

ORIGINAL

Effect of Energy Drink Consumption on Executive Functions in Health Science Students

Efecto del consumo de bebidas energéticas en las funciones ejecutivas en estudiantes de Ciencias de la Salud

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Cite as: Torres-Soto NY, Peña-Torres EF, Martínez-Ramírez B, Rojas-Armadillo M de L, León-Rojas D, Corrales-Baldenebro AL. Effect of Energy Drink Consumption on Executive Functions in Health Science Students. Health Leadership and Quality of Life. 2025; 4:871. <https://doi.org/10.56294/hl2025871>

Submitted: 20-06-2025

Revised: 18-08-2025

Accepted: 26-10-2025

Published: 27-10-2025

Editor: PhD. Neela Satheesh 

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ABSTRACT

Introduction: the aim of this study was to analyze the relationship between energy drink consumption and executive function performance in Health Sciences students.

Method: a quantitative, non-experimental, cross-sectional, and correlational-causal design was applied, with a sample of 200 students from the Autonomous University of the State of Quintana Roo. Of these, 105 were women (52,5 %) and 95 were men (47,5 %), with an average age of 21 years. Data were collected using the Energy Drink Consumption Scale (EDCS) and the EFE-CO Scale, which assesses executive functions. The analysis included descriptive statistics, Pearson's correlation, and a Structural Equation Model (SEM).

Results: significant correlations ($p < 0,001$) were found between higher energy drink consumption and poorer performance in functions related to monitoring, inhibition, and emotional control. The SEM model confirmed a moderate direct effect of energy drink consumption on executive functions, with a factor loading of $\lambda = 0,66$.

Conclusions: it was concluded that frequent consumption of energy drinks is associated with significant cognitive impairment in university students. These findings highlight the importance of promoting preventive and educational strategies from a public health and academic perspective, in order to reduce the risks associated with their consumption.

Keywords: Energy Drinks; University Students; Executive Functions; Public Health.

RESUMEN

Introducción: el objetivo de este estudio fue analizar la relación entre el consumo de bebidas energéticas y el desempeño de las funciones ejecutivas en estudiantes de Ciencias de la Salud.

Método: se aplicó un diseño cuantitativo, no experimental, transversal y correlacional-causal, con una muestra de 200 estudiantes de la Universidad Autónoma del Estado de Quintana Roo. De ellos, 105 eran mujeres (52,5 %) y 95 eran hombres (47,5 %), con una edad promedio de 21 años. Los datos se recopilaron mediante la Escala de Consumo de Bebidas Energéticas (EDCS) y la Escala EFE-CO, que evalúan las funciones ejecutivas. El análisis incluyó estadística descriptiva, correlación de Pearson y un Modelo de Ecuaciones Estructurales (SEM).

Resultados: se encontraron correlaciones significativas ($p < 0,001$) entre un mayor consumo de bebidas energéticas y un menor desempeño en las funciones relacionadas con la monitorización, la inhibición y el control emocional. El modelo SEM confirmó un efecto directo moderado del consumo de bebidas energéticas sobre las funciones ejecutivas, con una carga factorial de $\lambda = 0,66$.

Conclusiones: se concluyó que el consumo frecuente de bebidas energéticas se asocia con un deterioro cognitivo significativo en estudiantes universitarios. Estos hallazgos resaltan la importancia de promover estrategias preventivas y educativas desde una perspectiva de salud pública y académica para reducir los riesgos asociados a su consumo.

Palabras clave: Bebidas Energéticas; Estudiantes Universitarios; Funciones Ejecutivas; Salud Pública.

INTRODUCTION

Energy drinks (ED) are non-alcoholic products formulated with caffeine, taurine, guarana, sugars, glucuronolactone, inositol, and B vitamins, whose stimulating effects are aimed at improving physical performance, increasing concentration, maintaining alertness, and reducing feelings of fatigue. Their promise of “instant energy” is based on stimulation of the central nervous system, promoting a state of alertness and endurance that, while it may be perceived positively in the short term, has also been associated with a number of adverse effects at both the physical and cognitive levels.^(1,2)

In recent decades, the consumption of energy drinks has gained alarming ground among adolescents and young adults, becoming a common practice in educational, recreational, and even work contexts.⁽³⁾ This consumption has increased significantly, driven by marketing strategies that present them as enhancers of physical and mental performance and well-being.⁽⁴⁾ Their global expansion is due not only to intensive marketing but also to an advertising narrative that positions these products as allies of physical and intellectual performance, despite the fact that the scientific evidence supporting such benefits is still limited and, in many cases, contradictory.⁽⁵⁾

According to data from the Spanish Observatory on Drugs and Addictions in 2023, 74,7 % of young people between the ages of 15 and 18 have tried an energy drink at least once, and 28,3 % consume them weekly. In Latin America, the figures follow a similar trend: recent studies indicate that between 45 % and 60 % of university students consume energy drinks on a regular basis, with the main reasons reported being increased academic performance, reduced fatigue, and improved concentration.⁽⁶⁾

