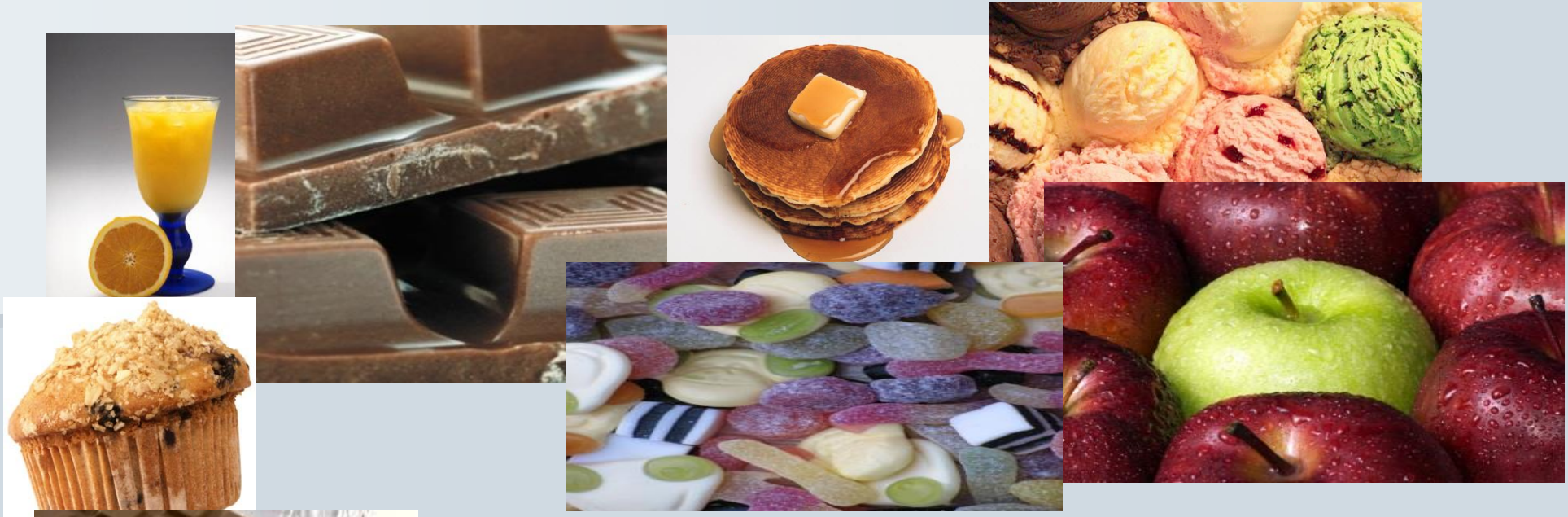
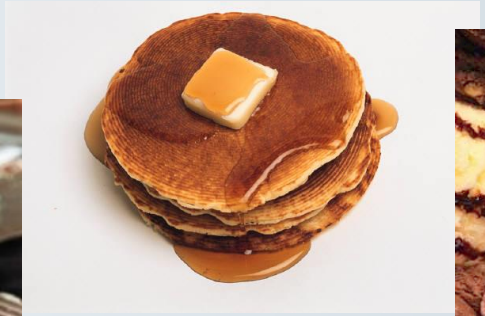


Impact of repeated exposure to sweetness on acceptance, preference and intake of sweet-tasting products

Prof. Katherine Appleton
Bournemouth University, UK



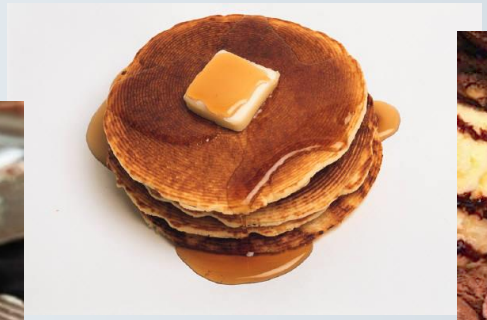
There is a clear, evidence-based global public health mandate to limit the consumption of free sugars in the diet.

Do we also need to limit the consumption of sweet taste?

Sweet taste is innately rewarding, as characterized by a universal liking for high levels of sweetness in infancy and childhood.

