Low-calorie sweeteners and weight – a systematic review of human and animal studies

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Disclosures

- I have received funding for research from Sugar Nutrition UK, provided consultancy services for Coca-Cola Great Britain and received speaker's fees from the International Sweeteners Association and the Global Stevia Research Institute.

- I will be referring to a systematic review and meta-analyses of effects of low-calorie sweeteners on energy intake and body weight. This review was initiated by ILSI-Europe, who also provided administrative support, hosted meetings of the authors, and paid the academic authors travel expenses and honoraria. Two of the eleven authors of the review are food industry employees, and one was an ILSI-Europe employee.

ILSI Europe
International Life Sciences Institute

Theoretically, low-calorie sweeteners ought help reduce body weight because:

- By replacing all or some sugar, low-calorie sweeteners reduce the energy content of foods and especially drinks

- And reduced energy intake in a meal or snack is not fully compensated for by increased energy intake at the next or subsequent meals or snacks

Rogers P. J. & Brunstrom J. M. (2016) *Physiology and Behavior, 164,* 465-471

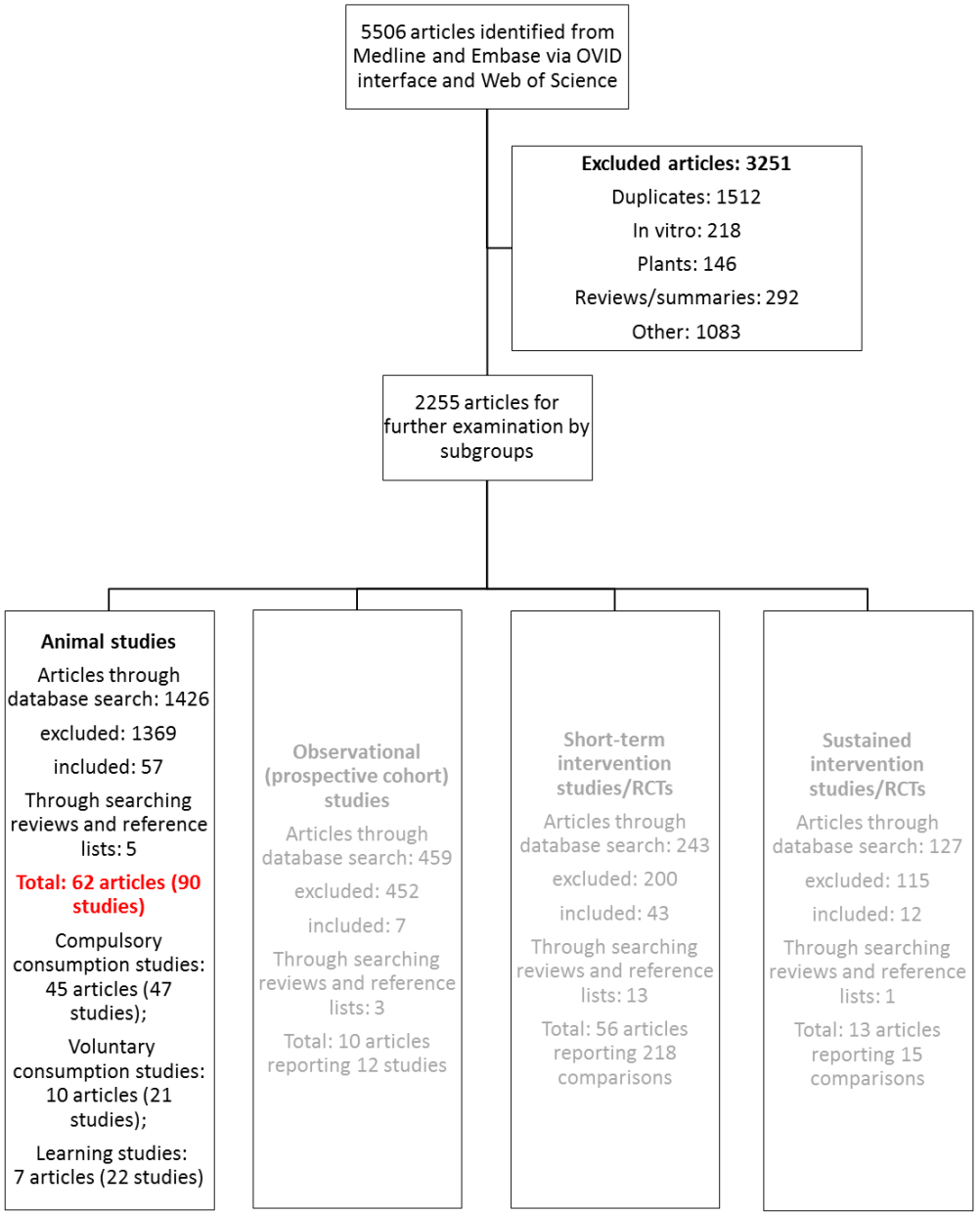
International Journal of Obesity

Does low-energy sweetener consumption affect energy intake and body weight? A systematic review, including meta-analyses, of the evidence from human and animal studies

OPEN

P J Rogers[1], P S Hogenkamp[2], K de Graaf[3], S Higgs[4], A Lluch[5], A R Ness[6], C Penfold[6], R Perry[6], P Putz[7], M R Yeomans[8] and D J Mela[9]

International Journal of Obesity (2016) 40, 381-394



Effects of low-calorie sweeteners consumption on body weight: **animal studies**

- BW gain when LCS added to food or drink, compulsorily or voluntarily consumed compared with BW gain on the food or drink without LCS:

  68 studies: 22↓ 37→ 9↑

Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

Effects of low-calorie sweeteners consumption on body weight: **animal studies**

- BW gain when LCS added to food or drink, compulsorily or voluntarily consumed compared with BW gain on the food or drink without LCS:

  68 studies: 22↓ 37→ 9↑

- BW gain when LCS added to a dietary supplement compared with BW gain when glucose added to the same dietary supplement:

