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How is television time linked to cardiometabolic health in adults? A critical systematic review of the evidence for an effect of watching television on eating, movement, affect and sleep

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ABSTRACT

Objective To improve our understanding of how television (TV) time is linked to cardiometabolic health among adults by systematically and critically evaluating the evidence that watching TV is associated with increased food consumption, lack of movement or negative affect or affects subsequent sleep.

Design Systematic review.

Data sources Web of Science and PubMed.

Eligibility criteria Studies that provided quantitative evidence on short-term associations of watching TV with dietary intake, characteristics of sitting, affect and sleep among samples of healthy adults (≥18 years old).

Data extraction and synthesis Study quality was assessed using the National Heart, Lung, and Blood Institute Quality Assessment Tools; studies deemed to be of low quality were excluded from the review. Due to heterogeneity of study designs and measurements, the findings were synthesised using narrative summary accompanied by custom plots.

Results We identified 31 studies that met the inclusion criteria. Most of the associations reported by the studies included in this review were weak or inconsistent. There was no strong evidence to suggest that food consumption is higher while watching TV than in other contexts or that TV is a particularly 'sedentary' behaviour. Affect was less likely to be positive while watching TV than in other contexts but was not more likely to be negative. Two small studies suggest that TV may impact sleep via suppressing melatonin and delaying bedtime.

Conclusion There is currently no strong evidence to suggest that TV might impact cardiometabolic health via increasing food consumption, being linked with prolonged/inactive sitting, affect or subsequent sleep. Additional research is required to understand how TV fits within everyday lives and relates to eating, sitting, affect and sleep to improve our understanding of how it might impact cardiometabolic health.

Strengths and limitations of this study

- ► This review synthesises for the first time a diverse body of evidence that tests for associations between watching TV and food consumption, characteristics of sitting, mood/affect and sleep, to shed light on mechanisms by which TV time might impact cardiometabolic health.
- ► A systematic approach was taken in gathering and appraising the evidence.
- ► Custom plots were produced to visualise the findings of individual studies, including the magnitude, direction and statistical significance of associations.
- ► The outcomes and designs of included studies were too heterogeneous for estimating overall summary estimates using meta-analysis.

INTRODUCTION

Television (TV) time has been associated with poor cardiometabolic health outcomes among adults, including cardiovascular mortality,[1 2] incidence of type 2 diabetes[1 2] and increases in adiposity.[3] TV time is generally assumed to be sedentary and sedentary time is now a well-established risk factor for poor cardiometabolic health.[1 4] However, the association between TV time and poor health outcomes is stronger than the association between total sitting time and poor health outcomes[1 5] or than between time spent sitting in other contexts, such as sitting at work, and health outcomes.[6–9] For studies based entirely on self-reported measures, lower measurement error in the assessment of TV time than in the assessment of other sedentary behaviours is likely to contribute to such a difference.[10–12] However, the relationship between self-reported TV time and cardiometabolic outcomes is also stronger

than the relationship between objectively assessed sedentary time and those same outcomes,[13–15] a finding that is unlikely to be attributable to measurement error. It is possible that TV time has a particularly adverse impact on cardiometabolic health and this suggestion is repeatedly made in the literature.[1 5 7 16]

Several possible explanations for the larger observed effects of TV time have been put forth. Most commonly, it has been suggested that dietary intake while watching TV (particularly snacking) may contribute to its effect.[1 5 7 16] It has also been suggested that the way in which sitting occurs while watching TV may be important, for example, if it is characterised by particularly low energy expenditure (EE) or low levels of muscular activation.[1 5 16] Detrimental impacts of TV on sleep and mental health (potentially partly via short-term affective responses) have also been noted as potential mechanisms by which TV might adversely impact cardiometabolic health.[16–18] However, the evidence lending support to these suggested possible explanations has not, to our knowledge, been exhaustively or critically evaluated.

The purpose of this critical systematic review is to improve our understanding of how TV time is linked to cardiometabolic health among adults. To this end, we have critically evaluated the available literature that provides evidence regarding short-term associations between watching TV and food consumption, characteristics of sitting, affect, and sleep.

METHODS

Eligibility criteria

Studies were eligible for inclusion in the review if they provided quantitative evidence of dietary intake, characteristics of sitting, or affect while watching TV or subsequently on the same day as watching TV, or on sleep subsequently on the same day. Studies could be experimental or observational as long as they described behaviours while watching TV or on the same day subsequent to watching TV. Participants in the studies had to be non-institutionalised adults (≥18 years old) who were not exclusively characterised by a particular health status (eg, only overweight or obese adults). All studies had to be published in English in 2000 or later as TV viewing practices change over time.

Information sources and search strategy

The literature was searched in March 2021 using Web of Science Core Collections and PubMed. The search strategy included terms to identify studies that measured TV time across all disciplines (online supplemental file 1). The reference lists of all included papers were also checked. We had initially set out to address a broader research question, aiming to capture all studies that examined TV time in relation to any factors that might impact cardiometabolic health; the search strategy was therefore intentionally broad and we did not specify outcome variables of interest a priori. Given the diversity of studies identified, we subsequently chose to narrow the scope of our research question to focus only on studies that measured the variable of interest while watching TV (or immediately after) among adults.

Study selection

The titles and abstracts of the retrieved studies were screened for relevance. A subsample (10%) was independently screened by both authors to ensure agreement and consistency; any discrepancies were discussed until an agreed application of inclusion and exclusion criteria was reached, then one author (JW) screened the remainder of titles and abstracts. The full-texts of studies with relevant abstracts were consulted to determine eligibility. Both authors confirmed the eligibility of each full-text, and any cases of disagreement were resolved through discussion.

Quality assessment

The quality of each eligible full-text was assessed based on the National Heart, Lung, and Blood Institute Quality Assessment Tools for observational cohort and cross-sectional studies (for observational studies) and for controlled intervention studies (for experimental and intervention studies) (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools). In order to draw on the highest standards of evidence, studies deemed to have low internal validity based on the quality appraisal were excluded from the review. The quality assessment of each study was confirmed by both authors and any disagreements were discussed until consensus was reached.

Data extraction

The data from each eligible study were extracted into a spreadsheet with predefined columns for the general study details (location, date), study design, methodology, sample characteristics, statistical analyses (including covariates) and main findings regarding the behaviour(s) of interest .

Synthesis of results

The results of the associations between TV time and the outcome of interest were organised by categories of outcome variables that emerged from the search (diet, characteristics of sitting, affect, sleep). Because of heterogeneity of study outcomes and study designs, meta-analysis was not used. Therefore, the results were synthesised using narrative summary accompanied by visualisation of study findings. We constructed custom plots designed to illustrate each study's findings to provide a visual summary of the strength of the evidence for each outcome. We plotted the reported effect size if the paper reported this; if studies did not report effect size but reported sufficient information to calculate it (eg, mean and SD), we calculated the standardised mean difference (SMD) using the R package *metafor* (online supplemental file 2). If 95% CIs or SEs were reported, these were converted to SD using the formula suggested in the Cochrane handbook

(https://handbook-5-1.cochrane.org/chapter_7). When calculating the effect size within experimental studies that used within-subjects designs, we imputed correlations of 0.5 to account for repeated measurements; sensitivity analyses using correlations of 0.6 and 0.8 were also conducted to examine the extent to which the imputed correlation might affect the results (shown in online supplemental file 2). While we acknowledge that the interpretation of the magnitude of effect sizes is arbitrary and context-specific, for the purposes of plotting we classified effect sizes as negligible (SMD<0.20, OR<1.50 or correlation (r)<0.10), small (SMD=0.20–0.49, OR=1.50–2.49, r=0.10–0.29), medium (SMD=0.50–0.79, OR=2.50–4.29, r=0.30–0.49) or large (SMD≥0.80, OR≥4.30, r≥0.50) based on standard conventions.[19]

Within the plots, the included papers are ordered from most robust to least robust evidence, primarily on the basis of study design (eg, within-subjects prioritised over between-subjects) and sample size. Whether the finding of the study was statistically significant is denoted through a filled (black) symbol with the direction of the association denoted by a positive sign (+), negative sign (−), zero (0) or question mark (?) if the direction could not be ascertained; non-significant associations are unfilled. The strength of the effect size is denoted by number of boxes (one=negligible, two=small, three=medium, four=large) based on the reported or calculated effect size. Where the effect size was not reported and could not be calculated in a standardised way (eg, regression coefficient, graphical presentation of means), we plotted the findings with a triangle, filled (or not) to denote statistical significance. Significance was determined based on (1) the calculated or reported CIs not crossing 0 or (2) the study reported a p value <0.05 where effect size with CIs was not reported and could not be calculated.

Patient and public involvement

No patients involved.

RESULTS

Search results

The flow of studies through the review process is shown in figure 1. From the original 13036 unique records retrieved by the database searches, 31 were eligible for inclusion. An additional 5 papers were retrieved through reference lists and 5 papers were excluded (4 due to poor study quality), leaving 31 studies included in the review (see online supplemental file 3 for study details, including information on statistical modelling with covariates listed).

