Title: Acute effects of active gaming on ad-libitum energy intake and appetite sensations of 8-to-11 year-old boys.

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Abstract

The present study examined the acute effects of active gaming on energy intake (EI) and appetite responses in 8-11 y boys in a school-based setting. Using a randomized crossover design, 21 boys completed four individual 90 min gaming bouts, each separated by 1 week. The gaming bouts were 1) seated gaming no food or drink; 2) active gaming no food or drink; 3) seated gaming, food and drink offered ad-libitum and 4) active gaming, food and drink offered ad-libitum. In the two gaming bouts during which foods and drinks were offered, EI was measured. Appetite sensations; hunger, prospective food consumption and fullness were recorded using visual analogue scales (VAS) during all gaming bouts at 30 min intervals and at two 15 min intervals post-gaming. In the two bouts with food and drink, no significant differences were found in acute EI (MJ) (p=0.238). Significant differences were detected in appetite sensations for hunger, prospective food consumption and fullness between the four gaming bouts at various time-points. The relative energy intake calculated for the two gaming bouts with food and drink (active gaming 1.42±0.28 MJ; seated gaming 2.12±0.25 MJ) was not statistically different. Acute EI in response to active gaming was no different to seated gaming and appetite sensations were influenced by whether food was made available during the 90 min gaming bouts.

Introduction

By the age of 10-11 y, one in three English children are now classified as being either overweight or obese [1]. In England, only 21% of boys and 16% of girls aged between 5 and 15 y achieve physical activity (PA) guidelines, and time spent being sedentary appears to be increasing[2]. It is widely believed that this lack of PA has become a major contributor to children's positive energy balance [3].

Seated media activities, including television viewing, computer use and playing computer games are thought to reduce the time children spend undertaking sports and other physical activities [4-8]. For children aged ≤ 11 years, associations have been found between sedentary activities such as television viewing and computer use and the spontaneous intake of unhealthy foods and drinks[9-11]. The more recently introduced active video games however require physical movement from the player. Linked to a television set via a console, active games need the player to physically interact with on-screen images through a tracking device within a camera (The Eye Toy , Sony Computer Entertainment®), a handheld controller (Nintendo Wii ™, Nintendo©) or a web-cam device (Xbox 360 Kinect, Microsoft). As such, these video games might present an appealing way to increase children's PA and thus offset any spontaneous energy intake (EI) [12]. Recent laboratory-controlled investigations have indeed established that active video game play can increase children's energy expenditure (EE) threefold, in comparison to sedentary pursuits (watching television or playing seated video games) [13-16]. Some active game play has been shown to elicit an intensity of 5 METS (moderate PA) with games such as "EyeToy Knockout'' (PlayStation 2, Sony, Tokyo, Japan) [17, 18]. Moreover, 15 min of Nintendo Wii Fit jogging, has been found to elicit an average of 5.35 METS in obese children ([19]). Such findings suggest that active video games have the potential to contribute significantly to levels of EE and help children meet the recommended moderate to vigorous physical activity (MVPA) levels.

To the authors' knowledge Mellecker and colleagues (2010) were the first to explore acute EI during active gaming in children [20]. During two, 1 hour laboratory gaming sessions (seated and activity enhanced), snacks were made available ad-libitum to 9-13 y children. No significant differences in snack consumption were found between the seated and activity enhanced video gaming conditions. During both trials Mellecker and Colleagues (2010) found that the mean EI was on average, 66% above resting levels [20]. This suggests that the additional PA elicited by the active gaming bout may not actually offset the EI in this group. No measures of appetite were explored however and EE was not estimated, failing to provide insight into any potential mechanisms for these changes in EI.

In relation to seated gaming, there have also been no differences reported in appetite when compared with resting conditions, in both male adolescents (aged 15–17 y) [21] and boys (aged 9-14 y) [22]. In the adolescent group, EE and ad libitum EI were significantly higher than after resting[21], whilst the food intake of the younger boys (9-14 y) was lower after 30 minutes of seated video game-play versus the identical period of resting[22]. Nonetheless, when EE was subtracted from EI, both groups were found to be in positive relative energy intake [21, 22]. The findings of paediatric gaming studies thus far however, suggest that active game play might be a healthier substitute for seated media activities.

