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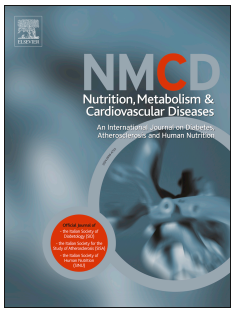

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Regular Brief Interruptions to Sitting after a High-Energy Evening Meal Attenuate Glycemic Excursions in Overweight/Obese Adults

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Abstract

Objectives. Modern Western lifestyles are characterized by consumption of approximately 45% of total daily energy intake at the evening meal, followed by prolonged sitting while watching television (TV), which may deleteriously impact glycemic control. After a high-energy evening meal (dinner), we examined whether regular, brief activity bouts during TV commercial breaks could acutely lower postprandial glucose and insulin responses in overweight/obese adults, compared to prolonged uninterrupted sitting.

Methods. Nine overweight/obese adults (29.7 ± 4.06 $kg \cdot m^{-2}$; aged 32 ± 3 years; 5 male) completed two laboratory-based conditions of three and a half hours: prolonged sitting during TV viewing (SIT); and, prolonged sitting interrupted every 20 min with 3 min of light-intensity body-weight resistance activities (active commercial breaks; ACBs). Venous postprandial glucose and insulin responses to dinner were calculated as positive incremental area under the curve (iAUC) from baseline. Interstitial glucose was measured using a continuous glucose monitor and quantified as total AUC (tAUC).

Results. Compared to SIT, plasma glucose iAUC was reduced by 33% [3.4±1.0 vs 5.1±1.0 (mean±SEM) $mmol \cdot h \cdot L^{-1}$, p=0.019] and plasma insulin iAUC by 41% (813±224 vs 1373±224, p=0.033$pmol \cdot h \cdot L^{-1}$) for the ACB condition. During the ACB condition there was a significant reduction in interstitial glucose tAUC (24.4±5.2 vs 26.9±5.2$mmol \cdot h \cdot L^{-1}$, p<0.001), but this did not persist beyond the laboratory observation period.

Conclusions. Regular brief light-intensity activity bouts can attenuate glycemic responses during television viewing time following a high-energy evening meal in overweight/obese adults.

Introduction

Nutritional survey data from Australia (1), the USA (2) and UK (3) indicate that the average adult consumes a high proportion of their daily energy in the evening, with the main meal and post-meal snacking contributing approximately 45% of total daily energy intake. High end-of-day energy intake has been shown to disrupt normal metabolic homeostasis compared to ingestion earlier in the day (4). Compared to when energy consumption at breakfast or lunch predominates, consumption of ≥33% of daily energy intake in the evening is associated with a two-fold increased risk of obesity and may contribute to the development of subsequent co-morbidities (5).

In conjunction with high end-of-day energy consumption, middle-aged and older overweight/obese adults typically accumulate high volumes of sedentary time (defined by low-energy expenditure ranging from 1.0-1.5 metabolic equivalents in a sitting or reclining position) in the afternoon and evening (6) . In particular, prolonged periods of sitting time can be accrued watching television (TV) – the most common form of sedentary behavior (7) – and can amount to four to five hours per day (7). Population based studies have shown that TV viewing is associated with increased risk of obesity, type 2 diabetes (T2D), cardiovascular disease and premature death (8) as well as unhealthy dietary patterns in adults (9).

The combined impact of high-energy intake and prolonged sitting time in the evening may drive higher glycemic excursions, which can increase the risk of cardiovascular disease (10), contribute to positive energy balance, and ultimately lead to long-term weight gain. Indeed, the elevations in plasma glucose and insulin concentrations that have been reported during prolonged sitting (11, 12) may be amplified in the context of sitting during TV viewing following an evening meal. This may be further exacerbated due to the circadian

rhythm in insulin sensitivity, with diminished responsiveness observed in the evening compared to the morning (13). Frequently interrupting prolonged sitting with brief bouts of either light-intensity walking (11, 12) or simple body-weight resistance activities (12) lowers daytime postprandial glucose and insulin concentrations in overweight/obese adults and those with T2D. However, the effects of breaking up prolonged sitting during TV viewing time on glucose and insulin responses following the evening meal have not been investigated.

We examined the effects of regular, brief light-intensity activity interruptions during TV commercial breaks, compared to prolonged uninterrupted sitting, on glucose and insulin responses to an evening meal in overweight/obese adults.