High levels of sweetness or sustained exposures to sweet taste may maintain or promote a generalized desire for sweet taste in the diet.

Such a generalized ‘sweet tooth’ could make it challenging for individuals to reduce intakes of free sugars.


Alternatively, the consumption of a sweet food may reduce the consumption of other sweet foods. Sensory-specific satiety - exposure to a food with one sensory attribute can lead to reductions in the pleasantness of foods/beverages with that attribute.

It is possible to formulate foods and beverages that retain their sweetness at a substantially reduced free sugar content.

Exposure to sweet taste from dietary sources with low levels of sugars may not only replace consumption of free sugars, but could also reduce the desire for sweet taste from other sources.

What is the impact of a high exposure to sweet taste?

Recommendations for Public Health

Recommendations for the Food Industry

World Health Organization and Pan American Health Organization

- a reduction in exposure to sweet taste could facilitate adaptation to lower sugar intakes.

Public Health England, UK

- little evidence that exposure to sweet taste impacts subsequent intakes.

Systematic review of the published evidence available

Does dietary exposure to sweetness in humans impact on the subsequent generalized acceptance, preference, choice and/or intake of other sweet foods/beverages in the diet?

Searches

Three academic databases – PubMed, PsychInfo, FSTA

All years of records

Three search strings - all including a ‘sweetness’ word, an ‘exposure’ word, and an ‘outcome’ word

Limited to only articles, published articles, articles in English

Early search results were reviewed, and modifications made

Reference lists of included articles were also searched

Article Inclusion

Articles were suitable for inclusion if:

- reported an investigation of the repeated exposure to or a manipulation of sweet taste through foods and beverages in the diet, and comparator,
- included a subsequent measure of perception, acceptance, preference, choice and/or intake of other sweet foods and beverages,
- conducted in humans aged over 6 months

Article Selection

Searches were conducted by one researcher and duplicates removed. Search results were screened by two researchers independently based on title and abstract.

All articles screened for suitability by two researchers independently.

Review Outcomes

Data on methodology, outcomes, and risk of bias (4 domains) were subsequently extracted by two researchers independently.

Conclusions and risk of bias for each study in relation to our research question were discussed and agreed by the whole research team.

