Negative social evaluation impairs executive functions in adolescents with excess weight: Associations with autonomic responses.

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Abstract

Background: Adolescents with excess weight suffer social stress more frequently than their peers with normal weight.

Purpose: To examine the impact of social stress, specifically negative social evaluation, on executive functions in adolescents with excess weight. We also examined associations between subjective stress, autonomic reactivity and executive functioning.

Methods: Sixty adolescents (aged 13-18 years) classified into excess weight or normal weight groups participated. We assessed executive functioning (working memory, inhibition and shifting) and subjective stress levels before and after the Trier Social Stress Task (TSST). The TSST was divided into two phases according to the feedback of the audience: positive and negative social evaluation. Heart rate and skin conductance were recorded.

Results: Adolescents with excess weight showed poorer executive functioning after exposure to TSST compared to adolescents with normal weight. Subjective stress and autonomic reactivity were also greater in adolescents with excess weight than adolescents with normal weight. Negative social evaluation was associated with worse executive functioning and increased autonomic reactivity in adolescents with excess weight.

Conclusions: The findings suggest that adolescents with excess weight are more sensitive to social stress triggered by negative evaluations. Social stress elicited deterioration of executive functioning in adolescents with excess weight. Evoked increases in subjective stress and autonomic responses predicted decreased executive function. Deficits in executive skills could reduce cognitive control abilities and lead to overeating in adolescents with excess weight. Strategies to cope with social stress in order to prevent executive deficits could be useful to prevent future obesity in this population.

Keywords: Obesity; adolescence; social stress; executive functions; autonomic reactivity

INTRODUCTION

Overweight and obesity in adolescence have sharply increased over recent decades, reaching epidemic levels (1). The socioeconomic changes that have occurred in recent decades in Western societies, associated with the unlimited access to food, have modified the way we perceive food and regulate intake. These processes are increasingly influenced by a variety of factors besides homeostatic regulation, like sensory cues (e.g., taste, smell, texture and appearance), availability, motivational and affective states, pleasure seeking, etc. All of these factors influence what and how much people eat even when they are not hungry (2). In the last few years, obesity is being increasingly considered as a brain-related dysfunction similar to that occurring in addictions (3), where the motivational value of highly palatable food is significantly increased, while the top-down or executive control mechanisms that would normally regulate reward-driven responses are diminished (4, 5). Executive control mechanisms are relevant to the regulation of eating behavior (6), since they allow for adjustment of behaviour in a flexible way in situations that require a change in a strong habitual response or resistance to temptation (7). The abnormal interaction between reward signal processing and executive control functioning has also been related to a tendency to select immediate and appetizing (high in calories and/or sugar) rewarding choices, although these have negative consequences in the long term (8, 9). The imbalance between these two systems can be greater in adolescence, a period characterized by the relative immaturity of the prefrontal cortex, responsible for executive control, in addition to the relative maturity of striatal areas responsible for reward processing (10). Therefore, during adolescence, the activity of rewards system may prevail over that of executive control mechanisms (11).

Another factor that can impair top-down control mechanisms is stress. Stress has a harmful impact on cognitive skills, such as attention, cognitive control and decision-making, which may contribute to obesity-related behaviours in adolescents (12). Furthermore, psychosomatic theories hold that people with obesity tend to eat in response to emotional distress, showing an "emotional eating pattern" (i.e., consuming food impulsively) when under negative emotional states (13). Stress can also enhance the propensity to eat high calorie "palatable" food via its interaction with central reward pathways (14). For example, ghrelin and cortisol increase in response to social stressors and influence reward motivation, thus modulating consumption of appetizing food (15, 16)

During adolescence, peer relations are particularly salient and can serve as a robust source of distress (17). Adolescents with excess weight suffer from social stress, such as bullying or social marginalization-exclusion, more frequently than their peers (18), being subjected to frequent teasing about their body (19). Negative stereotypes toward peers with excess weight begin early in childhood (20) and these social stressors can negatively affect social adjustment and academic achievement (21). In this context, study of the detrimental influence of social stress on executive functions may be of crucial importance to understand deficient diet-related decision-making and poor emotional-regulation-related overeating in adolescents.