Methods

Overweight/obese men and women aged 25 to 65 years were recruited via local advertisements (Supplementary Figure S1). Exclusion criteria included: pregnancy; employment in a non-sedentary occupation (e.g. tradesperson); regularly engaged in moderate-intensity exercise ≥150 min/week for >3 months; known diabetes; current smoker (within three months of the start of the trial); use of hypoglycemic, antihypertensive, lipid lowering or antidepressant medications; known physical activity contraindications, major illness/physical problems (acute or chronic) that may limit the participants ability to the perform simple body-weight resistance activities during the active commercial breaks (ACB).

This randomized crossover trial (ACTRN12616000798460) was undertaken at the Baker Heart and Diabetes Institute and was approved by the institutional ethics committee. Eligible participants provided written informed consent and attended the laboratory on three separate occasions. This included a familiarization visit on the day prior to the first experimental visit, where participants were familiarized with the testing procedures, fitted

with a continuous glucose monitor (CGM) and anthropometric measures including height, weight, waist and hip circumference were measured using standard techniques. Since moderate-intensity physical activity has been shown to have no residual effects on plasma glucose past a 17 hour period (14), the two experimental conditions were separated by a 24 hour washout period. This short washout period also helped minimize the potential influence of changes in menstrual phase between conditions. Condition order was randomly assigned by a third party using computer-generated random numbers and sealed envelopes (block randomization with balanced block sizes). Study personnel were blinded to the condition order until the familiarization visit.

On the condition days, participants reported to the laboratory at 1700 h. The clinic room was set up to simulate a 'domestic-type' environment that included a TV, armchair and small table. The participants were requested to not consume any food or drink (except water) after 1400 h that day and were asked to refrain from any moderate-vigorous intensity exercise, alcohol and caffeine in the 24 hours prior to each condition. At the beginning of each condition, resting blood pressure (BP), hunger and fatigue were measured. Participants were then provided with a standardized dinner meal prior to the commencement of a self-selected movie from a list of movies of the same genre (drama). The movies were modified such that commercials were shown at 20 min intervals. The commercials included promotional clips from not-for-profit organizations (Baker Heart and Diabetes Institute, Cancer Council, Donate Life, and travel organizations). These were selected to remove the persuasive content of regular TV commercials, particularly food advertising which has been suggested to cue food desirability and overconsumption (9).

Dietary intake on the condition days were assessed for energy and macronutrient composition using weighed/measured food records and Australia-specific dietary analysis software (Foodworks, Xyris Software, Australia). On the second condition day, participants

were instructed to replicate all food and drink consumed up until 1400 h on the first condition, but were given no further instructions after leaving the laboratory. To employ a pragmatic approach and assimilate a typical Western dietary composition (1-3), the dinner meal comprised 45% of each participant's estimated daily energy requirements (Schofield equation (15), 1.5 physical activity factor and standardized to participants' body weight) with a macronutrient profile of 53-55% energy from carbohydrate, 12-15% energy from protein, and 30-33% energy from fat. Participants were given a 20 min period to consume their evening meal, which consisted of a commercially available chicken and rice meal.

During the trial week, participants wore an accelerometer (Actigraph model GT3X+) on the hip to assess physical activity intensity and duration and an inclinometer (activPAL^{3TM} Model) on the thigh to assess posture. Participants were asked to record their sleep and wake times each day.

On experimental days, baseline and postprandial venous samples were collected by intravenous cannula approximately 15 min prior to the evening meal and then at 30 min intervals during each condition. After consuming the evening meal, participants completed one of the two experimental conditions, in a randomized order. 1) Participants sat for the entire duration of a TV movie (three and a half hours; typical duration of a telemovie), which included 3 min TV commercials every 20 min (SIT). They were instructed to minimize excessive movement when sitting, only rising from the seated position to take a lavatory break at a designated time (50m return walk). Those who did not need to use the lavatory were also instructed to walk to and from the lavatory. 2) This followed an identical procedure to SIT (including lavatory break), except that participants were directed to perform simple, light-intensity body-weight resistance activities during the commercial breaks (ACB). The 3 min bout of activity was divided into a total of nine 20 sec segments. They were instructed to complete 20 secs of body weight half-squats, followed by calf raises and finally

brief gluteal contractions in-between single leg knee raises and to repeat 3 times (12). These lower-body activities were selected because they can be implemented easily without moving away from the TV, using one's own body weight; involve large muscle groups (gluteal and quadriceps), thereby maximizing the effect of muscle-mediated glucose uptake and reducing postprandial glucose concentrations; and, reduce the likelihood of dislodging the cannula (which may occur during upper body exercise).