In Mexico, the consumption of energy drinks has become a growing problem, especially among adolescents and young adults, many of whom are unaware of the actual ingredients in these products, which increases their vulnerability to their potential harmful effects.⁽⁵⁾ Despite containing high doses of stimulants such as caffeine (30 to 45 mg) and taurine (250 to 400 mg per 100 ml), these drinks are freely marketed in the country. The combination of these compounds has been associated with a variety of physiological and psychological disorders, including loss of appetite, sleep disorders, increased blood pressure and heart rate, arrhythmias, anxiety, irritability, depressive symptoms, and difficulties with attention and concentration, which can seriously compromise executive functions.^(7,8) In addition, their consumption has been linked to an increased risk of initiating the use of addictive substances.⁽⁹⁾ Various studies warn that its intake can trigger significant adverse effects, ranging from nervousness and insomnia to serious cardiovascular complications such as seizures and arrhythmias.^(3,10,11) Among the most commonly reported effects are tachycardia, anxiety, hypertension, and metabolic disorders, which tend to intensify when these drinks are consumed in excess or combined with other substances such as alcohol, a common practice in recreational settings among young people.^(11,12)

A particular concern in the field of mental health and neuropsychology revolves around the possible impact of these drinks on executive functions, a set of complex cognitive processes that enable planning, organizing, decision-making, inhibiting impulsive responses, regulating emotions, and monitoring behavior to achieve goals.⁽¹³⁾ These functions, which depend largely on frontal lobe activity, are fundamental to learning, social adaptation, and academic success, especially during adolescence and youth, critical periods for the development of judgment, self-regulation, and habit formation. Impairments in executive functions can significantly impact academic performance, interpersonal relationships, and overall mental health.⁽¹⁴⁾

Recent studies have shown that regular consumption of energy drinks in adolescents is associated with concentration problems, anxiety, sleep disorders, and other adverse effects on mental and cognitive health.^(15,16) A study conducted with American adolescents⁽¹⁷⁾ evaluated the acute effects of a functional energy drink on cognitive performance and mood during cognitively demanding tasks. The results indicated significant impairment in sustained attention, working memory, and processing speed, as well as chronic mental fatigue and increased alertness and perceived energy. The available empirical evidence indicates that high consumption of caffeine, the main component of energy drinks, can interfere with executive functioning. In 2024, Witch conducted a study demonstrating that excessive caffeine consumption is related to deficits in cognitive flexibility and

inhibitory control by affecting the activation of the frontal networks of the brain.⁽¹³⁾ Authors such as Kennedy and Wightman¹ also warn that the combination of caffeine with other bioactive substances, such as taurine, can induce neurochemical dysfunctions that compromise processes such as planning, decision-making, and working memory, which are key elements of executive functions. International epidemiological studies reinforce these concerns. For example, in a study of adolescents in Shanghai, researchers reported a higher prevalence of impulsivity, anxiety, and behavioral problems in young people who frequently consumed energy drinks.⁽¹⁸⁾ These findings suggest a possible relationship between regular consumption and a deficit in emotional and cognitive self-regulation, which may be mediated by neurochemical mechanisms such as the dysregulation of dopamine and acetylcholine, neurotransmitters involved in executive processes.

At the same time, it has been observed that the social environment and easy access to these products play a crucial role in their proliferation. The availability of energy drinks in stores, supermarkets, and vending machines, coupled with advertising campaigns targeting young people and the use of influencers on social media, has contributed significantly to normalizing their consumption. According to data from the University of Valladolid, 58,3 % of consumers do not know precisely what ingredients these drinks contain, and the main reasons reported for consumption were taste (68,5 %), fun (37,6 %), the search for better academic performance (17,5 %), and social pressure (9,2 %).⁽¹⁹⁾

For their part, longitudinal and experimental studies have provided greater robustness by establishing temporal and causal relationships between energy drink consumption and health outcomes. For example, Galimov *et al.*⁽⁹⁾ conducted a longitudinal study in adolescents and found that frequent consumption of these drinks predicted, over 12 months, a higher risk of initiation of addictive substance use. Complementarily, Silva *et al.*⁽¹¹⁾ observed in a longitudinal analysis of an adolescent population that sustained consumption of energy drinks was associated with a higher prevalence of cardiovascular and sleep disorders, evidencing cumulative effects over time. In terms of clinical trials, O'Shea *et al.*⁽¹⁷⁾ demonstrated, through a randomized, double-blind, placebo-controlled design, that an acute dose of energy drink can temporarily improve working memory and sustained attention, although they warned of a potential overstimulation effect with long-term risks.