To date, the effects of active gaming on appetite and EI have not been explored in 8-11 y boys. Furthermore, all of the previous studies have been strictly laboratory-controlled and the gaming protocols employed did not resemble the active game play of young children. We have recently published data describing the active gaming practices of 7-11 y children from Newcastle-upon-Tyne (North East England, UK) [23] to enable active gaming interventions to be designed that are representative of young people's habitual gaming practices.

The primary aims of the present study were therefore to explore acute EI and appetite sensations during active gaming and seated gaming, in 8-11 y boys. Secondary aims were to measure PA, estimate both EE and relative energy intake and establish time to eating onset.

Materials and methods

Design

A randomised, cross-over design was used to compare acute EI and appetite sensations of 8-11-year-old boys during four gaming bouts each separated by 1 week, utilising methods identified in a previous study[23]. The four gaming bouts were: 1) 90 min seated gaming, no food or drink offered; 2) 90 min active gaming, no food or drink offered; 3) 90 min seated gaming with food and drink offered ad-libitum; 4) 90 min active gaming with food and drink offered ad-libitum. The boys were stratified according to school year into two groups of two so that a total of four boys were tested on each occasion. They were randomly assigned to a different gaming bout every week either with or without food. This meant that food and drinks were available to all four boys at the same time so that appetite sensations were not influenced by the sight of food and another boy eating. By the end of four weeks they had completed each of the four trials.

Ethical approval for the study was granted by the University of Northumbria, Faculty of Health and Life Sciences Ethics Committee. Written informed consent was obtained from both the parent (or main carer) and from the child, prior to data collection.

Participants

To recruit 8-11 y males, consent was obtained from head teachers of two primary schools located within the city of Newcastle upon Tyne (North East England, UK of matching achievement levels[24]. The researchers distributed recruitment packs to all eligible boys who expressed an interest in participating and they were asked to take this home. The pack contained a letter addressed to their parent/main carer with a full explanation of the study and consent forms for them and their child to sign and return to school. Signed consent was received for 22 boys and 21 of these (mean age 9.8±0.9 y) took part in and completed the study. The boy who did not complete the study was excluded due to the parent being unable to standardize his EI. Boys were excluded from participating when injury or illness prevented them from being able to play active video games or if they had intolerances or allergies to the foods provided in the study.

Preliminary measures

Prior to the first gaming bout, the researchers visited the school to meet the children and their parent or main carer. The purpose of the visit was to familiarise the boys (and where applicable their parent or main carer) with the gaming consoles, the games, the gaming session format, the self-reported weighed food diaries and visual analogue scales (VAS) used to measure appetite sensations. A demonstration of the right hip placement of accelerometers (Actigraph LLC © GT3X+) to enable measurement of PA during the gaming bouts was also provided. The boys were asked to complete a food preference questionnaire during the familiarisation session to ensure the foods and drinks offered during the study were not disliked by them. The boys were also familiarised with the appetite and mood VAS and completed the Dutch Eating Behaviour Questionnaire for children (DEBQ-C), as a measure of dietary restraint [25].

Anthropometric measurements were taken, with stature and seated height measured to the nearest 0.01 m using a Harpenden Portable Stadiometer (Holtain Limited, Pembs, UK). Body weight was measured to the nearest 0.1 kg using portable SECA scales (SECA United Kingdom). Waist circumference was measured to the nearest 0.01 m with a non-elastic flexible tape at each boy's natural waist whilst standing as a indicator of central adiposity [26].

Protocol

Each boy was provided with a self-report, weighed food diary and a set of food weighing scales (Salter ©, Kent, UK) to use prior to all intervention days. With the help of their parent or main carer they were asked to weigh and record all foods and drinks they consumed from 17:00 the

evening preceding, until after they had consumed breakfast on the morning of each intervention day. A photocopy of this food diary was provided to each parent and they were asked to replicate their child's food and drink intake prior to each gaming bout on three further intervention days. The boys were also asked to abstain from all physical education at school on the day of the study and PA from 17:00 the evening preceding.

The boys attended school as normal at 08:55. If any of the boys usually consumed a snack during their morning break (10:40), they were provided with this in each intervention week by the research team. The snack was dependant on the personal food intake of the boy and was the same each week. At lunchtime (12:00) in the first week, each boy consumed a packed lunch prepared by the research team which comprised their preferred food and drink items. The food and drink items consumed were weighed and recorded by the research team so that an identical lunch could be provided in each of the three subsequent visits.