Several studies have found deficits in executive functioning in adults and adolescents with excess weight (22-25). However, to the best of our knowledge, no study has analyzed the influence of social stress on executive functions in adolescents with excess weight. Therefore, this study examined the effect of a social stressor on executive performance in adolescents with excess *versus* normal weight. For this purpose, the Trier Public Speaking Stress Social Task (TSST) (26, 27) was used. We analyzed the specific influence of negative social evaluation on executive functioning and autonomic responses in adolescents with overweight. We hypothesized that excess weight adolescents would show decreased executive performance after exposure to social stress relative to normal weight adolescents. Outcome measures were working memory, cognitive inhibition, and shifting (ability to follow different rules in a task and change between them). Additionally, subjective and physiological (autonomic) indexes of stress were recorded. For this purpose, heart rate (HR) and skin conductance (SC) were continuously recorded during the TSST. Since adolescents with overweight are more often exposed to negative peer evaluations than adolescents with normal weight (18, 19), we expected greater increases in perceived stress, HR and SC in excess *versus* normal weight participants during the TSST. Furthermore, negative associations between stress-induced subjective and physiological responses and post-TSST executive performance were hypothesized.

METHOD

Participants

Sixty adolescents, 25 males and 35 females between 13 and 18 years of age, participated. They were selected based on their sex and age-adjusted BMI percentile in accordance with the guidelines of the International Obesity Task Force (IOFT) (28). Normal weight participants (n=30) had BMIs ranging between the 5^{th} and 84^{th} percentiles, and excess weight participants (n=30) had BMIs > the 85^{th} percentile. Table 1 displays the socio-demographic, BMI and body fat percentage data. Participants were recruited from high schools located in Jaén (Spain). They were screened for medical and developmental conditions, medication use, and learning disabilities. Inclusion criteria were: (i) aged range between 13 and 18 years; (ii) BMI > 5^{th} percentile; and (iii) no history of neurological, psychiatric or eating disorders [measured using the Eating Disorder Inventory (EDI-2)]. All participants had normal or corrected-to-normal vision.

Executive Measures

Working memory–Letter-Number Sequencing (29): Participants were read a sequence in which letters and numbers were combined, and were asked to reproduce the sequence, first putting the numbers in ascending order and then the letters in alphabetical order. The sum of the correct answers was considered.

Inhibition and shifting–Five-digit test (FDT (30): The FDT consists of four conditions of increasing complexity. Conditions 1 and 2 evaluate processing and response speed. In condition 3 (inhibition), participants have to count the number of digits contained within various boxes, which constitutes an interference effect because the boxes contain groups of digits that do not correspond to their arithmetic value. Finally, in part 4 (shifting), participants have to count or read, depending on whether the outline of the box is normal (count, 80% of stimuli) or of double thickness (read, 20% of stimuli). The difference in performance time between part 3 and the mean of parts 1 and 2 (inhibition score), and the difference in performance time between part 4 and the mean of parts 1 and 2 (shifting score), were considered. Thus, a higher score denotes worse performance (i.e., the participant took more time). Errors in parts 3 (inhibition) and 4 (shifting) were also analyzed.

Social stress task

To induce social stress in the laboratory, a validated Virtual Reality version of the Trier Social Stress Task (TSST-VR) was used (26). This version of the TSST was previously used in young people and has been shown to produce a significant increase in subjective stress and arousal, skin conductance and cortisol levels (27, 31). Participants had to deliver a speech about their personal characteristics, including both positive and negative aspects, in front of a simulated audience. The task is divided into two parts (each 2 min 30 s long). In the first task, the audience was interested and attentive to the speech, giving nods of understanding to the participant (i.e., positive social evaluation). In the second part, the audience began to show signs of disagreement with the speech, talking and murmuring among themselves and criticising the participant´s words (i.e., negative social evaluation). The task included four phases: a baseline rest period (3 min), delivery of the task instructions and preparation for the speech by the participant (3 m), speech during positive social evaluation, and speech during negative social evaluation. This virtual reality version of the TSST is able to induce modest but significant increases in cortisol and subjective stress responses (26).