Additionally, Richards and Smith⁽²⁰⁾ in a two-year follow-up study of young college students, found that frequent consumption of energy drinks predicts higher levels of anxiety and depressive symptoms, reinforcing the association with mental health problems. For their part, Shah *et al.*⁽²¹⁾ documented in a controlled clinical trial that consuming 500 ml daily for two weeks increased systolic blood pressure and reduced sleep quality, suggesting an early cardiovascular risk even in healthy young adults. Likewise, Wassef and Wassef⁽²²⁾ reviewed the existing evidence and concluded that repeated consumption of energy drinks has adverse effects on the cardiovascular system, particularly on blood pressure and endothelial function, highlighting the importance of considering these risks in young people. Finally, the meta-analysis by Fuentealba-Garrido *et al.*⁽²³⁾ together with the systematic review by Harnod *et al.*⁽²⁴⁾ agreed that the immediate cognitive benefits are limited and that repeated consumption is more related to adverse neuropsychological and cardiovascular consequences. Overall, gaps remain regarding the link between regular consumption of energy drinks and cognitive performance in health sciences students, a population with high academic demands, irregular schedules, and possible normalization of use for performance purposes. From a public health perspective, it is essential to rigorously analyze the effects of regular consumption of these beverages on students' cognitive functioning, considering that executive functions are key predictors of academic success and psychosocial well-being. Understanding the factors that compromise them, such as the consumption of stimulant substances, is fundamental to promoting healthier and more sustainable educational environments. In light of this background, this research is part of the current debate on youth consumption practices, the university environment, and the need to strengthen mental health and neuro-education policies in the field of health sciences education. Therefore, the objective of this study was to analyze the relationship between energy drink consumption and executive function performance in health sciences students.

METHOD

Participants

A quantitative, non-experimental, cross-sectional, and correlational-causal approach was used. The sample consisted of 200 students in their first to fifth semesters of the bachelor's degree programs in Medicine, Nursing, and Pharmacy during February and March 2025, belonging to the Health Sciences Division of the Autonomous University of the State of Quintana Roo. The sample was selected for convenience and calculated with a confidence level of 95 % and a margin of error of 5 %, using the formula proposed by Villavicencio.⁽²⁵⁾

For the selection of participants, only students belonging to the basic cycle (first to fifth semester) were included, as they were in the classroom in person during the research period and where data collection was possible. Those who were not enrolled in the basic cycle were excluded, as well as those who used recreational or illicit drugs, had learning disabilities, or were undergoing pharmacological treatment that could alter metabolism, cardiovascular function, the central nervous system, or other factors relevant to the study.

Instruments

The instruments used in the development of this research are described below:

Personal data form: Sociodemographic data were collected, including gender, age range, grade point average, degree, semester, hours of sleep, monthly family income, and average and type of energy drink consumed.

EFECO Questionnaire (The Executive Functioning Questionnaire): The EFECA Scale, designed for the assessment of executive functions in a self-report format, is an instrument developed by García-Gómez⁽²⁶⁾ consisting of a total of 67 items, structured under a 3-point Likert-type response format in which the response options are never = 0, sometimes = 1, often = 2, and very often = 3. With a high internal consistency index, with a Cronbach's alpha coefficient of $\alpha = .96$, this scale projects high levels of reliability, making it viable for use in this study. Its main purpose is to measure various executive functions, such as monitoring (2, 6, 11, 12, 25, 29, 31, 35, and 43); inhibition (3, 14, 15, 18, 21, 33, 34, 37, 42, and 46); cognitive flexibility (4, 23, 27, 32, 49, and 59); emotional control (7, 19, 48, 50, 55, 63, and 67); planning (22, 28, 39, 61, 62, 58, and 44); organization of materials (1, 9, 10, 26, 30, 45, 51, and 60); initiative (8, 17, 20, 36, 40, 47, 53, 56, 64, and 65); and working memory (5, 13, 16, 24, 38, 41, 52, 54, 57, and 66).

Energy Drink Consumption Scale (EDCS): This scale was developed specifically for this study with the aim of evaluating factors related to energy drink consumption among university students. The instrument consists of 20 items written in a 5-point Likert format (1 = Strongly disagree to 5 = Strongly agree), which explore dimensions such as: "Personal motivations" (items 1-5): reflect the most common individual reasons for starting or continuing consumption; "Beliefs about perceived effects" (items 6- 10): capture the positive cognitive expectations that, according to the author, reinforce consumption behavior; "Influence of the social environment" (items 11-15): address peer pressure, social modeling, and availability, which are identified as relevant predictors; "Consumption patterns" (items 16-20): these allow the measurement of frequency, increase, and perceived dependence, which were linked to a higher risk of problematic use. Its construction was based on the theoretical postulates of Malinauskas et al.⁽²⁷⁾, who highlight the various determinants of the use of these beverages in the student population.

Data analysis

Both instruments were administered through the Qualtrics platform, and the corresponding link was distributed by email with the aim of recruiting as many participants as possible. Before participating, individuals were informed about the study's objective, possible risks and benefits, the procedure, and data confidentiality, in accordance with the informed consent form. Throughout the research process, compliance with the bioethical principles established in the PAHO Report (2025) and the 1964 Declaration of Helsinki was ensured.⁽²⁸⁾ To this end, informed consent was obtained from all participants, ensuring the confidentiality of the information collected at all times and protecting the integrity and well-being of the subjects involved.