To ensure appropriate movement standardization and tempo, participants followed a pre-prepared video recording on a second screen while the movie was paused. Range of motion (knee/hip 45 to 90° for half-squats) was tailored to the participants (ahead of time during the familiarization visit). We

Code-labeled samples were sent to an independent National Association of Testing Authorities (NATA)/The Royal College of Pathologists of Australasia (RCPA)-accredited laboratory on the day of testing for the determination of fasting and postprandial plasma glucose and triglyceride concentrations. Glucose was measured in plasma (fluoride/oxalate) using a hexokinase method and insulin was measured as per instructions using a commercial radioimmunoassay kit (EMD Millipore Corporation, Billerica, MA, USA) with the laboratory technician blinded to the order of experimental conditions. All insulin samples were run in duplicate. If the results were >10% different they were re-analyzed. Inter-assay variability was 6% based on laboratory quality control samples that were included in all runs. Plasma triglycerides (from Lithium Heparin tubes) were completed on an Abbott Archicenter ci16200 analyzer (Abbott Laboratories, Illinois).

Participants were fitted with a continuous glucose monitoring device (CGM; Medtronic iPro2, Minneapolis, Minnesota, USA), inserted into the lower back, from the evening prior to condition one until the evening following condition two (to capture interstitial glucose concentrations every five min over 24 hour prior to and following each

condition, to examine carry over effects of the intervention). To calibrate the CGM, capillary blood glucose samples were collected three times per day using a commercially available time-stamped glucometer (Abbott Freestyle Optium, Witney, Oxfordshire, UK).

Three measures of clinic BP were obtained after the participants' had been resting quietly for at least ten min via an automatic digital BP machine (Omron HEM-907, Japan) prior to dinner and at the end of the condition. The first BP measure was discarded and the second two were averaged for the analysis.

Self-reported hunger and fatigue were measured using validated Visual Analogue Scales for appetite (16) and fatigue (17) prior to and after consuming the evening meal, one and a half hours after the commencement of the movie and at the completion of the movie.

Positive incremental area under the curve (iAUC) (trapezoidal method) (18) was calculated for venous glucose and insulin concentrations during the trial conditions. Mean insulin/glucose ratio, a surrogate marker of insulin sensitivity (19), was determined as the ratio of insulin (microU·L^{-1}·min) to glucose (mmol·L^{-1}) for each 30 min sample.

CGM data were summarized into four time periods totaling 19 hours: 1) precondition; 2) condition; 3) pre-sleep and; 4) nocturnal. Precondition period was defined from 1600 h (to avoid residual effects of the last meal) to the time that dinner was served. Pre-sleep period was defined as the time when the participants left the laboratory to when they went to sleep. Nocturnal period was derived from activPAL-defined sleep time to wake time the following day (0900 h) and was confirmed by comparison with self-reported sleep and wake times. The length of each period was standardized (two hours for precondition, four hours for condition, two hours for pre-sleep and eight hours for nocturnal) to account for differences between participants. Total AUC (tAUC) values were statistically adjusted for baseline (blood glucose levels in the 30 min prior to dinner), in order to account for baseline values that were

different between conditions (18). A number of common glycemic variability indices were calculated including: SD of glucose calculated as the standard deviation of all glucose readings; mean amplitude of glycemic excursions (MAGE) determined as the average amplitude of glucose excursions greater than one standard deviation; and continuous overall net glycemic action at 1 hour (CONGA-1) calculated as the standard deviation of differences between each observed blood glucose reading and the reading recorded 60 min previously.

Descriptive data are presented as mean ± standard deviation for continuous variables and n (%) for categorical variables. All other data were normally distributed and are presented as marginal means ± standard error of the mean (SEM). Generalized linear mixed models with random intercepts were used to evaluate the effect of the experimental condition (ACB) on the selected outcomes, adjusted for known or suspected confounders (age, sex and body mass index [BMI]), pre-prandial values and period effects (condition order). All data were analysed using Stata 14 for Windows (StataCorp LP) and $p<0.05$ was considered statistically significant.

Results

Ten participants were recruited for the study; however, data from one participant were excluded because of the participant falling ill during the study visit, prior to consuming the dinner meal. The baseline values for the anthropometric, clinic BP and biochemical measures from the ACB and SIT conditions were averaged and are presented in Table 1. All participants were overweight or obese, but otherwise healthy. One female participant was taking oral contraceptive medication, but otherwise no other medication was being administered.