Procedure

After obtaining permission from the high school´s directors, the study was presented to each class of students and their participation was requested. The students who were interested in taking part sent us the informed consent form, which was signed by their parents if they were minors. Then, the participants were assigned to a group and a specific day on which to complete the experimental session. Six high schools in Jaén participated in the study. The recruitment rate was approximately 4% of the total number of students approached. Sessions started at 4 p.m. and participants were required to be satiated (having had lunch about 1 hour before) and to not have taken any caffeine. Weight and height were self-reported by participants for recruitment purposes and BMI was calculated in the laboratory, using the exact height and weight data collected on arrival. Body composition measures were also collected using the Bodystat®1500 monitoring unit. The EDI-2 (32), validated in young people, was administered to rule out eating disorders (binge eating, anorexia nervosa and bulimia nervosa). Then, executive functioning measures were conducted before TSST onset (pre-TSST) and immediately after completion of the TSST (post-TSST). The post-TSST evaluation was administered immediately after TSST. During the two evaluations, participants first completed the Letter-Number Sequencing and then the Five Digit Test. Subjective stress was measured by a visual analogue scale (VAS, ranging from 1 to 10; no stress to extreme stress) before and after exposure to TSST. The virtual reality TSST was carried out in a soundproof room, with white walls and without any distracting stimuli. The equipment consisted of a computer running the program containing the social scenes, and a projector for their display on the wall. Previous validation studies indicated increases in skin conductance and salivary cortisol during the task, both when scenes were presented via goggles or projected on to a screen (31). However, participants rated task immersion as being higher with the wall-screen presentation versus the goggles (31). Surround-sound headphones were used to allow perception of the sound emanating from the room where the audience was situated, and the murmurs and comments of the listeners. The Ethics Committee of the Universidad de Jaén approved the study. Both participants and parents signed informed consent forms.

Psychophysiological Data Acquisition and Processing

HR and SC were continuously recorded during the TSST using a Biopac MP150 polygraph (Biopac Systems Inc., USA). HR (beats per minute) was derived from an electrocardiogram (ECG) recorded at 1000 Hz. ECG electrodes (Ag/AgCl) were attached to the participant’s right mid-clavicle and the lowest left rib (left wrist as the ground). HR was extracted from ECG recordings using the software AcqKnowledge 3.9.1 (Biopac Systems Inc.) and edited for artifacts (when present) via linear interpolation. SC (micro-Siemens, μS) was recorded at a sampling rate of 500 Hz using Ag–AgCl electrodes filled with an inert 0.05 M NaCl electrolyte cream and attached to the palmar surface of the second and third middle phalanges of the participant's non-dominant hand. Two participants (one from each group) had unusable SC recordings.

Statistical analyses

Group comparisons were carried out with Student's *t*-test for independent samples. Responses to the TSST were analyzed by repeated measures ANOVA with Time (pre- and post-TSST) as the repeated-measures factor and Group (Excess versus Normal weight) as the between-subject factor. Although the TSST consisted of four phases, given our specific interest in the effect of social evaluation, HR and SC analyses were restricted to the difference between the latter two parts of the TSST involving social evaluation (positive *versus* negative social evaluation). Associations between variables were analyzed by Pearson's correlations. To simplify the correlation analysis, change scores were computed as the difference between the post- and pre-TSST values.

RESULTS

Associations between measures

In the whole sample, the change in HR was positively associated with changes in stress VAS scores ($r=0.32$, $p=0.013$), "shifting errors" ($r=0.30$, $p=0.02$), "inhibition errors" ($r=0.38$, $p=0.003$) and the "shifting score" ($r=0.26$; $p=0.046$). The change in SC correlated inversely with the change in Letter-Number Sequencing ($r=-0.33$, $p=0.01$), and positively with the change in stress VAS scores ($r=0.26$, $p=0.047$). Finally, the change in stress VAS scores correlated positively with the change in "inhibition errors" ($r=0.46$, $p<0.001$). BMI was positively associated with post-TSST "inhibition errors" ($r=0.51$, $p<0.001$), "shifting errors" ($r=0.32$, $p=0.001$) and stress VAS scores ($r=0.31$, $p=0.015$).

Subjective stress

A Time x Group interaction was found for stress VAS scores ($F_{1,58}$=9.76, p=0.003, η_p^2=0.14). While in adolescents with excess weight stress levels increased from pre- to post-TSST evaluation ($F_{1,29}$= 65.89, p<0.001, η_p^2=0.69), the change in adolescents with normal weight did not reach significance ($F_{1,29}$=2.66, p=0.115, η_p^2=0.08) (Table 2).

Psychophysiological measures

No group differences were found in HR or SC during the pre-TSST evaluation. A Time x Group interaction was found for HR ($F_{1,58}$=8.26, p=0.006, η_p^2= 0.13) (Figure 1). While HR increased in adolescents with excess weight from the positive to the negative social evaluation phase of TSST ($F_{1,29}$=8.45, p=0.007, η_p^2=0.23), no change was observed in adolescents with normal weight ($F_{1,29}$=1.16, p=0.29, η_p^2 =0.04). A Time x Group interaction was also observed in SC ($F_{1,56}$=4.76, p=0.033, η_p^2=0.08) (Figure 2). While SC decreased in adolescents with normal weight from the positive to the negative social evaluation phase of the TSST ($F_{1,28}$=17.15, p<0.001, η_p^2=0.38), no change was observed in adolescents with excess weight ($F_{1,28}$=0.24, p=0.63, η_p^2=0.01).

