**UNIVERSIDADE FEDERAL DE ALAGOAS**

**FACULDADE DE NUTRIÇÃO**

**MESTRADO EM NUTRIÇÃO**

**ASSOCIAÇÃO ENTRE O CONSUMO DE ALIMENTOS ULTRAPROCESSADOS E DESFECHOS DE SAÚDE MENTAL: ANÁLISES SECUNDÁRIAS DE ENSAIOS CLÍNICOS**

**JOÃO VICTOR LAURINDO DOS SANTOS**

**MACEIÓ-2025**

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**Dissertação apresentada à Faculdade de Nutrição da Universidade Federal de Alagoas como requisito à obtenção do título de Mestre em Nutrição.**

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Instituto Federal de Alagoas

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# MESTRADO EM NUTRIÇÃO
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**"ASSOCIAÇÃO ENTRE O CONSUMO DE ALIMENTOS ULTRAPROCESSADOS E DESFECHOS DE SAÚDE MENTAL: ANÁLISES SECUNDÁRIAS DE ENSAIOS CLÍNICOS"**

**por**

*João Victor Laurindo dos Santos*

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# RESUMO

SANTOS, J. V. L. **Associação entre o consumo de alimentos ultraprocessados e desfechos de saúde mental: análises secundárias de ensaios clínicos.** 2025. 77 f. Dissertação (Mestrado em Nutrição) – Programa de Pós-Graduação em Nutrição, Faculdade de Nutrição, Universidade Federal de Alagoas, Maceió, 2025.

A saúde mental é um componente essencial do bem-estar geral, e sua relação com o consumo de alimentos ultraprocessados (AUP) tem ganhado grande destaque nas pesquisas. Esta dissertação, composta por dois artigos, investigou essa relação em diferentes grupos populacionais, com o objetivo de preencher lacunas na literatura. O primeiro artigo, intitulado "Associação entre o consumo de alimentos ultraprocessados e o desempenho cognitivo entre adolescentes de cidades subdesenvolvidas no Brasil", teve como objetivo avaliar a associação entre o desempenho cognitivo e o consumo de AUP em adolescentes residentes em cidades do interior do Nordeste brasileiro. O estudo incluiu 116 adolescentes, com uma idade média de 14 anos, dos quais 50 (43,1%) apresentaram baixo desempenho cognitivo. A ingestão energética média foi de 1973,5 kcal, com 24,2% proveniente de AUP. Os participantes com baixo desempenho cognitivo consumiram 26,5% (IC95%: [22,2; 30,7] %) da ingestão energética diária proveniente de AUP, comparado a 22,5% (IC95%: [18,8; 26,2] %) daqueles com desempenho cognitivo médio-alto (P = 0,17). Não foram observadas diferenças significativas na ingestão total de energia e macronutrientes entre os grupos. Embora o consumo de AUP tenha sido semelhante à média brasileira, não foi encontrada uma associação significativa entre o consumo de AUP e o desempenho cognitivo nesta amostra de adolescentes de baixa renda. O segundo artigo, intitulado "Associação entre o consumo de AUP e o transtorno de ansiedade generalizada em adultos com obesidade buscando perda de peso", teve como objetivo avaliar a relação entre os sintomas do transtorno de ansiedade generalizada (TAG) e o consumo de AUP em adultos com obesidade que buscavam perder peso. O estudo transversal incluiu 148 adultos (19-59 anos) recrutados de uma universidade brasileira. O consumo alimentar foi avaliado por meio de três recordatórios de 24 horas, classificados de acordo com a classificação NOVA. O TAG foi medido utilizando a Escala de Transtorno de Ansiedade Generalizada 7 (GAD-7). Modelos de regressão

