Video game playing increases food intake in adolescents: a randomized crossover study\textsuperscript{1–3}

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ABSTRACT

Background: Video game playing has been linked to obesity in many observational studies. However, the influence of this sedentary activity on food intake is unknown.

Objective: The objective was to examine the acute effects of sedentary video game play on various components of energy balance.

Design: With the use of a randomized crossover design, 22 healthy, normal-weight, male adolescents (mean ± SD age: 16.7 ± 1.1 y) completed two 1-h experimental conditions, namely video game play and rest in a sitting position, followed by an ad libitum lunch. The endpoints were spontaneous food intake, energy expenditure, stress markers, appetite sensations, and profiles of appetite-related hormones.

Results: Heart rate, systolic and diastolic blood pressures, sympathetic tone, and mental workload were significantly higher during the video game play condition than during the resting condition ($P < 0.05$). Although energy expenditure was significantly higher during video game play than during rest (mean increase over resting: 89 kJ; $P < 0.01$), ad libitum energy intake after video game play exceeded that measured after rest by 335 kJ ($P < 0.05$). A daily energy surplus of 682 kJ (163 kcal) over resting ($P < 0.01$) was observed in the video game play condition. The increase in food intake associated with video game play was observed without increased sensations of hunger and was not compensated for during the rest of the day. Finally, the profiles of glucose, insulin, cortisol, and ghrelin did not suggest an up-regulation of appetite during the video game play condition.

Conclusion: A single session of video game play in healthy male adolescents is associated with an increased food intake, regardless of appetite sensations. The trial was registered at clinicaltrials.gov as NCT01013246.  

INTRODUCTION

Video games have enormous mass appeal and are omnipresent in the daily schedule of most children and teenagers. As of 1999, video games accounted for 30% of the US toy market, which helped the video game industry to earn between $6 and $9 billion, outselling even the motion picture industry (1, 2). Nearly all American teens (97%) aged 12–17 y play computer, web, console, or mobile games (3). Nearly one-third (31%) of teen gamers play games every day, and another 1 in 5 (21%) play games 3–5 d/wk (3).

The increased prevalence of electronic game play (computer and video games) has been paralleled by an increase in body weight and has prompted researchers to examine the effect of this medium on various aspects of health (4). Because electronic games are relatively new devices, older epidemiologic studies had lower prevalent usage and generally found no association with obesity (5, 6). Recent observational studies, however, are more consistent in showing a direct connection between electronic games and overweight as well as obesity (7–10). In particular, a study from Switzerland found a nearly 2-fold increased risk of obesity for every hour spent playing electronic games daily (11). An inverse relation between time spent playing seated video games and daily physical activity has also been reported (12). In addition, playing computer games has been shown to reduce the time that teenagers spend on meals (13).

Studies that examined the link between electronic games and obesity are limited by their observational design and were mainly aimed at linking the sedentary nature of this activity with the increased risk of being overweight or obese. No experimental study to date has tested the potential of sedentary video games to induce an increased spontaneous energy intake. This issue is of particular importance, because recent experimental studies have shown an overconsumption of food with the practice of computer-related activities (14, 15). The objective of the current study was to investigate the acute effects of video game playing on components of energy balance. We hypothesize that video game playing is accompanied by increased spontaneous food intake in a way that could favor a positive energy balance and potential weight gain in the long run.