Executive functions

During the pre-TSST evaluation, excess weight participants showed greater scores in the inhibition condition of FDT (i.e., lower inhibition) than normal-weight participants (t=2.08, p=0.042, δ=0.54). No other significant differences arose during pre-TSST (see Table 1). Significant Time x Group interactions were found for Letter-Number Sequencing ($F_{1,58}$=16.82, p<0.001, η_p^2 =0.23) (Figure 3), "inhibition errors" in FDT ($F_{1,58}$=31.34, p<0.001, η_p^2=0.35), "shifting errors" in FDT ($F_{1,58}$=10.80, p=0.024, η_p^2= 0.08) (Figure 4) and "shifting score" in FDT ($F_{1,58}$=15.47, p=0.039, η_p^2 =0.07). Adolescents with normal weight significantly increased their performance after the

TSST in Letter-Number Sequencing ($F_{1,29}$=26.14, p<0.001, η_p^2=0.47) and "shifting score" ($F_{1,29}$= 23.02, p<0.001, η_p^2=0.44) and decreased their "inhibition errors" (FDT) ($F_{1,29}$=6.59, p=0.01, η_p^2=0.19). By contrast, adolescents with excess weight increased their "inhibition errors" (FDT) ($F_{1,29}$=25.38, p<0.001, η_p^2=0.467) and, marginally, their "shifting errors" (FDT) ($F_{1,29}$=4.15, p=0.051, η_p^2=0.13).

DISCUSSION

Adolescents with excess weight, compared to those of normal weight, showed impairments in measures of inhibition and shifting, and higher subjective stress levels, in response to the TSST. Furthermore, adolescents with excess weight showed a differential psychophysiological pattern during the TSST. HR increased during the negative social evaluation phase (relative to the positive phase) in this group, while no change was observed in adolescents with normal weight. SC decreased in adolescents with normal weight from the positive to the negative social evaluation phase, suggesting habituation to the situation, but did not change in adolescents with excess weight. Skin conductance is a variable that usually displays a decrease over the recording period, denoting habituation to the situation. A flat recording, without any sign of decrease, is usually interpreted as indicating a high electrodermal level (33).

Our findings suggest that adolescents with overweight-obesity have enhanced sensitivity to social stressors. This is manifested both at subjective and physiological levels. Subjectively, the greater increase in stress levels indicates that adolescents with excess weight perceive the situation as more stressful than do adolescents with normal weight. At the physiological level, results indicate a greater mobilization of physiological resources and autonomic reactivity during social stress, particularly during negative social evaluation, in adolescents with excess weight. The most common motivation for using a public speaking task is that it elicits a social evaluation-related threat (34). The inclusion of the two phases of the TSST as a function of feedback from the audience (positive *versus* negative) allowed for a more specific analysis of social evaluation, making our results more innovative. Taken together, these results support the utility of differentiating between positive versus negative social evaluation during the TSST for the study of the impact of social stress on autonomic and cognitive functions.

The observed negative impact of social stress on executive functioning in adolescents with excess weight is consistent with a previous study which showed impaired attention after TSST in adolescents with excess weight compared to adolescents with normal weight (27). Negative emotional states in adults are known to impair cognitive capacity; for example, depressive symptoms in people with obesity impair executive function (35). Furthermore, emotional eating patterns, which are more prevalent in this population (15), may additionally affect executive functioning. Specifically, socially stressful situations evoke negative mood states and impair impulse control. The joint influence of executive deficits and emotional eating patterns would lead to further eating disinhibition. However, no previous studies have analyzed the effects of emotional states on executive functioning in adolescents with excess weight.