There was no difference in precondition interstitial glucose concentrations, dietary intake, sitting time or physical activity between the condition days as shown in Table 2.

There were also no differences in total dietary intake between condition days. The trial meal provided 50% (5186±374KJ) of participants' total dietary intake on the ACB condition day and 51% on the SIT condition day. Six of the nine participants consumed a snack following both conditions after they left the laboratory, thereby consuming on average 64±13% of their total energy intake in the evening of the ACB condition (trial meal and post dinner snack) and 64±14% in the evening of SIT (p=0.95 for ACB compared to SIT).

Compared to SIT, significant reductions in both mean plasma glucose (6.0±0.3 vs 6.4±0.3mmol·L^{-1}, p=0.047) and serum insulin (434±81 vs 625±81pmol·L^{-1}, p=0.046) concentrations were observed during the ACB condition (Figure 1a and b respectively).

Glucose positive iAUC was reduced by 33% during the ACB condition (3.4±1.0 vs 5.1±1.0mmol·h·L^{-1}, p=0.019; Figure 1c) and insulin positive iAUC was also reduced by 41% for ACB compared to the SIT condition (813±224 vs 1373±224pmol·h·L^{-1}, p=0.033; Figure 1d). There was a significant reduction in insulin/glucose ratio in the ACB condition compared to SIT (10.4±1.7 vs 13.4±1.7, p<0.001).

A description of the interstitial glucose profiles are shown in Figure 2. Compared to SIT, a significant reduction in interstitial glucose tAUC was observed during the ACB condition period (24.4±5.2 vs 26.9±5.2mmol·h·L^{-1}, p<0.001). However, no significant reductions were observed during the pre-sleep (p=0.93) or nocturnal (p=0.13) periods, even after adjusting for post condition carbohydrate intake (p=0.27 and p=0.41 respectively) or post condition total energy intake (p=0.58 and p=0.13 respectively).

During the ACB condition period there was a significant reduction in glycemic variability, as determined by CONGA-1, SD of glucose and MAGE, compared to SIT (0.6±0.1 vs 1.0±0.1mmol·L^{-1}, p=0.002, 0.4± 0.1 vs 0.7±0.1mmol·L^{-1}, p=0.016 and 1.4±0.3 vs 2.0±0.3 p<0.001 respectively). The reduction in CONGA-1 remained significant after

adjusting for mean glucose concentrations (p=0.016) however, the reductions in SD (p=0.07) and MAGE (p=0.44) were no longer significant.

Overall perceived fatigue scores were lower during the ACB condition compared to SIT (50±3 vs 57±3, p=0.008). There was no difference in perceived hunger ratings between the conditions (p=0.70). No significant differences were observed between the ABC and SIT conditions for triglyceride concentrations (2.38±0.20 vs 2.25±0.20mmol·L^{-1}, p=0.58) or clinic systolic (108±2 vs 104±2mmHg, p=0.23) or diastolic BP (61±2 vs 58±2mmHg, p=0.13).

Discussion

This is the first evidence that regular brief interruptions to prolonged sitting during TV viewing, following consumption of a high-energy evening meal typical of a modern diet in most Western societies, attenuates glycemic excursions in overweight/obese adults. Specifically, interrupting TV viewing time with simple, light-intensity body-weight activities had beneficial effects on postprandial glucose and insulin AUC (reduction of 33% and 41% respectively), mean insulin/glucose ratio (a surrogate marker of insulin sensitivity) and glucose variability compared to prolonged uninterrupted sitting. Since most Western adults typically consume a large proportion of their daily energy requirements in the evening, while also spending prolonged periods of time sitting, such findings may have real-world implications for glycemic control during the evening period. Given the potential detrimental effects of prolonged sitting whilst watching TV following the evening meal, interrupting sitting time with light-intensity activities during commercial breaks may be a useful strategy to avoid exaggerated postprandial glycaemia.