SUBJECTS AND METHODS

Subjects

Twenty-two healthy, normal-weight (5th percentile to less than the 85th percentile) male adolescents between 15 and 19 y of age...
were recruited for the study via advertisements and by word of mouth. Given the exploratory nature of this study, we decided to restrict our investigation to males only to avoid unnecessary complexity into the design. Volunteers were excluded from participation for any of the following reasons: smoking, unstable body weight (±4 kg) during the 6 mo preceding testing, regular physical exercise (>3 h/wk), excessive intake of alcohol (>7 drinks/wk), substance abuse, metabolic disease (eg, thyroid disease, heart disease, and diabetes), medication use that could interfere with the outcome variables, eating disorder, highly restrained eating behavior (score of ≥10 for cognitive dietary restraint on the Three-Factor Eating Questionnaire), irregular eating pattern (eg, skipping breakfast), and inability to comply with the protocol. All subjects (or the parents of subjects aged <18 y) gave written informed consent to participate in this study, which received approval from the Municipal Ethical Committee of Copenhagen and Frederiksberg. Volunteers participated in 3 visits: an information meeting (preliminary visit aimed at discussing the procedures and protocol requirements) and the 2 actual experimental conditions. Vigorous physical activity was not allowed 24 h before testing, and a normal sleep schedule had to be respected for the 3 d before testing. The subjects were required to arrive at the University of Copenhagen research laboratory in a fasting state and were in good health on the test days.

Study protocol

We used a within-subject experimental design, in which each participant was engaged, in a random order, in each of the 2 following 1-h conditions, both of which followed by an ad libitum lunch: 1) rest in a sitting, relaxing position on a comfortable chair (control condition) and 2) video game play. These 2 conditions were randomly assigned by using a computerized randomization scheme. The video game FIFA 09, a soccer video game played on Xbox 360 (Microsoft, Redmond, WA), was selected on the basis that the game is easy to learn, is popular, and can be played in 1 h. Instructions on how to operate the video game were given to the participants during the preliminary visit and again immediately before the video game play condition. The participants were encouraged to do their best and were told that they were competing against other players in the study. A gift certificate (value of 1200, 500, and 300 Danish krone) was given to the top 3 scorers to stimulate competitive engagement while playing the game.

One at a time, on 2 different occasions 1–4 wk apart, the participants arrived at the laboratory at 0730 after fasting overnight. Visual analog scales were used to record subjective measures of appetite at 0745, and the participants were provided breakfast at 0800, the caloric content of which corresponded to 25% of the estimated daily energy requirement. The participants then had to refrain from eating until the ad libitum lunch. The 1-h experimental intervention consisted of 1 of the 2 testing conditions, starting at 1030. The participants were asked to relax on a comfortable chair (without any mental workload) between the end of the breakfast and the beginning of the testing condition. Blood samples were collected every 10 min during the experimental conditions, and energy expenditure was assessed by using indirect calorimetry during the concomitant time period. The participants were thereafter given an ad libitum test lunch to evaluate spontaneous energy intake. The meals served (breakfast and ad libitum test lunch) were representative of standard meals in Denmark, ie, foods that boys were likely to be familiar with and to like. A schematic overview of the study protocol is shown in Figure 1.

Anthropometric measurements

Body weight, height, and waist circumference were measured according to standardized procedures recommended at the Airlie Conference (16). Body mass index (BMI) was calculated as body weight divided by height squared (in kg/m²). For participants aged <18 y, age- and sex-specific cutoffs linked to adult cutoffs proposed by Cole et al (17) were used to determine BMI.

Breakfast

The breakfast given to participants after a 12-h overnight fast provided 25% of the estimated daily energy requirement (10% of energy as protein, 30% of energy as fat, and 60% of energy as carbohydrate). All subjects were given the same breakfast. The meal consisted of carrot Kaiser buns, butter, raspberry jam, hazelnut-flavored sweet spread (Nutella; Ferrero, Malmö, Sweden), cheese, and orange juice. The meal was designed to match requirements in a controlled weight-maintenance diet, estimated from average basal energy expenditure equations (18). All participants consumed the entire breakfast within 15 min.

Ad libitum lunch

To measure spontaneous energy intake in an experimental context, the participants were offered an ad libitum lunch

![Figure 1](https://academic.oup.com/ajcn/article-abstract/93/6/1196/4597697/346x65)
immediately after each experimental condition. The ad libitum meal was spaghetti bolognese (961 kJ/100 g; macronutrient composition: 15% of energy as protein, 30% of energy as fat, and 55% of energy as carbohydrate) and 200 mL tap water. The participants were instructed to eat at a constant pace and to stop eating when they felt satiated. They had a maximum of 30 min to consume the meal, and the serving of pasta was larger than the expected intake (900 g offered). The meal was weighed before the lunch, and the uneaten portion was weighed after the lunch. Ad libitum energy intake was assessed by a food technician using calculations performed on the amount of the meal consumed. The ad libitum test meal has been shown to be reproducible in our laboratory (19).