Inhibition, shifting and working memory were negatively affected by social stress in our excess weight adolescents. This suggests that social stress has a detrimental impact on executive functioning in these adolescents, and this may influence their eating behaviour. Usually, in pre-post cognitive evaluations, performance improves in the second evaluation due to practice effects arising from repeated administration (36, 37). In fact, in this study working memory improved significantly in the normal weight group from the pre- to post- TSST evaluation. However, adolescents with excess weight did not benefit from this learning experience, and in fact their performance decreased. A previous study (27) using the same experimental protocol also found increases in attention performance in normal weight participants from the pre- to post-TSST evaluation, while excess weight participants were unable to benefit from the practice effect. These results may be due to the greater levels of stress during the TSST in adolescents with excess weight. Stress negatively affects abilities that require conscious attention and effortful information processing, reducing therefore cognitive efficiency (38). Greater cortisol responses to the TSST were found in the previous study (27), and results of the present study showed higher heart rate and electrodermal reactivity to the social stress task in adolescents with excess weight. Furthermore, autonomic reactivity after TSST, specifically electrodermal response, correlated inversely with working memory performance in the whole sample. Therefore, the greater autonomic and stress response in adolescents with excess weight can increase stress interference in this group and therefore lead to a deficit in learning from the repeated administration of the tasks.

Executive functioning may have multiple direct and indirect influences on obesity in adolescence. Although available evidence links executive functioning and obesity (24, 39), the specific mechanisms mediating this association are less well-known. Some studies have found that executive dysfunction is associated with obesity-related behaviours in childhood and adolescence via increasing intake, disinhibiting eating, and reducing physical activity. The inability to inhibit impulses predicted higher food intake, a higher body weight and less weight loss after a weight reduction intervention (40). Deficits in inhibition can impact impulse control and thus the capacity to restrict intake of appetizing foods (high fat/sugar). Impairments in shifting may influence the capacity to regulate and modify eating behaviours in order to prevent harmful health consequences. Furthermore, this deficit may lead to adolescents with excess weight persisting in their unhealthy eating habits. Impairments in working memory could affect the ability to maintain cognitive control, making it more difficult to engage in healthy activities and intervention programs. Finally, disinhibited eating in obese adolescents was associated with reduced orbitofrontal volume and executive dysfunctions, which were most pronounced in terms of working memory and inhibition (41). Conversely, executive function skills were positively associated with healthy eating habits, such as fruit and vegetable intake, and physical activity (42, 43).

We observed group differences before social stress only in the "inhibition score" (FDT), with lower performance in excess than normal weight adolescents. However, no differences were found in shifting or working memory. These results are concordant with a previous study reporting selective alterations in inhibition in adolescents with obesity versus normal weight adolescents (43). Another study found selective alterations in inhibition and shifting, but not working memory, in excess weight and obese adolescents (24). In contrast, others authors found significant differences between obese and normal adolescents in working memory as well as attention, but not in intelligence or verbal fluency (44). Discrepancies between studies may be due to differences in testing methods, samples and levels of BMI.

As expected, the change in subjective stress was positively associated with the change in HR, SC and "inhibition errors" (FDT). This suggests that levels of subjective stress may modulate both psychophysiological responses and executive-inhibition functions. In this way, negative social evaluations may induce a greater increase in stress levels and autonomic responsiveness, and a reduction of inhibition capacity, in excess weight adolescents relative to those with normal weight. The deleterious influence of negative social evaluation on executive control in adolescents with excess weight may exacerbate difficulties in eating behaviour control, eventually triggering overconsumption.

The change in HR during social evaluation was positively associated with the change in "shifting errors", "inhibition errors" and "shifting score" in the whole sample. The change in SC was negatively associated with the change in Letter-Number Sequencing performance (i.e., greater habituation of skin conductance was associated with better working memory). These results suggest that modulation of autonomic activity by social stress may index, or additionally influence, executive functioning in adolescents with excess weight. This harmful effect on executive functioning may lead to problems in real life, such as poor regulation of eating habits. However, studies in adults also using the TSST did not find differences in HR, blood pressure or cortisol responses between obese and normal weight individuals (15). This discrepancy may be due to the non-inclusion of specific positive-negative evaluation phases in their TSST, or may reflect a greater vulnerability to social stress in adolescents than adults. In line with the greater autonomic response found in our study, a greater cortisol response after the TSST has been previously found in excess weight than in adolescents with normal weight (27).

Executive functioning is still developing during adolescence, since prefrontal areas reach full development at maturity (45). A growing body of literature suggests an altered balance between the earlier-developing limbic system and the later developing frontal/executive system (46) during adolescence. Furthermore, in this period, the opinions of peers and general social evaluation become a central aspect for self-image development (47). Adolescents with excess weight frequently suffer from negative social evaluations and social stressors during their everyday lives, which may lead to greater vulnerability to social stress, especially if a negative social evaluation component is included. It would be reasonable to assume that adolescents with excess weight would show a blunted stress response due to habituation to repeated stress exposure. However, previous studies using this same TSST protocol found greater increases in salivary cortisol in excess weight than in normal weight adolescents (27). These results suggest the development of a sensitization process to social stress in adolescents with excess weight.