The combined impact of high-energy food consumption and prolonged sitting in the evening may be particularly harmful for health. The rhythmic expression and activity of metabolic pathways is largely coordinated by circadian locomotor output cycles kaput

(CLOCK) genes, and mutations in CLOCK genes are associated with obesity, hyperglycemia and hyperinsuliemia(20). Circadian patterns in satiety hormones, energy expenditure(21) and insulin secretion/action in humans have also been reported, with insulin sensitivity diminishing as the day progresses (22). Disruptions to circadian rhythms, including by consumption of large amounts of energy at the end of the day, may modify the daily cycling of metabolic hormones (e.g. insulin, glucagon, adiponectin, corticosterone, leptin and chemerin) (23), impair glucose stimulated insulin secretion and insulin sensitivity inducing glucose intolerance and lead to obesity and T2D (24). In healthy and normal-weight subjects, nighttime eating results in higher blood glucose, insulin and triglyceride levels compared to when the same meal is ingested earlier in the day (4). An increase in postprandial glucose concentrations at nighttime has been observed in shift workers (25) and is associated with declines in beta cell function (26). At the same time, prolonged sitting is detrimentally associated with cardio-metabolic risk markers (27) and postprandial glycaemia (11, 12). While the underlying mechanisms linking prolonged sitting with increased cardio-metabolic risk remain to be fully elucidated, it is possible that the absence of skeletal muscle activity, the associated reduction in energy expenditure and reduced arterial blood flow/shear stress during prolonged sitting could all contribute to a decrease in glucose uptake. Together, the combination of high end-of-day energy consumption, reduced insulin sensitivity in the evening and prolonged sitting, may contribute to greater glycemic excursions and adverse metabolic and cardiovascular consequences. That said, our findings are acute observations and future research should investigate the chronic effects of high-energy consumption and prolonged sitting in the evening.

Our findings of a reduction in absolute plasma glucose and insulin concentrations are in line with recent experimental studies demonstrating that breaking up five to seven hours of prolonged daytime sitting, in the acute laboratory setting, has beneficial effects on

postprandial glucose and insulin responses (11, 12). However unlike previous reports, this is the first study to examine the effects of breaking up prolonged sitting during TV viewing in overweight/obese adults specifically with simple body-weight resistance activities. These activities were easily completed (light-intensity), pragmatic and simulated actions akin to those often performed around the home (i.e. half-squats which is a similar movement to rising from a chair) and thus our findings are likely to be ecologically valid. Others (28) have shown that stepping on the spot during TV commercials increases energy expenditure and decreases body fat percentage, waist and hip circumference. These findings suggest that following a high-energy evening meal, any activity that raises energy expenditure beyond that of sitting is likely to have favorable effects on health. Although not assessed in the current study, TV commercials, particularly food advertisements, influence appetite (9) and there is a purported association between the amount of time spent watching TV and preference for highly palatable, energy dense food (29). This may further compound the negative effects of prolonged sitting during TV viewing.

In contrast to previous work in patients with T2D (30), we did not observe significant carryover benefits in glycemic control (as measured via CGM) beyond the condition period. These discrepancies are likely explained by differences in study populations and study design. Participants in the present study were healthy and likely more insulin-sensitive, and thus more efficient at clearing blood glucose following the interventions. Furthermore, most previous interventions of this nature have examined the impact of interrupting prolonged sitting across longer “whole-day” periods – with higher overall volumes of physical activity and prolonged sitting – which may have overemphasized subsequent carryover differences in glycemic control. Finally, participants were not given specific instructions to standardize food consumption and physical activity following the experimental conditions. Whilst this likely provides a better indication of what occurs in the free-living setting, it limits the ability

to robustly compare carryover effects of the intervention on interstitial glucose concentrations and may have also influenced our post condition results.

Key strengths of our study include participants being examined following a free-living day, with standardization of the evening period only. Thus, our results are likely to be representative of real-world settings. Participants were also provided with a standardized dinner, typical of most Western diets, as opposed to less ecologically valid test drinks. We recognize a limitation of this study is that it involved a relatively small number of participants, which increases the risk of type one or two error. Nonetheless, the decreases in glucose and insulin mean values and iAUC in response to the evening meal were statistically significant and are in line with previous daytime studies in small cohorts (31). These results support the notion that interrupting prolonged sitting during TV viewing has beneficial effects on postprandial glycaemia however, further research in larger samples are required to confirm our findings, along with the mechanisms that may underlie them.

Conclusions

In overweight/obese adults, regular brief activity bouts during commercial breaks attenuated glycemic responses associated with consumption of a high-energy evening meal followed by prolonged sitting during TV viewing. Given that adults in most Westernized societies consume a large proportion of their daily evening, and it is not uncommon for adults to sit for prolonged periods watching TV at that time, these findings suggest there is an opportunity for pragmatic context-specific interventions to reduce cardio-metabolic disease risk.

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Table 1. Participant characteristics.