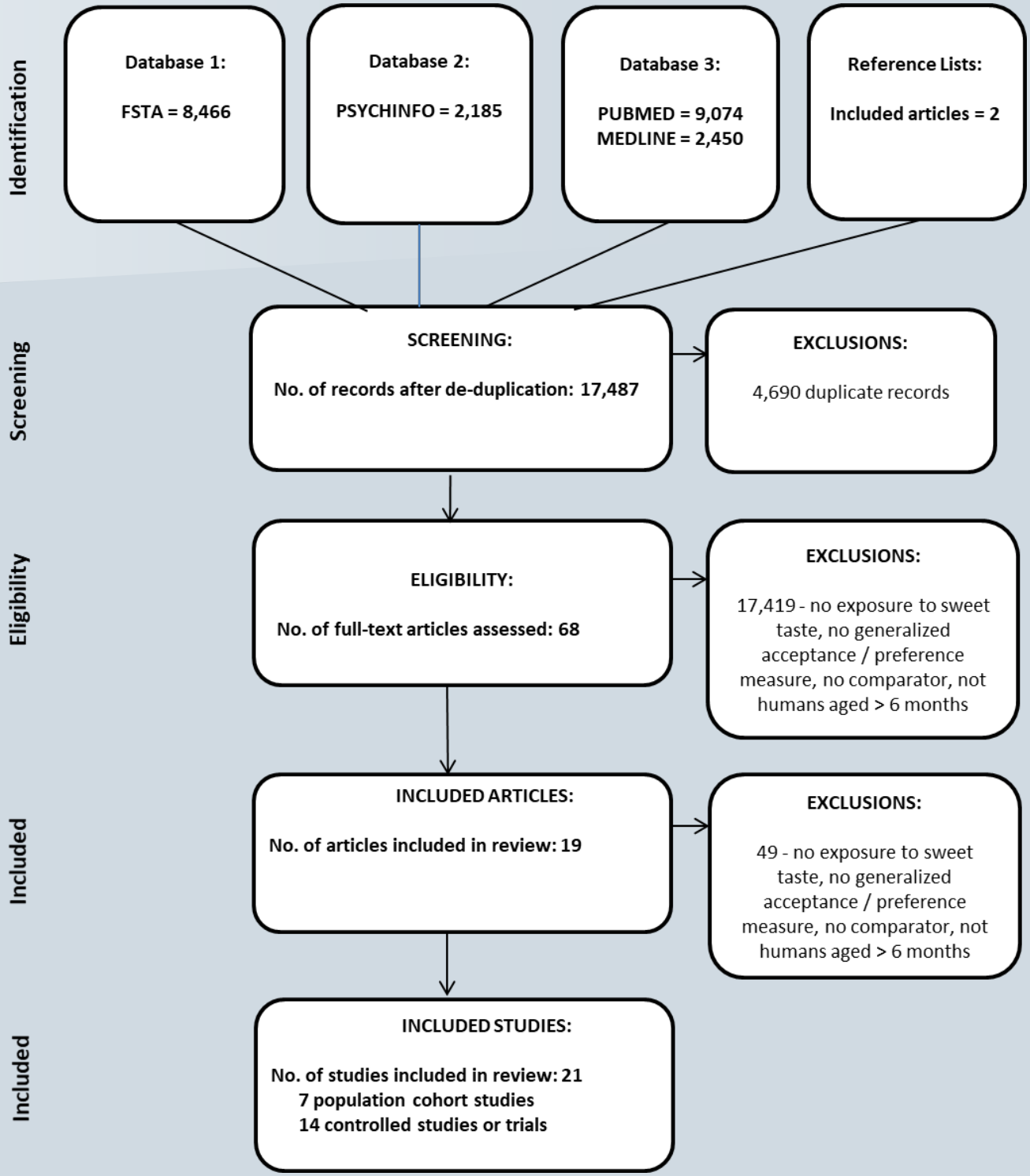
Registered on PROSPERO on 24th November, 2016:

Appleton K, Mela D, Bertenshaw E, de Graaf K, Tuorila H. Sweet taste exposures: effect on acceptance and preference for sweet taste in the diet. PROSPERO 2016: CRD42016051840.

Results

Searches -

15th August, 2017.



Results - 7 population cohort studies – 3 retrospective

Ref.	Study population, age at E	Exposure (E) Intervention	Exposure (E) Interven-tion assessment	Exposure (E) Comparator	A / R	Outcome (O)	Outcome (O) assessment
Liem et al., 2004	60 children (43 completers) aged 4-5 yrs	High restriction group (median split) based on reported frequency of restriction (n=22)	Parent completed FFQ of 13 sweet foods for past month.	Low restriction group (median split) based on reported frequency of restriction (n=21)	R	Preference for sweetness concentrations	Paired comparison test and rank ordering of five orangeades, of different (0.14M - 0.61M) concentrations of sucrose
Liem & Menn-ella, 2002	83 children (80 completers) aged 4-7 yrs	Mothers added sugar to child's diet on a routine basis (N=51)	Parent completed retrospective recall of behaviour	Mothers never added sugar to child's diet (N=29)	A	Preference for sweetness concentrations	Forced choice of pairs of 6 apple juices (10ml) differing in sweetness (0.16-0.93 M sucrose). Number of times of 15, each child preferred the 3 sweetest juices.
Beau-champ & Moran 1984	63 black US children, aged 6 mo	Consumption of sucrose-sweetened water: 1) when < 6 mo (n=18) 2) for > 6 mo (n=29)	Parent completed retrospective recall at 24 mo	Never fed sweetened water by 24 mo (n=16)	A	Intake of plain vs. sucrose-sweetened water and fruit flavoured drink	Volume (ml) consumed of plain and sweetened water (0.2M and 0.6M) and fruit flavoured drink (0.6M) in laboratory setting