Visual analog scales
The participants were instructed to fill in 8 visual analog scales for their sensations of hunger, satiety, prospective food consumption, fullness, and desire to eat something sweet, salty, rich in fat, or meat/fish. They also rated their opinion on the general palatability of the meal and on the overall perceived mental workload of the experimental conditions (from “not cognitively demanding at all” to “extremely demanding”). The visual analog scales is a line (100 mm in length) with statements anchored at each end, expressing the most positive and the most negative rating of the subjects’ appetite sensations. The visual analog scales have been shown to be both reproducible and valid for measuring appetite sensations in our laboratory (20). Although visual analog scales have not been validated in this young population, it is the assessment method of choice for appetite sensations. The visual analog scales were completed on several occasions during each experimental condition: at fasting (0745), before the experimental condition (1015), immediately after the experimental condition (1135), and immediately after the ad libitum lunch.

Dietary record
All participants were instructed to complete a dietary record after each experimental condition for the evaluation of the degree of potential compensation in food intake for the rest of the day (21). The research coordinator explained to every participant how to complete the record until bedtime and how to measure quantities of ingested foods. Mean energy and macronutrient intakes were calculated by using a computerized version of the Danish Nutrient Database, Dankost 3000 (version 1.4C; National Food Agency of Denmark, Søborg, Denmark). The dietary records were returned to the study staff in person or by using a prepaid envelope. All food records were complete.

Respiratory measurements
Energy expenditure in each 1-h experimental condition was measured by indirect calorimetry with the use of a face mask as described in detail elsewhere (22). Indirect calorimetry measurements were performed for the whole 1-h period. Energy expenditure was calculated by using the formula of Weir, assuming a fixed protein catabolism (23). The ventilated-hood system (Jaeger Oxycon Pro, Cardinal Health Care GmbH, Hoechberg, Germany) was validated by using an alcohol burning test on a weekly basis with a CV of 1.5%.

Heart rate variability and blood pressure measurements
Heart rate variability (HRV) represents the fluctuation of heart rate around mean heart rate and provides valuable information on the activity of the cardiac autonomic nervous system. We recorded beat-to-beat (RR) heart rate intervals during each 1-h experimental condition using an Actiheart (Camntech, Cambridge, United Kingdom). The ratio of low-frequency to high-frequency power (LF/HF ratio) in the frequency spectrum of RR intervals was used to obtain a marker of sympathovagal balance (24). Increases in the LF/HF ratio are associated with increased sympathetic tone. Furthermore, seated blood pressure measurements were obtained with the use of an electronic device (A&D Instruments LTD, Abingdon, United Kingdom) according to standardized procedures. The blood pressure measurements were taken at both 0750 and halfway through the experimental condition (1100).

Biochemical analyses
Blood samples were drawn through an indwelling superficial forearm catheter at several time points during each 1-h experimental condition (−10, 0, 10, 20, 30, 40, 50, and 60 min). Approximately 8 mL blood was obtained from the nondominant forearm at each time point under standardized laboratory conditions. Samples were drawn into heparinized tubes, centrifuged, separated into aliquots, and frozen at −80°C until analyzed. Samples from each subject were analyzed continually in a single batch to eliminate assay variation. Blood samples were analyzed for plasma glucose [measured enzymatically (ABX Pentra 400, Montpellier, France), with intra- and interassay CVs of 0.75% and 2.1%, respectively], serum insulin [determined by chemiluminescent immunometric assay (Immulite, Los Angeles, CA), with intra- and interassay CVs of 2.6% and 7.4%, respectively], serum cortisol [determined by chemiluminescent immunometric assay (Immulite), with intra- and interassay CVs of 5.2% and 7.7%, respectively], and total plasma ghrelin [determined by enzyme-linked immunosorbent assay (Millipore, Billerica, MA), with intra- and interassay CVs of 4.0% and 7.8%, respectively].