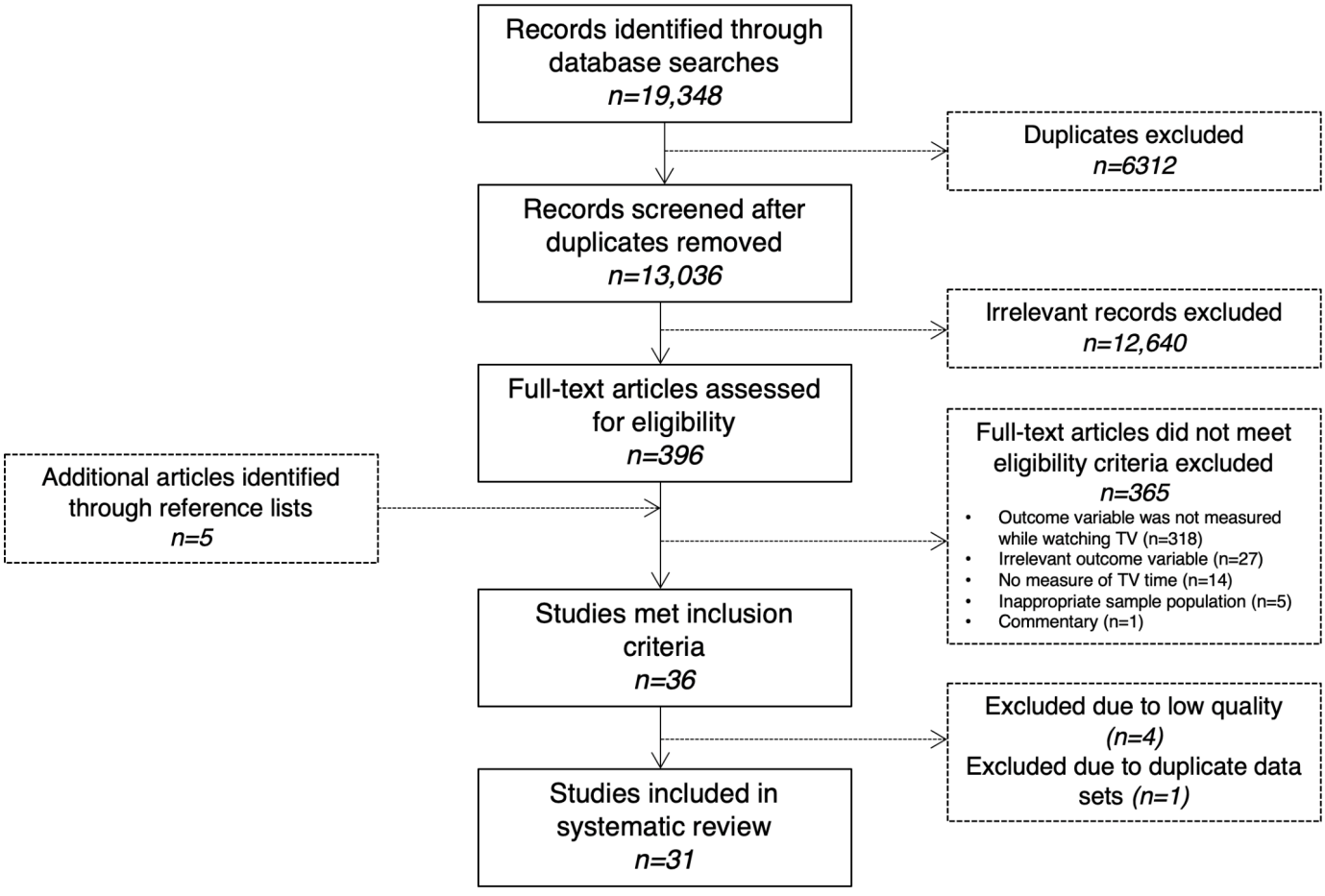

Figure 1 Flow of studies through the review process.

Characteristics of included studies

Twenty-five studies were experimental, primarily focused on links between TV and food consumption (n=19); the remainder focused on EE of sitting or movement while watching TV (n=4) or the effects of TV on subsequent sleep (n=2). Most experimental studies used a within-subjects study design (n=17) and were conducted in Europe (n=11) or North America (n=9), Australia (n=3) and Japan (n=2). Sample sizes ranged from 13 to 120; 10 studies included only female participants while one study included only men.

Six studies were observational, including studies examining food consumption (n=4) and affect (n=2) while watching TV in free-living contexts. Five of these studies were based in the USA and one in New Zealand with sample sizes ranging from 40 to 538.

Food and drink consumption while watching TV

Experimental studies

TV versus doing nothing

There is some evidence to suggest that more food is consumed while watching TV compared with while doing nothing else in a laboratory setting (figure 2 and online supplemental file 3). Nine experimental studies compared food consumption while watching TV compared with a control condition spent alone with no distraction.[20–28] Seven studies found that participants had higher consumption in terms of energy intake[20–22 24 26] or mass[26–28] during the TV condition compared with the control condition (generally small effect sizes), although this did not reach significance in most cases. In sensitivity analyses, effect sizes increased from small to medium in

Study	Study design (n)	Outcome measure	Association	
			Overall	Women
TV vs doing nothing				
Hetherington 2006	Within subjects (n=37)	Meal intake (kJ)	++	
Martin 2009	Within subjects (n=48)	Meal intake (kcal)	△-	
Rosenthal 2017	Within subjects (n=20)	Meal intake (kcal, g)	+	
Moray 2007	Within subjects (n=20)	Meal intake (ounces)	△+	
Braude 2014	Within subjects (n=62)	Snack intake (kJ)		▲+
Bellisle 2004	Within subjects (n=48)	Meal intake (kJ)		++
Bellisle 2009	Within subjects (n=40)	Meal intake (kJ, g)		△?
Ogden 2013	Between subjects (n=81)	Snack intake (g)		+ +
Mittal 2010	Between subjects (n=32)	Snack intake (kJ)		+ + +
TV vs other condition				
Hetherington 2006	Within subjects (n=37)	With friends (kJ)	-	
Hetherington 2006	Within subjects (n=37)	With strangers (kJ)	△+	
Martin 2009	Within subjects (n=48)	While reading (kcal)	△+	
Bellisle 2004	Within subjects (n=48)	Listening to audio story (kJ)		-
Bellisle 2009	Within subjects (n=40)	Listening to audio story (kJ, g)		△?
Bellisle 2009	Within subjects (n=40)	With strangers (kJ, g)		△+
Blass 2006	Within subjects (n=20)	Listening to music (kcal)	▲+	
Lyons 2012	Between subjects (n=120)	With handheld video games (kcal)	-	
		With motion-controlled video games (kcal)	+ +	
Ogden 2013	Between subjects (n=81)	While driving (g)		+ + +
Ogden 2013	Between subjects (n=81)	While talking to researcher (g)		+ + +

Figure 2 Summary plot of effect sizes for experimental effects of TV on food consumption compared with doing nothing else or doing something else. Strength of effect size is denoted by number of boxes (one=negligible to four=large); triangles denote cases where effect size could not be calculated. Filled (black) symbols denote significant associations; non-significant associations are unfilled.

two studies[20 22] when a larger correlation coefficient was imputed (online supplemental file 2).

TV versus other activity

There is little evidence to suggest that more food is consumed while watching TV compared with while doing other activities in a laboratory setting (figure 2 and online supplemental file 3). Seven studies compared food consumption while watching TV with consumption while doing other tasks, including listening to audio stories,[20 23] listening to classical music,[29] reading,[25] simulated driving,[27] playing video games,[30] eating with a researcher or strangers[22 27] and eating with friends.[22] Five of these studies reported no differences in the amount of food consumed between the TV condition and the other experimental condition they tested.[20 22 23 25 30] The remaining two studies reported higher consumption while watching TV compared with while listening to classical music,[29] driving[27] or while conversing with a researcher.[27] Sensitivity analyses suggested larger imputed correlations did not materially change the findings (online supplemental file 2).

Effect of TV on later consumption on the same day

Three studies, all in laboratory settings, tested whether the consumption of a snack while watching TV (compared with while not watching TV) would result in higher food consumption at a meal or snack later on in the same day (consumed without TV)[24 31 32] (online supplemental file 3). Two of these studies found that when the earlier snack had been consumed while watching TV, significantly more was eaten in the subsequent TV-free meal/snack[24 31]; the third did not find subsequent consumption was higher after the eating-with-TV exposure.[32]

Role of TV content

There is little evidence to suggest that the content of TV being watched influences food consumption in experimental settings (online supplemental file 3). Four studies examined food consumption when exposed to food advertisements compared with either neutral (non-food) advertisements[33–35] or no advertisements,[25 35] all reporting no main effect of commercial condition (although Anschutz *et al*[33] reported a significant interaction with gender such that women ate more when exposed to food commercials compared with neutral commercials but the opposite was true for men). Three studies evaluated the impact of TV content on food consumption[24 36 37]; two of these reported that participants ate more when watching boring or repeated showings of TV compared with engaging or novel TV,[36 37] while the third reported no difference in consumption when participants watched funny, boring or sad TV shows.[24] One study[38] compared snack consumption following exposure to either a clip of a cooking show or a nature show, reporting no difference in overall consumption between the groups (although more chocolate balls were consumed following exposure to the cooking show than the nature show).

Observational studies

Four observational studies examined dietary patterns while watching TV in free-living settings among voluntary/convenience samples of adults in New Zealand,[39] African-American women in Chicago[40] and young adults in the USA[41 42] (figure 3 and online supplemental file 3).

The most detailed evidence comes from the study by Gemming *et al*[39] in New Zealand, which linked 24-hour dietary recalls to wearable camera recordings on three separate measurement days, allowing for an in-depth assessment of the contextual details (eg, location, environment, social context, presence of screens) surrounding each eating episode noted in the recall. In their sample, 17% of eating episodes (22% of meals and 12% of snacks) took place while watching TV. Snacks consumed while watching TV were higher in energy (by 514 kJ (123 kcal)) than snacks consumed when no TV was viewed. There was no difference in meal energy intake or duration of meals or snacks while watching TV compared with when no screen was viewed.

The remaining three studies examined the contexts of self-reported eating and drinking using ecological momentary assessment[40] and food diary entries annotated with contextual information.[41 42] These studies found that 30%[40] and 26%[41] of snacking and eating occasions, respectively, took place while watching TV. Among young adults in the USA, Stroebele and de Castro[42] reported that an average of 1.03 meals per day took place with the TV on, but meal size did not differ with or without the TV on. Compared with food and drink consumed while 'not doing anything else', a larger proportion of snacks[40] and sugar-sweetened beverages[41] and smaller proportions of water, fruit, vegetables and cereals/grains[41] were consumed while watching TV compared with while doing nothing else.

Characteristics of sitting while watching TV

Four experimental studies examined associations between watching TV and characteristics of sitting, specifically EE[43–45] and level of movement.[46] Three experimental studies compared the EE of watching TV with the EE of other sedentary behaviours.[43–45] The most robust evidence indicated that the EE of sitting while watching TV was lower than the EEs of typing, playing a handheld video game (both small effect sizes), and playing a screen-based video game while sitting (large effect size; figure 4).[45] The other two studies found no difference between the EE of watching TV and the EE of typing at a desk,[44] reading at a desk[44] or working on a laptop computer[43] in their samples (figure 4 and online supplemental file 3), although their relatively small sample sizes and lack of a priori power calculations may mean their non-significant findings were due to underpowered samples.

A laboratory-based study compared the level of movement captured using hip-worn, triaxial accelerometry while watching TV (seated on a chair without armrests) compared with other sedentary behaviours among adults.[46] Total movement (which we calculated as vector

Study	Method	Variable of interest	While watching TV compared to	Finding
Gemming 2015	**Wearable cameras** worn for three days linked with 24-hour diet recalls on those days (n=40)	Snack energy intake (kJ)	At home with no TV	▲+
		Meal energy intake (kJ)	At home with no TV	△+
Ghosh Roy 2019	**Ecological momentary assessment** (5 prompts per day) to ascertain the context of any snack or beverage consumption that occurred since the previous prompt (n=79)	Snacks consumed (%)	While doing nothing else	■■
		Sugar-sweetened beverages consumed (%)	While doing nothing else	□-
Laska 2011	**7-day food diary** with contextual information provided for each instance of eating or drinking (n=48)	Sugar-sweetened beverages consumed (%)	While doing nothing else	▲+
		Water consumed (%)	While doing nothing else	▲-
		Fruit and vegetables consumed (%)	While doing nothing else	▲-
		Cereals and grains consumed (%)	While doing nothing else	▲-
		Cookies and sweetened baked goods consumed (%)	While doing nothing else	△-
		Candy/gummy fruit snacks consumed (%)	While doing nothing else	△0
		Frozen desserts consumed (%)	While doing nothing else	△0
		Salty snacks consumed (%)	While doing nothing else	△+
		Fried side dishes consumed (%)	While doing nothing else	△-
Stroeble 2004	**7-day food diary** in which participants specified whether the TV was on in each instance (n=78)	Meal size (kJ)	Without the TV on	△?