Data analysis was performed using SPSS statistical software version 28 to calculate univariate statistics for the scales, including minimum and maximum values, means, standard deviations, and Cronbach's alpha coefficients as a measure of internal consistency, considering values $>0,60$ to be acceptable. To analyze the normality of the data, measures of dispersion and variability of asymmetry and kurtosis were calculated for the normality parameters.

The content and construct validity of the *Energy Drink Consumption Scale (EDCS)* was evaluated using confirmatory factor analysis (CFA) with the Maximum Likelihood (ML) method. Model fit was examined using the BBNFI, BBNFI, CFI, and RMSEA indices. Internal consistency was estimated using Cronbach's alpha coefficient and McDonald's Omega coefficient, considering values equal to or greater than 0,80 to be adequate.

Subsequently, EQS 6.1 software was used to perform a Structural Equation Model (SEM) to analyze the effect of energy drink consumption on executive functions. Given the number of items in the instrument, indicator parcels were constructed following the methodological recommendations of Hau and Marsh.⁽²⁹⁾

To assess the fitness of the model, three types of indicators were considered: statistical, practical, and population-based.⁽³⁰⁾ Among the statistical indicators, the relative chi-square ($\chi^2/g.l.$) was used, with values below 5 considered acceptable.⁽³¹⁾ The practical indicators included Bentler-Bonett's Non-Normed Fit Index (BBNFI), the Comparative Fit Index (CFI), and the Non-Normed Fit Index (NNFI), which are interpreted as satisfactory when they exceed a value of 0,90, Likewise, the Root Mean Square Error of Approximation (RMSEA) was examined, where values less than 0,08 indicate a reasonable fit and values less than 0,05 indicate an excellent fit of the model.⁽³²⁾

RESULTS

Sociodemographic characteristics

The information obtained from the students who participated in this research was distributed as follows: 105 (52,5 %) were women and 95 (47,5 %) were men, aged between 18 and 31, with an average age of 21. Forty-eight percent reported having an average sleep schedule of 7 to 8 hours, in contrast to 37 % who sleep

approximately 5 to 6 hours each day. In general, the average grade of most students was between 9 and 9,9 for 57,5 % of students, and when the type of beverage they consume most frequently was analyzed, it was identified that they are Powerade with 30 % and Red Bull with 21 % (table 1).

Table 1. Descriptive statistics of the sociodemographic variables of the participants (n= 200)					
Variable	n	%	Variable	n	%
Gender			Monthly family income		
Male	95	47,5	\$0 - \$2,500	16	8,0
Female	105	52,5	\$2 501 - \$5 000	34	17,0
Age range			\$5 001 - \$10 000	49	24,5
18 - 24	192	96,0	\$10 001 - \$20 000	53	26,5
25 - 31	8	4,0	\$20 001 - \$40 000	32	16,0
Bachelor's degree			+\$40,000	16	8,0
Medicine	69	34,5	Average		
Nursing	70	35,0	7,0 - 7,9	25	12,5
Pharmacy	61	30,5	8,0 - 8,9	50	25,0
Semester			9,0 - 9,9	115	57,5
1st semester	67	33,5	10	10	5,0
2nd semester	44	22,0	Type of energy drink consumed		
3rd semester	40	20,0	Red Bull	42	21,0
4th semester	36	18,0	Monster	13	6,5
5th semester	13	5,5	Powerade	60	30,0
Hours of sleep			Volt	32	16,0
7 to 8 hours	96	48,0	Amper	21	10,5
5 to 6 hours	74	37,0	Rockstar	18	9,0
4 to 5 hours	24	12,0	Live 100 %	14	7,0
3 to 4 hours	8	4,0			

Univariate statistics of the scales

Table 2 shows the results obtained in the univariate analysis with asymmetry (As) and kurtosis (K-S) values, as well as the minimum, maximum, mean, standard deviation, and Cronbach's alpha coefficients for each of the scales and subscales applied in the study. In the case of the Executive Functions in Everyday Contexts Scale, a high internal consistency coefficient ($\alpha = 0,95$) was observed, which demonstrates its high reliability. In particular, the subscales of monitoring ($\alpha = 0,95$), inhibition ($\alpha = 0,95$), cognitive flexibility ($\alpha = 0,93$), emotional control ($\alpha = 0,94$), planning ($\alpha = 0,94$), organization of materials ($\alpha = 0,94$), initiative ($\alpha = 0,95$), and working memory ($\alpha = 0,96$) also showed outstanding internal consistency indices. These results confirm the psychometric soundness of the scale and the stability of its dimensions.

As for the Energy Drink Consumption Scale, the Cronbach's alpha coefficient obtained was $\alpha = 0,84$, which is considered acceptable and supports the reliability of the instrument. Likewise, its specific dimensions, personal motivations ($\alpha = 0,84$), beliefs about perceived effects ($\alpha = 0,84$), influence of the social environment ($\alpha = 0,84$), and consumption patterns ($\alpha = 0,84$), reflected uniform and adequate internal consistency.