Questionnaires
In an attempt to better characterize the adolescents, 3 questionnaires (Danish version) were administered during the preliminary visit. The 51-item Three-Factor Eating Questionnaire (25) was used with the particular purpose of verifying that the subjects were not restrained eaters. The purpose of this questionnaire is to assess 3 factors related to cognition and eating behaviors: cognitive dietary restraint (intent to control food intake), disinhibition (overconsumption of food in response to cognitive or emotional cues), and susceptibility to hunger (food intake in response to feelings and perceptions of hunger). This questionnaire has been validated, and its 3 scales have been reported to show good test-retest reliability (25, 26). In addition, each participant completed the Pittsburgh Sleep Quality Index (27), a self-rated questionnaire that assesses sleep quality and disturbances over the preceding month. Sleep hygiene was assessed in this study because sleep duration has been shown to influence appetite sensations (28). A total score >5 is associated with poor sleep. Finally, Cohen’s Perceived Stress Scale (29) was completed to evaluate the level of stress in the participants’
everyday life. This questionnaire contains 10 questions, and a score <10 indicates good management of stress.

Statistical analysis

The power calculation analysis showed that data from 22 subjects gave us a power \((1 - \beta)\) of 0.9, which was sufficient to show changes in energy intake as low as 5%, with an \(\alpha\) of 0.05 (repeated-measures analysis of variance; ANOVA). Before the statistical analysis was conducted, all data were tested for normality by using the Shapiro-Wilk W test and variance homogeneity. A repeated-measures ANOVA was conducted on the means of all variables. Analyses of glucose and hormonal data were based on repeated-measures ANOVA, including the factors “condition” (video game playing compared with resting) and “time” (7 time points). Pairwise comparisons of single time point values were performed by using a paired Student’s t test. Correlation analyses were used to explore the relation between ad libitum energy intake and different variables. Effect sizes were examined by using Cohen’s \(d\) method, reflecting the magnitude of the difference between groups in SD units. Cohen’s \(d\) is computed by subtracting the average score for the control group from the average score for the video game play group and then dividing the difference by the pooled SD. Effect sizes are considered negligible if <0.2, small if between 0.2 and 0.5, moderate if between 0.5 and 0.8, and important if >0.8. Differences were considered significant at \(P < 0.05\). Data are presented as means ± SDs unless otherwise specified. All statistical analyses were performed by using SPSS Statistics 18.0 (SPSS Inc, Chicago, IL).

RESULTS

Participants’ characteristics

The descriptive characteristics of the subjects enrolled in the present study are shown in Table 1. None of the subjects were restrained eaters, and they all had low disinhibition and susceptibility to hunger scores. In addition, they had a fairly good sleep quality in general and moderately high perceived stress in their everyday life.

Stress markers

As expected, heart rate and systolic and diastolic blood pressures were significantly higher during the video game play condition than during the resting condition \((P < 0.01; \text{Table 2})\). The video game play condition was also characterized by an increased sympathetic tone, as reflected by the significantly higher LF/HF ratio \((P < 0.05)\). Finally, mental workload was significantly higher in the video game play condition than in the resting condition, as expected \((P < 0.01)\).

Energy balance

We observed that energy expenditure was significantly higher during the video game play condition than during the resting condition (mean increase over resting: 89 kJ; \(P < 0.01; \text{Figure 2}\)). However, ad libitum energy intake after the video game play condition exceeded that measured after rest by 335 kJ \((P < 0.05)\), resulting in a positive energy balance of 246 kJ (59 kcal).

\[ P < 0.05 \] after 1 h of video game play. Interestingly, the eating time was the same in both conditions \((12.6 \pm 2.7 \text{ compared with } 12.8 \pm 2.4 \text{ min for the resting and video game play conditions, respectively}); but did not result in a significantly different eating rate \((211 \pm 86 \text{ kJ/min compared with } 231 \pm 87 \text{ kJ/min for the resting and video game play condition, respectively, } P = 0.10)\). The effect size was large for the difference in energy expenditure between both experimental conditions \((\text{Cohen’s } d \text{ value: } 1.47)\) and small for the difference in ad libitum energy intake \((\text{Cohen’s } d \text{ value: } 0.32)\). Correlation analyses between ad libitum energy intake and other variables (eg, stress markers, mental workload, and eating behaviors) did not show any significant associations (data not shown).