linear ajustados para fatores de confusão, como sexo, idade, status econômico e nível de atividade física, foram utilizados para analisar a associação entre os sintomas de ansiedade e o consumo de AUP. Escores mais elevados no GAD-7 foram associados a maior consumo de AUP ($\beta$ = 0,445%; IC95%: 0,042%–0,849%; p = 0,031), representando 22,8% da ingestão energética total. Não foi encontrada uma associação significativa entre a ansiedade e o consumo de sódio, açúcar ou gordura saturada. Adultos com obesidade buscando perda de peso e com sintomas mais elevados de ansiedade consumiram mais AUP, sugerindo uma relação entre ansiedade e padrões alimentares. Isso indica que o estado emocional pode influenciar as escolhas alimentares neste grupo. Em resumo, o consumo de AUP impacta de forma diferente cada grupo: em adolescentes de baixa renda, não houve relação com o desempenho cognitivo, mas foi associado a maiores sintomas de ansiedade em adultos com obesidade. Fatores contextuais e individuais desempenham um papel crucial nesta relação, e estudos longitudinais são necessários para entender melhor as causalidades e os mecanismos envolvidos.

**Palavras-chave:** Ingestão de Alimentos; Alimentos ultraprocessados; Saúde Mental; Ansiedade; Cognição.

# ABSTRACT

SANTOS, J. V. L. **Association between the consumption of ultra-processed foods and mental health outcomes: secondary analyses of clinical trials.** 2025. 77 p. Dissertação (Mestrado em Nutrição) – Programa de Pós-Graduação em Nutrição, Faculdade de Nutrição, Universidade Federal de Alagoas, Maceió, 2025.

Mental health is an essential component of overall well-being, and its relationship with the consumption of ultra-processed foods (UPF) has gained significant attention in research. This dissertation, composed of two articles, explored this relationship in different population groups, aiming to fill gaps in the literature. The first article, titled "Association between the consumption of ultra-processed foods and cognitive performance among adolescents from underdeveloped cities in Brazil," aimed to evaluate the association between cognitive performance and UPF consumption in adolescents residing in cities in the interior of northeastern Brazil. The study included 116 adolescents, with an average age of 14 years, of whom 50 (43.1%) exhibited low cognitive performance. The average energy intake was 1973.5 kcal, with 24.2% coming from UPF. Participants with low cognitive performance consumed 26.5% (95% CI: [22.2; 30.7] %) of their daily energy intake from UPF, compared to 22.5% (95% CI: [18.8; 26.2] %) in those with medium-high cognitive performance (P = 0.17). No significant differences in total energy and macronutrient intake were observed between the groups. Although UPF consumption was similar to the Brazilian average, no significant association was found between UPF consumption and cognitive performance in this sample of low-income adolescents. The second article, titled "Association between UPF consumption and generalized anxiety disorder in adults with obesity seeking weight loss," aimed to evaluate the relationship between symptoms of generalized anxiety disorder (GAD) and UPF consumption in adults with obesity attempting to lose weight. This cross-sectional study included 148 adults (19-59 years) recruited from a Brazilian university. Food consumption was assessed using three 24-hour recalls, classified according to the NOVA classification. GAD was measured using the Generalized Anxiety Disorder 7 (GAD-7) scale. Linear regression models adjusted for confounding factors, such as sex, age, economic status, and physical activity, were used to analyze the association between anxiety symptoms and UPF consumption. Higher GAD-7 scores were associated with greater UPF

consumption ($\beta$ = 0.445%; 95% CI: 0.042%–0.849%; p = 0.031), which accounted for 22.8% of total energy intake. No significant association was found between anxiety and the consumption of sodium, sugar, or saturated fat. Adults with obesity seeking weight loss who exhibited higher anxiety symptoms consumed more UPF, suggesting a relationship between anxiety and eating patterns. This indicates that emotional state may influence food choices in this group. In summary, UPF consumption impacts each group differently: in low-income adolescents, no relationship was found with cognitive performance, but a link was observed with higher anxiety symptoms in adults with obesity. Contextual and individual factors play a crucial role in this relationship, and longitudinal studies are necessary to better understand the causalities and mechanisms involved.