Table 2. Analysis of univariate statistics and reliability of the scales							
Scale/Subscales	As	K-S	Min	Max.	x	DE	α
Executive Functions in Everyday Contexts	0,513	-0,656	0,00	30,0	10,55	0,872	0,95
Monitoring	0,824	-0,426	0,00	30,00	10,07	0,890	0,95
Inhibition	0,549	-0,642	0,00	30,00	10,19	0,860	0,95
Cognitive flexibility	0,460	-0,740	0,00	30,00	10,22	0,881	0,93
Emotional control	0,533	-0,670	0,00	30,00	10,18	0,888	0,94
Planning	0,476	-0,453	0,00	30,00	10,22	0,826	0,94
Organization of materials	0,409	-0,910	0,00	30,00	10,17	0,903	0,94

Initiative	0,484	-0,702	0,00	30,00	10,20	0,875	0,95
Working memory	0,372	-0,712	0,00	30,00	10,26	0,860	0,96
Energy drink consumption	0,357	-0,293	0,01	50,00	40,52	0,823	0,84
Personal motivations	0,438	-0,392	0,01	50,00	30,36	0,812	0,84
Beliefs about perceived effects	0,339	-0,491	0,01	50,00	40,56	0,818	0,84
Influence of social environment	0,412	-0,697	0,01	50,00	30,34	0,826	0,84
Consumption patterns	0,401	-0,195	0,01	50,00	30,45	0,831	0,84

Validations of the energy drink consumption scale

Confirmatory factor analysis using the maximum likelihood method showed a satisfactory fit for the four-factor correlated model. The χ^2 statistic was significant ($\chi^2_{(164)}=236,7$, $p<0,001$), although the $\chi^2/\text{g.l.}$ ratio remained at adequate values (1,44), indicating model parsimony. The incremental fit indices showed an excellent fit: BBNFI=0,95, BBNNFI=0,96, and CFI=0,97. In terms of error indices, the RMSEA was 0,045 (90 % CI [0,036-0,054]) and the SRMR=0,043, both within the recommended criteria ($p<0,05$). Taken together, these results confirm the construct validity and relevance of the proposed multifactorial model for ECBE.