Table 1

\textbf{Table 1}

Descriptive characteristics of adolescents\(^1\)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Value ((n = 22))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>16.7 ± 1.1</td>
</tr>
<tr>
<td>Body weight (kg)</td>
<td>68.7 ± 8.8</td>
</tr>
<tr>
<td>BMI (kg/m(^2))</td>
<td>21.5 ± 1.9</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>77.5 ± 6.9</td>
</tr>
<tr>
<td>Three-Factor Eating Questionnaire</td>
<td></td>
</tr>
<tr>
<td>Cognitive dietary restraint</td>
<td>3.86 ± 2.70</td>
</tr>
<tr>
<td>Disinhibition</td>
<td>4.73 ± 2.16</td>
</tr>
<tr>
<td>Susceptibility to hunger</td>
<td>5.82 ± 2.42</td>
</tr>
<tr>
<td>Pittsburgh Sleep Quality Index score</td>
<td>4.67 ± 1.62</td>
</tr>
<tr>
<td>Cohen’s Perceived Stress Scale score</td>
<td>11.6 ± 3.1</td>
</tr>
</tbody>
</table>

\(^1\) All values are means ± SDs.

Appetite control

We used 8 visual analog scales to quantify subjective appetite sensations. The visual analog scales were administered at 4 time points during each visit \((0745, 1015, 1135, \text{ and after the ad libitum lunch})\). The participants ate significantly more at the ad libitum lunch after the video game play condition, but no significant difference in appetite sensations was observed between the 2 experimental conditions (data not shown). In addition, we evaluated the compensation in food intake for the rest of the day with the use of a dietary record \((\text{Table 3})\). We observed no

Table 2

\textbf{Table 2}

Assessment of heart rate variability (HRV) and mental workload during the two 1-h experimental conditions\(^2\)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control</th>
<th>Video game play</th>
<th>Effect size(^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (beats/min)</td>
<td>66 ± 7</td>
<td>76 ± 10*</td>
<td>1.27</td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>109 ± 11</td>
<td>122 ± 15*</td>
<td>0.99</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>68 ± 8</td>
<td>78 ± 13*</td>
<td>0.93</td>
</tr>
<tr>
<td>HRV (LF/HF ratio)</td>
<td>2.03 ± 1.28</td>
<td>2.43 ± 1.26**</td>
<td>0.32</td>
</tr>
<tr>
<td>Mental workload (VAS score)</td>
<td>18 ± 20</td>
<td>49 ± 25*</td>
<td>1.40</td>
</tr>
</tbody>
</table>

\(^1\) All values are means ± SDs; \(n = 22\). LF, low frequency; HF, high frequency; VAS, visual analog scale. Comparisons between groups were analyzed by repeated-measures ANOVA, and effect sizes were examined by using Cohen’s \(d\) method. \(*\*,**Significantly different from the control value: \(\ast P < 0.01, \ast\ast P < 0.05\).

\(^2\) Effect sizes were considered negligible if <0.2, small if between 0.2 and 0.5, moderate if between 0.5 and 0.8, and important if >0.8.
compensation in food intake in either of the 2 experimental conditions.

Hormonal profiles

As shown in Figure 3, repeated-measures ANOVA showed that plasma glucose concentrations increased significantly more during the video game play condition than during the resting condition (P < 0.01 for time × condition interaction). Concentrations of serum insulin decreased during the 2 experimental conditions (P < 0.01 for time), but the differences were not significantly different between conditions (time × condition interaction: P = 0.16). Likewise, concentrations of serum cortisol decreased during the two 1-h experimental conditions (P < 0.05 for time), but did not differ between conditions (time × condition interaction: P = 0.13). Analyses of total plasma ghrelin concentrations did not result in any significant differences.