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**REVISÃO DA LITERATURA**

# LISTA DE SIGLAS E ABREVIATURAS

ABEP          Associação brasileira de empresas de pesquisa

ABESO         Associação brasileira para o estudo da obesidade e da síndrome metabólica

ACK           Acessulfame potássico

APA           Associação americana de psicologia

AUP           Alimentos ultraprocessados

CCEB          Critério de classificação econômica Brasil

CMC           Carboximetilcelulose

DSM-5         Manual diagnóstico e estatístico de transtornos mentais 5.ª edição

GAD-7         *Generalized Anxiety Disorder 7*

IBGE          Instituto brasileiro de geografia e estatística

IFAL          Instituto Federal de Alagoas

IMC           Índice de massa corporal

IPAQ          Questionário internacional de atividade física

MPM           *Multiple pass method*

NHANES        *National health and nutrition examination survey*

OMS           Organização Mundial da Saúde

P80           Polissorbato 80

POF           Pesquisa de Orçamentos Familiares

QI            Quociente de Inteligência

ReBEC         Registro brasileiro de ensaios clínicos

TAG           Transtorno de ansiedade generalizada

TALE          Termo de assentimento livre e esclarecido

TCLE          Termo de consentimento livre e esclarecido

TDAH          Transtorno de déficit de atenção e hiperatividade

TIG-NV        Teste de Inteligência Geral Não Verbal

UFAL          Universidade Federal de Alagoas

# SUMÁRIO

1. **APRESENTAÇÃO**

A saúde mental é definida pela Organização Mundial da Saúde (OMS), como um estado de bem-estar em que a pessoa tem consciência de suas capacidades, consegue enfrentar o estresse diário, trabalha de maneira produtiva e contribui para a sua comunidade (OMS, 2022). Não se trata apenas da ausência de transtornos mentais, mas de um equilíbrio emocional, psicológico e social que possibilita uma vida funcional e satisfatória (OMS, 2022). Condições clínicas como os transtornos mentais representam desvios desse estado de equilíbrio, resultando em efeitos negativos na qualidade de vida e no bem-estar geral (APA, 2014). Entre os transtornos mentais, a ansiedade é o mais prevalente globalmente, afetando uma grande parte da população (OMS, 2022; Javaid et al., 2023). Além disso, a redução do desempenho cognitivo, manifestada por dificuldades na memória, atenção ou tomada de decisão, também pode comprometer a saúde mental, evidenciando a interdependência entre cognição e bem-estar psicológico (Bierman et al., 2008; Saczynski et al., 2010; Levens; Gotlib, 2012; Rock et al., 2014; Millan et al., 2012).

Nesse sentido, a qualidade da dieta tem sido apontada como um potencial fator de risco para desfechos de saúde mental em vários estudos. Muitos desses estudos têm investigado padrões alimentares, como o mediterrâneo e o ocidental, além de índices de qualidade da dieta (Jacka et al., 2011; Gibson-Smith et al., 2018; Oddy et al., 2009; Munoz et al., 2008; Quirk et al., 2013). No entanto, a literatura científica atual tem explorado cada vez mais o papel dos alimentos de acordo com o grau de processamento (Lane et al., 2024; Hecht et al., 2022; Godos et al., 2023; Mazloomi et al., 2023). Esses estudos estão utilizando a chamada classificação NOVA (Monteiro et al., 2019).

Segundo a classificação NOVA, os alimentos ultraprocessados (AUP) são definidos como formulações industriais que contêm predominantemente ingredientes de uso exclusivo da indústria, acrescidos de aditivos alimentares, com pequenas quantidades ou nenhuma de alimentos integrais (Monteiro et al., 2019). Esses produtos passam por extensos processos industriais e frequentemente apresentam alta densidade energética, e em muitos casos, são ricos em carboidratos refinados, gorduras saturadas e sódio, enquanto frequentemente são pobres em proteínas, fibras e micronutrientes (Monteiro et al., 2019).