Figure 3 Summary plot of eating patterns while watching TV in free-living contexts. Strength of effect size is denoted by number of boxes (one=negligible to four=large); triangles denote cases where effect size could not be calculated. Filled (black) symbols denote significant associations; non-significant associations are unfilled.

Study	Study design (n)	Outcome measure	Finding
Experimental studies			
Energy expenditure (EE)			
Mansoubi 2015	Within subjects (n=51)	EE TV vs typing	■- ■-
		EE TV vs handheld game (PSP)	■- ■-
		EE TV vs seated video game (Wii)	■- ■- ■- ■-
Newton 2013	Within subjects (n=25)	EE TV vs typing	□-
		EE TV vs reading	□-
Creasy 2016	Between subjects (n=36)	EE TV vs computer	□- □-
Level of movement			
van der Berg 2019	Within subjects (n=18)	Acceleration TV vs reading	■+ ■+ ■+
		Acceleration TV vs writing	■+ ■+ ■+ ■+
		Acceleration TV vs typing	■+ ■+ ■+ ■+
		Acceleration TV vs playing cards	□0
		Acceleration TV vs preparing food while seated	□+
		Acceleration TV vs 'natural' sitting	■+ ■+ ■+
		Acceleration TV vs sitting motionless	■+ ■+ ■+ ■+

Figure 4 Summary plot of effect sizes for characteristics of sitting while watching TV. Strength of effect size is denoted by number of boxes (one=negligible to four=large); triangles denote cases where effect size could not be calculated. Filled (black) symbols denote significant associations; non-significant associations are unfilled.

Study	Study design (n)	Outcome measure	Finding
Kuykendall 2020	Cross-sectional (n=538)	*Positive activated affect*	
		TV vs physically active leisure	- - - -
		TV vs social leisure	- - - -
		TV vs cognitively stimulating leisure	- -
		TV vs creative leisure	- - -
		TV vs cultural activities	- - - -
		Positive deactivated affect	
		TV vs physically active leisure	△-
		TV vs social leisure	△+
		TV vs cognitively stimulating leisure	-
		TV vs creative leisure	- -
		TV vs cultural activities	△+
		Negative activated affect	
		TV vs physically active leisure	-
		TV vs social leisure	-
		TV vs cognitively stimulating leisure	-
		TV vs creative leisure	△-
		TV vs cultural activities	△-
		Negative deactivated affect	
		TV vs physically active leisure	+ +
		TV vs social leisure	+ +
		TV vs cognitively stimulating leisure	+ +
		TV vs creative leisure	+ +
		TV vs cultural activities	+ +
Goodwin 2005	Cross-sectional (n=69)	*Positive affect*	
		TV vs other leisure	- -
		TV vs productive activities	- -
		TV vs maintenance activities	-
		Negative affect	
		TV vs other leisure	0
		TV vs productive activities	-
		TV vs maintenance activities	0

Figure 5 Summary plot of effect sizes for affect while watching TV. Strength of effect size is denoted by number of boxes (one=negligible to four=large); triangles denote cases where effect size could not be calculated. Filled (black) symbols denote significant associations; non-significant associations are unfilled.

magnitude of acceleration) was higher while watching TV compared with while reading, writing, typing and sitting both 'naturally' (ie, with free movement) and motionless, but did not significantly differ from movement while playing cards or preparing food while seated (figure 4).

In sensitivity analyses using larger imputed correlation coefficients, the effect sizes slightly increased for the difference in the EE of TV compared with typing and for the difference in vector magnitude of acceleration for TV versus reading, preparing food and sitting naturally (online supplemental file 2).

Affect during TV viewing

In two studies, participants self-reported their affect while watching TV within their everyday lives (figure 5 and Online supplemental file 3). Using a day reconstruction approach for the previous day in which leisure activities and affect were reported, Kuykendall *et al*[47] found that respondents generally experienced poorer affect while watching TV compared with while engaged in other leisure activities, in terms of lower positive activated and deactivated affect (energetic/alert/vigorous and peaceful/at ease/serene, respectively) and higher negative deactivated affect (bored/tired/dull). However, negative activated affect (anxious/jittery/nervous) was generally lower while watching TV compared with other leisure activities. In a separate sample using similar methods, levels of relaxation were higher while watching TV than during physical activity (but similar to other

leisure activities), levels of happiness and satisfaction were lower when watching TV compared with other activities (except for physical activity, which was similar to TV), and feelings of sadness did not differ between TV and other leisure activities.

In a study using experience sampling methods over the course of a week, Goodwin *et al*[48] found that mean positive affect scores were lower while watching TV compared with while engaging in other leisure activities (eg, hobbies) or while doing productive activities (eg, work or volunteering); negative affect score did not differ while watching TV compared with while doing any other activities. In sensitivity analysis, only the effect size of the difference in positive affect during TV versus productive activities increased (from small to medium) with larger imputed correlations (online supplemental file 2).

Impact of TV viewing on sleep

One small experimental study (n=13)[49] and one small intervention study (n=16),[50] both in Japan, were included here (online supplemental file 3). Komada *et al*[49] tested the effect of TV displays on melatonin and cortisol secretion at night in a laboratory setting. Melatonin and cortisol are hormones involved in the body's sleep-wake cycles, and the production of melatonin in the body promotes sleep and is known to be suppressed by bright light.[51] Komada *et al*[49] found that a TV display with higher blue light intensity was associated with a suppressive effect on melatonin levels but not on cortisol levels. Asaoka *et al*[50] conducted an intervention in which university students and elderly adults limited their TV time to 30 min a day for 1 week, following a week-long 'control' in which participants went about normal activities. During the week of restricted TV time, the university students went to bed significantly earlier and slept significantly longer compared with the control week; the intervention had no effect on sleep duration among the elderly.

DISCUSSION

This critical systematic review aimed to improve our understanding of how TV might impact cardiometabolic health by evaluating and synthesising available fair-quality and high-quality evidence on the effects of watching TV on food consumption, characteristics of sitting, affect and subsequent sleep. Most of the associations found were weak or inconsistent. There was no strong evidence from laboratory or free-living settings to suggest that food consumption while watching TV is higher than food consumption in other contexts. There was also no clear evidence to suggest that sitting while watching TV (in laboratory contexts) might be a particularly 'sedentary' behaviour. The association between TV and affect was complex. Positive affect and certain aspects of negative affect (eg, anxiousness or nervousness) tended to be lower while watching TV compared with other leisure activities, while other aspects of negative affect (eg, sadness) did not differ; feelings of tiredness or boredom were higher while watching TV compared with other leisure activities. There was a very small amount of evidence to suggest TV may impact sleep by suppressing melatonin and by impacting bedtime, at least in younger people.

The evidence on the impact of watching TV on food consumption is weak. In laboratory contexts in which fixed (and often large) amounts of food were placed in front of participants, participants tended to consume more while watching TV compared with while doing nothing else but more often than not this difference was not statistically significant, and there was very little evidence that consumption was higher while watching TV than during other potentially distracting activities such as listening to music. There is a very small amount of evidence that consumption of food while watching TV (compared with doing nothing) may be associated with greater subsequent intake than consumption while not watching TV. Evidence from free-living contexts, in which TV viewing conditions and food availability are quite different, suggested that energy intake while watching TV versus not did not significantly differ for meals but differed by a small amount for each snacking episode.[39 42] Observational studies found 17%–26% of eating events and 12%–30% of snacking events occurred while watching TV[39–41]; however, no evidence was available to describe what proportion of TV-watching was accompanied by eating to determine whether TV 'triggers' food consumption. It is worth highlighting that the studies cited most often as evidence to suggest links between TV and snacking or higher food intake are not based on measurements of food consumption *while watching TV*; rather, this evidence shows that those with higher TV time have higher total energy consumption, higher snack intake or less-healthy diets than those with lower TV time with the causality of this association entirely unclear.[52–56] Further research in free-living contexts is needed to improve our understanding of the possible co-occurrence of TV watching and food consumption to test the hypothesis that watching TV leads to greater energy intake or greater intake of foods associated with cardiometabolic risk. The use of devices such as wearable cameras (eg Gemming *et al*[39]) may prove particularly useful for this to assess the contexts of eating episodes (with and without TV), the contexts of TV viewing episodes (with and without eating) and the co-occurrence of the two. TV viewing may also affect diet in other ways not examined here.

There was little evidence to suggest that TV might be a particularly 'sedentary' behaviour. Compared with other seated activities, one of three experimental studies found that EE was lower while watching TV and another experimental study showed incidental movement was *higher* while watching TV. The ecological validity of these findings is unclear as the settings for TV watching in these studies (eg, on chairs without armrests, for short and fixed amounts of time) do not reflect TV-watching conditions in free-living contexts. We did not find any studies that examined whether watching TV may induce prolonged uninterrupted bouts of sitting, which have been shown to

interfere with glucose and lipid metabolism.[57 58] We also did not find any studies that examined the characteristics of sitting while watching TV in free-living contexts. There is evidence that those with higher self-reported TV time have higher free-living accelerometer-measured prolonged sedentary time[59] and fewer breaks in sedentary time,[59 60] but these studies do not provide evidence that this prolonged sedentary time or lack of breaks is directly linked with time spent watching TV. Further research in free-living contexts should make use of mixed methodologies, for example, by combining accelerometry with wearable cameras, using electromyographic shorts and diaries, or applying direct observation methods (see Aunger and Wagnild[61]; Troiano *et al*[62] for review) to improve our understanding of characteristics of sitting specifically during TV viewing.

There is little evidence to support the hypothesis that TV may impact cardiometabolic health via impacting affect. The two studies that examined affect while watching TV (both in free-living contexts) found that positive affect and feelings of happiness tended to be lower while watching TV than during other leisure activities, while the relationship between negative affect and TV depended on what aspect of negative affect was measured; overall negative affect and feelings of sadness were not higher or lower while watching TV, boredom and tiredness was higher, and anxiousness and nervousness were lower while watching TV compared with during other leisure activities.[47 48] These findings suggest that TV may be a form of leisure that is 'numbing' in that it may ease negative feelings but not necessarily increase positive feelings. The role of TV in everyday lives as a method of stress management and relaxation and as a way to escape negative or depressed feelings has been previously described.[63–66] In light of this, it is possible that measured mood or affect while watching TV may represent 'emotional spillover' from activities preceding TV time.[47] From a measurement perspective, it would be useful to assess how affect might change over the course of TV viewing instances to better understand how TV might alter emotional states throughout the course of viewing.

Mental health status may be an important confounder of the association between TV and cardiometabolic health. Depression, for example, has been prospectively associated with both high TV time[67] and poor cardiometabolic health outcomes.[68] There is mixed evidence suggesting prospective associations between TV time and depression or depressive symptoms.[69–72] Further research is needed to disentangle the relationships between TV, mood/affect and mental health, and cardiometabolic health outcomes.