DISCUSSION

Collectively, our data provide preliminary evidence in male adolescents that playing a video game for 1 h is accompanied by a greater caloric intake at a subsequent ad libitum meal than is relaxing on a comfortable chair for 1 h (control condition). Moreover, the overconsumption of food after playing video games was observed without increased subjective sensations of hunger and appetite—an observation that is supported by the objective markers of appetite, ie, profiles of appetite-related hormones and substrates that were not suggestive of an up-regulation of appetite. It is, however, unknown whether “eating in the absence of hunger” is related more to an impairment in satiety signal capacity or to the mental stress–induced reward system.

The issue of “mental stress” associated with video game playing is of particular interest and might partly explain the increase in food intake associated with this sedentary activity. The higher sympathetic tone and mental workload in the video game play condition than in the resting condition is consistent with other studies that have found significant increases in various stress markers with seated video game playing in children and adults (30, 31). Furthermore, these results agree with recent experimental studies showing that computer-related activities represent a particular type of sedentary activity—they are stressful and biologically demanding for the body (14, 15). Moreover, computer-related activities have also been reported to promote overconsumption of food without increased sensations of hunger and appetite (14, 15). These observations suggest that mental workload might add a new component to the notion of “sedentariness,” by increasing the positive energy gap that is more likely to occur when one is inactive.

The significantly higher energy expenditure during the 1-h video game play condition (89 kJ over resting) agrees with previous studies in the field (30–32). Although statistically significant, the modest increase in energy expenditure during video game play should not be regarded as a means of promoting energy expenditure, and the seated gaming environment should still be considered “sedentary.” In contrast, the clinical implication of an energy surplus of 335 kJ (80 kcal) in spontaneous food intake after 1 h of video game play is not trivial and may contribute to the energy gap underlying obesity. This energy gap might be even greater if we account for the surplus of 436 kJ measured for the rest of the day with the use of a dietary record. Interestingly, it has been estimated that reducing the energy gap by 100 kcal/d could prevent weight gain in most of the population (33).

The observation that participants were not hungrier after the video game play condition than after the control condition but ate more at the ad libitum lunch was not unexpected in the light of the relevant literature in this field of investigation. Indeed, it has increasingly been recognized that television viewing increases food intake regardless of appetite sensations (34, 35). Likewise, recent experimental studies have reported that computer-related activities increase spontaneous food intake without increased sensations of hunger and appetite (14, 15). Additionally, results from a recent randomized crossover study have shown that an acute psychological stress (mental arithmetic task) was associated with eating in the absence of hunger (36). The disconnection between subjective appetite sensations and measured energy intake is very interesting, and we speculate that playing video games impairs satiety signal capacity and/or solicits the mental stress–induced reward system. Future research should include novel brain imaging techniques during video game play in an attempt to identify brain areas that might be linked to increased

TABLE 3

Mean energy and macronutrient intakes for the rest of the day in each of the experimental conditions

<table>
<thead>
<tr>
<th>Intake</th>
<th>Control</th>
<th>Video game play</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total energy (kJ)</td>
<td>6057 ± 2368</td>
<td>6493 ± 2223</td>
</tr>
<tr>
<td>Fat (kJ)</td>
<td>1783 ± 1006</td>
<td>2062 ± 1004</td>
</tr>
<tr>
<td>(%)</td>
<td>28.6 ± 10.4</td>
<td>31.0 ± 7.5</td>
</tr>
<tr>
<td>Carbohydrate (kJ)</td>
<td>3205 ± 1498</td>
<td>3466 ± 1220</td>
</tr>
<tr>
<td>(%)</td>
<td>52.4 ± 11.5</td>
<td>53.5 ± 7.5</td>
</tr>
<tr>
<td>Protein (kJ)</td>
<td>1067 ± 446</td>
<td>947 ± 292</td>
</tr>
<tr>
<td>(%)</td>
<td>19.0 ± 7.9</td>
<td>15.3 ± 3.8</td>
</tr>
</tbody>
</table>

1All values are means ± SDs; n = 22. Comparisons between groups were analyzed by repeated-measures ANOVA. There were no significant differences between experimental conditions.
spontaneous food intake. Furthermore, future research is recommended to elucidate faster eating after video game play, because previous studies have reported that a higher eating rate is related to higher weight (37, 38).