	Mean ± SD (n=9)
Age (years)	32±3
Male, n (%)	5 (56)
Weight (kg)	85.0±19.9
Waist circumference (cm)	94±10
Body mass index ($kg \cdot m^{-2}$)	29.7±4.06
Waist hip ratio	0.86±0.08
Clinic systolic blood pressure (mmHg)	104±13
Clinic diastolic blood pressure (mmHg)	60±6
Baseline blood glucose ($mmol \cdot L^{-1}$)	4.7±0.3
Baseline insulin ($pmol \cdot L^{-1}$)	144±84
Baseline triglycerides ($mmol \cdot L^{-1}$)	2.0±1.3

Baseline refers to the average of venous blood samples taken prior to the sitting and active commercial break conditions.

Table 2. Precondition interstitial glucose concentration, dietary intake, sitting time and physical activity and total dietary intake on the sitting (SIT) and active commercial break (ACB) condition days.

	SIT (n=9)	ACB (n=9)	P value
Precondition			
Interstitial glucose tAUC (mmol.h.L-1)	23.8±1.3	22.8±1.3	0.39
Energy (KJ)	3506±504	3681±433	0.80
Protein (g)	30±5	31±4	0.98
Total fat (g)	28±7	28±7	0.95
Carbohydrate (g)	110±15	121±13	0.59
Sitting time (min/day)	322±34	366±37	0.27
Light intensity activity (min/day)	173±27	162±18	0.71
Moderate to vigorous intensity activity (min/day)	36±7	34±8	0.81
Total dietary intake			
Energy (KJ)	10246±1148	10538±1169	0.86
Protein (g)	98±11	102±12	0.82
Total fat (g)	86±16	79±13	0.73
Carbohydrate (g)	301±23	328±34	0.52

Data are mean ±SEM. tAUC, total area under the curve. Precondition period was defined from 1600 h to the time that dinner was served for interstitial glucose, and from wake time to the start of the experimental condition for dietary intake, sitting time and physical activity. Sitting time was assessed via inclinometer and physical activity parameters were derived via accelerometer.

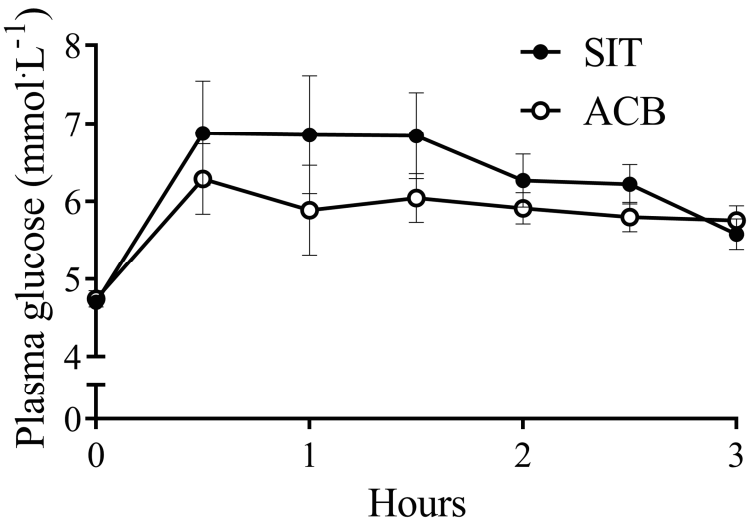
Figure legends.

Figure 1. Effect of active commercial breaks (ACB) on mean ± SEM for plasma glucose (a) and insulin (b) concentrations compared to the prolonged uninterrupted sitting condition (SIT). The positive glucose and insulin incremental area under the curve (iAUC) mean ± SEM adjusted for age, sex, body mass index and condition order are shown in panel c and d. *indicates a significant reduction of 33% in positive glucose iAUC and 41% in positive insulin iAUC ($p < 0.05$).