O Guia Alimentar para a População Brasileira, publicado em 2014 e baseado na classificação NOVA, recomenda a limitação do consumo de AUP devido às suas características nutricionais e potenciais impactos negativos à saúde (Brasil, 2014;

Monteiro et al., 2019; Vitale et al., 2023; Lane et al., 2024). Embora haja essa recomendação, o consumo desses alimentos tem aumentado na população brasileira. Segundo análises do consumo alimentar divulgadas pela Pesquisa de orçamentos familiares (POF), realizadas entre 2008-2009 e 2017-2018, observou-se um crescimento na participação dos AUP (Louzada et al., 2023). No período mais recente da POF, os AUP representaram 19,7% das calorias consumidas diariamente pelos brasileiros (IBGE, 2020).

No contexto do consumo de AUP e seus desfechos em saúde mental, as evidências sugerem associações significativas. Lane et al. (2024) identificaram que o consumo elevado de AUP está associado ao aumento no risco de ansiedade, o que corrobora com os achados de Coletro et al. (2022). Estudos com crianças e adultos revelaram que o consumo elevado de AUP está associado a piores resultados cognitivos (Cardoso; Machado; Steele, 2022; Liu et al., 2023).

Apesar das evidências existentes sobre os efeitos dos AUP nos desfechos de saúde mental, ainda há lacunas na literatura. Não foram identificados estudos específicos que associam AUP ao desempenho cognitivo em adolescentes, tampouco há pesquisas que explorem a relação entre o consumo de AUP e indivíduos com obesidade, especialmente no que tange à ansiedade. Diante da crescente preocupação com o consumo de AUP e da falta de dados sobre seus efeitos em contextos menos explorados, é essencial conduzir mais estudos sobre essa temática.

Sendo assim, o presente estudo tem por objetivo investigar se existe associação entre o consumo de AUP e desfechos de saúde mental, como desempenho cognitivo em adolescentes e sintomas de transtorno de ansiedade generalizada (TAG) em adultos.

Esta dissertação está dividida em: (a) um capítulo de revisão da literatura, onde será abordado sobre alimentos ultraprocessados e saúde mental e (b) dois artigos de resultados: i) *Association between ultra-processed food consumption and cognitive performance among adolescent students from underdeveloped cities in Brazil: a cross-sectional study*. ii) *Association between the consumption of ultra-processed foods and generalized anxiety disorder in adults with obesity seeking weight loss*.

## 2. REVISÃO DA LITERATURA

## 2.1. Alimentos ultraprocessados (AUP)

### 2.1.1. Definição

A alimentação é um dos pilares fundamentais para a promoção da saúde e o bem-estar ao longo da vida. Nas últimas décadas, temos observado mudanças profundas nos padrões alimentares em todo o mundo, a transição nutricional, marcada pela substituição de dietas tradicionais, ricas em alimentos frescos e minimamente processados, por dietas ocidentais, onde predomina o consumo de alimentos processados e ultraprocessados (Popkin; Ng, 2022). Fatores como urbanização, mudanças no estilo de vida, publicidade agressiva e disponibilidade econômica têm sido apontados como principais propulsores desse processo (Popkin; Ng, 2022). Para melhor compreender esses padrões de consumo e seus impactos, é essencial discutir a classificação dos alimentos com base no grau de processamento, como proposto pela classificação NOVA.

A classificação NOVA foi desenvolvida por Monteiro et al. (2010), é amplamente utilizada em estudos para categorizar alimentos e bebidas de acordo com o nível de processamento a que foram submetidos. Na classificação NOVA os alimentos são distribuídos em 4 grupos (Monteiro et al., 2019):

O grupo 1 é composto por alimentos *in natura* e minimamente processados, que são alimentos que passam por processamentos mínimos, principalmente físicos, como remoção de partes não comestíveis, secagem, trituração, pasteurização, congelamento, entre outros. A finalidade do processamento é aumentar a vida útil dos alimentos, facilitar sua preparação ou diversificá-los. Exemplos típicos incluem grãos, legumes, verduras, frutas, carnes, entre outros.