Results - 7 population cohort studies – 4 prospective

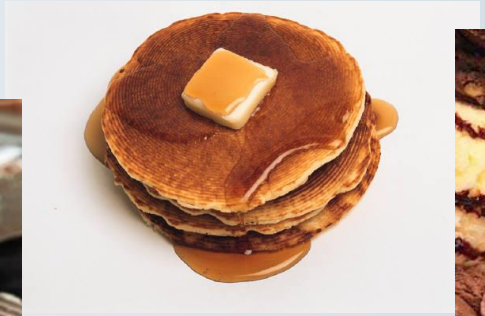
Ref.	Study population, age at E	Exposure (E) Intervention	Exposure (E) Intervention assessment	Exposure (E) Comparator	A / R	Outcome (O)	Outcome (O) assessment
Foterek et al. 2016	288 children, aged 0.5-0.75 yrs	% g consumed from commercial / total complementary foods: 1) Medium tertile (43.1-71%) 2) Highest tertile (>71%)	3 consecutive day detailed weighed diary at 0.5-0.75 yrs	% g consumed from complementary foods: Lowest tertile (<=43.0)	A	Dietary intake of relative (%energy /d) and absolute (g/d) added sugar	3 consecutive days, detailed weighed diary, at time of choosing
Sonneville et al. 2015	1163 children, aged 1 yr	Fruit juice intake/d: 1) small - 1-7oz (n=619); 2) medium - 8-15oz (n=235); 3) large - 16oz (n=47)	Parent completed questionnaire for past month	Fruit juice intake/d: None - 0oz (n=262).	A	Dietary intake (servings/d) of fruit juice, and SSBs (soda, fruit drinks).	Semi-quantitative child FFQ
Okubo et al. 2016	493 children in 3rd and 5th wave of study, aged 16-24 mo at 3rd wave.	Exposure to SSBs (non-100% fruit juice, other sweetened juice) at aged 16-24 mo: 1) 1-3/wk (n=107); 2) 4-6/wk (n=51); 3) >1/day (n=57)	Parent completed questionnaire assessing preceding month	Exposure to SSBs (non-100% fruit juice, other sweetened juice) at aged 16-24 mo: <1/wk (n=278)	A	Dietary intake, of fruit, confect-ionary, 100% FV juice, SSBs (fermented milk drinks, sugar-sweetened drinks, cocoa).	Brief-type Dietary History Questionnaire (FFQ of child's diet) translated to consumption grams/1000kcal/day).
Fiorito et al. 2010	170 non-Hispanic white girls, aged 5 yrs.	Any LESB or SSB consumption at 5 years (N=101)	3 x 24hr recall	No LESB or SSB consumption at 5 years (N=69)	A	Dietary intake of milk, fruit juice, fruit drinks, soda, sweetened tea/ coffee, and % added sugars	3 x 24hr recall, by mothers with girls at ages 5, 7, 9, by girls at ages 11, 13, 15