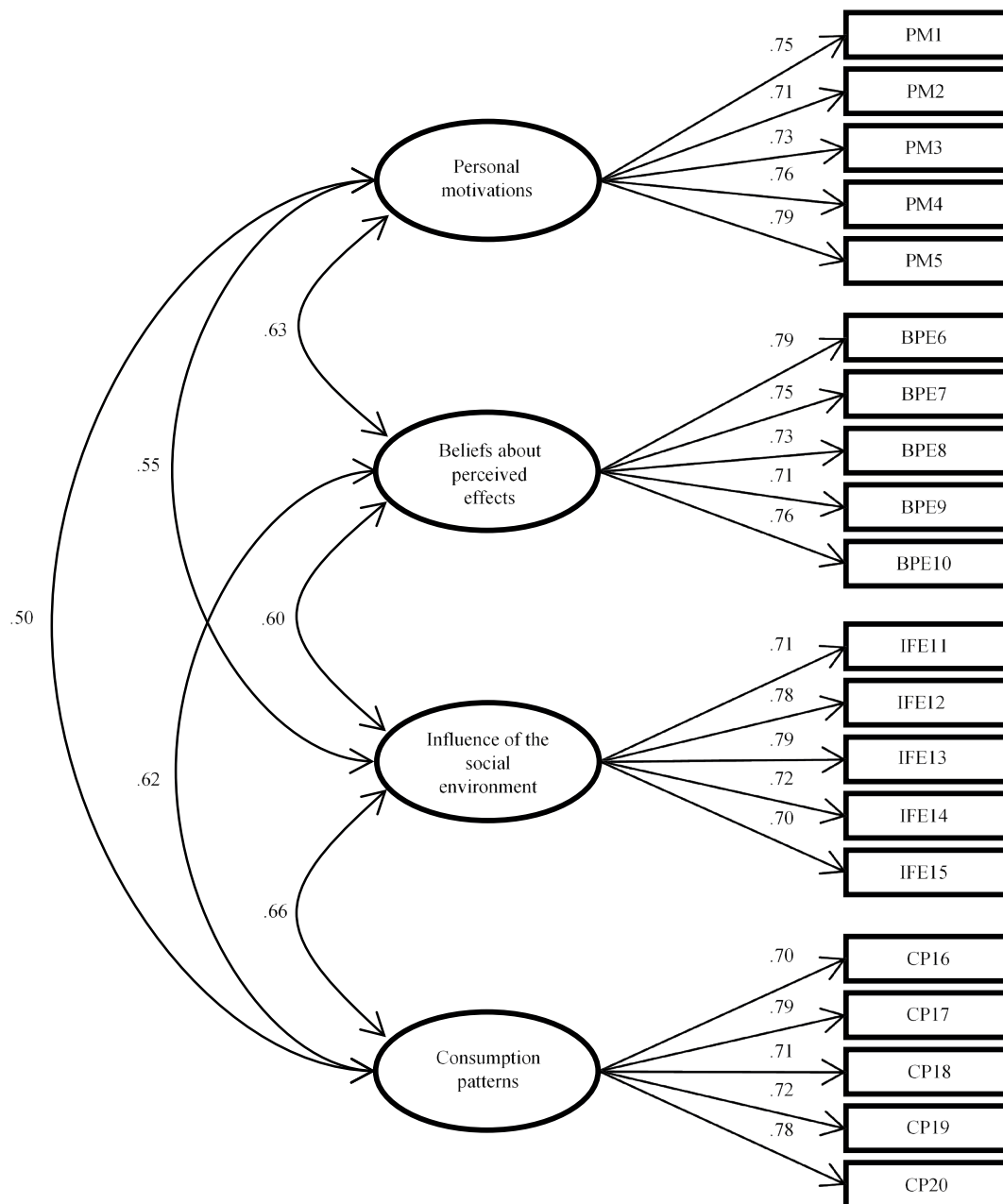


Figure 1. Confirmatory model of energy drink consumption. ($\chi^2_{(164)}=236,7$, $p<0,001$, $\chi^2/\text{gl}=1,44$, BBNFI=0,95, BBNNFI=0,96, CFI=0,97 y RMSEA = 0,045, SRMR=0,043)

Pearson's r correlation analysis

Table 3 shows the results of Pearson's correlation analysis between energy drink consumption and the different dimensions of executive functions. In all cases, positive and statistically significant correlations ($p < 0,001$) were observed, indicating a consistent association between the two constructs. Specifically, energy drink consumption showed a moderate relationship with the eight factors of executive functioning, with correlations ranging from 0,59 to 0,62, being slightly higher in the case of monitoring ($r = 0,62$, $p < 0,001$), followed by inhibition and emotional control ($r = 0,61$, $p < 0,001$), while the other dimensions, such as planning, initiative, cognitive flexibility, working memory, and organization of materials, had coefficients close to $r = 0,60$ ($p < 0,001$). These results suggest that higher energy drink consumption is associated with less efficient performance in fundamental executive processes, especially those related to self-control, emotional regulation, and task management. Furthermore, particularly high correlations were identified between the dimensions of executive functions themselves, with coefficients above .85 in all cases. For example, the relationship between initiative and working memory ($r = 0,93$, $p < 0,001$), as well as between initiative and planning ($r = 0,92$, $p < 0,001$), indicated that these cognitive skills tend to manifest jointly and share a common functional basis. Other strong associations included inhibition with monitoring ($r = 0,90$, $p < 0,001$), cognitive flexibility with emotional control ($r = 0,89$, $p < 0,001$), planning with organization of materials ($r = 0,90$, $p < 0,001$), and monitoring with working memory ($r = 0,89$, $p < 0,001$), reinforcing the integrative and interdependent nature of executive functioning.

Table 3. Pearson correlation analysis of executive function factors and energy drink consumption ($n=200$)

Variables	INHI	CF	EC	MON	PLA	OM	INIT	WM	EDC
INHI	1								
CF	0,90**	1							
EC	0,88**	0,89	1						
MON	0,90**	0,89	85**	1					
PLA	0,90**	0,90	0,87**	0,87**	1				
OM	0,89**	0,87	0,85**	0,87**	0,90**	1			
INIT	0,90**	0,89	0,86**	0,90**	0,92**	0,90**	1		
WM	0,90**	0,87	0,85**	0,89**	0,90**	0,89**	0,93**	1	
EDC	0,61**	0,60**	0,61**	0,62**	0,60**	0,59**	0,60**	0,60**	1

Structural Equation Model

Finally, figure 1 shows the structural equation model obtained to analyze the effect of energy drink consumption on executive functions in the sample. In this model, the latent construct "Energy Drink Consumption" (EDC) is composed of three observable indicators (*parcels*), which have high factor loadings ranging from 0,72 to 0,93, reflecting adequate internal consistency of the construct. In turn, the latent variable "Executive Functions," assessed using the EFECO scale, was composed of eight dimensions: monitoring, inhibition, cognitive flexibility, emotional control, planning, organization of materials, initiative, and working memory. All these dimensions had factor loadings greater than 0,90, indicating that they robustly explain the behavior of the underlying construct. The structural relationship between energy drink consumption and executive functions showed a standardized weight of 0,66, suggesting a moderate and statistically significant effect, indicating that higher energy drink consumption is associated with impaired executive function performance.

The model goodness-of-fit indices allow us to affirm that the proposed structure adequately represents the observed data. The chi-square statistic value was 95 376 with 43 degrees of freedom ($p < 0,001$), which, although it indicates a significant difference, should be interpreted with caution due to its sensitivity to sample size. However, the relative chi-square value ($X^2/df = 2,21$) is within the acceptable range. In addition, the comparative fit indices were excellent: $BBNFI = 0,97$, $BBNNFI = 0,98$, and $CFI = 0,98$. The root mean square error of approximation (RMSEA) was 0,07, which is considered an acceptable value. Finally, the reliability indicators, both Cronbach's alpha (0,96) and the composite reliability coefficient RHO (0,98), show high internal consistency of the model. Taken together, these results support the validity of the proposed model and suggest that energy drink consumption may have a negative impact on various dimensions of executive functions in the study population.