  22 studies: 0↓ 3→ 19↑

Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

Sweet taste as a predictor of food energy (sugar) content

High-intensity sweeteners and energy balance

Susan E. Swithers *, Ashley A. Martin, Terry L. Davidson

Department of Psychological Sciences, Purdue University, West Lafayette, IN, USA

Physiology & Behavior 100 (2010) 55–62

Unsweetened yogurt 3 d/wk

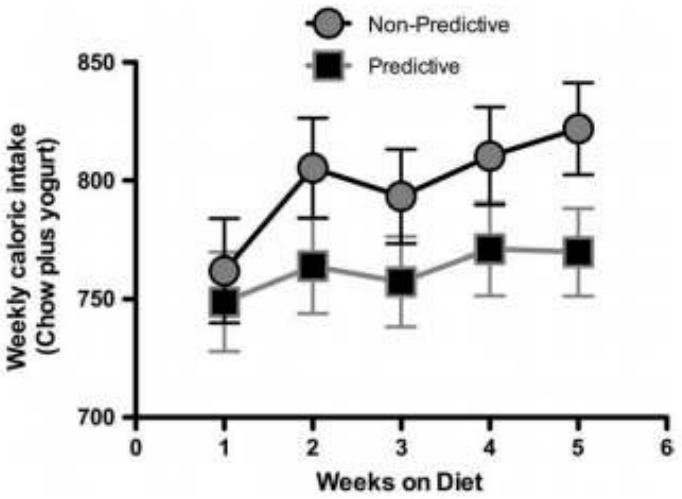
Sweetened yogurt 3 d/wk

Non-predictive (of additional calories) = Saccharin

OR

Predictive (of additional calories) = Glucose

Rat chow ad libitum



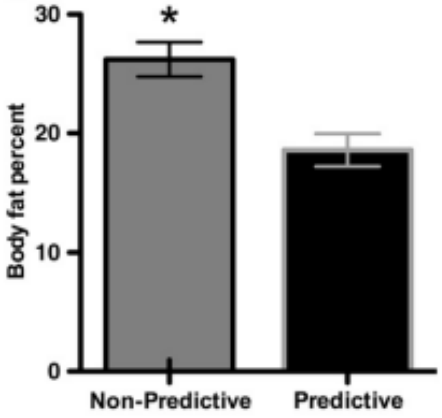
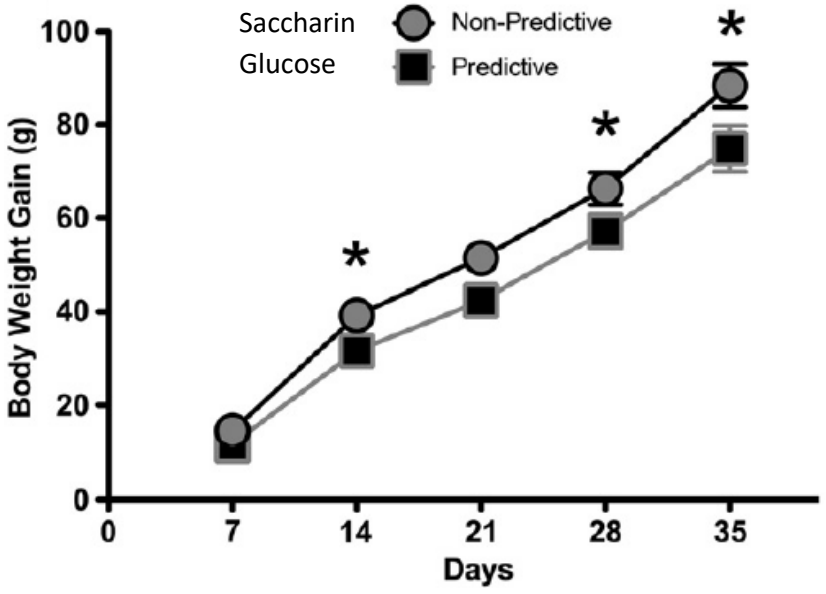
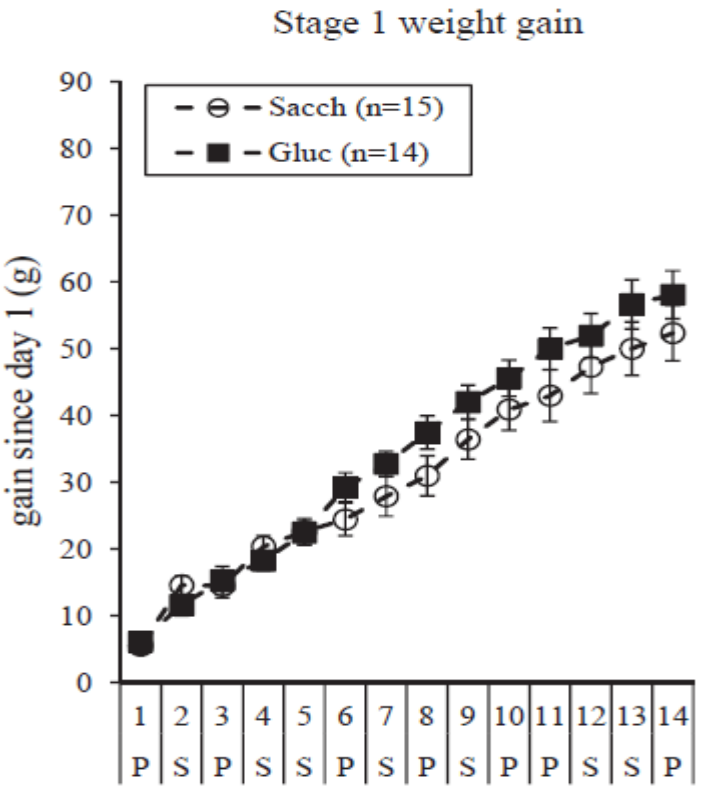


Fig. 2. Total caloric intake tended to be greater in rats given access to saccharin-sweetened yogurt diet supplements in which sweet taste did not predict increased calories (Non-Predictive group) compared to animals given glucose-sweetened yogurt diet supplements (Predictive group) in which sweet taste did reliably predict increased calories (*ns* = 8–9 per group).