Results – 14 controlled intervention studies – 9 shorter-term

Ref.	Study popn	Exposure (E) Intervention	E assess-ment	Exposure Comparator	A / R	Outcome (O)
Griffioen-Roose et al. 2012	39 healthy lean adults	fully controlled dietary intervention: sweet tasting foods only	24hr (noon - noon)	fully controlled dietary intervention: 1) savoury tasting foods only; 2) sweet and savoury foods	A	1) Intake of 8 sweet, 8 savoury foods. 2) Explicit liking, wanting, food choice, implicit wanting 3) Appetite something sweet, savoury
Mattes 1990	24 lean young adults	Sweetened cereal every weekday/wk 1) Sucrose sweetened 2) Aspartame sweetened	5 consec-utive days	Unsweetened cereal every weekday/week	A	Intake - % energy from sweet, salty, sour and bitter food and drink: 1) Mean at next meal 2) Mean daily intake over 5 days
Liem & de Graaf 2004 children	63 (59) children	8 days exposure to up to 200ml orangeade = sucrose + no citric acid (sweet) (n=19)	8 days, up to 200ml	1) 8 days exposure to up to 200ml orangeade = sucrose + citric acid (sour) (n=20) 2) no orangeade (control) (n=20)	A	Preference for sugar concentration
Liem & de Graaf 2004 adults	46 adults	8 days exposure to up to 200ml orangeade = sucrose + no citric acid (sweet) (n=16)	8 days, up to 200ml	1) 8 days exposure to up to 200ml orangeade = sucrose + citric acid (sour) (n=16) 2) no orangeade (control) (n=14)	A	Preference for sugar concentration
Hethering-ton et al. 2000	25 (21) adults	Chocolate consumed 2 hr after lunch for 15 days.	15 d	French fries consumed 2 hr after lunch for 15 days.	A	1) Pleasantness and 2) Preference of 8 foods. 3) Free-living intake of all 8 foods
Sullivan & Birch 1990	39 children	15 exposures, twice/week of sweet tofu (14g sucrose/100g) (n=14)	15 exposures, 9 weeks	15 exposures, twice/week of 1) salted tofu (2g salt/100g) (n=11) 2) plain tofu (n=14)	A	1) Preference for 6 foods 2) Preference for 3 foods
Ogden et al. 2013 Study 1	53 children	75g chocolate coins to give to child following restrictive rules (n=24)	2 days (approx. 20 coins)	75g chocolate coins to give to child following non-restrictive rules (n=29)	R	1) Demanding, eating chocolate coins 2) Demanding, eating other sweet foods
Ogden et al. 2013 Study 2	86 children	As study 1 but Easter eggs in place of chocolate coins (n=45)	2 weeks	As study 1, but Easter eggs for 2 week (n=41)	R	1) Demanding, eating chocolate coins 2) Demanding, eating other sweet foods
Hethering-ton et al. 2002 Study 1	29 lean healthy males	Milk chocolate for 22 days (n=13).	22 d	Bread & Butter intake for 22 days (n=16).	A	1) Pleasantness and 2) Preferences for 6 foods 3) Frequency of intake of all 6 foods

Results – 14 controlled intervention studies – 5 longer-term

Ref.	Study popn	Exposure (E) Intervention	E assess-ment	Exposure Comparator	A / R	Outcome (O)
Tey et al. 2012	124 healthy adults	12 weeks, 50g/d (1100kj) milk chocolate (n=33)	12 weeks	1) 12 weeks, 42g/d (1100kj) hazelnuts / day (n=32) 2) 12 weeks, 50g/d (1100kj) salted potato crisps / day (n=28) 3) 12 weeks, no additional food (n=31)	A	Liking for 3 sweet and 3 savoury foods (chocolate, marshmallows, cookies and hazelnuts, potato chips, salted pretzels), before and after acute ad libitum intake of intervention or random food
Brown & Grunfeld 1980	50 infants, mean 3.8 - 4.1 mo at start	Mothers expressed desire to avoid sugar, given information & baby foods without added sugar (n=25, 20 completers)	3 mo	Mothers who did not express a desire to avoid sugar (n=25, 20 completers)	R	1) Intake of sweetened and unsweetened baby foods supplied for home use (leftovers weighed); 2) Parents perception of preferences
Wise et al. 2016	33 OW adults, regular consumers of SSBs (2/day)	Instructions to reduce simple sugar intake by 40% by increasing complex CHO, fats, protein. No replacing sugars with LES (n=16)	3 mo (mo 2-4)	Instructions to maintain usual diet (n=17)	R	1) Taste intensity, 2) Most preferred intensity, and 3) Pleasantness of 8 vanilla puddings and 9 raspberry beverages. 4) Threshold detection
Piernas et al. 2013	210 OW adults consuming >= 280 kcal /d from drinks	Replacement of 2 servings/day of SSB with water: 4 beverages provided/day (water group) (n=108)	6 mo	Replacement of 2 servings/day of SSB with diet beverages: 4 beverages provided /day (DB group) (n=105)	R	Dietary intake of total sugars, added sugars and sweet food groups - SSB, and LES beverages; tea / coffee sweetened with LES; and with sugar; desserts and sweeteners.
Hedrick et al. 2017	292 adults consuming >= 200 kcal/d from SSBs	Reduce SSB intake to <240ml SSB/d	6 mo	No dietary intervention or instructions reported (physical activity intervention)	R	Dietary intake of (non-manipulated) sweet food groups - SSBs, total fruit, whole fruit, 100% fruit juice, artificially sweetened beverages


Discussion

Very little evidence is currently available – 7 population cohort studies (2320 children), 14 intervention studies (291 children, 822 adults).