The results of the study show that energy drink consumption significantly influences executive functions, particularly causing impairment in various dimensions of executive functions, such as monitoring, inhibition, working memory, and planning. These cognitive processes are essential for learning, emotional self-regulation, decision-making, and the achievement of academic and social goals. Therefore, the results are particularly relevant in the university context, where students face high levels of cognitive demand and academic pressure. Several recent studies have demonstrated these effects.

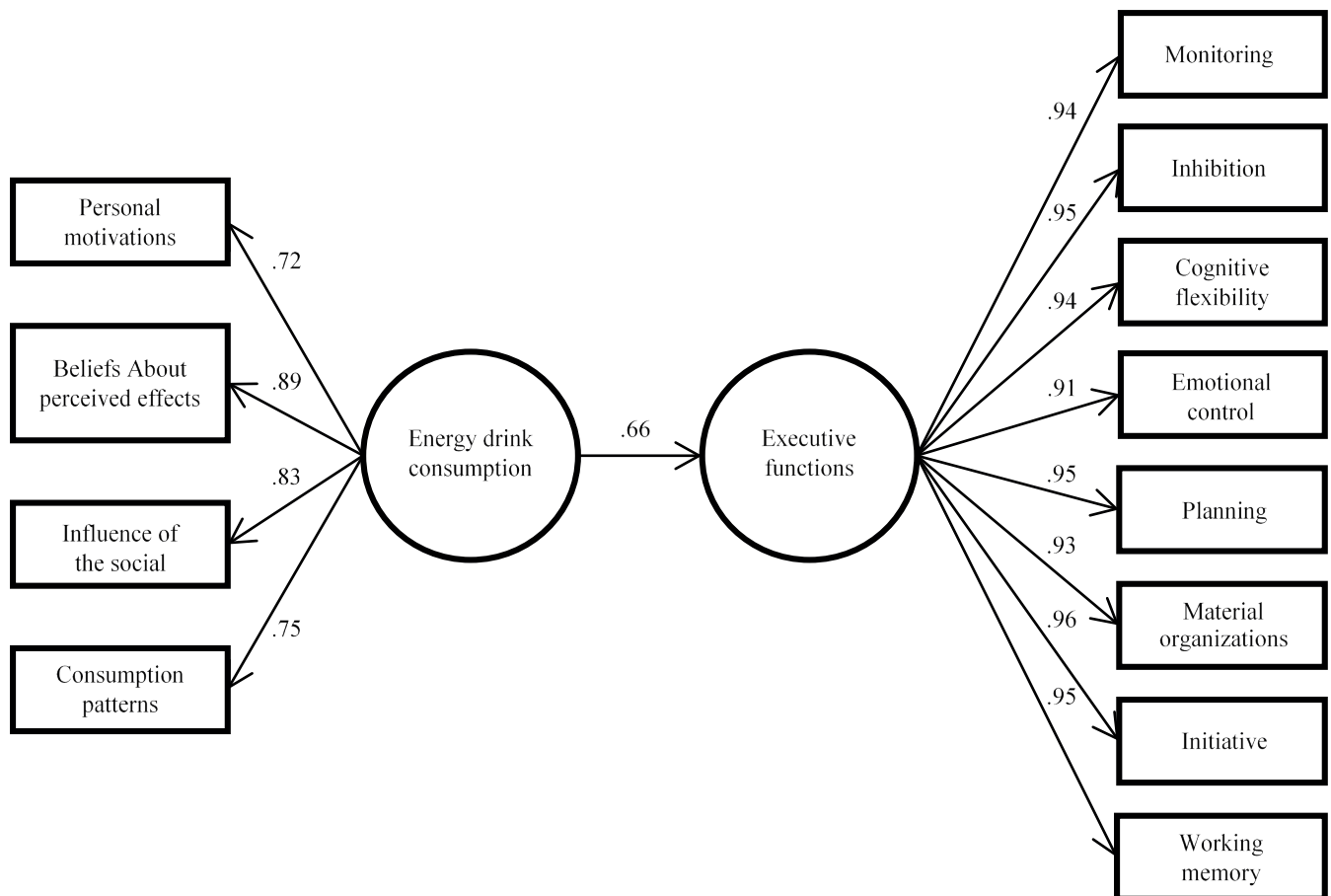


Figure 2. Effect of energy drink consumption on executive functions. Bondad de ajuste: $\chi^2 = 95,376$, 43g.l, $p < 0,001$, χ^2 relativa= 2,21, BBNFI= 0,97, BBNFI= 0,98, CFI= 0,98, RMSEA= 0,70, Alfa de Cronbach= 0,96, Coeficiente RHO= 0,98

DISCUSSION

Trigueros et al.⁽³³⁾ found that daily consumption of energy drinks in adolescents is associated with greater difficulties in behavior self-regulation, including inhibition and working memory. Similarly, Pereira et al.⁽³⁴⁾ identified that consumption of energy drinks such as Red Bull can temporarily improve sustained attention and working memory, although they warn of the risk of overstimulation and adverse effects in the long term.