Gaming sessions took place, at the end of the school day (15:15) on school premises as an after-school club and commenced at 15:30 until 17:00. The gaming sessions were implemented for 90 min, as we found this to be the average time 7-11 y children spent playing active gaming consoles[23]. The boys were tested in sub-groups of four, with each of the four intervention arms taking place on the same school day of each week, for four consecutive weeks.

Gaming interventions

The design of the individual gaming bouts was based on data we have published which described the active gaming practices of 7-11 y children from Newcastle upon Tyne[23]. Thus the gaming console used for the active gaming bouts was Nintendo Wii™ and the game used was Nintendo Wii™ Sports tennis. During each gaming bout, two boys played Nintendo Wii™ Sports tennis and two the seated game. The seated game utilised was 'Mario and Sonic at the London 2012 Olympic Games', played on Nintendo 3DS. The pair who were assigned to the Nintendo Wii™ played together against the computer, whilst the two boys who played the Nintendo 3DS played individually against the computer. In doing this, peer influence related to winning or losing [27] was avoided along with any subsequent effects on EI.

The food and drink items provided during the gaming sessions were also based on the previous findings [23]and were 130g apples (raw, slices and cored), 50g crisps [potato chips (Walkers©, ready salted)], 250 mL semi-skimmed milk, 350 mL Robinson's apple and blackcurrant squash (no added sugar). All food items were pre-weighed by the researchers to the nearest gram using electronic portable scales (Salter ©, Kent, UK) and all drinks were measured to the nearest

millilitre. The crisps and apple were placed in clear plastic bags and the milk and squash were placed in coloured drinks bottles so that volumes were not identifiable. They were all numerically coded by the researchers and placed at a station designated to each individual boy. All of the foods and drinks were offered ad-libitum. The researchers noted each bag or bottle taken by the boys and then weighed or measured anything left over so that amounts consumed could be calculated and recorded. If further food and drink items were required during the gaming bouts, additional portions were served.

To estimate EI from the food and drink items served, individual food labels, an online resource (www.asda.com) and MicroDiet (Downlee Systems ©, Derbyshire, UK) were employed. For each boy, exercise EE was subtracted from the amount of energy consumed during each gaming bout to calculate relative energy intake. When the gaming bouts commenced, the time of the first eating episode for each boy was recorded.

Appetite

Hunger, fullness and prospective food consumption were assessed using paper-based VAS. 'How full do you feel now?' anchored by very full (0) and not full at all (100), and prospective food consumption ''How much would you like to eat now?'' anchored by a lot (0) and nothing at all (100). The boys were requested to place a vertical mark along the 100 mm horizontal lines at set times, prior to, during and following gaming cessation on all intervention days. Scales were collected at baseline (0 min: 15:30), 30 min (16:00), 60 min (16:30), at the end (90 min: 17:00), 15 min post (17:15) and 30 min post gaming (17:30).

Physical activity assessment

During every gaming bout, the PA levels of each boy were measured by accelerometry using an Actigraph© LLC, GT3X+ worn on the right hip[28]. The majority of accelerometer research favours placement on the right hip as there is evidence to support this as being the optimum site [29, 30]. Furthermore, when 11-17 y children played Nintendo Wii™ Sports tennis, right hip accelerometer placement was found to have a closer relationship with EE than when positioned on the right or left wrist [31]. The boys wore the accelerometer between 15:30 and 17:00 on each gaming intervention day, with PA counts recorded at 10 s epochs. At the end of every gaming session, the data was downloaded utilising Actilife 6 data analysis software and interpreted using recommended child-appropriate activity cut-off values[32]. Activity counts were integrated into 60 s epochs utilising the child appropriate cut-offs of Evenson et al.,(2008) so that they could then be converted into mean metabolic equivalents of time (METS) using the algorithm of [33] within the

Actilife version 6 software (ActiGraph Ltd, Pensacola, FL, USA). The following MET thresholds recommended for use with children were used to categorise data based on PA intensity: sedentary < 1.5 METs; light 1.5 to < 4 METs; moderate 4 to < 6 METs; vigorous > 6 METS[34].

