Self-reported executive function mediates the association between obesity and recent suicidality: A cross sectional web-based survey

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Abstract

Introduction: The purpose of this study was to test for mediation effects of self-reported executive function (EF) between obesity and past 30-days suicidality. *Method:* A web-based survey was conducted from March to September 2019, diffusing it to the general Mexican population via social networks. Suicidality was evaluated with the corresponding module of the Mini International Neuropsychiatric Interview-5th version, and a short form of the Behavioral Rating Inventory of Executive Functions-Adults was used to assess EF. Body mass index was computed from the self-reported height and weight. Independent causal mediation analyses were performed for each of the suicidality components: death thoughts, self-harm intention, suicide ideation, planning, intention and attempt, as outcomes, and obesity and EF as predictor and mediator, respectively. *Results:* Data from 1234 participants was analyzed, from which 274 classified as having obesity. EF proved to partially mediate around 20% of the proportion of the effect of obesity on suicide ideation, planning and attempt. *Discussion:* We suggest that, as the BMI of an individual progresses to the categories of obesity, the already deficient EF that contributed to the increase of BMI in the first place, may be now insufficient to cope optimally with the emotional and social stressors associated to obesity, thus leading to more frequent or intense suicide ideation, planning or attempts.

Keywords: suicide; obesity; executive function; mediation analysis; BRIEF-A.

Introduction

Executive function (EF) is crucial for the self-regulation of cognition and behavior, and its impairment may manifest in suicidality through cognitive inflexibility in the form of repetitive negative thinking and poor stress-coping skills, emotional dysregulation and impulsivity leading to suicide attempts, and deficits in mental updating and episodic foresight in the form of hopelessness and stasis in depressive feedback loop (Bredemeier & Miller, 2015).

Obesity has also been linked to both EF deficits and suicidality. It has been proposed that some predisposition from an early age to poor self-regulation of cognitive processes (e.g. attention and inhibition of distractions) and behavioral outputs (e.g. impulsive food intake or poor adherence to healthy diet) may act as a high-risk factor for increasing body mass index (BMI) throughout the lifespan, and that this in turn may produce brain anomalies (e.g. low-grade inflammation, impaired insulin regulation) that feedback to the EF deficits (Smith, Hay, Campbell, & Trollor, 2011; Yang, Shields, Guo, & Liu, 2018). Regarding its association with suicide, the evidence is mostly mixed, with the majority of the studies reporting negative correlation between BMI and suicide, but consistent positive correlations mostly with regards to suicide ideation (Amiri & Behnezhad, 2018).

Evidence of the association between EFs, obesity and suicidality also come from neuroimaging studies indicating frontal lobe dysfunction in the top-down control of the limbic system, as well as the fact that both obesity and suicidality share mild-to-moderate and high association, respectively, with mental health problems commonly linked to EF (Snyder, Miyake, & Hankin, 2015), such as affective, anxiety and impulse control disorders (Taylor et al., 2012).

In our current study, we address two issues of the literature relating EF to obesity and suicidality: (1) The vast majority of them has been conducted using performance-based measures of EF, despite the fact that their ecological validity is still a matter of debate (Ziemnik & Suchy, 2019). Self-reports may provide useful information when evaluating EF, since they are more closely related to real-world complex behaviors and thus can provide more ecologically valid assessment (Meltzer et al., 2017). (2) The studies tend to analyze these phenomena through bivariate correlations, between-group comparisons or through aggregation of covariates in regression models, bypassing the role of EF as a mediator. This is particularly true concerning the association between obesity and suicide risk, since the mediation of EF could help to understand their link.

Understanding EF as a key component of the still vaguely understood relationship between obesity and suicidality, further helping to improve prediction. The purpose of this study then was to test for mediation effects of EF between obesity and past 30-days suicide ideation, planning and attempt. We performed a web-based survey, which allows for larger recruitment of participants and also for a more private setting to disclose valid but sensitive information, such suicidality (Whitlock, Pietrusza, & Purington, 2013) or anthropometrics (Pursey, Burrows, Stanwell, & Collins, 2014).