The findings are consistent with recent scientific literature. Several studies have documented that regular consumption of energy drinks is associated with a number of adverse physical and psychological effects. Nadeem et al.⁽²⁾, in a meta-analysis, identified that chronic consumption of these drinks is related to nervousness, insomnia, anxiety, and difficulty concentrating, all of which are factors that affect the performance of executive functions. Similarly, Wicht et al.⁽¹³⁾ used functional neuroimaging techniques to demonstrate that the expectation of caffeine consumption can alter activity in frontal brain regions, compromising cognitive flexibility and planning ability.

Added to this is the work of Kennedy and Wightman¹, who point out that the combination of caffeine with other ingredients such as taurine and sugars, common in energy drinks, can induce neurochemical dysfunctions by affecting dopamine and adenosine systems, neurotransmitters that are fundamental for working memory, sustained attention, and self-control. These biochemical alterations help explain why negative effects on executive functions are not only to be expected but also recurrent among frequent consumers.

In the university setting, other research has supported these findings. Pintor-Holguín et al.⁽⁷⁾, that a considerable proportion of medical students consume energy drinks on a regular basis, without full knowledge of their components or adverse effects. The students reported sleep disturbances, mental fatigue, and difficulty concentrating, which is consistent with the profile of executive impairment identified in the present study, especially in monitoring ($r = 0,62$) and emotional control ($r = 0,61$).

In addition, international studies such as that by Luo et al.⁽³⁵⁾ have shown that frequent consumption of energy drinks in adolescents is linked to impulsive behavior, aggression, and emotional self-regulation problems. Such behaviors reflect deficiencies in functions such as inhibition and emotional control, suggesting that executive function impairment may be a global phenomenon that transcends cultural and educational contexts.

One of the most notable strengths of the study lies in the use of a structural equation model (SEM), which allowed for an integrative examination of the relationship between consumption and executive functions. The model revealed a moderate ($\lambda = 0,66$), statistically significant direct effect between energy drink consumption and impaired executive functions. In addition, the model fit indicators (BBNFI= 0,97, BBNNFI= 0,98, CFI= 0,98, RMSEA = 0,07) indicate an excellent fit to the observed data. These results provide robust empirical evidence that reinforces the validity of the proposed theoretical model.

Executive functions, as has been extensively documented by Arcos⁽³⁶⁾, are fundamental predictors of academic success, emotional stability, and social adaptation. A deterioration in these functions compromises the student's ability to organize complex tasks, manage time, and maintain attention, negatively affecting their school performance and well-being. This creates a negative feedback loop, in which the student may resort to energy drinks as a compensatory strategy, thus aggravating the initial symptoms.

From a public health perspective, the results of this study underscore the urgent need to design and implement preventive interventions targeting university students. It is essential to generate awareness campaigns about the risks associated with the consumption of energy drinks, as well as to limit their sale and promotion in educational settings. As suggested by the National Institute of Public Health⁽³⁷⁾, regulating access to these drinks should be a priority in health policies targeting young populations. The study also raises opportunities for psychoeducational intervention. Since executive functions are malleable processes, they can be strengthened through specific programs in neuroeducation, emotional regulation, and strategic planning. These interventions could not only mitigate the negative effects of stimulant consumption but also promote healthier and more sustainable learning environments. In summary, the results of this study offer clear and compelling evidence of the negative impact of frequent energy drink consumption on the executive functioning of college students. In light of these findings, it is essential that the education, health, and regulatory sectors work in a coordinated manner to protect the cognitive health of young people, promote informed decisions, and encourage healthy lifestyles that favor the comprehensive development of new generations.

Among the main limitations is the possible social desirability bias in the responses, which could be mitigated in future studies through greater anonymity, probabilistic sampling, and, if feasible, longitudinal designs or randomized trials that allow for the evaluation of temporality and an approximation of causality. Furthermore, the sample consisted mainly of first-semester students in health sciences programs, which limits the generalizability of the findings. It is plausible that the relationship between energy drink consumption and executive functions differs in students who are further along in their studies and have a heavier academic load; therefore, future research should include cohorts from different semesters and model the moderating effect of academic load.

CONCLUSIONS

This study provides clear evidence of the relationship between energy drink consumption and impaired executive functions in university students, particularly in key areas such as planning, working memory, and inhibitory control, which are fundamental to academic and social performance. These results highlight the importance of raising awareness among students about the risks associated with excessive consumption of stimulants, promoting informed and responsible decisions. At the same time, they emphasize the need to address this issue from a comprehensive perspective that involves the educational, health, and regulatory sectors in order to mitigate its possible adverse effects and contribute to the cognitive well-being of the young population.

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FUNDING

The authors did not receive any funding for the development of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

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