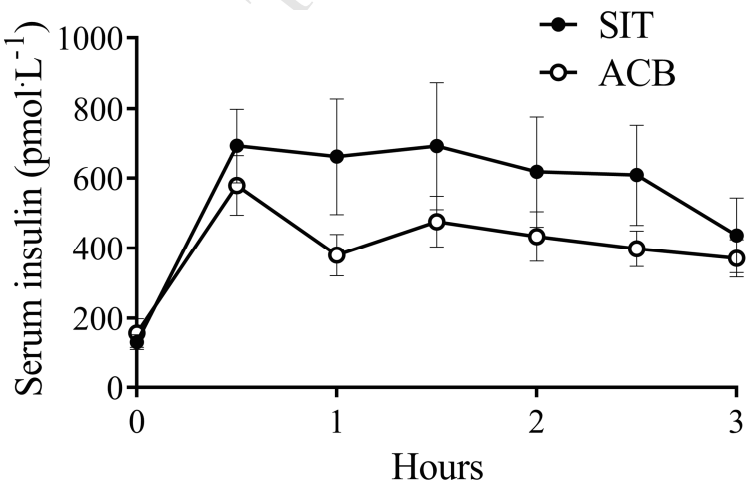
Figure 2. Mean (solid and dashed black line) ± SEM (grey area either side of mean) interstitial glucose concentrations. Interstitial glucose concentrations were measured during the active commercial break (ACB) and sitting (SIT) conditions, pre-sleep period (determined as the time when the participants left the laboratory to when they went to sleep on average for all participants) and nocturnal period (determined as the period from activPAL-derived sleep time to wake time the following day on average for all participants). The length of each period was standardized (two hours for precondition, four hours for condition, two hours for pre-sleep and eight hours for nocturnal) to account for differences between participants. The dotted vertical lines denote the start and end of dinner consumption and each respective time-period.

Supplementary Figure S1. Consort diagram of participant flow. One participant was excluded following the second condition due to suspected type 2 diabetes. BMI, body mass index; ACB, active commercial break condition; SIT, sitting condition.

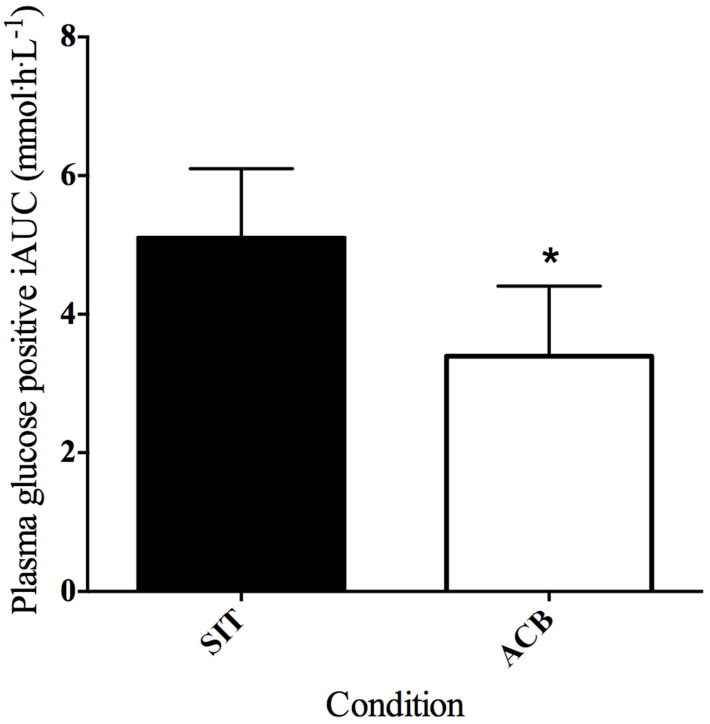
a)



b)



c)


Plasma glucose positive iAUC (mmol·h·L-1)
8
6
4
2
0
*
SIT
ACB
Condition

d)

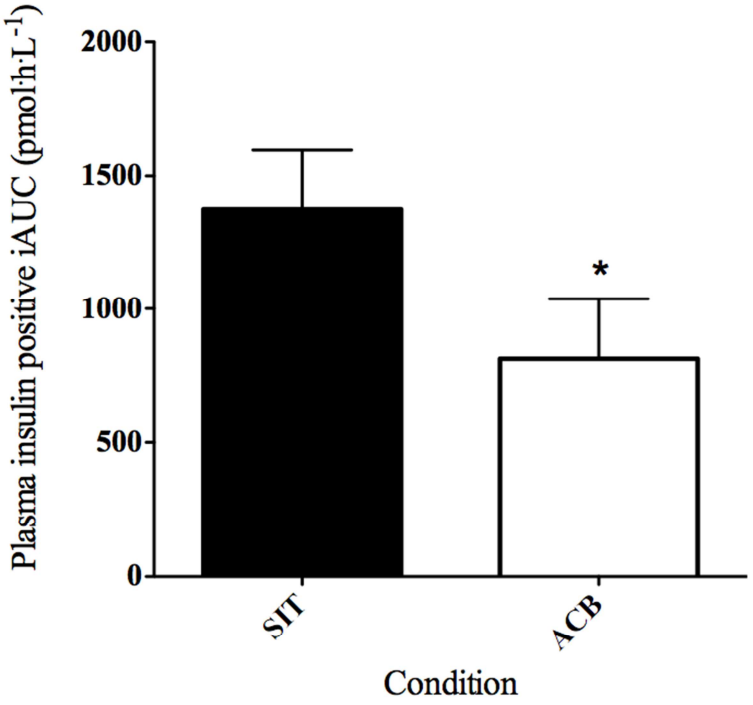

Plasma insulin positive iAUC (pmol·h·L-1)
2000
1500
1000
500
0
*
SIT
ACB
Condition