Method

Participants

The sample was recruited across the Mexican territory using a web-based survey, and diffusing it via social networks from March to September 2019. Eligibility criteria were: ≥ 18 years-old, literacy and having understood and accepted the informed consent.

Measures

Demographics and anthropometric measures

This brief questionnaire inquired the participant about: gender (male, female), years of age, educational attainment (from none to beyond college), weight (kg) and height (cm).

Behavior Rating Inventory of Executive Functions–Adults (BRIEF-A), Short form

This inventory assesses executive functions in everyday life (Roth, Lance, Isquith, Fischer, & Giancola, 2013). We used a Spanish-translated abbreviated 17-item version (Basuela-Herreras, 2016). The BRIEF-A displays statements concerning difficulties related to the control of goal-oriented behavior and asks the respondent to grade his/her own behavior according with the options: “Never”=1 to “Often”=3. Total score can be computed, with higher scores indicating more severity of executive dysfunction; for this study, we also computed sum scores from the three-factor model proposed by Roth et al. (2013): Emotional Regulation, Behavioral Regulation and Metacognition.

This version of the BRIEF-A has been used in another web-based survey with general Mexican population (Sierra-Aparicio, Magaña-Quijano, Vargas-Quñones, Martínez-García, & Toledo-Fernández, 2019), proving association with expected outcomes and thus suggesting concurrent validity.

Mini International Neuropsychiatric Interview, 5th version: Suicidality module (MINI-5)

This is a structured clinical interview widely used for diagnosis of psychiatric disorders (Sheehan et al., 1998). For this study, we employed the first five items of this interview, which inquires about suicide cognitions and behaviors in the previous month (past 30

days): death thoughts, self-harm intention, suicide ideation, suicide planning and suicide attempts. Responses are dichotomously coded (“Yes/No”).

Procedure

The online survey was designed and implemented using Google Forms. The link to the survey was originally sent to authors’ acquaintances via social networks and then by using the paid services of Facebook for diffusion. The invitation to participate included a brief message encouraging both participation and forwarding of the link and message to other respective acquaintances.

Once the potential participant opened the link, the informed consent was displayed explaining objectives, activities, voluntary participation, confidentiality, low risks and possibility of return of individual results (participants who completed evaluation were given the option to provide an individual e-mail, to identify data to collect, and a general description of the results with contact information in case of needing psychological attention). Before beginning with the survey, potential participants were inquired about understanding of informed consent and acceptance of participation; when responding negatively to one of these questions, the survey ended; otherwise, participants underwent the full evaluation with this sequence: demographics and anthropometric questions, BRIEF-A and the suicidality questionnaire. The complete survey takes no more than eight minutes to complete.

Statistical analysis

Flow of participants was described from web-based invitation to total analyzed sample. Descriptive analysis was performed using mean and standard deviation for numerical

variables, and frequency and percentage for categorical variables. Following guidelines from the World Health Organization (Nuttall, 2015), BMI was computed with the reported height and weight, and two groups were formed considering a BMI < 30 as the “Without obesity” group, and ≥ 30 for the “With obesity” group. Both groups were compared using bivariate statistics: student t test for numerical and chi square for categorical variables.

To test whether EF is a mediator in the association between obesity and suicidality, we performed causal mediation analysis (CMA) using the approach by Imai et al. (2010). This approach is an extension of the work from Baron and Kenny (1986). Imai et al. (2010) approach is more flexible and allow to use non-parametric estimation, which is needed for dichotomous outcomes, and non-parametric bootstrap to calculate standard errors.

To perform CMA a series of regression models must be fit. First step: the association between the predictor and the outcomes must be significant. Considering that gender and age are consistently associated to suicide (Nock et al., 2008), we controlled them. Second step: the model tests the association between the predictor and the mediator. Third step: Fitting a model including the predictor, the mediator and the confounders. Finally, average direct effects (ADE) and average causal mediated effects (ACME) are estimated comparing Steps 2 and 3, with 500 bootstrap simulations.

We carried the analysis in R 3.6.2 (R Core Team, 2019) using the package “mediation” (Tingley, Yamamoto, Hirose, Keele, & Imai, 2014). To control multiple comparisons we used False Discovery Rate (Benjamini & Hochberg, 1995). Significance was set at $p < .05$ after adjustment.