Sweet taste as a predictor of food energy (sugar) content



Swithers et al. (2010) *Physiology and Behavior, 100,* 55-62



Boakes et al. (2016) *Appetite, 105,* 105-128

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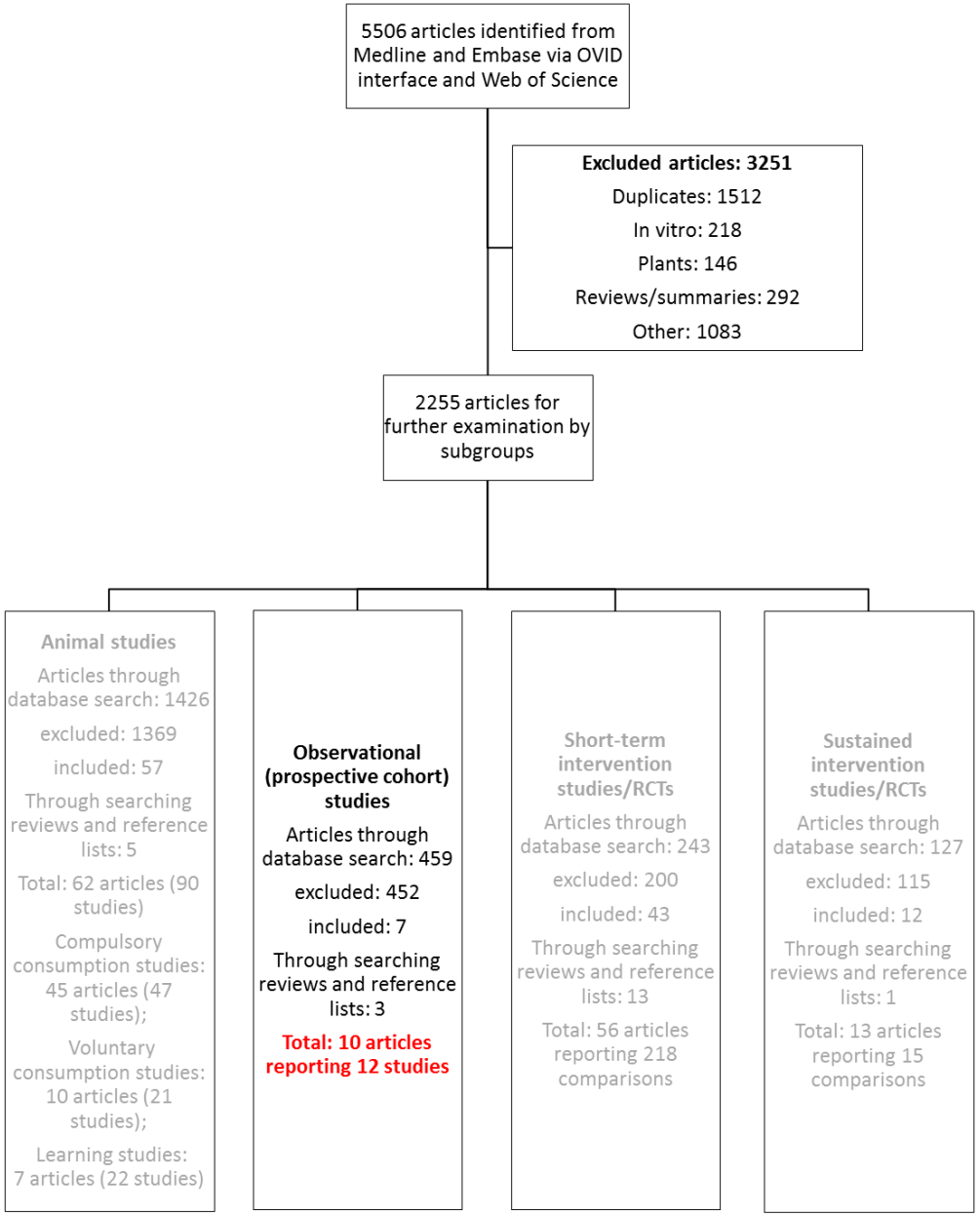
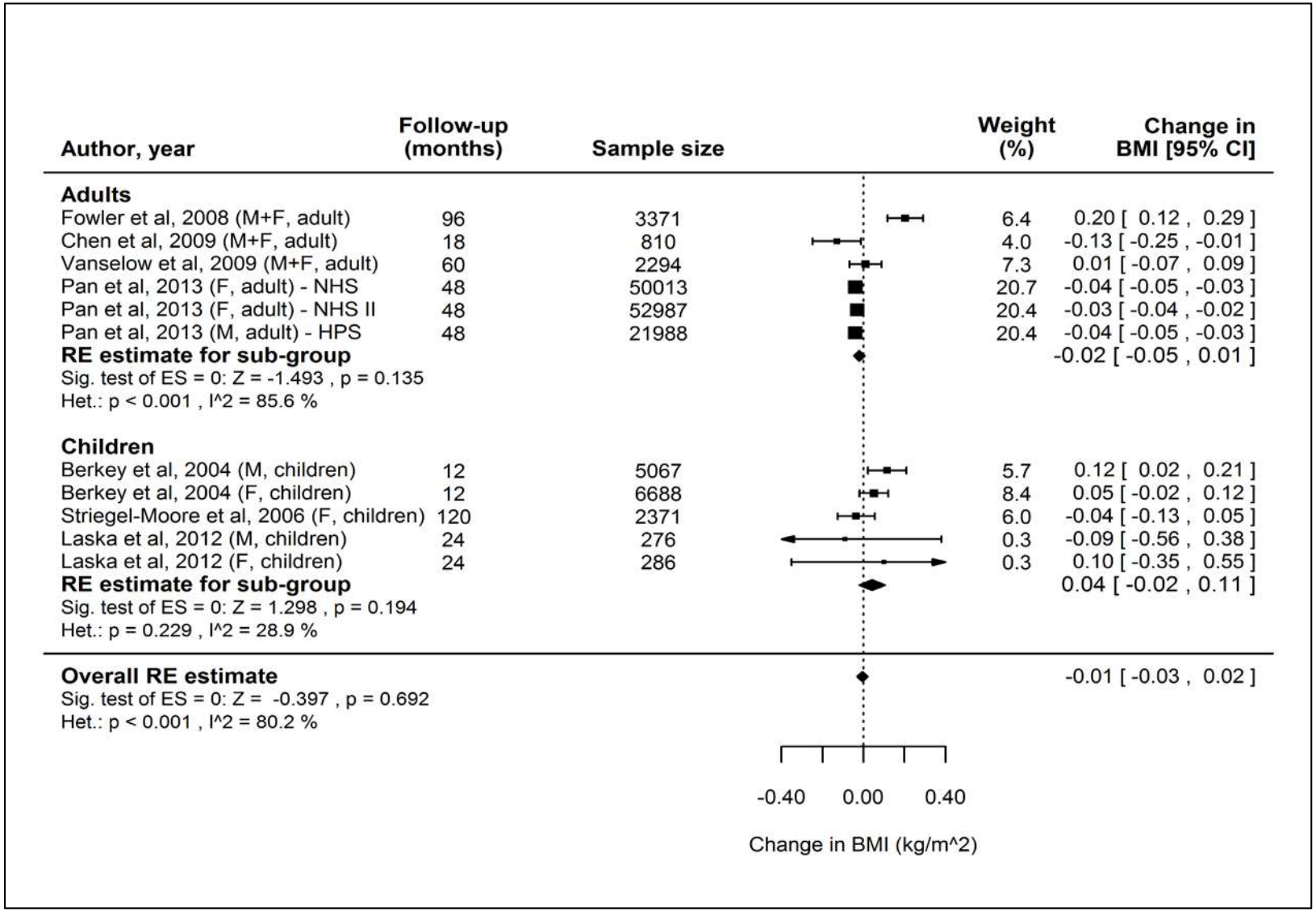


Low-calorie sweeteners consumption and BMI: **prospective cohort studies**



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Cause or effect?

International Journal of Obesity

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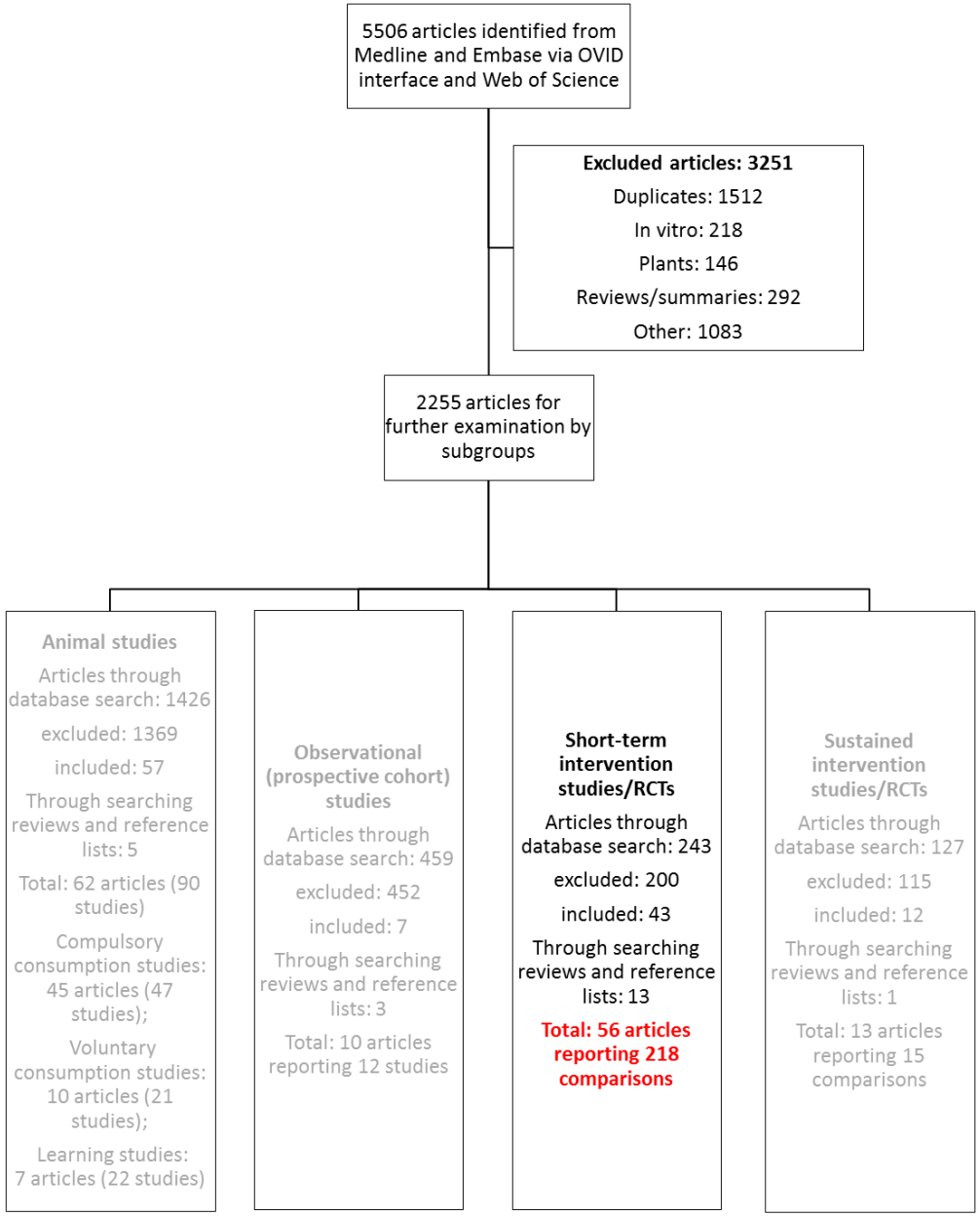