The absence of difference in appetite sensations between both conditions is in line with the profiles of plasma glucose and appetite-related hormones. Indeed, no significant differences in the profiles of serum insulin and cortisol and total plasma ghrelin (no time × condition interaction) were observed between conditions. In contrast, the concentrations of plasma glucose increased more during the video game play condition than during the resting condition. This difference probably reflects the higher release of glucose into the bloodstream by the liver in response to acute stress (fight-or-flight response). According to the glucostatic theory of appetite control (39, 40), an increase in blood glucose concentrations is expected to result in increased sensations of satiety. However, the increased food intake observed in the video game play condition was observed after the increase in blood glucose. Hence, the finding of an association between “eating in the absence of hunger” and video game play emphasizes that the nonhomeostatic hedonic component of feeding behavior plays an important role. These observations also suggest that our quest for reward and pleasure is not finely tuned to our biology, and the development of coping strategies is needed.

The main limitation of the current study was its controlled laboratory setting, whereby only healthy normal-weight male adolescents were recruited; this limited the generalizability of our results to the whole population. In free-living conditions, teenagers generally play video games for >1 h and together with friends. The presence of others (social facilitation) has been repeatedly reported to increase food intake (41, 42). Furthermore, teenagers also have access to palatable food while playing electronic games in a real-world setting and not only after the game. Here again, one might expect a higher spontaneous food intake associated with the use of video games, because of its level of distraction and its demand on attention resources, as is also seen with television viewing (34, 35). Additionally, the small sample size and preliminary nature of this investigation precluded any definitive conclusion. We hope that the results of the current study will generate larger and well-designed studies to address this issue in a timely fashion. Finally, the limitations of self-reported data (eg, visual analog scales and dietary records) should be considered.

With the advent of new-generation active video games, future research will need to distinguish between “active” and “passive” video games. Manufacturers have produced games that require players to dance, play the guitar or drums, and replicate the actions used in athletic competition. Not surprisingly, such active gaming has been shown to result in meaningful increases in energy expenditure and heart rate compared with the seated screen environment (43–45). Manipulating the gaming environment offers an appealing alternative for increasing energy expenditure in children and teenagers, who would otherwise be
spending time in sedentary screen-based activities, and testing whether active gaming interventions can provide sustainable increases in physical activity is needed. The net effect of active gaming on energy balance, however, is unknown and it cannot be excluded that children may compensate for the increased energy expenditure by increasing their energy intake more than after comparable traditional physical activity. This might particularly be the case with online gaming that is laden with targeted advertising for high-calorie beverages and food.

In conclusion, our results show that video game play in male adolescents induces a high spontaneous energy intake, regardless of appetite sensations. The increased food intake associated with video game play is a novel finding and is instrumental in gaining a better insight into the determinants of obesity. Given that gaming media are rapidly becoming the leisure-time activity of choice for most children and teenagers, a better understanding of the influence that these distinctive activities have on energy intake is desirable.

We express our gratitude to the participants for their excellent collaboration and to the staff of the Department of Human Nutrition for their skilled technical assistance.

The authors’ responsibilities were as follows—J-PC, AT, AA, and AS: designed the research; J-PC, AT, SN, and TP: conducted the research; J-PC, AT, SN, LK, and NTG: analyzed the data; J-PC: wrote the manuscript; and J-PC: had primary responsibility for the final content. All authors read and approved the final manuscript. The funding organization played no role in the design, implementation, analysis, or interpretation of the data. The authors declared no conflicts of interest.

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