Results

A total of 1246 individuals open the link to the survey and read the informed consent; from this, 12 rejected participation, thus an $n=1234$ was considered for analyses. Imputations were done in cases with no more than three missed items in the BRIEF-A only, using mean value of responses of each individual case. From 29 identified cases, 26 showed no more than one missing value.

From the total sample, 1023 (82.90%) respondents were female and 211 (17.09%) were male, with a mean age of 27.9 ($SD = 11.46$, range: 18-71 years-old); 51.21% ($n = 632$) of them reported having completed college or a further degree. Weight's and height's ranges were 36-150 cm and 140-193 kg, with a mean BMI of 26.11($SD = 5.77$). Table 1 displays descriptive statistics for the groups formed from the BMI categories. Within the group with obesity ($n = 274$ [22.20% of N]), class 1 was the most prevalent category ($n = 173$ [63.13%]), followed by class 2 ($n = 72$ [26.27%]) and 3 ($n = 29$ [10.58%]). Within the group without obesity ($n = 960$ [77.79% of N]), 56 (5.83%) individuals qualified as being underweight. Individuals with obesity were five years older on average.

Concerning main variables of interest, total scores of the BRIEF-A ranged from 17 to significant between-groups differences were observed for the total score of the BRIEF-A and the Emotional Regulation factor, with the obesity group showing higher scores; this group also showed higher proportions of individuals reporting death thoughts, self-harm intention and suicide planning in the previous month (Table 1).

Regarding the CMA, in the first step there was a significant association between obesity and every outcome. However, in the third step, significant associations remained for

ideation and planning, not for attempt. The interpretation from this finding indicates that the self-report of executive functions is a partial mediator for ideation and planning, and a complete mediator for attempt. It is important to note that the percentage of mediated effect was about 20%, suggesting that four fifths of the association between suicide and obesity are still unexplained (Table 2).

Discussion

The purpose of this study was to test the mediating effect of EF between obesity and suicidality. We found that EF was a significant partial mediator of recent suicide ideation and planning, and a complete mediator of recent suicide attempt; in all cases, proving to mediate around 20% of the proportion of the effect of obesity on these manifestations of suicidality.

This finding may support our original assumption that the consistent association of obesity with suicide ideation but not suicide attempts, as reviewed in the scientific literature (Amiri & Behnezhad, 2018), may be explained by lack of analysis of EF as a crucial mediator. As already commented (Smith et al., 2011; Yang et al., 2018), it is likely that some of the behaviors associated to increased BMI, such as poor adherence to a healthy diet or impulsive food intake, are partially due to deficits of EF, as are also suicidality via inflexible negative thinking or poor emotion regulation. Our findings further stretch this notion by suggesting that individuals with a BMI corresponding to the classes 1-3 of obesity are at higher probability of reporting recent suicide behaviors as the EF deficits increase (particularly from the mean score of a self-report measure, such as the BRIEF-A).

We hypothesize that, as the BMI of an individual progresses to the categories of obesity, the already compromised EF that partially led to the increase of BMI in the first place, may be now insufficient to cope optimally with the emotional and social stressors associated to obesity (Talen & Mann, 2009), leading to an increased risk of suicide ideation, planning or attempts. Neurobiological consequences of obesity feedback this loop, meaning that, as the years living with obesity go on, a consequent neurological damage caused by hyperlipidemia, low-grade inflammation or impaired insulin regulation (Smith et al., 2011; Yang et al., 2018) accumulates, decreasing the EF efficiency to cope with stressors. Future studies should aim to test this hypothesis using a prospective longitudinal design.