Therefore, due to all of the factors listed above, adolescents with excess weight are an important target group for cognitive interventions based on stress regulation strategies, executive function improvement and prevention of harmful eating behaviours. In this regard, some evidence already suggests that executive functioning training for obese children can improve working memory, inhibition and shifting, being useful in weight-loss maintenance (48).

Regarding its strengths, our study used an innovative strategy to evaluate the impact of social stress, particularly negative social evaluation, on adolescents with excess weight, as well as the inclusion of autonomic variables as objective indices of stress. Among the limitations, we used a virtual reality audience in our TSST instead of the actual public, which might have decreased the realism of the situation and the stress-elicited responses. However, this version of the TSST was validated in previous studies and produced a reliable stress response (26, 27, 31). Furthermore, the inclusion in future studies of a non-stress control condition (also with two cognitive evaluations) is recommended to rule out more possible general disruption of cognitive processes in excess weight adolescents. Regarding the study design, the absence of any counterbalancing of the order of presentation of positive versus negative feedback conditions might have influenced the results. Therefore, this aspect should be taken into account in future studies. Additionally, we did not assess factors like emotional eating or loss of control in eating behaviour, which may be relevant to overeating. Finally, longitudinal studies are necessary to better analyse the influence of stress-induced executive functioning decrements on the propensity to overeat and become obese in the future in adolescents with excess weight.

In summary, our results showed a harmful impact of social stress, specifically negative social evaluation, on executive functioning of adolescents with excess weight. Adolescents with overweight performed worse after TSST in inhibition and shifting than those with normal weight, and they did not benefit from learning in the domain of working memory, in contrast to adolescents with normal weight. Furthermore, in association with the observed decreases in neuropsychological performance, adolescents with excess weight showed greater subjective and autonomic stress responses to negative social evaluation. Given the relevance of high order executive functions to self-control of eating behaviour (49, 50), the results presented herein highlight the value of assessing the social evaluation context, and how it may be associated with differential changes in cognitive functioning in adolescents with overweight. This stress-mediated impairment in cognitive functioning could increase the risk for future obesity. Interventions aimed at social stress coping strategies and improvement of executive functions could be useful in the prevention of obesity in adulthood.

Authors' Statement of Conflict of Interest. The authors declare no conflicts of interest.

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Figure 1

Figure 1. Mean heart rate (beats per minute) during the positive and negative social evaluation phases of the Trier Social Stress Task. Bars indicate standard error of the mean.