Energy expenditure

For each boy, Henry's body mass, stature and sex-specific equations were used to calculate basal metabolic rate (BMR)[35]. Energy expenditure was then calculated as recommended by Ridley, Ainsworth and Olds (2008), as follows; METS x BMR (MJ·min·d) x 90 min gaming = MJ [36]. This particular method of EE estimation accounts for age, sex, body mass (kg) and stature (m), unlike other prediction equations which utilise only one or two of these physiological characteristics [34, 37-39].

Statistical analysis

Means and SEM are presented for all data. VAS ratings for subjective appetite sensations (hunger, prospective food consumption and fullness) were calculated as time-averaged area under the curve (AUC) for the gaming (15:30 – 17:00) and post gaming period (17:00 – 17:30) (120 min). PASW Statistics (version 18.0, SPSS Inc., Chicago, Illinois) was used for all statistical analyses. One-way repeated measures ANOVA were used to detect differences between mean PA, EE and baseline appetite values. Two-way repeated measures ANOVA (trial × time) were used to detect differences in appetite sensations and following a significant interaction effect, simple main effects analyses were utilised. This approach enabled comparison between the four gaming bouts across all time points. A Bonferroni correction was made when significant differences were identified. Energy intake, % macronutrient intake [carbohydrate (CHO, fat and protein (PRO)], relative energy intake and time to eating onset were analysed using dependent t-tests. For significant differences found in the t-test analyses, Cohen's *d* effect size was calculated and interpreted against the effect size categories of ≤0.20 = small effect, ~ 0.50 = moderate effect, and ≥0.80 = large effect [40]. Statistical significance was set at $p < 0.05$ for all analyses.

Results

Population characteristics

Preliminary measurements established mean ($_{SD}$) stature 1.39 ($_{SD}$ 0.06) m; body mass 35.5 ($_{SD}$ 7.6) kg; waist circumference 64.3 ($_{SD}$ 8.4) cm and BMI 18.4 ($_{SD}$ 3.65) kg/m^2 of the boys.

According to UK age and gender-specific BMI centiles [41], the majority of the boys were classified as having a healthy body mass (71.4%), 14.3% were classified as overweight and 14.3% as obese. The mean maturity offset was -1.0 ($_{SD}$ 1.0) y from peak height velocity, indicating that the boys were of similar maturation status. In addition, all boys were identified as being unrestrained eaters according to the Dutch Eating Behaviour Questionnaire[25], with a mean ($_{SD}$) dietary restraint score of 1.7 ($_{SD}$ 0.5) categorized as being average for boys of this age (1.53 $_{SD}$ 1.95) [25].

Appetite

All values for appetite are displayed in Table 1. There were no detectable differences in mean baseline appetite sensations (hunger, prospective food consumption or fullness) between any of the four gaming conditions as illustrated in Table 1. The time-averaged area under the curve appetite values however, revealed significant differences between gaming conditions. Participants felt more hungry during seated gaming without food compared with when they were both seated (p=0.006) and active gaming with food (p=0.009). More specifically, they felt more hunger at 30 min, 60 min and 90 min during the above gaming conditions, as indicated in Figure 1. In relation to prospective food consumption, the participants felt they wanted to eat more during seated gaming without food, compared with during seated gaming with food (p=0.002) and active gaming with food (p=0.008). They felt they wanted to eat more during the above gaming conditions at 60 min and 90 min (p=0.042), as shown in Figure 2. They felt less full during seated gaming without food compared with when they were seated gaming with food (p=0.003). They also felt less full when active gaming without food compared with when they were both seated (p=0.002) and active gaming with food (p=0.014). The boys felt less full during the above gaming bouts at 60 min, as illustrated in Figure 3.

Physical activity METS and Energy Expenditure (MJ)

All values for PA (METS) and EE are displayed in Table 2. Active gaming elicited only light PA and seated gaming was sedentary. The PA METS during active gaming with food were significantly greater than seated gaming with food (p<0.001, effect size 0.6). Likewise the PA METS during active gaming without food were significantly greater than seated gaming without food (p<0.001, moderate effect size 0.7). As expected, no differences were found between active gaming with or without food (p=1.000) and between seated gaming with or without food (p=0.389).