There is a very small body of evidence to suggest that TV time may impact sleep, which may in turn impact cardiometabolic health. One small study included in this review found that blue light from a TV display suppressed melatonin,[49] which may lead to a disruption in circadian rhythms, and another small study found that a reduction in TV time led to an earlier bedtime in young people.[50] Thus, TV time may be linked to sleep disruption and later bedtimes, but much more evidence is needed to demonstrate this effect. The hypothesis that watching TV reduces sleep quantity or quality should be tested in people during their everyday lives, and might involve using wearable cameras to assess TV time and accelerometry to assess sleep quality and quantity.

This review did not identify strong evidence for any mechanism through which TV time has been posited to adversely impact cardiometabolic health. It is possible, however, that these factors may interact or have a multiplicative effect. For example, the combination of low EE of sitting while watching TV (based on laboratory evidence) with the slightly higher energy intake from snacks while watching TV could potentially produce a larger effect than either of these aspects on their own.

Importantly, even if such associations are observed in everyday lives, causality requires careful consideration as they may be the result of confounding, whereby, for example, chronic stress may prompt consumption of calorically dense foods[73] and may also prompt TV-watching as a way to relax, perhaps concurrently. More generally, while the association between socioeconomic position (SEP) and TV time is likely to vary globally across cultural and economic contexts, low SEP is consistently linked to high TV time in 'western' countries such as the UK,[74] the USA,[75] Australia[76] and Canada.[77] Within these contexts, low SEP itself is associated with some of the outcomes considered here, as well as with poor cardiometabolic health outcomes[78–81] and may thus confound the relationship between TV viewing, diet, sitting characteristics, affect and sleep, and health outcomes. More empirical evidence, particularly using ethnographic or mixed-methods approaches, is needed to understand the place of TV in everyday lives and its potential role in the development of cardiometabolic disease, with particular attention to the question of whether watching TV is causally implicated in changing health-related practices. Experimental studies are also useful in helping disentangle causality.

The findings of this review must be interpreted in light of the limitations in the evidence base. The vast majority of included studies reported statistically significant results but often with very small effect sizes, suggesting possible publication bias. The associations seen in this review should therefore be interpreted with caution as statistically significant findings may be over-represented in the literature base. The majority of included studies examining food consumption and characteristics of sitting were laboratory-based, thus the ecological validity of such findings is unclear. Methods that capture these kinds of data in free-living contexts, such as use of wearable cameras or electromyographic shorts, may be useful for providing insights into the ways in which TV occurs in real-life settings. These methods will also be relevant for examining the contexts and possible health-related consequences of screen-related practices more broadly beyond just TV time. Key strengths of this review include its systematic approach and that it is the first to comprehensively examine and evaluate evidence of the assertions

commonly made in the literature explaining why TV is particularly detrimental to cardiometabolic health.

CONCLUSIONS

There is currently no strong evidence to suggest that TV impacts cardiometabolic health via effects on food consumption, prolonged/inactive sitting, affect or sleep. Further research exploring the putative mechanism(s) by which TV viewing might impact cardiometabolic health is required. We suggest that studies make use of innovative and/or mixed methods, such as wearable cameras, participant observation or diaries, to improve our understanding of how TV fits within everyday lives and how it may impact cardiometabolic health outcomes, or whether relationships between TV time and cardiometabolic health reflect confounding.

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REFERENCES

1 Patterson R, McNamara E, Tainio M, *et al*. Sedentary behaviour and risk of all-cause, cardiovascular and cancer mortality, and incident type 2 diabetes: a systematic review and dose response meta-analysis. *Eur J Epidemiol* 2018;33:811–29.
2 Grøntved A, Hu FB. Television viewing and risk of type 2 diabetes, cardiovascular disease, and all-cause mortality: a meta-analysis. *JAMA* 2011;305:2448–55.
3 Pinto Pereira SM, Power C. Sedentary behaviours in mid-adulthood and subsequent body mass index. *PLoS One* 2013;8:e65791.
4 Ekelund U, Tarp J, Steene-Johannessen J, *et al*. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: systematic review and harmonised meta-analysis. *BMJ* 2019;366:l4570.
5 Ekelund U, Steene-Johannessen J, Brown WJ, *et al*. Does physical activity attenuate, or even eliminate, the detrimental association of sitting time with mortality? A harmonised meta-analysis of data from more than 1 million men and women. *Lancet* 2016;388:1302–10.
6 Pinto Pereira SM, Ki M, Power C. Sedentary behaviour and biomarkers for cardiovascular disease and diabetes in mid-life: the role of television-viewing and sitting at work. *PLoS One* 2012;7:e31132.
7 Hu FB, Li TY, Colditz GA, *et al*. Television watching and other sedentary behaviors in relation to risk of obesity and type 2 diabetes mellitus in women. *JAMA* 2003;289:1785–91.
8 Wennman H, Vasankari T, Borodulin K. Where to sit? type of sitting matters for the Framingham cardiovascular risk score. *AIMS Public Health* 2016;3:577–91.
9 Dempsey PC, Hadgraft NT, Winkler EAH, *et al*. Associations of context-specific sitting time with markers of cardiometabolic risk in Australian adults. *Int J Behav Nutr Phys Act* 2018;15:114.
10 Chastin SFM, Dontje ML, Skelton DA, *et al*. Systematic comparative validation of self-report measures of sedentary time against an objective measure of postural sitting (activPAL). *Int J Behav Nutr Phys Act* 2018;15:21.
11 Wijndaele K, DE Bourdeaudhuij I, Godino JG, *et al*. Reliability and validity of a domain-specific last 7-d sedentary time questionnaire. *Med Sci Sports Exerc* 2014;46:1248–60.
12 Clark BK, Sugiyama T, Healy GN, *et al*. Validity and reliability of measures of television viewing time and other non-occupational sedentary behaviour of adults: a review. *Obes Rev* 2009;10:7–16.
13 Maher CA, Mire E, Harrington DM, *et al*. The independent and combined associations of physical activity and sedentary behavior with obesity in adults: NHANES 2003-06. *Obesity* 2013;21:E730–7.
14 Stamatakis E, Hamer M, Tilling K, *et al*. Sedentary time in relation to cardio-metabolic risk factors: differential associations for self-report vs accelerometry in working age adults. *Int J Epidemiol* 2012;41:1328–37.
15 Wagnild JM, Hinshaw K, Pollard TM. Associations of sedentary time and self-reported television time during pregnancy with incident gestational diabetes and plasma glucose levels in women at risk of gestational diabetes in the UK. *BMC Public Health* 2019;19:575.
16 Whitaker KM, Buman MP, Odegaard AO, *et al*. Sedentary behaviors and cardiometabolic risk: an isotemporal substitution analysis. *Am J Epidemiol* 2018;187:181–9.
17 Stamatakis E, Ekelund U, Ding D, *et al*. Is the time right for quantitative public health guidelines on sitting? A narrative review of sedentary behaviour research paradigms and findings. *Br J Sports Med* 2019;53:377–82.
18 Stamatakis E, Davis M, Stathi A, *et al*. Associations between multiple indicators of objectively-measured and self-reported sedentary behaviour and cardiometabolic risk in older adults. *Prev Med* 2012;54:82–7.
19 Cohen J. *Statistical power analysis for the behavioral sciences*. Hillsdale: Lawrence Erlbaum Associates, 1988.
20 Bellisle F, Dalix AM, Slama G. Non food-related environmental stimuli induce increased meal intake in healthy women: comparison of television viewing versus listening to a recorded story in laboratory settings. *Appetite* 2004;43:175–80.
21 Braude L, Stevenson RJ. Watching television while eating increases energy intake. examining the mechanisms in female participants. *Appetite* 2014;76:9–16.
22 Hetherington MM, Anderson AS, Norton GNM, *et al*. Situational effects on meal intake: a comparison of eating alone and eating with others. *Physiol Behav* 2006;88:498–505.
23 Bellisle F, Dalix A-M, Airinei G, *et al*. Influence of dietary restraint and environmental factors on meal size in normal-weight women. A laboratory study. *Appetite* 2009;53:309–13.
24 Mittal D, Stevenson RJ, Oaten MJ, *et al*. Snacking while watching TV impairs food recall and promotes food intake on a later TV free test meal. *Appl Cogn Psychol* 2011;25:871–7.
25 Martin CK, Coulon SM, Markward N, *et al*. Association between energy intake and viewing television, distractibility, and memory for advertisements. *Am J Clin Nutr* 2009;89:37–44.
26 Rosenthal R, Raynor H. The effect of television watching and portion size on intake during a meal. *Appetite* 2017;117:191–6.
27 Ogden J, Coop N, Cousins C, *et al*. Distraction, the desire to eat and food intake. towards an expanded model of mindless eating. *Appetite* 2013;62:119–26.