Short-term effects of low-calorie sweeteners on energy intake

'Preload'

= <1 kcal

'Test meal'
1500 kcal served

Total energy intake

900 kcal

Illustrative results based Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

Short-term effects of low-calorie sweeteners on energy intake

‘Preload’

= <1 kcal

150 kcal

‘Test meal’
1500 kcal served

Total energy intake

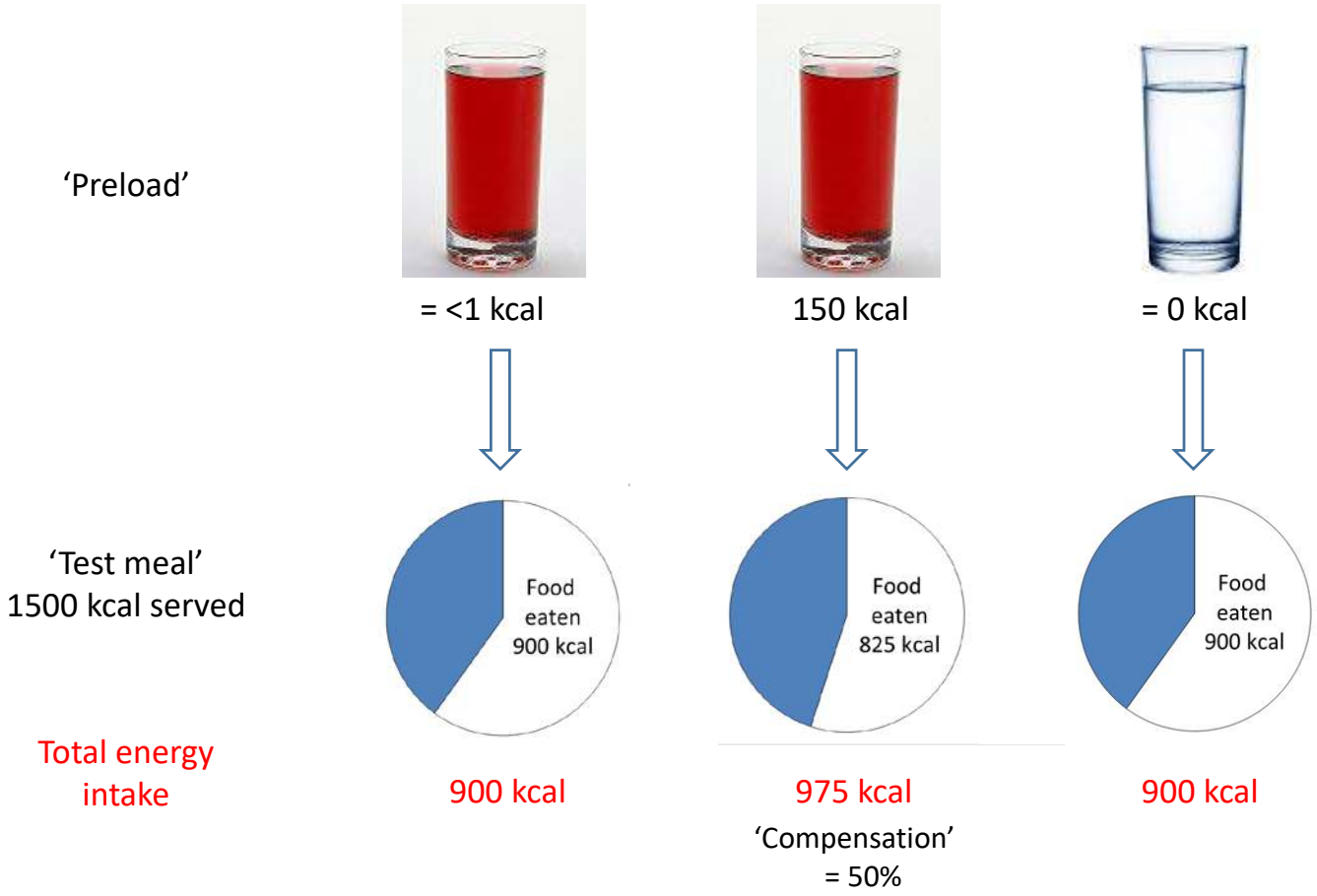
900 kcal

975 kcal

‘Compensation’
= 50%

Illustrative results based Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

Short-term effects of low-calorie sweeteners on energy intake