Energy intake (MJ), relative energy intake [EI – EE (MJ)] and time to eating onset (min)

All values for EI, relative energy intake and time to eating onset, are displayed in Table 2. No significant differences were found in total EI (MJ) between the seated and active gaming bouts in which the foods and drinks were offered (p=0.238). Mean relative energy intake (MJ) was significantly greater after seated gaming in comparison to active gaming (p=0.031, effect size 0.3). The average time to eating onset (min) was significantly longer during active gaming with food, in comparison to seated gaming with food (p=0.017, effect size 1.0).

Discussion

The present study found no differences in the acute ad-libitum EI of 8-11 y boys during 90 min of active gaming when compared with seated gaming. Despite the lack of difference in EI, it took considerably longer for the first eating episode during active gaming to occur (17.10 min versus seated gaming 6.90 min). Sensations of hunger, fullness and prospective food consumption appeared to be influenced by whether food was made available during the gaming bouts. This was illustrated by the boys feeling more hungry, less full and wanted to eat more during the gaming conditions without food. Furthermore there were no differences in appetite between the seated and active gaming bouts with food.

To the best of our knowledge this is the first study to have investigated acute ad-libitum EI during active gaming using a genuine active game, in 8-11 y boys. The lack of difference in EI and macronutrient intake between active and seated gaming found in the present study is consistent with findings in adults when playing Nintendo Wii™ and Xbox 360[42]. In the previously cited study, EI during active gaming when compared with seated gaming was also not significantly different. Over the one hour gaming periods, the adults consumed an average of 3.13±2.26 MJ when seated versus 2.32±2.08 MJ when active.

The only comparison that can be made with paediatric active gaming studies might be with the study by Mellecker and colleagues (2010), during which 9-13 y old children played a seated video game or an enhanced activity gaming device. In their investigation, the total energy consumed by the children during the seated gaming bout was equivalent to 1.57 $MJ \cdot h^{-1}$ and during active gaming was 1.60 $MJ \cdot h^{-1}$. When calculated per hour, the values of Mellecker and colleagues (2010) were similar to those found in the present study (1 h of seated gaming 1.92 MJ; 1h of active gaming 1.53 MJ). Although in the present study, EI during seated gaming was higher and during active gaming was lower than found by Mellecker and colleagues [20]. The differences in EI findings between the previously cited study [20] and those determined presently, might be due to the former study being conducted in the unfamiliar setting of the laboratory and with the active gaming being a

seated gaming device played whilst walking on a treadmill. As such the active gaming format might not have been as stimulating or challenging for the children as an actual active video game. Our intention with the use of Nintendo Wii Sports™ tennis and the primary school settings was to provide an intervention in an environment the participants were more accustomed to than the laboratory.

Total EI during 90 min of seated gaming was calculated to be 2.88 MJ, and for active gaming 2.30 MJ. When considering the daily estimated average requirement (EAR) for energy for UK males aged 9 y (the average age of the present study population) is 7.70 MJ[43], the EI due to seated and active gaming equated to 34% and 27% of daily EAR, respectively. Relative energy intake which was estimated for seated and active gaming by subtracting the value for estimated EE from EI which was 2.42±0.33 MJ and 1.64±0.27 MJ, respectively. As such EI during active gaming with food was not offset by the greater estimated energy expenditure. Instead, a positive relative energy intake was produced by both games which could contribute to a state of positive energy balance. The consumption of food or drinks by children during active gaming therefore should not be encouraged. Furthermore, the estimated EE from active gaming was equivalent to only light PA and so in contrast to the findings of O'Donovan, Roche and Hussey (2014), would not contribute to children's MVPA [19].

Due to this present study being an acute investigation, the EI of the boys was not monitored after the gaming bouts had ended (17:00) so it is not known whether compensation for the gaming EI occurred later. The only paediatric study [44] thus far to have investigated compensation due to active gaming EE, also did not establish any difference in EI in a post gaming meal, when compared with 1 h of resting and seated gaming. At the end of the active gaming trial however, the participants in the previously cited study, were established as being in negative energy balance, which was then compensated for 24 h later by an increase in EI [44]. However, the previous study offered the food *ad-libitum* following the active gaming in a post-trial test meal and not during the conditions, as in the present study and this might explain the difference in findings. In the current study, it is possible that the boys compensated for the extra EI during both gaming trials at a later time, either by a down-regulation in EI or an increase in EE. If no compensation did occur however such substantial levels of energy surplus could contribute to a state of positive energy balance, which could be clinically meaningful with regards to weight status. Particularly when a reduction of only 0.46 to 0.69 MJ per day might be all that is required to reduce the energy gap to bring about a decrease in body weight in children [45].