28 Moray J, Fu A, Brill K, *et al*. Viewing television while eating impairs the ability to accurately estimate total amount of food consumed. *Bariatr Nurs Surg Patient Care* 2007;2:71–6.
29 Blass EM, Anderson DR, Kirkorian HL, *et al*. On the road to obesity: television viewing increases intake of high-density foods. *Physiol Behav* 2006;88:597–604.
30 Lyons EJ, Tate DF, Ward DS, *et al*. Energy intake and expenditure during sedentary screen time and motion-controlled video gaming. *Am J Clin Nutr* 2012;96:234–9.
31 Higgs S, Woodward M. Television watching during lunch increases afternoon snack intake of young women. *Appetite* 2009;52:39–43.
32 Ogden J, Oikonomou E, Alemany G. Distraction, restrained eating and disinhibition: An experimental study of food intake and the impact of 'eating on the go'. *J Health Psychol* 2017;22:39–50.
33 Anschutz DJ, Engels RCME, van der Zwaluw CS, *et al*. Sex differences in young adults' snack food intake after food commercial exposure. *Appetite* 2011;56:255–60.
34 Boyland EJ, Burgon RH, Hardman CA. Reactivity to television food commercials in overweight and lean adults: physiological, cognitive and behavioural responses. *Physiol Behav* 2017;177:182–8.
35 Wonderlich-Tierney AL, Wenzel KR, Vander Wal JS, *et al*. Food-Related advertisements and food intake among adult men and women. *Appetite* 2013;71:57–62.
36 Chapman CD, Nilsson VC, Thune Hanna Å, *et al*. Watching TV and food intake: the role of content. *PLoS One* 2014;9:e100602.
37 Mathur U, Stevenson RJ. Television and eating: repetition enhances food intake. *Front Psychol* 2015;6:1657.
38 Bodenlos JS, Wormuth BM. Watching a food-related television show and caloric intake. A laboratory study. *Appetite* 2013;61:8–12.
39 Gemming L, Doherty A, Utter J, *et al*. The use of a wearable camera to capture and categorise the environmental and social context of self-identified eating episodes. *Appetite* 2015;92:118–25.
40 Ghosh Roy P, Jones KK, Martyn-Nemeth P, *et al*. Contextual correlates of energy-dense snack food and sweetened beverage intake across the day in African American women: an application of ecological momentary assessment. *Appetite* 2019;132:73–81.
41 Laska MN, Graham D, Moe SG, *et al*. Situational characteristics of young adults' eating occasions: a real-time data collection using personal digital assistants. *Public Health Nutr* 2011;14:472–9.
42 Stroebele N, de Castro JM. Television viewing is associated with an increase in meal frequency in humans. *Appetite* 2004;42:111–3.
43 Creasy SA, Rogers RJ, Byard TD, *et al*. Energy expenditure during acute periods of sitting, standing, and walking. *J Phys Act Health* 2016;13:573–8.
44 Newton RL, Han H, Zderic T, *et al*. The energy expenditure of sedentary behavior: a whole room calorimeter study. *PLoS One* 2013;8:e63171.
45 Mansoubi M, Pearson N, Clemes SA, *et al*. Energy expenditure during common sitting and standing tasks: examining the 1.5 Met definition of sedentary behaviour. *BMC Public Health* 2015;15:516.
46 van der Berg JD, Stehouwer CDA, Bosma H, *et al*. Dynamic sitting: measurement and associations with metabolic health. *J Sports Sci* 2019;37:1746–54.
47 Kuykendall L, Lei X, Zhu Z, *et al*. Leisure choices and employee well-being: comparing need fulfillment and well-being during TV and other leisure activities. *Appl Psychol Health Well Being* 2020;12:532–58.
48 Goodwin PE, Intrieri RC, Papini DR. Older adults' affect while watching television. *Act Adapt Aging* 2005;29:55–72.
49 Komada Y, Aoki K, Gohshi S, *et al*. Effects of television luminance and wavelength at habitual bedtime on melatonin and cortisol secretion in humans. *Sleep Biol Rhythms* 2015;13:316–22.
50 Asaoka S, Fukuda K, Tsutsui Y, *et al*. Does television viewing cause delayed and/or irregular sleep?wake patterns? *Sleep Biol Rhythms* 2007;5:23–7.
51 Claustrat B, Brun J, Chazot G. The basic physiology and pathophysiology of melatonin. *Sleep Med Rev* 2005;9:11–24.
52 Bowman SA. Television-viewing characteristics of adults: correlations to eating practices and overweight and health status. *Prev Chronic Dis* 2006;3:A38.
53 Scully M, Dixon H, Wakefield M. Association between commercial television exposure and fast-food consumption among adults. *Public Health Nutr* 2009;12:105–10.
54 Thomson M, Spence JC, Raine K, *et al*. The association of television viewing with snacking behavior and body weight of young adults. *Am J Health Promot* 2008;22:329–35.
55 Charreire H, Kesse-Guyot E, Bertrais S, *et al*. Associations between dietary patterns, physical activity (leisure-time and occupational) and television viewing in middle-aged French adults. *Br J Nutr* 2011;105:902–10.
56 Robinson SM, Crozier SR, Borland SE, *et al*. Impact of educational attainment on the quality of young women's diets. *Eur J Clin Nutr* 2004;58:1174–80.
57 Dunstan DW, Kingwell BA, Larsen R, *et al*. Breaking up prolonged sitting reduces postprandial glucose and insulin responses. *Diabetes Care* 2012;35:976–83.
58 Benatti FB, Ried-Larsen M. The effects of breaking up prolonged sitting time: a review of experimental studies. *Med Sci Sports Exerc* 2015;47:2053–61.
59 Shibata A, Oka K, Ishii K, *et al*. Objectively-assessed patterns and reported domains of sedentary behavior among Japanese older adults. *J Epidemiol* 2019;29:334–9.
60 Wagnild JM, Pollard TM. Associations between television time and activPAL-Measured duration and pattern of sedentary time among pregnant women at risk of gestational diabetes in the UK. *J Phys Act Health* 2020;17:471–4.
61 Aunger J, Wagnild J. Objective and subjective measurement of sedentary behavior in human adults: a toolkit. *Am J Hum Biol* 2020;n/a(n/a:e23546.
62 Troiano RP, Pettee Gabriel KK, Welk GJ, *et al*. Reported physical activity and sedentary behavior: why do you ask? *J Phys Act Health* 2012;9 Suppl 1:S68–75.
63 Teychenne M, Ball K, Salmon J. Perceived influences on and strategies to reduce sedentary behavior in disadvantaged women experiencing depressive symptoms: a qualitative study. *Ment Health Phys Act* 2011;4:95–102.
64 Tefertiller A, Sheehan K. Tv in the streaming age: motivations, behaviors, and satisfaction of post-network television. *J Broadcast Electron Media* 2019;63:595–616.
65 Barwise P, Bellman S, Beal V. Why do people watch so much television and video? implications for the future of viewing and advertising. *J Advert Res* 2020;60:121–34.
66 Warren TY, Wilcox S, St George SM, *et al*. African American women's perceived influences on and strategies to reduce sedentary behavior. *Qual Health Res* 2018;28:1112–22.
67 Teychenne M, Abbott G, Ball K, *et al*. Prospective associations between sedentary behaviour and risk of depression in socio-economically disadvantaged women. *Prev Med* 2014;65:82–6.
68 Scott KM, Depression SKM. Depression, anxiety and incident cardiometabolic diseases. *Curr Opin Psychiatry* 2014;27:289–93.
69 Andrade-Gómez E, Martínez-Gómez D, Rodríguez-Artalejo F, *et al*. Sedentary behaviors, physical activity, and changes in depression and psychological distress symptoms in older adults. *Depress Anxiety* 2018;35:884–97.
70 Sui X, Brown WJ, Lavie CJ, *et al*. Associations between television watching and CAR riding behaviors and development of depressive symptoms: a prospective study. *Mayo Clin Proc* 2015;90:184–93.
71 Teychenne M, Abbott G, Lamb KE, *et al*. Is the link between movement and mental health a two-way street? prospective associations between physical activity, sedentary behaviour and depressive symptoms among women living in socioeconomically disadvantaged neighbourhoods. *Prev Med* 2017;102:72–8.
72 Lucas M, Mekary R, Pan A, *et al*. Relation between clinical depression risk and physical activity and time spent watching television in older women: a 10-year prospective follow-up study. *Am J Epidemiol* 2011;174:1017–27.
73 Adam TC, Epel ES, Stress EES. Stress, eating and the reward system. *Physiol Behav* 2007;91:449–58.
74 Stamatakis E, Coombs N, Rowlands A, *et al*. Objectively-assessed and self-reported sedentary time in relation to multiple socioeconomic status indicators among adults in England: a cross-sectional study. *BMJ Open* 2014;4:e006034.
75 Yang L, Cao C, Kantor ED, *et al*. Trends in sedentary behavior among the US population, 2001-2016. *JAMA* 2019;321:1587–97.
76 Clark BK, Sugiyama T, Healy GN, *et al*. Socio-demographic correlates of prolonged television viewing time in Australian men and women: the AusDiab study. *J Phys Act Health* 2010;7:595–601.
77 Herman KM, Saunders TJ. Sedentary behaviours among adults across Canada. *Can J Public Health* 2016;107:E438–46.
78 Agardh E, Allebeck P, Hallqvist J, *et al*. Type 2 diabetes incidence and socio-economic position: a systematic review and meta-analysis. *Int J Epidemiol* 2011;40:804–18.
79 Addo J, Ayerbe L, Mohan KM, *et al*. Socioeconomic status and stroke. *Stroke* 2012;43:1186–91.
80 Manrique-Garcia E, Sidorchuk A, Hallqvist J, *et al*. Socioeconomic position and incidence of acute myocardial infarction: a meta-analysis. *J Epidemiol Community Health* 2011;65:301–9.
81 Stringhini S, Carmeli C, Jokela M, *et al*. Socioeconomic status and the 25 × 25 risk factors as determinants of premature mortality: a multicohort study and meta-analysis of 1·7 million men and women. *Lancet* 2017;389:1229–37.

Search strategy for PubMed

All fields: “television time” OR “television viewing” OR “television watching” OR sedentary behavio?r OR “sedentary time” OR “screen time” OR “watching television” OR “viewing television”

Limits: Date range 2000 to present

Supplementary file 2. Effect size calculations, with sensitivity analyses conducted for studies that used within-subjects or repeated-measures designs.

Study	Condition comparison or outcome variable	Standardized mean difference (95% CI)	Notes
Characteristics of sitting			
Creasy 2016	Energy expenditure (kcal/15min) TV vs computer	-0.23 (-0.88, 0.43)	
Mansoubi 2015	Energy expenditure (METs) TV vs typing	-0.41 (-0.70, -0.12)	Imputed correlation 0.5, total sample
		-0.45 (-0.74, -0.17)	Imputed correlation 0.6, total sample
		-0.61 (-0.91, -0.31)	Imputed correlation 0.8, total sample
	Energy expenditure (METs) TV vs PSP	-0.30 (-0.58, -0.02)	Imputed correlation 0.5, total sample
		-0.33 (-0.62, -0.05)	Imputed correlation 0.6, total sample
		-0.47 (-0.76, -0.18)	Imputed correlation 0.8, total sample
	Energy expenditure (METs) TV vs seated Wii	-1.66 (-2.08, -1.24)	Imputed correlation 0.5, total sample
		-1.78 (-2.22, -1.33)	Imputed correlation 0.6, total sample
		-2.11 (-2.61, -1.62)	Imputed correlation 0.8, total sample
Newton 2013	Energy expenditure (METs) TV vs typing	-0.19 (-0.59, 0.20)	Imputed correlation 0.5
		-0.22 (-0.61, 0.18)	Imputed correlation 0.6
		-0.31 (-0.71, 0.09)	Imputed correlation 0.8
	Energy expenditure (METs) TV vs reading	-0.05 (-0.45, 0.34)	Imputed correlation 0.5
		-0.06 (-0.45, 0.33)	Imputed correlation 0.6
		-0.08 (-0.47, 0.31)	Imputed correlation 0.8
van der Berg 2019	Vector magnitude (cpm) TV vs reading	0.79 (0.26, 1.32)	Imputed correlation 0.5
		0.84 (0.30, 1.37)	Imputed correlation 0.6
		0.96 (0.40, 1.52)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs writing	0.97 (0.41, 1.53)	Imputed correlation 0.5
		0.99 (0.43, 1.55)	Imputed correlation 0.6
		1.03 (0.46, 1.60)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs typing	0.92 (0.37, 1.47)	Imputed correlation 0.5
		0.95 (0.40, 1.51)	Imputed correlation 0.6
		1.04 (0.47, 1.62)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs playing cards	0.00 (-0.46, 0.46)	Imputed correlation 0.5
		0.00 (-0.46, 0.46)	Imputed correlation 0.6
		0.01 (-0.46, 0.47)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs preparing food while seated	0.14 (-0.32, 0.61)	Imputed correlation 0.5
		0.16 (-0.31, 0.62)	Imputed correlation 0.6
		0.22 (-0.24, 0.69)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs natural sitting	0.71 (0.19, 1.22)	Imputed correlation 0.5
		0.78 (0.25, 1.31)	Imputed correlation 0.6

