subjects with overweight or obesity had lower serum carotenoid levels).			

Table S4 Subgroup analyses for the overweight or obesity in carotenoid supplementation groups and control groups

Factors	Numbers of studies			
	BW	**BMI**	**WC**	**TG**
Intervention time				
>12weeks	2	1	2	2
≤12weeks	6	5	4	3
Region				
Europe	2	0	2	2
Asia	6	6	4	3
Population type				
overweight	3	3	2	1
obesity	2	-	2	3
overweight & obesity	3	3	2	1
Population Gender				
F	3	1	2	2
M	2	2	1	-
F&M	2	2	2	3

BW, body weight**; BMI**, body mass index; **WC**, waist circumference; **TG**, Triglyceride; **F**, Female; **M**, Male; **F&M**, Female and male.

Table S4 Subgroup analyses for the overweight or obesity in carotenoid supplementation groups and control groups(continued)

Factors	Standard mean difference(95%CI),*P*			
	BW	**BMI**	**WC**	**TG**
Intervention time				
>12weeks	-8.428(-16.645, -0.211), 0.044	-	-3.559(-7.918,0.799),0.109	-5.846(-6.625, -5.068), <0.001
≤12weeks	-0.631(-1.613, 0.350), 0.207	-	-1.033(-2.314,0.247),0.114	0.607(-1.660, 2.873),0.600
Region				
Europe	-8.428(-16.645, -0.211), 0.044	-	-3.559(-7.918,0.799), 0.109	-5.846(-6.625, -5.068), <0.001
Asia	-0.631(-0.631,0.350), 0.207	-	-1.033(-2.314,0.247),0.114	0.607(-1.660, 2.873), 0.600
Population weight				
overweight	-1.158(-3.226,0.910),0.272	-1.659(-3.455,0.137),0.07	-1.626(-4.297,1.046), 0.233	-
obese	-8.428(-16.645, -0.211), 0.044	-	-3.559(-7.918,0.799),0.109	-
Overweight & obese	-0.055(-0.621,0.511),0.849	-0.176(-0.607,0.254),0.422	-0.400(-1.182,0.381),0.316	-
Population Gender				
F	-5.416(-10.680, -0.153), 0.044	-	-3.559(-7.918,0.799),0.109	-5.846(-6.625, -5.068),<0.001
M	-0.087(-0.455, 0.281),0.642	-0.701(-1.081, -0.322), <0.001	-	
F&M	-2.005(-4.534,0.524),0.120	-2.133(-4.747,0.481),0.110	-1.937(-4.045,0.171),0.072	0.607(-1.660,2.873),0.600

BW, body weight**; BMI**, body mass index; **WC**, waist circumference; **TG**, Triglyceride; **F**, Female; **M**, Male; **F&M**, Female and male.

Table S4 Subgroup analyses for the overweight or obesity in carotenoid supplementation groups and control groups(continued)

Factors	Heterogeneity I^2(%), *P*			
	BW	**BMI**	**WC**	**TG**
Intervention time				
>12	98.0, <0.001	-	98.2, <0.001	4.6, 0.306
≤12	94.1, <0.001	-	94.8, <0.001	94.4, <0.001
Region				
Europe	98.0, <0.001	-	98.2, <0.001	4.6,0.306
Asia	94.1, <0.001	-	94.8, <0.001	94.4, <0.001
Population weight				
overweight	97.0, <0.001	95.7, <0.001	98.0, <0.001	-
obese	98.0, <0.001	-	98.2, <0.001	-
overweight & obese	63.5, <0.065	38.3,0.198	61.3,0.108	-
Population Gender				
F	99.0, <0.001	-	98.2, <0.001	4.6,0.306
M	0.0,0.948	96.0, <0.001	-	-
F&M	95.8, <0.001	0.0, 0.677	94.2, <0.001	94.4, <0.001

BW, body weight**; BMI**, body mass index; **WC**, waist circumference; **TG**, Triglyceride; **F**, Female; **M**, Male; **F&M**, Female and male.