In 15-19 y adolescents, EI was monitored following seated gaming for the remainder of the day but no compensation was found to have occurred for the extra food consumed [21]. Although we acknowledge that in relation to an increase in EE, it is possible for children to compensate and increase EI 72 hours later to try and restore energy balance[46]. As such, future research that examines compensation post active gaming is warranted.

In relation to appetite, the boys felt significantly more hungry, less full and wanted to eat more during the gaming conditions without food, in comparison to the gaming conditions with food. However appetite sensations were no different between active and seated gaming with food. Thus far, only two other paediatric studies have investigated the acute effects of active gaming on subjective appetite [44, 47] and both of these reported similar findings to the present study. The appetite sensations of healthy male adolescents were no different during 1 h of resting, seated gaming and active gaming [44] or in obese adolescent males during 1 h of resting, seated gaming, active gaming and cycling [47]. As such, appetite and EI do not appear to be coupled due to active or seated gaming as they are with exercise [48].

These findings are also similar to those of seated gaming when compared with resting conditions [21, 22]. Both of the cited studies also observed no significant differences in appetite sensations, whilst EI obtained from an ad-libitum post-gaming meal differed in the two populations[21, 22]. In 11-13 y boys, EI was found to be significantly lowered by 0.25 MJ after 30 min of seated gaming[22], whilst 15 to 19 y males consumed similar amounts following seated gaming and resting[21]. It should be noted however that in the more recent study of 11-13 y boys, a glucose pre-load was administered at the start of the session which might have suppressed subsequent food intake[22].

The lack of difference in appetite sensations and EI between seated and active gaming with food observed in the present study population and during seated gaming in 15-19 y adolescents, could be that both seated and active gaming might lead the boys to over-consume without an increase in appetite sensations, as previously reported with television watching[49]. As such, both active and seated gaming might have the same distractive effect as television which appears to cause fullness sensations to be ignored, resulting therefore in an over-compensation in EI for gaming EE. Whether this over-compensation is due to the mental-stress-induced reward system[50] or an impairment in satiety signalling, has not yet been established [21, 51]. Future active gaming research with children might therefore consider the objective measurement of appetite hormones alongside VAS due to the latter being a subjective measure.

To the best of our knowledge this is the first paediatric study to investigate the influences of active gaming on acute appetite sensations and EI. The strengths of the study were, that it utilised an intervention designed from actual survey findings that had established the active gaming practices of 7-11 y children. In addition, the gaming bouts were implemented in a school-based setting, as an after-school club thus creating a more relaxed and familiar environment for participants, in contrast to that of a laboratory. Such a free-living and holistic design has evolved from our latest paediatric exercise and appetite research.

A limitation of the study was that only Nintendo Wii™ Sports tennis was utilised during the two, 90 min active gaming sessions. We felt however that it was important for the boys to play the same game to enable accurate comparison of the individual gaming bouts. Furthermore, the Nintendo Wii™ Sports tennis game utilises both upper and lower limbs during play, which should allow for greater body movement and thus higher activity counts and EE [18, 52] . The authors also recognise that the prediction of EE from METS obtained by accelerometry is not without error, particularly in children [36, 38]. The accelerometers were placed on the right hip however, and there is evidence to support this as being the optimum location [28, 29]. Furthermore, in 11-17 y males, the PA METS recorded from hip placement during 15 min play of Nintendo Wii™ Sport tennis, were shown to have the closest relationship to EE, than other body sites tested, which were the right and left wrists [52]. We considered it important however to implement the active gaming sessions in a manner that was most true-to-life, outside of the laboratory with two boys playing against one another. For this it was necessary to measure PA by accelerometry and thus estimate EE. Subsequent estimations of relative energy intake therefore will also not be without error. Therefore, we believe this study to have been exploratory in nature and we encourage researchers to use the paediatric responses to active gaming presented in this manuscript to help power future studies.