Figure 1

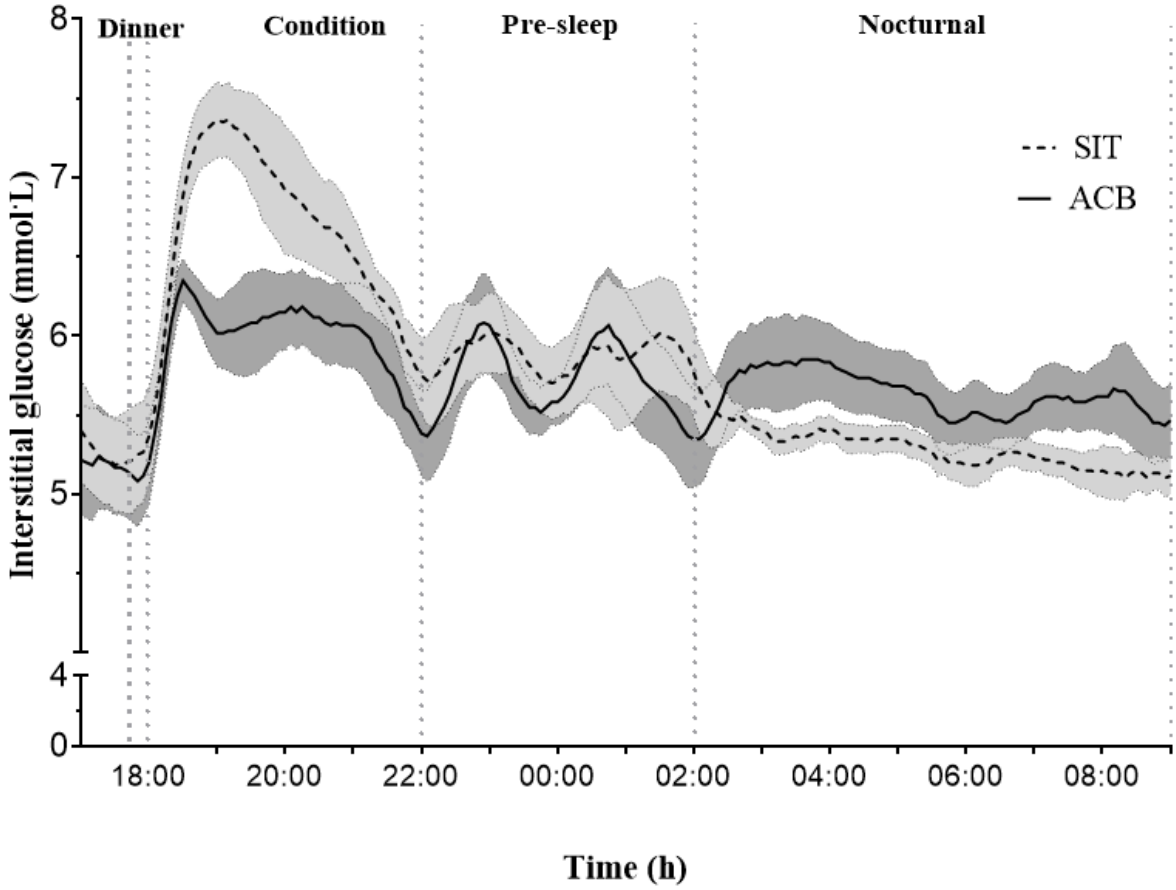


Figure 2.

Highlights:

I. Modern Western lifestyles involve the consumption of high amounts of energy intake at the evening meal, followed by high volumes of prolonged sitting time watching television (TV), which may be deleterious for health;

II. Compared to prolonged sitting while watching TV, regular brief light-intensity activity bouts lower postprandial glucose and insulin responses to an evening meal;

III. Given that adults consume large amounts of energy at the end of the day while at the same time, sitting uninterrupted for prolonged periods, undertaking regular activity bouts during TV viewing could minimise the adverse health consequences associated with such behaviour.