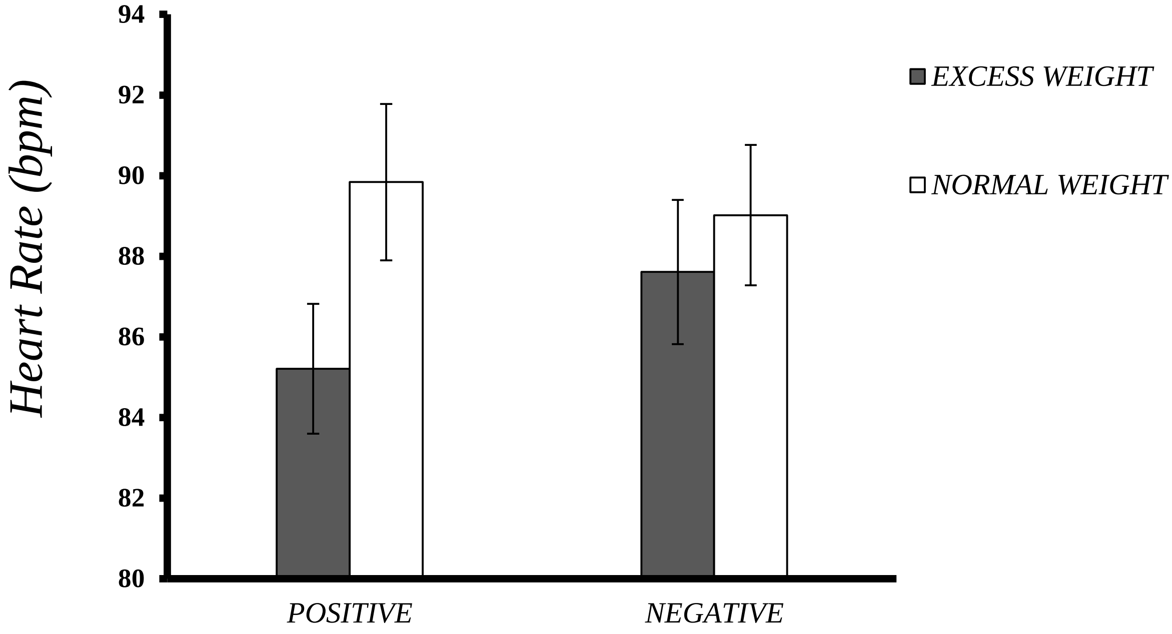

Figure 2. Mean skin conductance (micro-Siemens) during the positive and negative social evaluation phases of the Trier Social Stress Task. Bars indicate standard error of the mean.

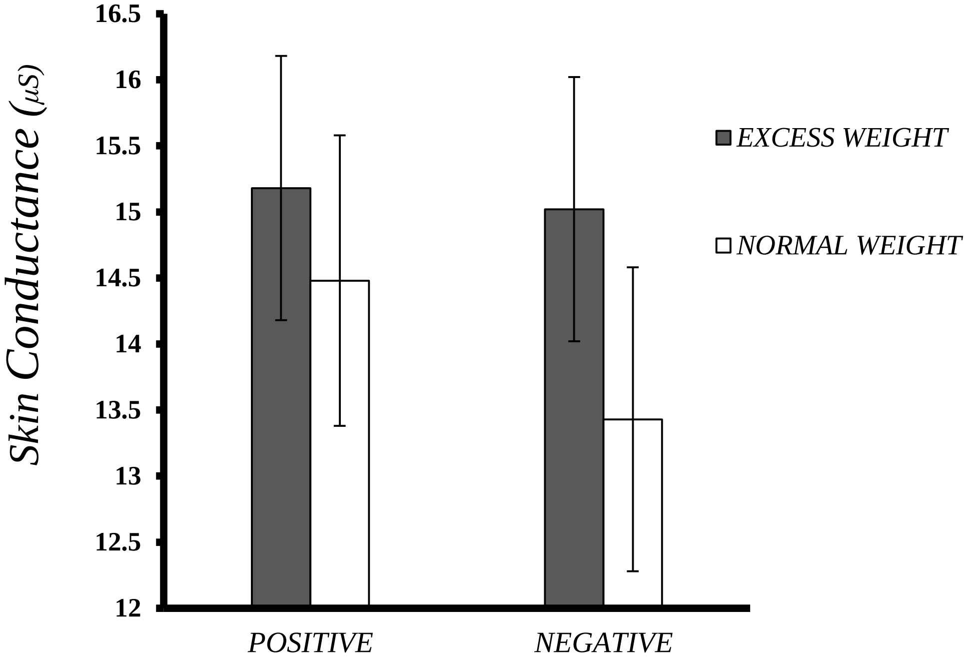

Figure 3

Figure 3. Working memory scores (Letter-Number Sequencing) before and after the Trier Social Stress Task (TSST). Bars indicate standard error of the mean.

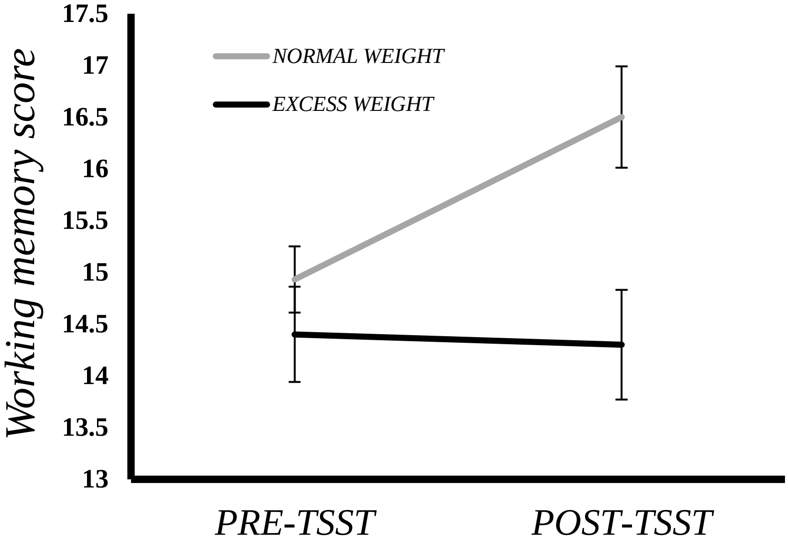

Figure 4

Figure 4. Inhibition and shifting errors (Five Digit Test) before and after the Trier Social Stress Task (TSST) in normal weight (NW) and excess weight (EW) adolescents. Bars indicate standard error of the mean.