		1.02 (0.45, 1.59)	Imputed correlation 0.8
	Vector magnitude (cpm) TV vs imposed sitting	0.94 (0.39,1.50)	Imputed correlation 0.5
		0.97 (0.41, 1.52)	Imputed correlation 0.6
		1.01 (0.44, 1.58)	Imputed correlation 0.8
Diet			
Bellisle 2004	Food intake (kJ), TV vs control	0.46 (0.16, 0.76)	Imputed correlation 0.5
		0.51 (0.21, 0.82)	Imputed correlation 0.6
		0.73 (0.41, 1.05)	Imputed correlation 0.8
Hetherington 2006	Food intake (kJ), TV vs control	0.34 (0.01, 0.67)	Imputed correlation 0.5
		0.38 (0.05, 0.71)	Imputed correlation 0.6
		0.52 (0.18, 0.86	Imputed correlation 0.8
Mittal 2011, experiment 1	Food intake (kJ), TV vs control	0.59 (-0.13, 1.29)	Snack consumed while watching TV
	Food intake (kJ), TV vs control	0.51 (-0.19, 1.22)	Meal consumed after TV/no-TV condition
Ogden 2013	Food intake (g), TV vs control	0.45 (-0.17, 1.07)	
Bellisle 2004	Food intake (kJ), TV vs audio story	-0.04 (-0.32, 0.25)	Imputed correlation 0.5
		-0.04 (-0.32, 0.24)	Imputed correlation 0.6
		-0.06 (-0.34, 0.23)	Imputed correlation 0.8
Hetherington 2006	Food intake (kJ), TV vs eating with friends	-0.13 (-0.46, 0.19)	Imputed correlation 0.5
		-0.15 (-0.47, 0.18)	Imputed correlation 0.6
		-0.21 (-0.53, 0.12)	Imputed correlation 0.8
Lyons 2012	Food intake (kcal), TV vs handheld video game	-0.06 (-0.50, 0.37)	Total intake
	Food intake (kcal), TV vs motion-controlled video game	0.36 (-0.09, 0.80)	Total intake
Ogden 2013	Food intake (g), TV vs driving	0.77 (0.13, 1.40)	
	Food intake (g), TV vs talking to researcher	0.73 (0.08, 1.37)	
Mood			
Goodwin 2005	Positive affect, TV vs other leisure	-0.25 (-0.49, -0.01)	Imputed correlation 0.5
		-0.28 (-0.52, -0.04)	Imputed correlation 0.6
		-0.39 (-0.63, -0.14)	Imputed correlation 0.8
	Positive affect, TV vs productive activities	-0.39 (-0.64, -0.15)	Imputed correlation 0.5
		-0.44 (-0.69, -0.19)	Imputed correlation 0.6
		-0.62 (-0.88, -0.36)	Imputed correlation 0.8
	Positive affect, TV vs maintenance activities	-0.01 (-0.25, 0.22)	Imputed correlation 0.5
		-0.01 (-0.25, 0.22)	Imputed correlation 0.6
		-0.02 (-0.25, 0.22)	Imputed correlation 0.8
	Negative affect, TV vs other leisure	0.00 (-0.24, 0.24)	Imputed correlation 0.5
		0.00 (-0.24, 0.24)	Imputed correlation 0.6
		0.00 (-0.24, 0.24)	Imputed correlation 0.8
	Negative affect, TV vs productive activities	-0.08 (-0.31, 0.16)	Imputed correlation 0.5
		-0.09 (-0.32, 0.15)	Imputed correlation 0.6

		-0.12 (-0.36, 0.12)	Imputed correlation 0.8
	Negative affect, TV vs maintenance activities	0.00 (-0.23, 0.24)	Imputed correlation 0.5
		0.00 (-0.23, 0.24)	Imputed correlation 0.6
		0.01 (-0.23, 0.24)	Imputed correlation 0.8

Supplementary File 3.
Summary of characteristics, measurements, and findings of studies examining food and drink consumption while watching TV.

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
Observational/free-living studies							
Gemming 2015 [39] Quality = good	Cross-sectional New Zealand	Recruited from the community and university (convenience)	Healthy adults in Auckland, n=40 (50%) Mean ages 35 (SD=17) and 28 (SD=7) for men and women, respectively	Instances of television time (only while eating) as identified during processing of SenseCam (wearable camera) recordings across 3 days	NA	Energy intake (kJ), energy density (kJ/g), and duration (min) of meals and snacks across contexts (including during TV) measured by 24-hour multiple pass dietary recall on days that wearable camera was worn	Snacks at home when viewing television were higher in energy intake (+514 kJ (47, 1077)) compared to snacks when no television was viewed. Meals at home while watching TV were not significantly longer (3.1 min (-0.6, 6.7)) than meals not viewing screens, and were not significantly higher in energy (543kJ (-32, 1120)).
Ghosh Roy 2018 [40] Quality = good	Cross-sectional USA *African American Women's Daily Life Study*	Recruited from community and university (convenience)	African American women aged 25-65 in Chicago, n=79 (100%) Mean age 44.6 (SD=10.6)	In each instance of reported snack or sweetened beverage consumption (see 'outcome measurement'), participants were asked what they were doing while eating or drinking; watching television was an option	Education, per capita income, age, auto ownership, BMI, weekday or weekend day measurement, hunger status, fast food restaurant and convenience store density in home neighborhood	Self-reported consumption of ≥1 snack food item (including French fries, salty snacks, cookies or sweetened baked goods, chocolate/candy, ice cream/frozen dessert) or ≥1 sweetened beverage in response to smartphone prompts which came 5 times per day across one week (ecological momentary assessment)	Consumption of snack foods was significantly more likely to occur while watching TV versus while doing nothing else (OR 1.8 (95%CI 1.2, 2.7)); no such association was seen for sugar-sweetened beverage consumption (OR 0.9 (95%CI 0.5, 1.6)).
Laska 2011 [41] Quality = fair	Cross-sectional USA	Recruited from community and	Young adults aged 18-23 from four groups (attending	All instances of eating and drinking were logged on a	N/A	Proportion of food consumption while watching TV compared	A larger proportion of calorically sweetened beverages (24% vs 15%) and

		university (convenience)	university and living on campus; attending university and living independently off-campus; attending university and living with parents; not attending university and living independently), n=48 (12 from each group), 56% female Mean age approximately 21	PDA over a 7-day period, and followed up with contextual questions, including whether they were watching TV during that instance of eating		to while not doing anything else, separately by food group: calorically sweetened beverages, water, coffee/tea drinks, milk, cookies and sweetened baked goods, candy/gummy fruit snacks, fruits and vegetables (fresh or 'other'), frozen desserts, non-milk dairy products, entrees, cereals/grains, and fried side dishes	smaller proportions of water (12% vs 17%), fruits and vegetables (26% vs 36%), and cereals/grains (25% vs 31%) were consumed while watching TV compared to while not doing anything else, respectively ($p<0.05$ for all). There were no significant differences among the other food groups listed in the previous column.
Stroebele 2004 [42] Quality = fair	Cross-sectional USA	Recruited from university for course credit	University students, n=78 (82%) Mean age 22 (0.9)	Television time was recorded on a diary in 15-minute intervals. Instances of eating while watching TV were recorded on food diaries (see 'outcome measurement' column)	N/A	Meal sizes, caloric intake, and meal frequency, ascertained from a 7-day food diary in which participants recorded the volume of all food and drinks consumed, with a specification concerning whether the TV was on in each instance	Meal sizes did not differ with and without TV (data not shown). There was no correlation between TV time (h/day) and total caloric intake or meal frequency (data not shown).
Experimental/laboratory studies							
Study, quality	**Study design, country**	**Target sample Sample size (% female) Mean (SD) age or age range**	**Study aim and experimental protocol**		**Main outcome measurement**	**Findings**	
Anschutz 2011 [33] Quality = fair	Between subjects Netherlands	Non-overweight university students, n=82 (50%) Mean age (SD) for men and women was 20.9 (2.5) and	Aim: to examine whether food commercial exposure would increase concurrent snack food intake among young adults Protocol: participants were randomized to 'food commercial' condition (30-minute nature TV clip interrupted by 3 food and 5 non-food commercials) or 'neutral		Food intake (kcal) based on weight of crisps and M&Ms consumed during the session Amount of food provided not specified	There was no effect of commercial condition on food intake (b=-0.52, SE=43.12, $p>0.05$) and the addition of commercial condition to the model had a negligible effect (change in R^2 <0.001); the interaction between sex and commercial condition was significant (women ate more when exposed to food commercials compared to neutral, while men ate more when exposed to neutral compared to food commercials)	

		20.4 (1.5), respectively	commercial' condition (30-minute nature TV clip with 8 non-food commercials)		
Bellisle 2004 [20] Quality = fair	Within subjects France	Women aged 18-50 with BMI between 18.5 and 24.9, n=48 (100%) Mean age 29.9 (1.4), range 18-50	Aim: To assess the impact of two environmental stimuli (TV and audio story) on meal intake Protocol: Participants ate a meal in four conditions each lasting minimum of 30 minutes and spaced one week apart: control (alone), while watching TV (no references to food or eating), while listening to a recorded detective story, and last meal (alone); order of TV and auditory conditions was randomized	Food intake (kJ) of meal (shepherd's pie and fruit sherbet) ~4850kJ (1160kcal) available	Compared to the baseline control condition (1751 (SE=84) kJ), meal size was larger in the TV (2023 (SE=84) kJ) and audio recording (2044 (SE=84) kJ) conditions ($p<0.001$). Meal size did not differ between the TV and audio recording conditions ($p>0.05$).
Bellisle 2009 [23] Quality = fair	Within subjects France	Healthy women of normal weight, half with high and half with low dietary restraint, total n=40 (100%) Overall mean age or range not reported	Aim: To assess the effects of dietary restraint and environmental factors on meal intake Protocol: Participants ate a meal in five conditions (randomized order) each lasting a minimum of 30 minutes and spaced one week apart: alone in a quiet room, in groups of 3, alone with TV (no food cues), alone with TV (including food advertisements), alone while listening to audio detective story	Food intake (g, kJ) of meal (shepherd's pie and fruit sherbet) ~6000kJ (1430kcal) available	Significantly less food (g, kJ) was consumed in the group meal condition compared to the others ($p<0.02$) in the pooled sample. Consumption was not different between the other conditions (data not shown).
Blass 2006 [29] Quality = fair	Within subjects USA	Undergraduate students, n=20 (75%) Mean age or range not reported	Aim: to test whether more was eaten when watching TV compared to not Protocol: participants were assigned to either pizza or mac and cheese (assignment protocol not stated) and either watched TV for 30 minutes (program of choice with original commercials included) or listened to *Rachmaninoff's Second Symphony* for 30 minutes; the experiment was repeated a week later for the other condition (counterbalanced order)	Food intake (kcal) of pizza or macaroni and cheese 12-inch pizza or family-size bowl (~900g) of macaroni and cheese available	More calories were consumed with the TV on (793.7kcal) than with TV off (538.2 kcal), $p<0.001$. There was no interaction effect between food type and condition.
Bodenlos 2013 [38] Quality = fair	Between subjects USA	Undergraduate students, n=80 (73%) Mean age 19.5 (1.0), range 18-22	Aim: to test whether exposure to a cooking show affected caloric intake Protocol: Participants were randomized to watch either a cooking show or Planet Earth for 10 minutes, followed by a 'taste test' of cheese curls, chocolate covered candies, and carrots	Intake (kcal) of cheese curls, chocolate covered candies, and carrots 800kcal in total available	No significant difference in overall calories consumed between the two conditions ($F(1,74)=3.32$, $p=0.07$), $d=0.38$ Those in the cooking show group consumed significantly more calories from chocolate covered candies than those in the nature group ($F(1,74)=3.90$, $p=0.05$), $d=0.51$