The evidence available is very limited,

highly heterogeneous,

addresses our research question indirectly

judgements of high risk of bias

Discussion

Longer-term studies – limited evidence that is largely equivocal.

Shorter-term studies – limited evidence that suggests that higher exposure to sweet taste results in reduced preferences for sweet taste, but no impacts on sweet food intake.

Population cohort studies – limited evidence that is largely equivocal.

Discussion

The evidence available does not provide clear consistent support for a relationship between sweet taste exposure and subsequent preferences

Short term interventions tend to suggest reduced preferences for sweet taste following higher exposure, but effects in cohort and long term interventions are equivocal.

Implications

More research is needed.

Sweet food consumption is unlikely to impact on future preferences.

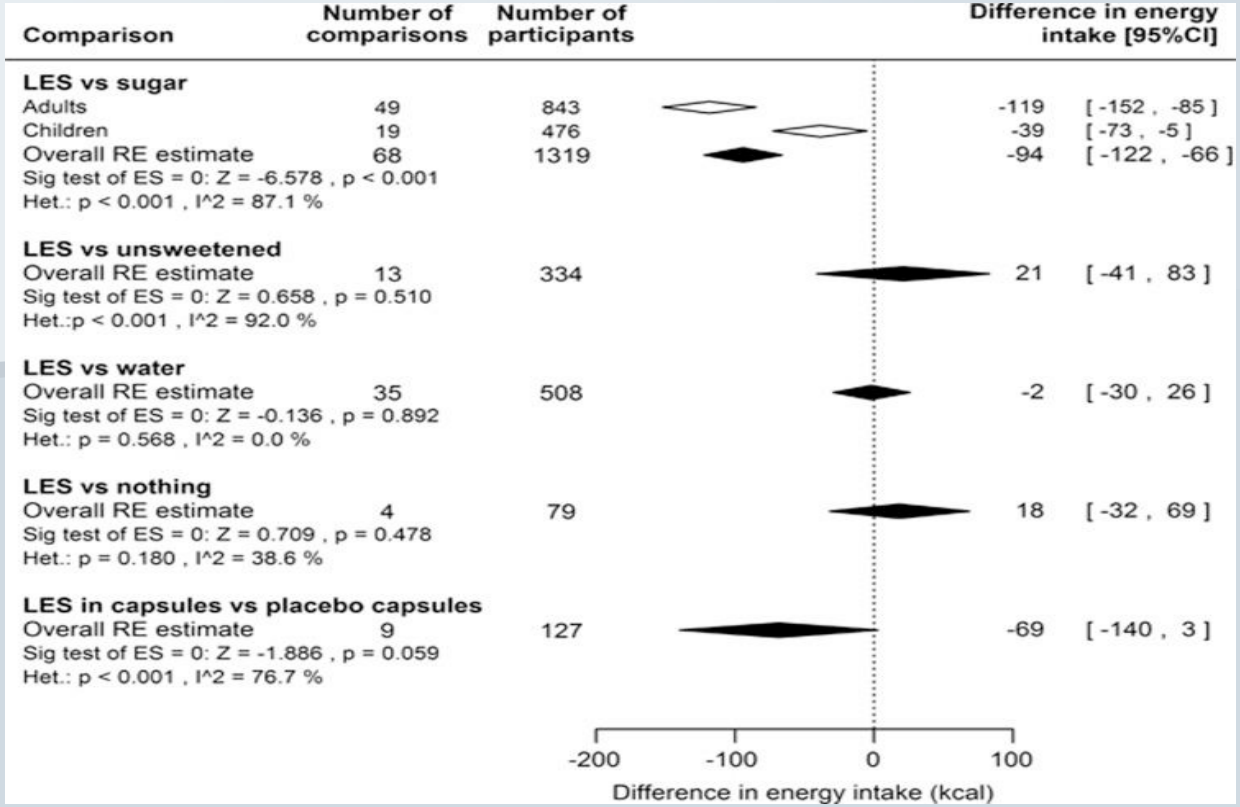
Reducing sweet food consumption is unlikely to impact on future preferences.