To conclude, the availability of food had a significant effect on appetite sensations during the gaming bouts. However there were no differences in the acute EI or appetite sensations of 8-11 y boys between 90 min active video gaming bout with food, when compared with seated gaming bout with food. Acute EI due to eating and drinking during active gaming was calculated as 37% (2.88±0.32 MJ) and during seated gaming was30% (2.30±0.28 MJ) of daily EAR (based on 9 y old boys). The relative energy intake estimated to have been produced from active gaming and acute ad-libitum EI was 1.64±0.27 MJ and for seated gaming was 2.42±0.33 MJ, which might contribute to positive energy balance. Appetite and EI responses to active and seated gaming require further exploration, in order to establish whether the observed acute over-compensation in EI is offset by subsequent EI and EE, after a gaming session has ended.

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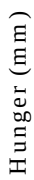
Figures



Prospective food consumption (mm)

Fullness (mm)

Figure captions

Figure 1

Mean $_{(SEM)}$ hunger sensations for all participants (n = 21). *At 30 min, participants felt less hungry during ○seated gaming with food compared with ●seated gaming without food (p=0.010). *At 60 min, they felt less hungry during Δactive gaming with food compared with ●seated gaming without food (p=0.025). †At 60 min they felt significantly more hungry during ▲active gaming without food in comparison to both ○seated (p=0.049) and Δactive gaming with food (p=0.013). *****At 90 min, participants felt significantly less hungry during Δactive gaming with food compared with both ●seated (p=0.032) and ▲active gaming without food (p=0.029).

Figure 2

Mean $_{(SEM)}$ prospective food consumption for all participants (n = 21). *At 60 min participants wanted to eat significantly more when ●seated gaming without food compared with Δactive gaming with food (p=0.030). *At 90 min, participants wanted to eat significantly more when ●seated gaming without food compared with ○seated gaming with food (p=0.042).

Figure 3

Mean $_{(SEM)}$ fullness sensations for all participants (n = 21). *At 60 min, the participants felt significantly less full when ●seated gaming without food than when ○seated gaming with food (p=0.011) † Δand active gaming with food (p=0.011). They also felt more full when ‡ Δactive gaming with food compared with ▲active gaming without food (p=0.023).

Tables

Table 1

Table 1. Mean and standard error values for all baseline and time-averaged area under the curve (AUC) appetite sensations for all gaming bouts.

		Hunger (mm)		Prospective food consumption (mm)		Fullness (mm)	
	Gaming bout	**Mean**	**SEM**	**Mean**	**SEM**	**Mean**	**SEM**
Baseline	Seated no food	43	8	46	8	55	9
	Active no food	52	7	55	7	60	7
	Seated with food	39	7	41	7	71	6
	Active with food	37	7	38	7	58	8
Time-averaged (AUC)	Seated no food	32	5	32	5	66	5
	Active no food	35	6	38	6	70	6
	Seated with food	47	4	55	6	50	4
	Active with food	50	4	50	5	52	5

Table 2

Table 2. Mean $_{(SEM)}$ PA METS, energy expenditure (EE) (MJ), energy intake (EI) (MJ), relative energy intake (MJ), time to eating onset (min) for all participants for each gaming bout.

	Seated no food		Active no food		Seated with food		Active with food	
	Mean	SEM	Mean	SEM	Mean	SEM	Mean	SEM
PA levels (METs)	1.38	0.07	2.14*	0.10	1.49	0.74	2.08†	0.90
EE (MJ)	0.43	0.02	0.69‡	0.03	0.51	0.03	0.66§	0.03
EI (MJ)					2.88	0.26	2.30	0.28
Relative energy intake (MJ)					2.42	0.25	1.64‖	0.28
Time of eating onset (min)					6.90	1.52	17.10¶	4.00

*PA (METS) were greater during active gaming without food than seated gaming without food (p<0.001).
†PA (METS) were greater during active gaming with food than seated gaming with food (p<0.001).
‡EE was significantly greater during active gaming without food than seated gaming without food (p<0.001).
§EE was significantly greater during active gaming with food than seated gaming with food (p<0.001).
‖Relative energy intake was significantly lower when active gaming with food than when seated gaming with food (p=0.031).
¶Time of eating onset (min) was significantly longer during active gaming with food (p=0.017).

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