Table S5 Publication bias (Egger test) and sensitivity analysis (trim and fill method) performed for included studies (RCTs)

	Egger test(***t, P***)	Number of trim and fill	SMD (95%CI),P^a	SMD (95%CI),P^b
Body weight(kg)	-3.26,0.017	2	-2.336(-3.801, -0.871),0.002	-3.357(-5.461,-1.254),0.002
BMI(kg m^{-2})	-0.98,0.383	-	-0.948(-1.883, -0.014),0.047	-
WC(cm)	-2.17,0.096	-	-1.839(-3.138, -0.539),0.006	-
HDL(mg dL^{-1})	-	-	0.757(0.101,1.413),0.465	-
LDL(mg dL^{-1})	-19.68,0.032	0	-1.300(-3.225,0.625),0.186	-1.300(-3.225,.625),0.186
TC(mg dL^{-1})	-	-	-2.095(-3.201,-0.989),<0.001	-
TG(mg dL^{-1})	-0.08,0.943	-	-1.875(-4.382,0.632), 0.143	-

[a] Original variation. [b] Variation after trim and fill.

SMD: Standard mean difference; **BMI**, body mass index; **WC**, waist circumference; **HDL**, high-density lipoprotein; **LDL**, Low Density Lipoprotein; **TC**, Total cholesterol; **TG**, Triglyceride.

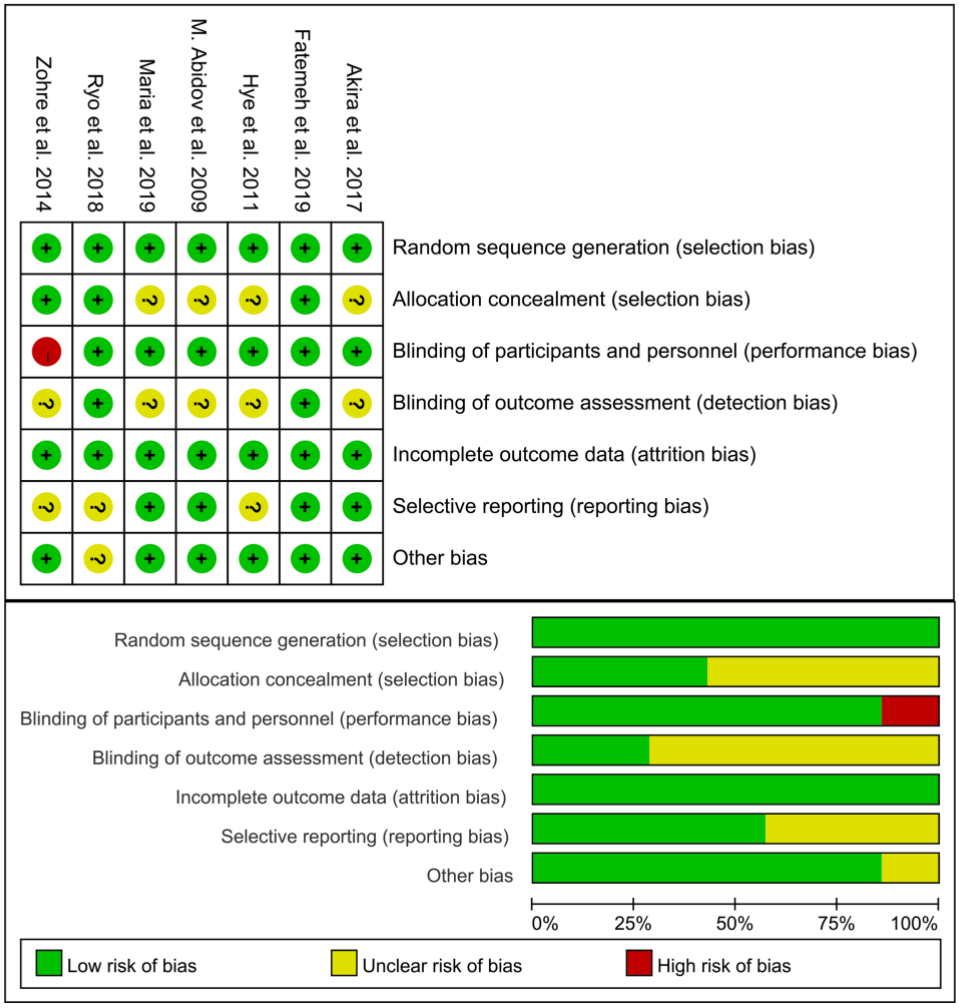

Figure S1: Risk of within-study bias (RCT)