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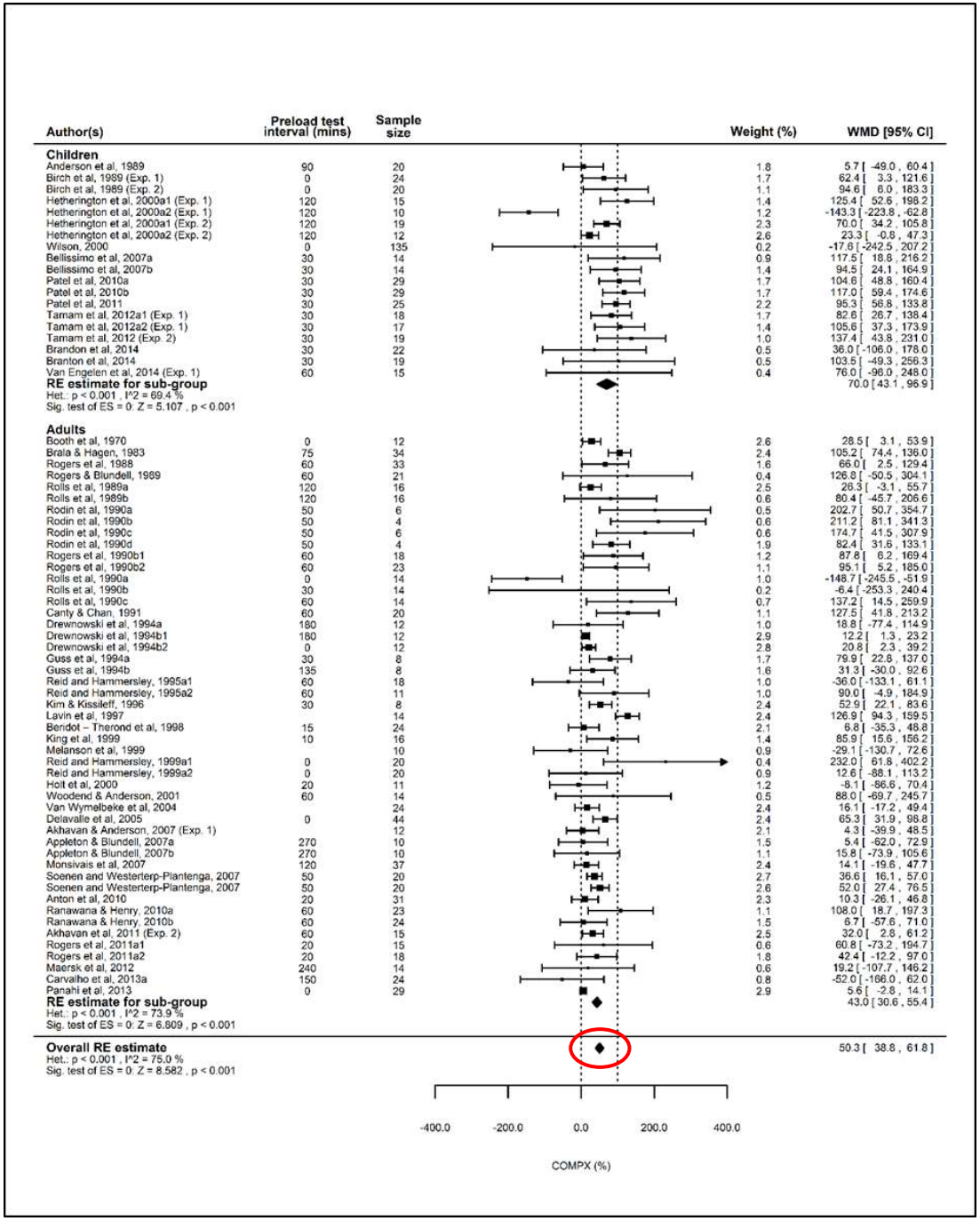


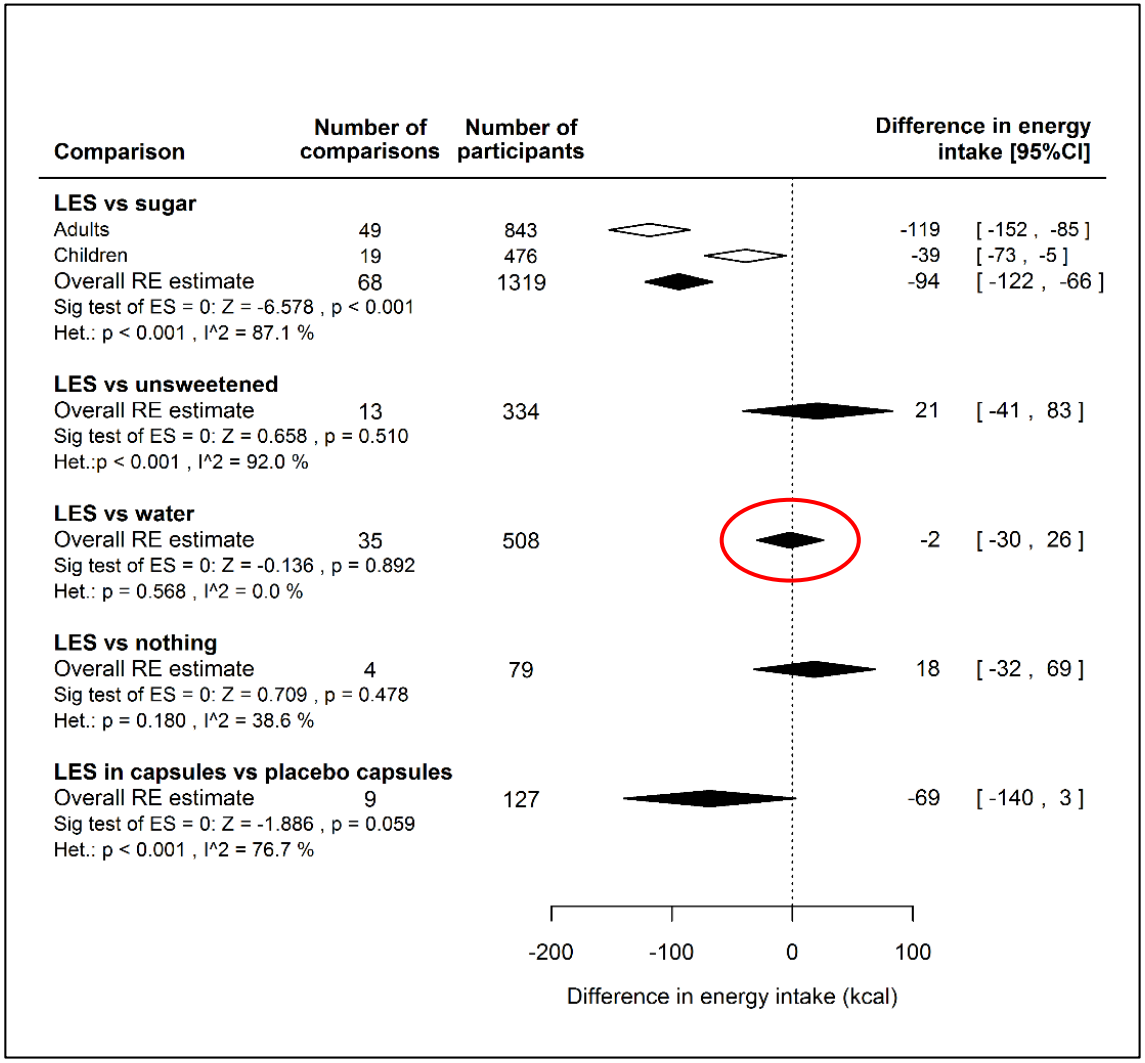
Details of short-term intervention studies results: 'compensation' (COMPX) scores

Preload, test-meal studies showed:

- Reduced energy intake versus sugar
  (70% compensation in children)
  (43% compensation in adults)
  (50% compensation overall)

Rogers et al. (2016)
International Journal of Obesity, 40, 381-394

Short-term effects of low-calorie sweeteners on energy intake



Preload, test-meal studies showed:

- Reduced energy intake after LCS versus sugar
- No effect on energy intake after LCS versus water