Consumer considerations

Concerns about safety and long term physiological consequences

Concerns about negative impacts on short term intake

Appleton KM, Blundell JE. Physiol Behav 2007;92:479-86
King NA, et al. Physiol Behav 1999;66:375-79



Rogers PJ et al. International Journal of Obesity 2016;40:381-94

Figure 3

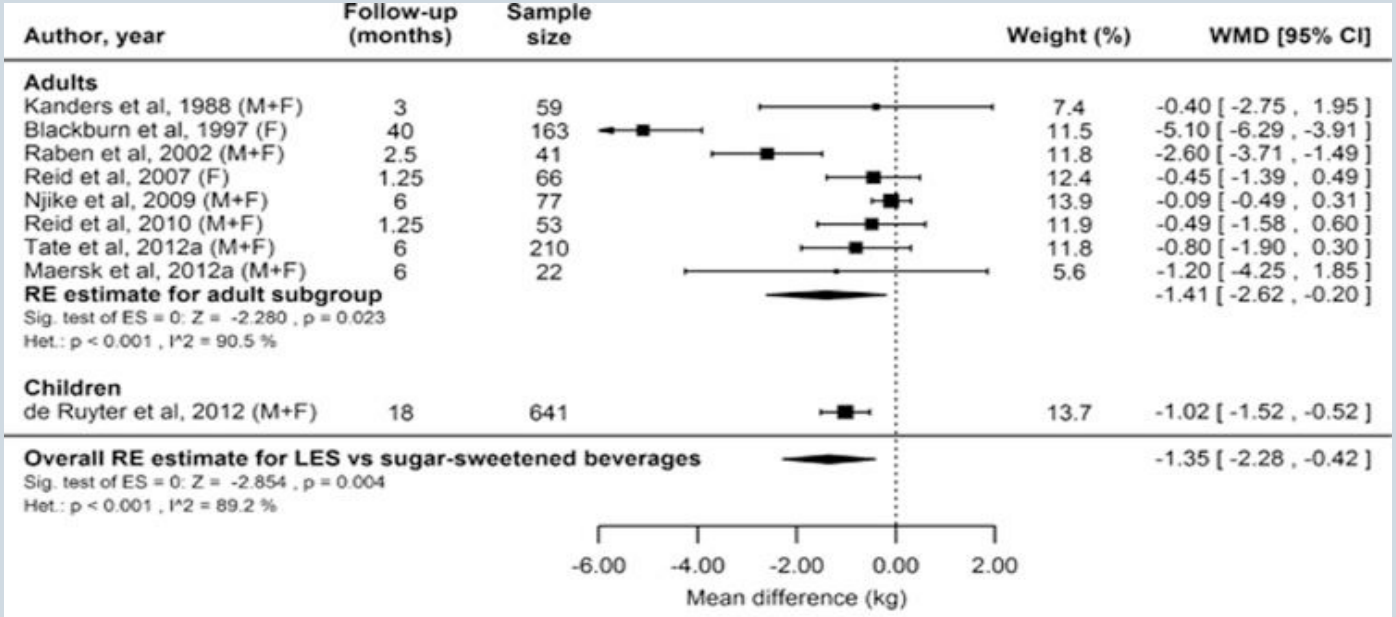


Figure 4

Limitations

No distinction between exposure in terms of intensity vs frequency

Limited assessment of the whole diet

Studies were of limited duration

More research is needed

– adequately powered randomized controlled trials, where exposure is well characterized and of sufficient duration.

Collaborators:
H Tuorila, University of Helsinki, Finland
EJ Bertenshaw, Unilever R&D Colworth, UK
K de Graaf, Wageningen University, NL
DJ Mela, Unilever R&D Vlaardingen, NL

Sources of Support: This work was funded by Unilever R&D.

Appleton KM, Tuorila H, Bertenshaw EJ, de Graaf K, Mela D. Sweet taste exposures and the subsequent acceptance and preference for sweet taste in the diet: Systematic review of the published literature. American Journal of Clinical Nutrition, 2018;107:405-19.
Correspondence: k.appleton@bournemouth.ac.uk

Sources of Support: Thanks to the International Sweeteners Association