O grupo 2 é composto por Ingredientes culinários processados ou da indústria alimentícia, que são substâncias derivadas de alimentos do grupo 1 ou da natureza através de processos como prensagem, centrifugação e refinamento. A finalidade do processamento é produzir ingredientes para utilização no preparo, tempero e cozimento de alimentos do grupo 1. Exemplos típicos incluem óleos, gorduras, açúcar e sal.

O Grupo 3 é composto por alimentos processados, que são produtos alimentícios resultantes da adição de substâncias do grupo 2 aos alimentos do Grupo 1. O processamento inclui métodos de preservação como enlatamento e fermentação.

A finalidade do processamento é prolongar a vida útil dos alimentos do grupo 1, modificar ou aprimorar suas qualidades sensoriais. Exemplos típicos incluem vegetais enlatados, peixes em conserva, frutas em calda, queijos e pães, entre outros.

O Grupo 4 é composto por alimentos ultraprocessados, que são formulações industriais feitas majoritariamente de ingredientes de uso exclusivo da indústria. O processamento inclui várias etapas e diferentes indústrias, começando com a fragmentação de alimentos integrais em substâncias através de processos físicos ou químicos, em seguida é feita a montagem dessas substâncias com pequena quantidade ou nenhuma de alimentos integrais, usando técnicas industriais como extrusão, moldagem e pré fritura. Os aditivos usados nesses produtos incluem corantes, sabores, emulsificantes e outros aditivos. A finalidade do processamento é torná-los palatáveis ou hiperpalatáveis. Exemplos típicos incluem refrigerantes, lanches embalados, sorvetes, pães industrializados, margarinas, biscoitos, bolos, cereais matinais, pratos pré preparados, nuggets, salsichas, sopas instantâneas, entre outros.

## 2.1.2. Epidemiologia de consumo

O consumo de AUP tem crescido significativamente em todo o mundo nas últimas décadas, com um aumento particularmente rápido em países de renda média e baixa, enquanto os países de alta renda já apresentam níveis elevados de consumo (Bake et al., 2020). Entre 2009 e 2019, as vendas per capita de AUP cresceram a uma taxa anual composta de 0,4% em países de alta renda, 2,8% em países de renda média-alta e 4,4% em países de renda média-baixa (Bake et al., 2020). Em 2019, as vendas per capita de AUP atingiram 109,3 kg em países de alta renda, 32,3 kg em países de renda média-alta e 9,7 kg em países de renda média-baixa (Bake et al., 2020).

Nos países desenvolvidos, os AUP frequentemente representam mais de 50% da ingestão total de energia da população, enquanto em muitos países em desenvolvimento, como os da América Latina, essa proporção se aproxima dos 30% (Marino et al., 2021; Marrón-Ponce et al., 2018; Cediel et al., 2018). No Brasil, segundo a análise do consumo alimentar divulgada pela POF 2017-2018, os AUP representaram 26,7% do total de calorias consumidas por adolescentes, 19,5% por adultos e 15,1% por idosos (IBGE, 2020).

O consumo de AUP varia globalmente e é influenciado por fatores sociodemográficos, como idade, gênero, raça/etnia, renda, escolaridade, status socioeconômico, insegurança alimentar, estado civil e local de residência. Uma revisão sistemática com metanálise realizada por Dicken, Qamar e Batterham (2023), abrangendo 32 países, identificou padrões distintos de consumo de AUP entre diferentes grupos populacionais, refletindo desigualdades sociais e econômicas:

Em relação à idade, adultos mais jovens e adolescentes apresentam os maiores consumos de AUP em 17 países, com diferenças de até 20% na ingestão total de energia. Por exemplo, no Brasil, adolescentes de 10 a 19 anos consomem 26,8% da energia total de AUP, enquanto idosos com 60 anos ou mais consomem 15,0%, uma diferença de 11,8%. Em contraste, em países como os Estados Unidos e a Bélgica, idosos também consomem quantidades significativas de AUP, com adultos de 60 anos ou mais nos EUA consumindo 52,8% da energia total de AUP.