Rogers et al. (2016)
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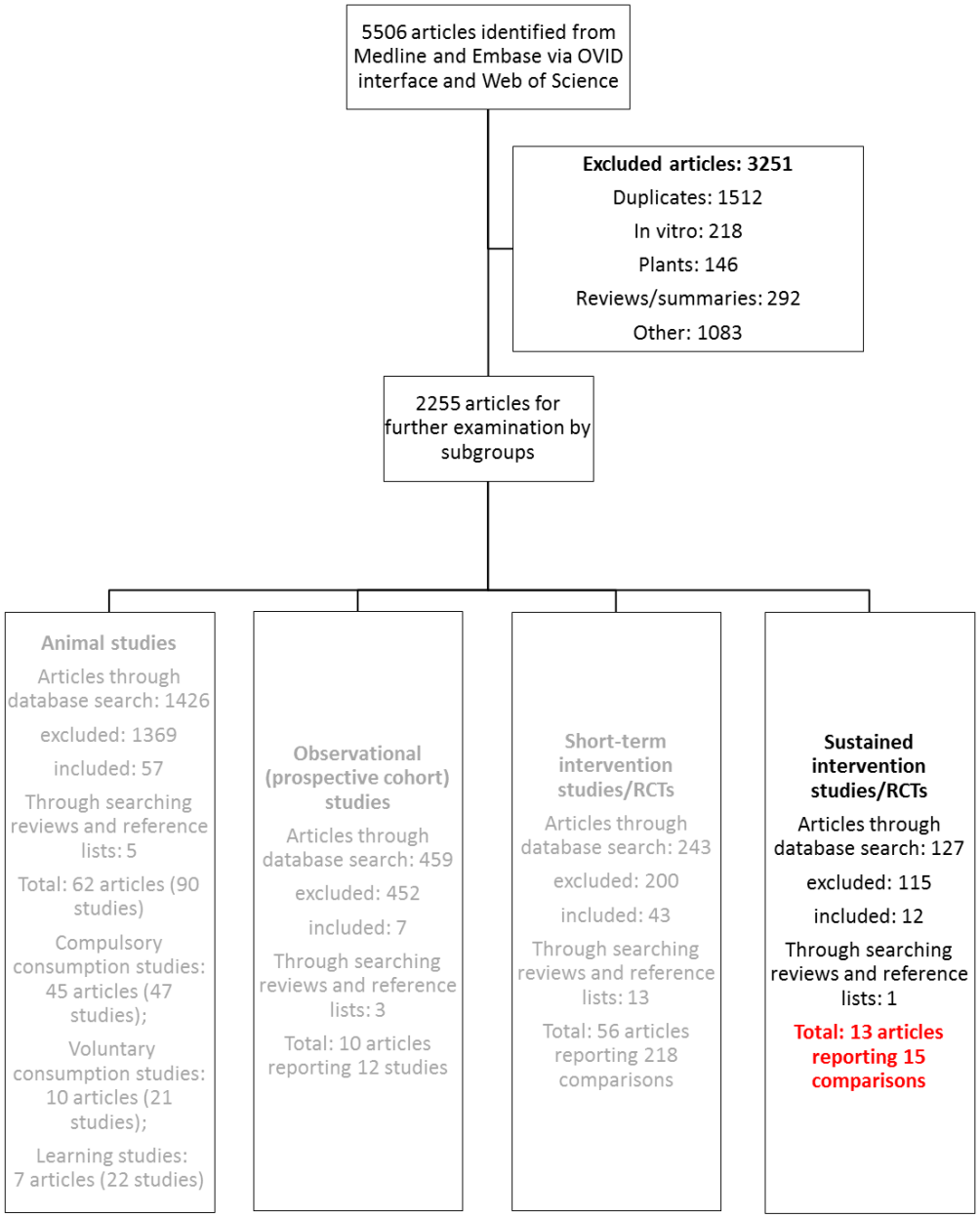
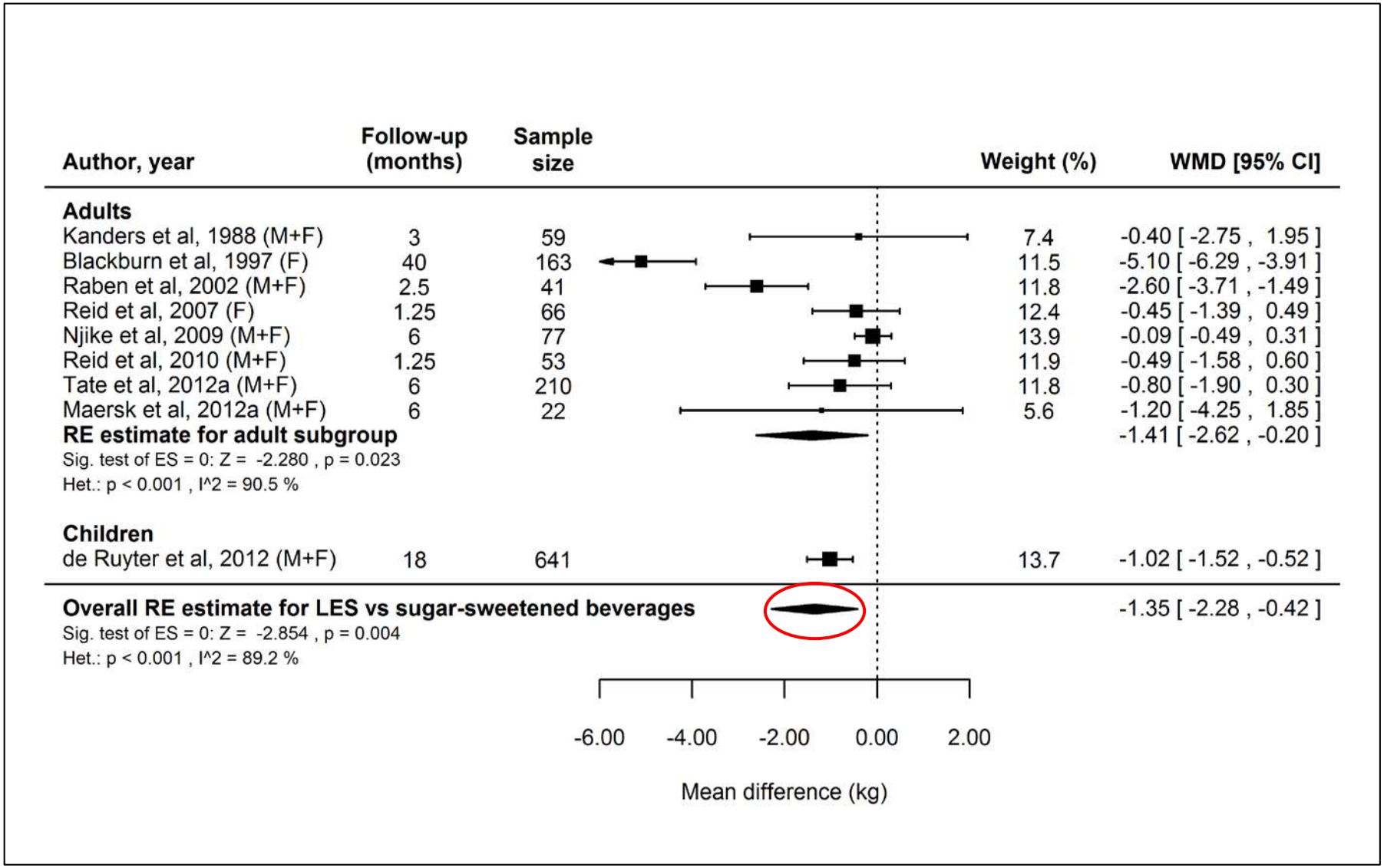
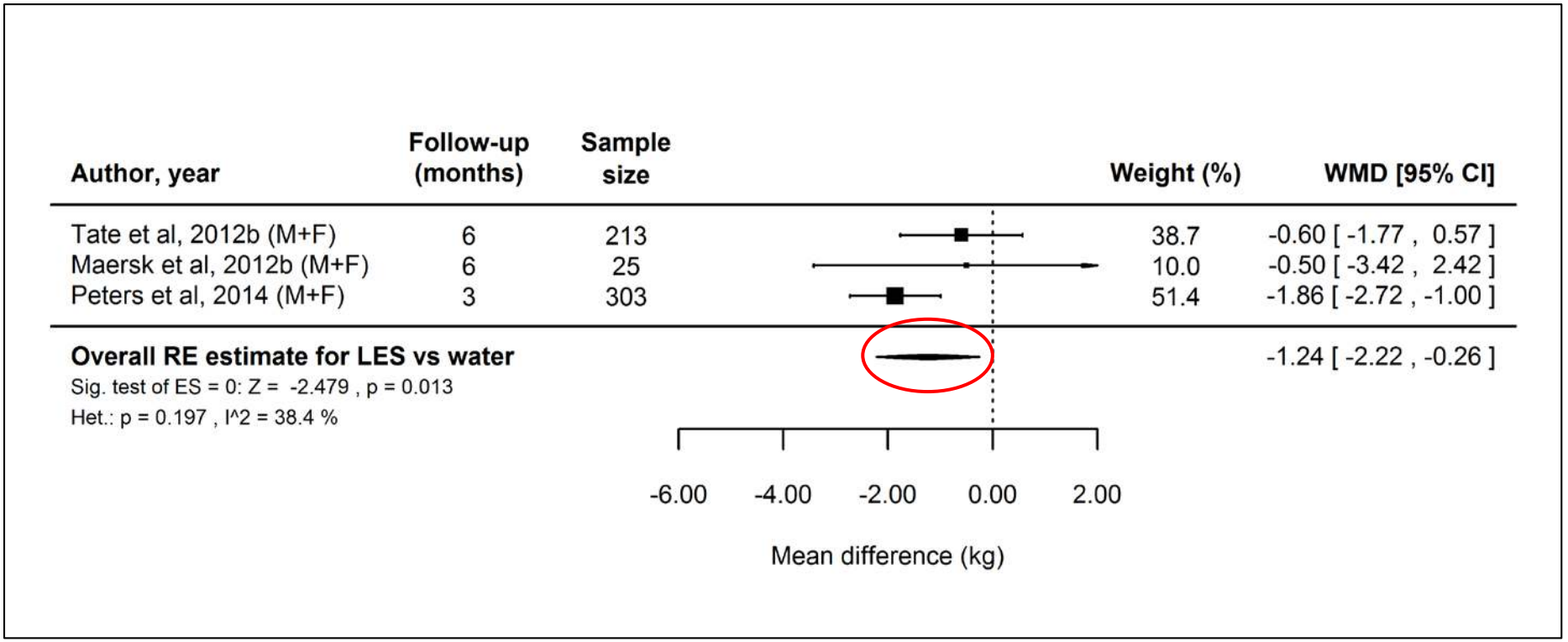