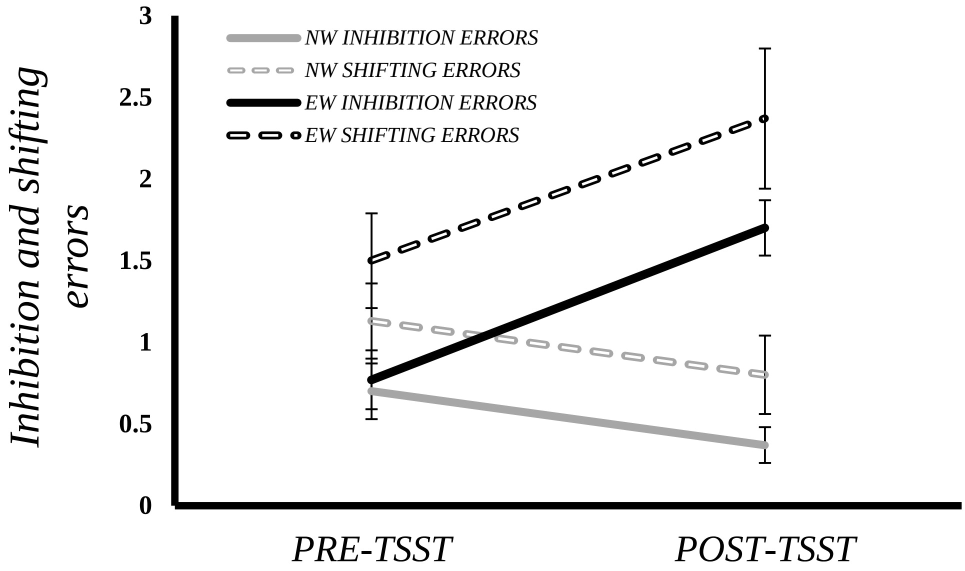

Table 1

Table 1. Participants' socio-demographic characteristics, BMIs and body fat percentage.

	EXCESS WEIGHT		NORMAL WEIGHT		t^a/chi square^b	p
	MEAN	SD	MEAN	SD		
AGE	15.38	1.75	15.41	1.36	-0.08[a]	0.935
SEX (%Men/ women)	46.7/53.3		36.7/63.3		0.62[b]	0.601
BMI	28.53	2.96	20.04	2.05	12.87[a]	<0.001
% BODY FAT	28.04	7.78	17.32	7.71	5.36[a]	<0.001

[a]value of Student's t;

[b]value of Chi-square $\chi 2$

Table 2. Descriptive scores and group comparisons for stress (VAS) and neuropsychological measures before TSST (PRE-scores) and after TSST (POST-scores)

	EXCESS WEIGHT		NORMAL WEIGHT		t	p	*d´*
	MEAN	SD	MEAN	SD			
Stress Pre	1.49	1.65	1.82	1.91	-0.72	0.474	0.18
Stress Post	4.03	2.45	2.59	2.18	2.39	0.020	0.62
Letter-Number Sequence Pre	9.03	2.53	8.73	1.76	0.53	0.597	0.14
Letter-Number Sequence Post	9.03	2.93	10.87	2.70	-2.52	0.015	0.65
Score-inhibition-FDT Pre	17.13	7.16	13.75	5.33	2.07	0.042	0.54
Score-inhibition-FDT Post	12.73	4.40	10.85	5.16	1.52	0.134	0.39
Score-shifting-FDT Pre	22.37	6.80	20.81	5.99	0.94	0.353	0.24
Score-shifting-FDT Post	21.07	3.86	16.52	4.84	4.02	<0.001	1.04
Errors-inhibition-FDT Pre	0.77	0,97	0.70	0.95	0.27	0.067	0.01
Errors-inhibition-FDT Post	1.70	0.95	0.37	0.61	6.44	<0.001	1.67
Errors-shifting-FDT Pre	1.50	1.57	1.13	1.25	1.00	0.321	0.26
Errors-shifting-FDT Post	2.37	2.35	0.80	1.29	3,19	0.002	0.83