It is interesting to notice that suicide planning followed the same direction of association with EF deficits than ideation and attempt, despite planning being a cognitive ability universally listed among the EFs. This finding may be explained by distinguishing between intellectual (or “cold”) and emotional (or “hot”) EF (Ardila, 2018). The former refers to the abilities needed in performance-based tests of cognitive ability, and it has been mostly associated to dorsolateral prefrontal activity, whereas the latter refers to the self-regulation of emotions and behavioral output, and it is mostly related to the ventromedial prefrontal cortex (Ardila, 2018). In this context, both suicide ideation and planning may be related to the same deficit in the emotional component of EF. Poor self-regulation of emotional distress may facilitate feelings of entrapment and suicide ideation (O’Connor, 2011), which in turn may work as a first stage of suicide planning, in which the goal is both established and emotionally invested. So, individuals with high suicidality are not deficient in their capacity to set sequences of behavior to attain goals or to solve complex problems, but

rather their planning capacities are increasingly coopted by unregulated negative emotional feedback.

An additional finding was the relatively high prevalence of suicidality. In Mexico, the 12-month prevalence of suicide attempt was .7% (Borges et al., 2019), whereas in our sample reached 17.9% in the past 30 days. When comparing our study to another web based survey, suicide ideation was much higher (40% vs 16%) (Park, Yang, & Kim, 2019). Most likely, our recruitment process biased the characteristics of the participants, since they were invited to fill the web-based survey presenting it as a study on mental health and obesity. Besides, an increased tendency and apparent need of individuals to disclose sensitive information within the context of anonymous web-based surveys versus in-person interview has been observed (Whitlock et al., 2013; Zulman et al., 2011), increasing the prevalence here reported. To our view, this highlights not only to the feasibility and relative validity of the web-based survey for mental health research, but also to the need to enforce the ethical procedures to provide a cost-effective beneficial response to those who willingly inform about high-risk thoughts and behaviors.

There are some limitations in this study. Firstly, though the use of a web-based survey comes with considerable advantages, particularly for the study of suicidality and obesity (Pursey et al., 2014; Whitlock et al., 2013), it also supposes some risks such as underestimation of weight and overestimation of height, especially in relation to gender (Gorber, Tremblay, Moher, & Gorber, 2007). We tried to reduce the possible effect of this bias by recruiting a large sample and by controlling for effects of gender within the main analysis. As well, thought there is growing evidence regarding the utility and validity of

web-based surveys for disclosure of sensitive information (Whitlock et al., 2013), it is still a concern that the lack of clinical guidance during response may lead to loose introspection.

A second limitation was the use of a short version of the BRIEF-A. As declared above, this was decided so as to reduce friction of the potential participants to respond the survey; however, it comes with the potential drawback of diminishing its content validity, especially when using the three-factor model that was tested with the original instrument (Roth et al., 2013). The utility of web-based self-report of EF has been commented for another instrument (Buchanan, 2015; Buchanan, Heffernan, Parrott, Ling, & Rodgers, 2010) and, given the similarity of their semantic content, we believe the version of the BRIEF-A is also suitable for online research, as it is hinted by the results of a previous study associating scores of the BRIEF-A with measures of depression and work productivity (Sierra-Aparicio et al., 2019).

We believe our findings highlight the need to assess EF in individuals with obesity, as a useful predictor of mental health outcomes. Further studies should test EF as mediator including more comprehensive measures, including both self-reports and performance-based tests.

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Figure 1. Prototypical model of mediation of executive function between obesity and suicidality.

Table 1. Participants' characteristics and statistical differences between groups of BMI.