Sustained intervention studies: effects of low-calorie sweeteners versus sugar on body weight



Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

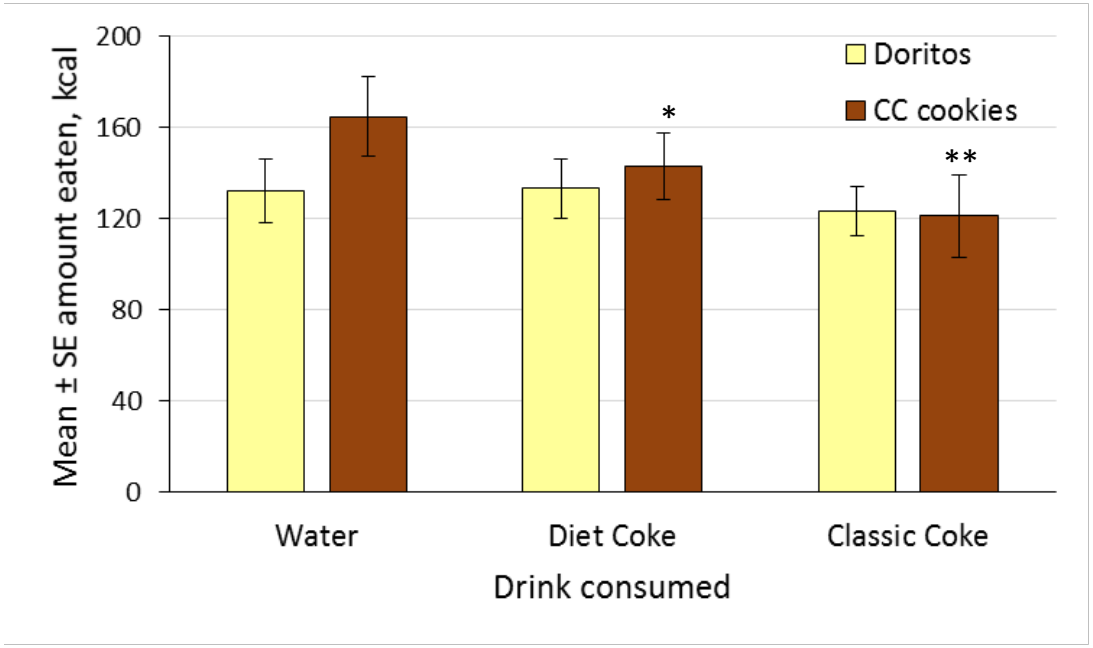
Sustained intervention studies:
effects of low-calorie sweeteners versus water on body weight



Rogers et al. (2016) *International Journal of Obesity,* 40, 381-394

Does consumption of low-calorie sweeteners increase or decrease desire for sweetness?

Effect of consuming sweet drinks on sweet and savoury food intake



Participants consumed the drink with a sandwich and with the subsequently presented Doritos (savoury) and chocolate chip cookies (sweet)

*p<.05, **p<.01, vs water

Rogers et al., in preparation

Does diet-beverage intake affect dietary consumption patterns? Results from the Choose Healthy Options Consciously Everyday (CHOICE) randomized clinical trial[1–3]

Carmen Piernas, Deborah F Tate, Xiaoshan Wang, and Barry M Popkin

Participants randomised to **water** (n=106) or **diet beverages** (n=104) in place of sugar-sweetened beverages for 6 months

Conclusions: Participants in both intervention groups showed positive changes in energy intakes and dietary patterns. The DB group showed decreases in most caloric beverages and specifically reduced more desserts than the water group did. Our study does not provide evidence to suggest that a short-term consumption of DBs, compared with water, increases preferences for sweet foods and beverages. This trial was registered at clinicaltrials.gov as NCT01017783. *Am J Clin Nutr* 2013;97:604–11.

Other meta-analysis reviews

- Miller & Perez (2014) *American Journal of Clinical Nutrition* 100, 765-777

  'RCTs indicate that substituting LCS options for their regular-calorie versions results in modest weight loss and may be a useful dietary tool to improve compliance with weight loss or weight maintenance plans.' (p 765)

- Azad et al. (2017) *Canadian Medical Association Journal* 189, E929-939

  'Evidence from RCTs does not clearly support the intended benefits of nonnutritive sweeteners for weight management.' (p E929)

Why do Azad et al. (2017) come to a different conclusion?