Boyland 2017 [34]	Within subjects UK	Females recruited from university (staff and students) and surrounding area, n=55 (100%) Mean age 32.4 (9.8), range 20-62	Aim: to examine consumption responses to televised food commercials in overweight and lean adult females Protocol: Participants attended two sessions in a counterbalanced order: TV show including commercials for high-calorie palatable foods and TV show including non-food commercials. Following the show, participants were given pizza to eat.	Intake (kcal) of pizza 2056kcal of pizza available	No main effect of condition or weight status on pizza intake or interaction between weight status and condition (p values >0.28).
Braude 2014 [21] Quality = fair	Within (and between) subjects Australia	Female undergraduates, n=62 (100%) Mean age 19.6 (2.2), range 18-29	Aim: To test whether TV affected sensory specific satiety Protocol: Participants were randomized to a single- or variety-foods group; both groups took part in a TV (*Friends,* no commercials) and no-TV condition (counterbalanced order) lasting 20 minutes and spaced one week apart. In the single-foods group, participants chose their preference between Maltesers, Skittles, almonds, or salted potato chips and were given 80g of it. Participants in the variety-foods group were given a 20g bowl of each food (totaling 80g).	Food intake (kJ, number of items) Variety condition totaled ~1600kcal available; single food condition depended on which food was picked	Participants consumed significantly more energy (z=2.37, p<0.025) and more items of food (z=2.07, p<0.05) in the TV condition compared to the no-TV condition.
Chapman 2014 [36] Quality = fair	Within subjects Sweden	Healthy female women, n=18 (100%) Mean age 22 (1.3)	Aim: to explore how the content of TV programs differentially impacts simultaneous eating behavior Protocol: Participants took part in three conditions (counterbalanced order) each lasting 30 minutes and spaced one week apart: watching an engaging TV program (comedy), a boring program (art lecture) or reading a non-engaging text about insects. Bowls of M&Ms and grapes were available in each condition.	Food intake (grams, kcal) 250 grams (~1200kcal) of M&Ms and 300 grams (~200kcal) of grapes were available	Significantly more food (grams) was consumed during the boring program (125g) compared to the engaging program (82g, p<0.01), but no difference in kcal (data not shown). No differences in grams or kcal consumption were reported between the engaging program vs text condition (109.3g vs 81.9g, p=0.05) or the boring program vs text conditions (+15.5 grams, p=0.26) (kcal data not shown).
Hetherington 2006 [22] Quality = fair	Within subjects UK	University staff and students, n=37 (43%) Mean age 28.3 (1.8), range 18 to 54	Aim: To test whether the social facilitation of eating occurs as a function of distraction (by comparing consumption in social contexts with TV and control conditions) Protocol: Participants took part in four conditions in a counterbalanced order at least 3 days apart: eating alone, eating with TV (game show, duration not fixed), eating with strangers, and eating with friends. The	Food intake (kJ) A buffet-style meal (13,743kJ/3283kcal) with 9 different food items was available	Participants consumed significantly more when eating in front of the TV (4350 (SE=252) kJ) and when eating with friends (4565) SE=272) kJ) compared to the control condition (3861 (SE=200) kJ). No differences were found between eating with strangers and any other condition.

			same buffet meal was available in all conditions.		
Higgs 2009 [31] Quality = fair	Within subjects UK	Female undergraduates of normal weight, n=16 (100%) Mean age 19 (1)	Aim: to examine whether watching TV during lunch would increase afternoon snack intake due to impaired memory Protocol: Participants had a standardized lunch either in quiet solitude (control) or with the TV on (comedy show with no references to food). Both conditions lasted 10 minutes and all participants ate the entire lunch in that time period. At least 2.5 hours later on the same day, participants were given three kinds of cookies broken into small pieces to taste test.	Amount (g) of cookies consumed Three kinds of cookies (40g of each) were available, totaling ~600kcal available	Participants consumed significantly more grams of cookies after the lunch-with-TV condition compared to after the lunch-without-TV condition ($F(1,15)=12.6$, $p<0.01$)
Lyons 2012 [30] Quality = fair	Between subjects USA	Adults aged 18-35, n=120 (50%) Mean age 24.1 (4.4)	Aim: to compare differences in energy intake among 2 sedentary screen behaviors (TV and video games) and one potentially active screen behavior (motion-controlled video game). Protocol: Participants were randomized to a TV, video game (PS3), or motion-controlled video game (Wii or Xbox 360) group. Each condition lasted 1 hour. During the condition, snacks and beverages were available for consumption.	Amount (kcal) of snacks and soda consumed Snack foods included M&Ms, baked Lay's, Doritos, and trail mix (nuts with dried fruit) (amounts provided not specified); soda included cans (3 of each) of Coca-Cola, Diet Coke, and Mountain Dew.	Energy consumption between the three groups was not significantly different ($p=0.07$). Mean intake during TV was 716 (407) kcal; during video games was 747 (540) kcal; and during motion-controlled video game was 553 (498) kcal.
Martin 2009 [25] Quality = good	Within subjects USA	Healthy adults aged 18 to 54 (BMI 20-35), n=48 (54%) Mean age 31.9 (SE=1.5)	Aim: to test the effect of TV viewing with and without ads on energy intake compared to a control and a reading condition Protocol: participants completed four conditions (each lasting 32 minutes) in a random order on two test days (experimental lunch and dinner after consuming a standardized breakfast): control, reading, TV without ads, TV with ads (half food-related, half not). The same buffet meal was available for all conditions.	Food intake (kcal) Buffet-style meals were available including 19 different items (totaling 4921kcal)	Energy intake did not vary by experimental condition ($F(3, 131)=0.30$, $p=0.81$); partial $\eta^2 \leq 0.01$
Mathur 2015 [37] Quality = fair	Within subjects Australia	Female undergraduates, n=45 (100%)	Aim: to test whether variability in engagingness of TV affects food intake	Food intake (g, kJ) of their first and	Significantly more snack food was consumed in the same condition (mean 76.2g, SD=36.2) than the different

		Mean age 19.5 (SD=2.2), range 18-29	Protocol: Participants completed two conditions in a randomized order one week apart: watching the same episode of *Friends* twice back-to-back ('same'), or 'watching two different episodes back-to-back ('different'), with each episode lasting 20 minutes and without advertisements). The first episode was watched without food; for the second episode, regardless of condition, they were given 80g each of their preferred two snacks (given the choices of almonds, Pringles, and M&Ms).	second preferred snacks	condition (mean 66.7g, SD 37.3, z=1.990 (*one-tailed), p<0.05).
Mittal 2010, experiment 1 [24] Quality = fair	Between subjects Australia	Females from the university with BMI between 18 and 25, n=32 (100%) Mean ages 20.8 (SD 3.8) and 20.3 (SD 3.9) in the two groups	Aim: to assess whether snacking with concurrent TV would result in eating more at a test meal later on Protocol: Participants were assigned to either a snack-with-TV or snack-without-TV condition, both lasting 20 minutes (TV program was choice between *Seinfeld* and *Friends*). In both conditions, they consumed as much as they wanted of their snack (potato chips, chocolate balls, and coke or orange juice). Then, after 45 minutes of psychological tests, they were given lunch (test meal).	Food intake (kJ) of the snack in the TV versus no-TV condition 2080kJ (~500kcal) offered (chocolate balls, Pringles, Coke/orange juice) Food intake (kJ) of the test meal following the snack conditions 2470kJ (~600kcal) offered (sandwiches, biscuits, crackers and dip)	Energy consumption of the snack did not differ between the snack-with-TV (1855.9 (264.2)kJ) and snack-without-TV (1667.7 (362.0) kJ) conditions (test statistics not shown). Energy consumption of the test meal was significantly higher among those who had watched TV with their snack (1584.6 (516.4) kJ vs 1354.9 (335.6) kJ), p<0.05 (*one-tailed)
Mittal 2010, experiment 2 [24] Quality = fair	Between subjects Australia	Females from the university, n=84 (100%) Overall mean age not reported but around 21 years	Aim: to determine whether the content of TV shows watched while snacking affect recall accuracy of food eaten during the show and intake on a later TV-free test meal Protocol: Participants were assigned to one of four conditions, each lasting 20 minutes: snack-without-TV, snack-with-boring-TV, snack-with-funny-TV, or snack-with-sad-TV. They consumed their snack (potato chips, chocolate balls, and coke or orange juice). Then, after 45 minutes of psychological tests, they were given lunch (test meal).	Food intake (kJ) between the snack-TV conditions 2411kJ (575kcal) offered (chocolate balls, Pringles, Coke/orange juice) Food intake (kJ) of the test meal following the snack conditions	There was no difference in the energy consumption of the snack across the four groups (test statistics not shown). Mean snack consumptions (kJ) were 2308.3 (262.4) for boring, 2291.6 (223.5) for sad, 2250.2 (289.7) for funny, and 2194.9 (322.0) for control. Energy consumption of the test meal was significantly higher in all three TV conditions compared to the no-TV condition (post-hoc pairwise p<0.02 in all three cases), but consumption did not differ between the three TV groups (test statistics not shown). Mean test meal consumptions

				4021kJ (960kcal) offered (sandwiches, crackers and dip, ice cream and chocolate, Coke/orange juice)	(kJ) were 2507.0 (438.2) for boring, 2842.0 (452.4) for sad, 2637.6 (540.3) for funny, and 2147.9 (527.2) for control.
Moray 2007 [28] Quality = fair	Within subjects USA	University students, n=20 (50%) Mean age 20.8 (range 18 to 23)	Aim: to determine whether TV promotes increased food consumption because it impairs one's ability to accurately estimate food intake Protocol: participants completed two conditions in counterbalanced orders, each lasting 25 minutes: eat with and without TV. After the meal, participants were asked to estimate how much food they had just consumed, using a visible tablespoon as a reference for 'one unit' (which was equivalent to 1.5oz of food).	Food intake (oz) between the TV and no-TV conditions Accuracy of food estimation, determined as estimated units minus actual units consumed 16oz macaroni and cheese provided	There was no difference in amount of food consumed between the TV and no-TV condition (2.5%, p>0.05). Unit estimation error was greater ($T_{0.05}$ 2.2, p=0.022) in the TV vs no-TV condition.
Ogden 2013 [27] Quality = fair	Between subjects UK	Females aged ≥18 who had a manual driving license, n=81 (100%) Mean age 22 (5.18), range 18-40	Aim: to compare the impact of different forms of distraction on eating behavior Protocol: participants were randomized to one of four conditions, each lasting 7 minutes: driving (simulation with a manual transmission), TV (*Friends*), social interaction (conversing with one of the researchers), or sitting alone. 100g of hula hoops (potato snacks) were available in each condition.	Grams of hula hoops consumed 100g were provided (~520kcal)	Those in the TV condition consumed more (28.61 (24.44) g) than those in the social (14.16 (12.33)g, p<0.01) and driving (14.02 (10.34)g, p<0.05) conditions, but no significant difference was seen compared to the alone condition (18.21 (20.9)g, p=0.06).
Ogden 2017 [32] Quality = fair	Between subjects UK	Females from the university, n=60 (100%) Mean age 24 (3.3)	Aim: to compare the impact of distraction and dietary restraint on food intake during a subsequent taste test Protocol: participants were randomized to one of three conditions, each lasting 5 minutes: watching TV, walking (along the corridor), and social interaction (talking with another research participant). During each condition, participants were told to consume a cereal bar. After the condition, participants took part in a taste test lasting 7 minutes during which they could consume as much	Mass and energy (kcal) of food consumed during the taste test 150g of each of the foods were provided	There was no main effect of condition on total mass or total calories consumed during the taste test (values not shown).