	Without obesity (<i>n</i> = 960)	With obesity (<i>n</i> = 274)	Statistical differences
	$\bar{x}$ (SD) or Freq. (%)	$\bar{x}$ (SD) or Freq. (%)	
Demographics and anthropometrics			
Sex			
Male	174 (18.12)	37 (13.50)	
Female	786 (81.87)	237 (86.49)	
Age	26.92 (11.14)	31.55 (11.85)	$t(420.45) = -5.78, p < .001, d = -.40$ [95% CI -.51, -.26]
Education			$\chi^2(1) = .05, p = .81, OR = .03$ [95% CI -.23, .30]
≤ High school	470 (48.95)	132 (48.17)	
≥ University	490 (51.04)	142 (51.82)	
Weight (kg)	63.26 (11.15)	92.05 (14.24)	
Size (cm)	163.23 (8.56)	162.62 (8.36)	
BMI	23.65 (3.16)	34.74 (4.35)	
BRIEF-A			
Total	31.92 (5.94)	32.92 (6.61)	$t(406.96) = -2.25, p = .025, d = -.15$ [95% CI -.29, -.02]
Emotional regulation	9.98 (2.22)	10.36 (2.42)	$t(412.32) = -2.34, p = .019, d = -.16$ [95% CI -.29, -.03]
Behavioral regulation	7.14 (1.73)	7.25 (1.79)	$t(429.12) = -.93, p = .353, d = -.06$ [95% CI -.19, -.06]
Metacognition	14.78 (3.64)	15.28 (3.82)	$t(425.29) = -1.94, p = .053, d = -.16$ [95% CI -.26, -.01]
Suicidality previous month			
Death thoughts^a	394 (41.51)	144 (52.74)	$\chi^2(1) = 10.85, p < .001, OR = .45$ [95% CI -.18, .72]
Self-harm intention^b	262 (27.37)	92 (33.57)	$\chi^2(1) = 3.99, p = .046, OR = .29$ [95% CI .005, .58]
Suicide ideation ^c	384 (40.29)	122 (44.68)	$\chi^2(1) = 1.69, p = .19, OR = .18$ [95% CI -.09, .45]
Suicide planning^d	188 (19.74)	73 (26.74)	$\chi^2(1) = 6.18, p = .013, OR = .39$ [95% CI .08, .70]
Suicide attempt ^e	69 (7.30)	29 (10.62)	$\chi^2(1) = 3.14, p = .076, OR = .41$ [95% CI -.04, .86]

Notes: Bolds indicate statistical significance in the between-group comparison.

Missing values (in superscript letters): a=12; b=3; c=18; d=9; e=17; f=20.

Abbreviations: BMI: body mass index; BRIEF-A: Behavioral Rating Inventory of Executive Functions–Adults (Short version); SD: standard deviation; 95% CI: confidence interval at 95%.

Table 2. Results from the models evaluating EF as a mediator between obesity and suicidality, controlling for age and gender.

	Ideation ^a	Planning ^b	Attempt
	<i>B (SE)</i>	<i>B (SE)</i>	<i>B (SE)</i>
First step (X→Y)			
Intercept	.91 (.25)***	-.398 (.34)	-2.007 (.51)***
Obesity	.55 (.15)***	.72 (.17)***	.61 (.24)*
Age	-.08 (.007)***	-.07 (.01)***	-.05 (.01)***
Gender	.89 (.18)***	.98 (.25)***	0.94 (.40)*
Second step (X→M)			
Intercept	31.92 (.19)***	31.92 (.19)***	31.92 (.19)***
Obesity	.99 (.41)*	.99 (.41)*	.99 (.41)*
Third step (X→Y M→Y)			
Intercept	-2.838 (.46)***	-4.70 (.61)***	-6.19 (.87)***
Obesity	.42 (.16)**	.55 (.18)**	.40 (.25)
Age	-.07 (.007)***	-.06 (.01)***	-.04 (.01)**
Gender	.84 (.19)***	.95 (.26)***	.86 (.40)*
BRIEF-A	.11 (.01)***	.12 (.01)***	.11 (.01)***
Causal mediation analysis	Estimate [95% CI]	Estimate [95% CI]	Estimate [95% CI]
Total Effect	.108 [.04, .18]***	.101 [.04, .17]***	.039 [.001, .08]*
ACME	.023 [.005, .05]**	.019 [.003, .04]**	.009 [.001, .02]**
ADE	.084 [.02, .15]**	.082 [.02, .14]**	.030 [-.006, .07]
% Mediated	.218 [.04, .56]**	.188 [.03, .49]*	.226 [-.007, 1.36]

Notes: * $p < .05$; ** $p < .01$; *** $p < .001$

Missing values (in superscript letters): $a=8$; $b=?$.

Abbreviations: ACME: average causal mediation effects; ADE: average direct effects; B: unstandardized coefficient; BRIEF-A: Behavioral Rating Inventory of Executive Functions–Adults (Short version); EF: executive function; M: Mediator; SE: standard error; X: Predictor; Y: Outcome; 95% CI: confidence interval at 95%.