SELF-REPORTED EXECUTIVE FUNCTION MEDIATES THE ASSOCIATION BETWEEN OBESITY AND RECENT SUICIDALITY: A WEB-BASED SURVEY

EL AUTORREPORTE DE FUNCIONAMIENTO EJECUTIVO MEDIA LA ASOCIACIÓN ENTRE LA OBESIDAD Y SUICIDALIDAD RECIENTE: UNA ENCUESTA EN LÍNEA

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Abstract

The study intended to test for mediation effects of self-reported executive function (EF) between obesity and past 30-days suicide-behaviors. A web-based survey was conducted diffusing it to the general Mexican population via social media. Suicide was evaluated with the corresponding module of the Mini International Neuropsychiatric Interview, and a short form of the Behavioral Rating Inventory of Executive Functions-Adults for EF. Body mass index was computed from the self-reported height/weight. Causal-mediation analyses was performed for each of the suicide variables, including obesity and EF as predictor and mediator, respectively. Data from 1234 participants was analyzed, 274 classified as having obesity. EF partially mediated 20% of the effect of obesity on suicide behaviors. As the BMI progresses to the categories of obesity, EF deficiencies may be 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.

Resumen

El presente estudio tuvo como objetivo evaluar el efecto de mediación del autorreporte de funcionamiento ejecutivo (FE) entre la obesidad y la conducta suicida en los 30 días previos. Se condujo una encuesta a través de la web, la cual se difundió a la población general de México a través de redes sociales. El suicidio fue evaluado con el módulo correspondiente de la Mini Entrevista Neuropsiquiátrica Internacional, y el FE con una versión breve de la Evaluación Conductual de la Función Ejecutiva para adultos. El índice de masa corporal se calculó del autorreporte de talla y peso. Se realizó análisis de mediación causal para cada una de las variables de suicidio, incluyendo la obesidad y el FE como predictores respectivamente. Se analizaron los datos de 1234 participantes, de los cuales 274 fueron clasificados dentro del grupo con obesidad. El FE mediaba aproximadamente el 20% del efecto de la obesidad en la conducta suicida. Los resultados sugieren que conforme el índice de Masa Corporal incrementa hacía la obesidad, el FE puede ser insuficiente para poder afrontar de forma óptima con los estresores emocionales y sociales asociados al incremento del peso, lo cual, trae como consecuencia una ideación, planeación intentos de suicidio más frecuentes o intensos.

PALABRAS CLAVE: suicidio; obesidad: funcionamiento ejecutivo: análisis de mediación; BRIEF-A.

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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 et al., 2011; Yang et al., 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 et al., 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 truth 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 et al., 2013) or anthropometrics (Pursey et al., 2014).

Methods

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 et al., 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. A higher score indicates more severity of executive dysfunction.

This version of the BRIEF-A has been used in another web-based survey with general Mexican population (Sierra-Aparicio et al., 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 inquire 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"). Though, to our knowledge, this interview hasn't been employed in online surveys, its items are very similar to those of another questionnaire that have been used in this fashion and which have shown significant correlation with this module of the MINI (Ballester et al., 2019)Mania/Hypomania[M/H], Panic Disorder[PD], Generalized Anxiety Disorder[GAD]. Also, the simplicity of their response method ("Yes/No") allows to be used in self-report format.

Procedure

The online survey was designed and implemented using Google Forms, following ethical standards from the Declaration of Helsinki. 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. The message also included a statement not to respond the survey if already done so.

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 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 used 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). Such 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 et al., 2014). To control multiple comparisons

we used False Discovery Rate (Benjamini & Ho-
chberg, 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%) respon-
dents 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%) indivi-
duals qualified as being underweight. Individuals
with obesity were five years older on average.

Concerning main variables of interest, score
of the BRIEF-A ranged from 17 to 49. Significant
between-groups differences were observed for
this score, with the obesity group showing higher
values; 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 execu-
tive functions is a partial mediator for ideation and
planning, and a complete mediator for attempt. Is
important to note that the percentage of media-
ted effect was about 20%, suggesting that four
fifths of the association between suicide and obe-
sity are still unexplained (Table 2).

Discussion

The purpose of this study was to test the me-
diating effect of EF between obesity and suicidali-
ty. We found that EF was a significant partial me-
diator 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 mani-
festations of suicidality.

This finding may support our original assump-
tion that the consistent association of obesity
with suicide ideation but not suicide attempts, as
reviewed in the scientific literature (Amiri & Beh-
nezhad, 2018), may be explained by lack of analy-
sis of EF as a crucial mediator. As already com-
mented (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 heal-
thy 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 defi-
cits increase (particularly from the mean score of a
self-report measure, such as the BRIEF-A).

We hypothesize that, as the BMI of an indivi-
dual 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 sui-
cide ideation, planning or attempts. Neurobiologi-
cal 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 impai-
red insulin regulation (Smith et al., 2011; Yang et
al., 2018) accumulates, decreasing the EF efficien-
cy 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

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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.