			of the foods (M&Ms, carrot sticks, grapes, and hula hoops) as they wished.		
Rosenthal 2017 [26] Quality = good	Within subjects USA	Young adults aged 18 to 35 with BMI between 18.5 and 24.9kg/m^2 n=20 (85%) Mean age 22.3 (3.7)	Aim: to test the independent and interactive effects of TV and portion size on food intake Protocol: participants took part in four randomized conditions one week apart: small portion with and without TV and large portion with and without TV. In the 'no TV' condition, participants ate quietly with no other activities for 30 minutes; the TV condition was a 30-minute episode of *Scandal*.	Food intake (grams and kcals) Small portion condition provided 1083 kcal (650 grams) of macaroni and cheese plus salad with dressing; the large portion provided 2166 kcal (1300 grams) of the same foods	Only a main effect of portion size was found for grams and kcals consumed. No main effect for TV was found for food intake ($F(1,16)=0.39$, $p=0.54$, $d=0.11$) and ($F(1,16)=1.10$, $p=0.31$, $d=0.17$)) measured as grams and kcals, respectively. No interactions for TV and portion size were found (>0.05).
Wonderlich-Tierney 2013 [35] Quality = fair	Between subjects USA	Undergraduates, n=83 (52%) Mean age 19.6 (3.5)	Aim: to examine the impact of TV advertisements on food intake Protocol: participants were randomized to one of three groups, each lasting 60 minutes: TV with food advertisements, TV with non-food advertisements, and TV with no advertisements. A jar of cookies was available throughout each condition.	Number of cookies eaten 26 cookies were available in each condition	There was no effect of condition on number of cookies eaten ($F(2,69)=1.50$, $p=0.23$), $R^2=0.04$

Summary of characteristics, measurements, and findings of included studies examining characteristics of sitting or mood while watching TV and sleep after watching TV

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
Characteristics of sitting							
Creasy 2016 [43] Quality = good	Experimental (between subjects) USA	Recruited at university (convenience)	Adults aged 18 to 40 with BMI between 20-35, n=74 (58%)* Mean age 24.2 (3.6) *In full study. Only those whose baseline conditions were sitting while watching TV or sitting at the computer (n=18 in each condition) are described here	Lab-based exposure (15 minutes) *Experimental aim: to examine the cumulative energy expenditure of various combinations of sitting, standing, and walking*	N/A	Energy expenditure (kcal per 15min, indirect calorimetry)	TV EE (18.66 (4.01) kcal/15min) not significantly* different from computer EE (19.63 (4.37) kcal/15min) **Based on confidence intervals crossing zero in our calculation of the standardized mean difference between the two groups; the paper itself did not test this (see Additional file 1)*
Mansoubi 2015 [45] Quality = good	Experimental (within subjects) UK	Recruited at university and in community in 2x2 format to obtain equal numbers of men/women and healthy weight/obese participants (convenience)	Adults aged ≥18, 47% of whom were obese, n=51 (51%) Overall mean age not reported	Lab-based exposure (10 minutes) *Experimental aim: to measure the energy expenditure of sedentary behaviours in normal weight and obese participants*	N/A	Energy expenditure (METs, indirect calorimetry)	TV EE (METs) (1.33 (0.24)) was significantly* lower than typing (1.45 (0.32)), playing a handheld computer game (1.41 (0.28)), and playing a screen-based computer game (2.06 (0.50)) * Based on confidence intervals crossing zero in our calculation of the standardized mean change between the conditions; the paper itself did not test this (see Additional file 1)
Newton 2013 [44] Quality = fair	Experimental (within subjects) USA	Recruited in community (convenience)	African American adults aged ≥18, n=25 (60%)	Lab-based exposure (30 minutes) *Experimental aim: to examine the energy*	N/A	Energy expenditure (METs, whole-room calorimetry)	TV EE (METs) (1.03 (0.15)) was not significantly different from EE of typing (1.06 (0.15)), or reading at a desk (1.04 (0.20))

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
			Mean age 38.2 (11.4), range 20-56	*expenditure of common sedentary behaviours*			
van der Berg 2019 [46] Quality = fair	Experimental (within subjects) Netherlands	Recruited from the university (convenience)	Adults aged 18 to 48 without mobility limitations, n=18 (44%) Mean age 27.3 (6.5)	Lab-based exposure (7 minutes) seated in a chair without armrests while watching TV on a computer screen *Experimental aim: to identify whether 'dynamic sitting (e.g., fidgeting) can be identified from triaxial accelerometry counts*	N/A	Accelerometer vector magnitude* while watching TV compared to natural sitting (allowed to move freely), imposed sitting (motionless), imposed fidgeting (told to move the upper body side to side and back to front), while reading a newspaper, while writing a letter, while playing cards, while typing on a computer, and while preparing food while seated *Paper reported mean acceleration in the vertical, anteroposterior, and mediolateral planes separately; we converted this to mean vector magnitude by taking the square root of the summed squares of all three axes	Accelerometer vector magnitude was significantly* higher while watching TV compared to natural and 'motionless' sitting, reading, writing, and typing; it was significantly lower while watching TV compared to imposed fidgeting. There was no difference in vector magnitude between TV and playing cards or between TV and preparing food while seated. **Based on confidence intervals crossing zero in our calculation of the standardized mean difference between the two groups; the paper itself did not test this (see Additional file 1)*
Mood							

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
Goodwin 2005 [48] Quality = fair	Cross-sectional USA	Convenience sampling	Older adults, n=69 (72%) Mean age 72.0 (6.4)	TV was reported on a paper diary when it was the current activity in response to pager prompts which came 6 times a day for 7 days between 8am and 8pm	N/A NB: affect while watching TV was compared to affect while engaged in other leisure activities (e.g., hobbies, reading), maintenance activities (e.g., cleaning, meal preparation), and productive activities (e.g., work or volunteering) which were reported in response to the pager prompts	Positive and negative affect 'in the moment' when prompted by the pager (i.e., while watching TV if that was the current activity). Mood descriptors were rated on a 5-point Likert scale; positive affect descriptors included things like 'enthusiastic', and negative affect descriptors included things like 'upset'	Positive affect was significantly lower while watching TV (mean 26.07 (SD 9.27)) compared to while doing other leisure activities (28.39 (9.35)) and productive activities (29.78 (9.36)), but was not significantly different compared to while doing maintenance activities (26.19 (9.65)) (see Figure 7). Negative affect while watching TV (10.871 (2.93)) did not significantly differ compared to while doing other leisure activities (10.873 (2.86)), during productive activities (11.09 (2.70)), or during maintenance activities (10.86 (2.74)).
Kuykendall 2020 [47] Quality = good	Cross-sectional USA	Recruited adults who had completed at least 500 assignments on Amazon Mechanical Turk with ≥96% approval rating	Full-time working adults *Study 1a:* n=264 (50%) Mean age 38.7 *Study 1b:* n=538 (50%) Mean age 37.2	*Study 1a & 1b:* Day reconstruction in which all activity episodes from the prior day were reported	N/A	*Study 1a:* For each leisure activity reported in the day reconstruction, the extent to which participants felt the following on a scale of 1 (not at all) to 11 (extremely) was reported: detached, relaxed, stressed,	*Study 1a:* Levels of relaxation were higher when watching TV than when engaging in physical activities; relaxation was similar while watching TV compared to other leisure activities. Levels of satisfaction and happiness were higher during all other leisure activities compared to while watching TV (except for physical activity, for which happiness was

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
						autonomy, meaning, mastery, affiliation, happy, sad, satisfied. *Study 1b:* For each leisure activity reported in the day reconstruction, the extent to which participants felt the following: positive activated (energetic, alert, vigorous); negative activated (anxious, jittery, nervous); negative deactivated (bored, tired, dull); or positive deactivated (peaceful, at ease, serene)	similar to TV). Feelings of sadness did not significantly differ while watching TV versus during other leisure activities. *Study 1b:* Positive activated affect was lowest while watching TV compared to all other activities; positive deactivated affect was lower while watching TV than some (but not all) activities. Negative activated affect was lower while watching TV compared to during active, social, and cognitively stimulating activities. Negative deactivated affect was higher while watching TV than during all other activities.
Sleep							
Asaoka 2007 [50] Quality = fair	Intervention Japan	Voluntary sample recruited from pool of previous research participants (university sample) and employment service center (elderly sample)	University students (n=8, 62.5%) and elderly adults (n=8, 62.5%) Mean age for university students 19.9 (0.8), range 19-21; for elderly adults 73.6 (2.7), range 70-78	Logged TV time in daily activity diary (used only to confirm the efficacy of the intervention for changing TV time, not used as a predictor variable)	None	Rising time, bedtime, total sleep time, nap total sleep time, and daytime total sleep time (between 8am and 8pm) all derived from self-reported sleep logs	Compared to the control week, university students went to bed significantly earlier ($p<0.05$), slept for significantly longer in total ($p<0.05$) and during the daytime ($p<0.05$) when TV was limited to 30 minutes per day; there were no significant changes in rising time, bedtime, or total sleep time among the elderly ($p>0.05$).
Komada 2015 [49] Quality = fair	Experimental (between and within subjects)	Convenience sample	Young Japanese men, n=13 (0%)	Lab-based exposure (107 minutes) on three night-time occasions.	N/A	Change in salivary melatonin and cortisol levels (taken both	The increase in melatonin levels was larger following the half-blue light exposure compared to

First author, year Quality assessment	**Study design, country, and name (if applicable)**	**Recruitment strategy**	**Target sample Sample size (% female) Mean (SD) age or age range**	**TV measurement details with operationalization used in analyses**	**Covariates included in model**	**Outcome measurement(s)**	**Finding for the association between TV and outcome measurement(s)**
	Japan		Mean age 22.7 (0.9), range 21-24	Participants were randomized to normal luminance or high luminance display groups. Regardless of group, all participants were exposed to both normal blue light and half blue light as well as a baseline (control) condition (random order).		before and after the 107-minute exposure)	the normal blue light exposure ($p<0.05$); there was no effect of luminance or luminance*blue light interaction on melatonin levels. There were no associations between blue light level, luminance, or their interaction on cortisol levels.