Table 1: Randomized controlled trials that evaluated nonnutritive sweetener interventions and long-term cardiometabolic health

Study,* country	No. of participants randomly assigned (% completed)	Sex	Population	Age, mean ± SD; yr	BMI, mean ± SD; kg/m²	Duration, mo	Type and source of NNS	Daily dose of NNS	Comparator(s)	Outcomes					Risk of bias†
										BMI	Weight	Waist	Body fat	HOMA-IR	
Blackburn et al. 1997,[38] USA	163 (53)	F	Obese, on weight-loss program	44 ± 10	37 ± 5	16	Aspartame ASB, packets, foodstuffs	Participants' discretion	Aspartame avoidance		•				High
Hsieh et al. 2003,[36] China	174 (97)	M, F	Mild hypertension	52 ± 7	23 ± 3	24	Stevioside capsules	1500 mg	Placebo	•					Low
Ferri et al. 2006,[37] Brazil	14 (86)	M, F	Mild hypertension	45 ± 7	27 ± 3	6	Stevioside capsules	3 phases: 3.8, 7.5, 15.0 mg/kg	Placebo	•				•	Unclear
Tate et al. 2012,[34] USA	213 (86)	M, F	Overweight, on weight-loss program	42 ± 11	36 ± 6	6	Unspecified ASB	Recommended ≥ 2 servings	Water, attention control‡		•	•			High
Maersk et al. 2012,[35] Denmark	33 (76)	M, F	Overweight	39 ± 8	33 ± 4	6	Aspartame ASB	1 L of diet cola	Water		•		•	•	High
Peters et al. 2016,[19] USA	308 (72)	M, F	Overweight, on weight-loss program	48 ± 11	34 ± 4	12	Unspecified ASB	At least 710 mL	Water with ASB avoidance		•	•			High
Madjd et al. 2015,[20] Iran	71 (87)	F	Overweight, on weight-loss program	32 ± 7	34 ± 3	6	Unspecified ASB	250 mL	Water	•	•	•		•	High

Why do Azad et al. (2017) come to a different conclusion?

- They **excluded** 6 out of 9 studies, representing 1,313 out of 1,708 participants, included in Rogers et al. (2016)

  Grounds for exclusion were study duration (<6 months) and participant age (≤12 y)

- **Comparator was water** (rather than sugar) in 4 out of 7 studies included

- 2 of the other 3 studies included compared **LCS in capsules** versus placebo capsules

- **One study (Madjd et al. 2015)** included was published after Rogers et al (2016) accepted for publication

  In this study, participants consumed water or LCS after lunch on 5 days a week

  Those consuming LCS lost less weight on a calorie-controlled diet

  Madjd et al. (2015) *American Journal of Clinical Nutrition,* 102, 1305-1312

Conclusions

- Rogers et al. (2016) *International Journal of Obesity* 40, 381-394

  'Overall, the balance of evidence clearly indicates that the consumption of low-energy sweeteners in place of sugar, in children and adults, leads to reduced energy intake and body weight, and possibly also compared with water.' (p 381)

Summary

- No reliable evidence that LCS disrupt the learned control of energy intake
- Reduced energy intake from a LCS drink is not fully compensated for in subsequent eating
- If anything, consumption of LCS in the short term reduces desire for and intake of sweet foods.
- Comprehensive systematic reviews of randomised controlled trials show that LCS versus sugar reduces body weight

University of BRISTOL

Sweet taste as a predictor of food energy (sugar) content

(1) 'We reasoned that if sweet tastes are normally valid predictors of increased caloric outcomes,* [THIS IS NOT TRUE]

(2) then exposing rats to sweet taste that is not associated with these outcomes should degrade this predictive relationship

(3) and impair energy intake and body weight regulation.'

*'In nature, and throughout most of our evolutionary history, sweetness has been a reliable predictor of the energy content of food.' (Swithers et al., 2010, p 56)

Swithers et al. (2010) *Physiology and Behavior, 100,* 55-62

Sweet taste predicts the sugars but not the energy content of foods and drinks

Correlations between sweetness and sugar and energy content of foods and drinks in three studies

	Sugar	Energy	Reference
Australia	.70	-.08	1
Netherlands	.67	not reported	2
United States	.70	.11	3

1. Lease et al. (2016) *Food Quality and Preference, 49,* 20-32
2. Van Dongen et al. (2012) *British Journal of Nutrition, 108,* 140-147
3. van Langveld et al. (2017) *Food Quality and Preference, 57,* 1-7

Sugar content does not predict the energy content of 'natural' foods

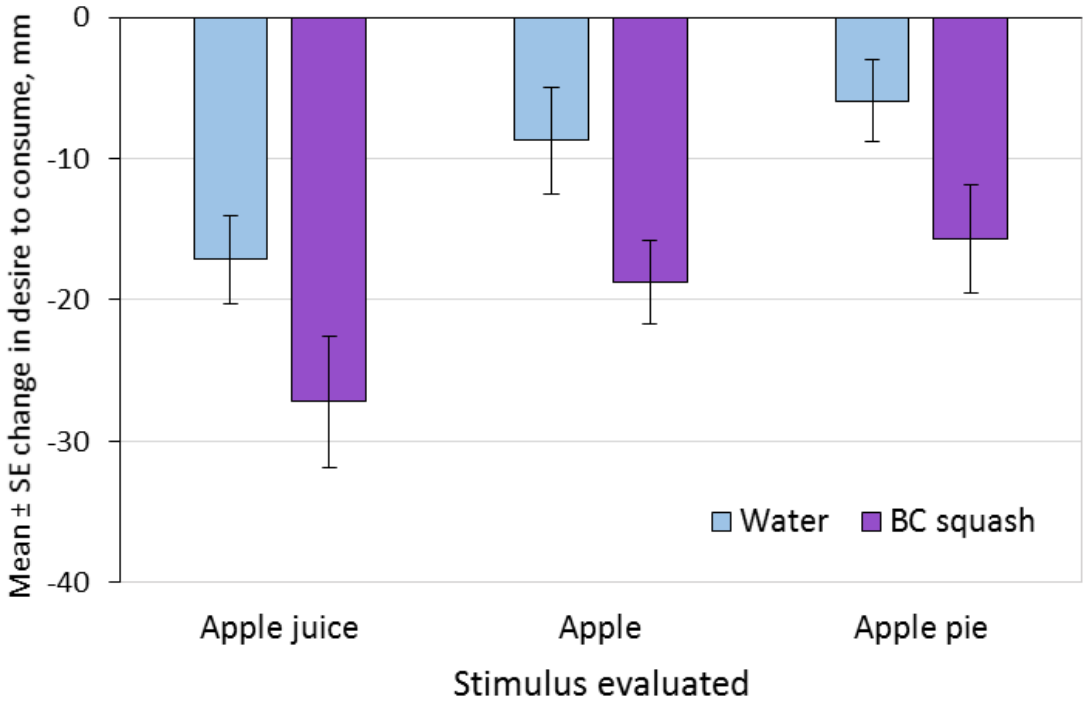
Energy, sugar and total carbohydrate content per 100 g of some 'natural' (i.e., minimally processed) carbohydrate-rich foods

	Energy, kcal	Sugar, g	Total CHO, g
Fresh fruits and berries, n=7	58	10.3	14.4
Roots and tubers, n=8	78	3.1	17.9
Grains, n=4	121	1.0	25.2

<u>Some individual fruits, per 100 g</u>
Strawberry = 5 g sugar, 33 kcal
Blueberry = 10 g sugar, 57 kcal
Grape = 16 g sugar, 67 kcal

Does consumption of low-calorie sweeteners increase or decrease desire for sweetness?

Effect of consuming a non-sweet drink (water) versus sweet drink (low-calorie blackcurrant squash) on desire to consume apple juice, fresh apple and apple pie



Effect of Drink, p=.003
Effect of Stimulus, p=.002
Drink x Stimulus, F<1

Rogers et al., in preparation