As diferenças de gênero são geralmente pequenas, mas, quando presentes, indicam um maior consumo entre homens na Austrália (homens: 38,8% vs. mulheres: 37,5%, diferença de 1,3%), Coreia do Sul (homens: 25,8% vs. mulheres: 25,0%, diferença de 0,8%), Canadá (homens: 48,6% vs. mulheres: 46,5%, diferença de 2,1%), Suíça (homens: 29,2% vs. mulheres: 28,4%, diferença de 0,8%) e Reino Unido (homens: 55,9% vs. mulheres: 52,8%, diferença de 3,1%). Por outro lado, no Brasil, Colômbia, Itália, Portugal e Espanha, as mulheres consomem ligeiramente mais AUP. No Brasil, por exemplo, mulheres consomem 21,8% da energia total de AUP, enquanto homens consomem 19,2%, uma diferença de 2,6%.

A raça/etnia também se mostrou um fator relevante, especialmente no Brasil, Estados Unidos e Reino Unido, onde as diferenças chegam a 10%–20% da ingestão total de energia. Nos EUA, brancos não hispânicos consomem 60,2% da energia total de AUP, enquanto hispânicos consomem 52,0%, uma diferença de 8,2%. No Brasil, indivíduos brancos predominam no maior quintil de consumo (57%), enquanto afrodescendentes estão mais concentrados no menor quintil (64%).

A renda demonstrou influências variadas entre os países. No Brasil e no Chile, uma maior renda foi associada a um maior consumo de AUP, com diferenças de até 15%. No Brasil, indivíduos no tercil de renda mais alta consomem 26,3% da energia total de AUP, enquanto aqueles no tercil mais baixo consomem 15,1%, uma diferença de 11,2%. Já nos Estados Unidos e na Austrália, ocorre o oposto, com maior consumo entre grupos de menor renda. Nos EUA, indivíduos com renda abaixo de 1,3 vezes o

nível de pobreza consomem 59,6% da energia total de AUP, enquanto aqueles com renda acima de 3,5 vezes o nível de pobreza consomem 57,7%, uma diferença de 1,9%.

A escolaridade também apresentou associações significativas em 10 dos 15 países analisados. No Brasil, Coreia do Sul, México e Portugal, níveis educacionais mais altos foram associados a um maior consumo de AUP. No Brasil, indivíduos com ensino superior consomem 26,3% da energia total de AUP, enquanto aqueles com ensino fundamental consomem 15,1%, uma diferença de 11,2%. Já na Austrália, Canadá e Estados Unidos, o padrão foi inverso, com maior consumo entre indivíduos de menor escolaridade.

O status socioeconômico, analisado em seis países, revelou discrepâncias: no México e na Colômbia, grupos de maior status consumiram mais AUP, com diferenças de 4,5% e 10,1%, respectivamente. No Reino Unido e na Austrália, o consumo foi maior entre grupos de menor status. No Reino Unido, indivíduos em ocupações manuais consomem 57,3% da energia total de AUP, enquanto aqueles em ocupações profissionais consomem 50,3%, uma diferença de 7,0%.

A insegurança alimentar, avaliada no Canadá, França e Portugal, mostrou-se associada a um maior consumo de AUP no Canadá e na França, mas sem relação significativa em Portugal. No Canadá, indivíduos com insegurança alimentar grave consomem 47,0% da energia total de AUP, enquanto aqueles com segurança alimentar consomem 37,5%, uma diferença de 9,5%.

Além disso, aspectos como estado civil e local de residência também influenciam os padrões de consumo. Em quatro países, solteiros, divorciados ou separados apresentaram maior consumo de AUP. Na Itália, por exemplo, solteiros consomem 1,26% a mais de AUP como proporção da energia total em comparação com casados. A urbanização também foi um fator relevante em 11 países, onde moradores de áreas urbanas consumiram mais AUP, com diferenças que chegaram a 10% no Brasil e 80% na Colômbia. No entanto, em países como Portugal, Reino Unido e Suíça, essa relação tornou-se insignificante após ajustes por outros fatores.