Comparing our findings with a recently published study (Brokke et al., 2020) which found no differences in BRIEF-A results between suicide ideators and suicide attempters from a sample of suicidal psychiatric patients, attributing this absent of effect to lack of self-awareness. In this regard, it is possible that unknown characteristics of that clinical sample (such as a more stable environment within the clinical facility) contributed to this finding, and that non-clinical samples such as ours (which are operating in an everyday less predictive environment) may have had at mind a sample of their own more regular behavior. This same study did find poorer cognitive control in the suicide attempters according to performance-based assessment of EF (e.g., Color-Word Interference Test, and Stroop Test), which suggest deficits in EF more closely related to their "cold" version (Ardila, 2018)and that this underlying deficit may contribute to the transition from mere ideation to attempt. Our study did not include performance-based measures, and it would be of interest for future research to explore the mediating effect of EF in clinical patients with obesity and recent history of suicidality (this is: individuals with more extreme expressions of these conditions). In this scenario, we hypothesized that deficits in cognitive and emotional regulation might express in lower scores in performance-based measures only in clinical samples, and that these deficits could mediate the transition from ideation to attempt in a more robust wat that in nonclinical samples.

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 et al., 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.

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)suicide, and psychological distress in a web-based survey on respondents, particularly those with relevant personal histories. Drawn from a random 8-college sample, 14,372 students completed the survey. Adjusted odds ratios were used to model the likelihood of responses based on respondent characteristics. The constant comparative method identified salient themes in qualitative data. Few individuals (2.7%. Their main advantages are the lower cost and time (Heiervang & Goodman, 2011)they may be biased by low and selective participation. We predicted that such biases would distort point-estimates such as average symptom level or prevalence but not patterns of associations with putative risk-factors. Methods: A structured psychiatric interview was administered to parents in two successive surveys of child mental health. In 2003, parents were interviewed face-to-face, whereas in 2006 they completed the interview online. In both surveys, interviews were preceded by paper questionnaires covering child and family characteristics. Results: The rate of parents logging onto the web site was comparable to the response rate for face-to-face interviews, but the rate of full response (completing all sections of the interview, in addition to the potential benefits when they are used as screening and referral procedures (Han et al., 2018). However, there are some limitations in this study. Firstly, the

employed design supposes some risks such as underestimation of weight and overestimation of height, especially in relation to gender (Gorber et al., 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 et al., 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). It is also worth noting that the BRIEF-A self-report measures are commonly used along with the ratings from external observers (such as parents or teachers) (Toplak et al., 2009), suggesting that future studies including complementary measures of EF, in addition to self-report, could improve the validity of the results.

A third potential limitation is that some of the sociodemographic variables, such as marital status and income were not included. This is highlighted by previous results in epidemiological research that indicate positive associations between both suicide behavior and obesity with poverty and being non-married (Bell & Thorpe, 2019; Iemmi et al., 2016; Kyung-Sook et al., 2018). It is strongly recommended to include these variables as confounders to improve the validity of results from surveys.

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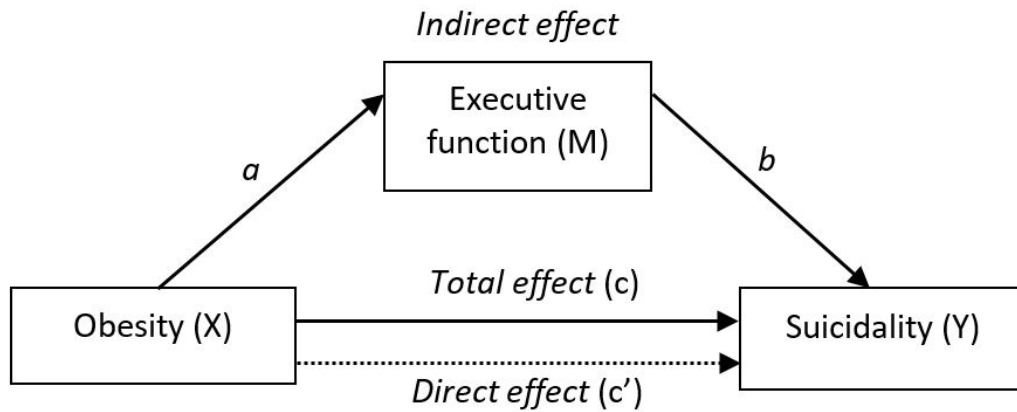
Figure 1. Prototypical model of mediation of executive function between obesity and suicidality.

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

	Without obesity (n = 960)	With obesity (n = 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 score	31.92 (5.94)	32.92 (6.61)	$t(406.96) = -2.25, p = .025, d = -.15$ [95% CI -.29, -.02]
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)	χ2(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
	B (SE)		B (SE)	B (SE)
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%.