2.1.3. Impactos dos AUP na saúde física

O aumento no consumo de alimentos ultraprocessados têm despertado grande interesse nos últimos anos devido a suas potenciais implicações negativas na saúde

física. Diversos estudos epidemiológicos têm mostrado uma correlação direta entre a ingestão desses alimentos e o aumento da prevalência de obesidade e doenças crônicas não transmissíveis (Lane et al., 2024; Pagliai et al., 2021; Vitale et al., 2023; Delpino et al., 2022; Wang et al., 2022; Lian et al., 2023).

Uma revisão guarda-chuva conduzida por Lane et al. (2024) avaliou a relação entre o consumo de alimentos ultraprocessados e diversos problemas de saúde. Os resultados indicaram que a exposição a esses alimentos está associada a um risco significativamente maior de mortalidade por doenças cardiovasculares (OR = 1,50; IC 95%: 1,37–1,63), desenvolvimento de diabetes tipo 2 (OR = 1,12; IC 95%: 1,11–1,13), ansiedade (OR = 1,48; IC 95%: 1,37–1,59), transtornos mentais comuns (OR = 1,53; IC 95%: 1,43–1,63), mortalidade geral (OR = 1,21; IC 95%: 1,15–1,27), depressão (OR = 1,22; IC 95%: 1,16–1,28) e obesidade (OR = 1,55; IC 95%: 1,36–1,77).

Pagliai et al. (2021) realizaram uma revisão sistemática com metanálise de estudos observacionais e identificaram várias associações significativas entre o consumo elevado de AUP e desfechos negativos para a saúde. O consumo de AUP foi associado a um aumento no risco de sobrepeso/obesidade (OR = 1,39; IC 95%: 1,29–1,50), circunferência abdominal elevada ou obesidade abdominal (OR = 1,39; IC 95%: 1,16–1,67), síndrome metabólica (OR = 1,79; IC 95%: 1,10–2,90) e níveis reduzidos de colesterol HDL (OR = 2,02; IC 95%: 1,27–3,21).

Complementando esses achados, Vitale et al. (2023) conduziram uma revisão sistemática e metanálise de estudos de coorte prospectivos e investigaram a relação entre o consumo de AUP e diversas condições de saúde. Eles observaram que o consumo elevado de AUP foi associado a um aumento do risco de diabetes (OR = 1,37; IC 95%: 1,20–1,56), hipertensão (OR = 1,32; IC 95%: 1,19–1,45), hipertrigliceridemia (OR = 1,47; IC 95%: 1,12–1,93), baixos níveis de colesterol HDL (OR = 1,43; IC 95%: 1,05–1,95) e obesidade (OR = 1,32; IC 95%: 1,20–1,45).

Em uma abordagem semelhante, Delpino et al. (2022) realizaram uma revisão sistemática e metanálise de estudos longitudinais, focando especificamente no risco de diabetes tipo 2 associado ao consumo de AUP. Eles encontraram que o consumo moderado de AUP aumentou o risco de diabetes tipo 2 (RR = 1,12; IC 95%: 1,06–1,17), enquanto o consumo elevado apresentou um risco ainda maior (RR = 1,31; IC 95%: 1,21–1,42).

Além disso, Wang et al. (2022) realizaram uma revisão sistemática e metanálise de estudos observacionais para investigar o risco de hipertensão relacionado ao

consumo de AUP. Os resultados mostraram uma associação significativa entre o consumo elevado de AUP e um aumento no risco de hipertensão (OR = 1,23; IC 95%: 1,11–1,37).

Por fim, Lian et al. (2023) conduziram uma revisão sistemática e metanálise de estudos observacionais para explorar a relação entre o consumo de AUP e o risco de câncer. Eles observaram que o consumo elevado de AUP foi associado a um aumento no risco de câncer colorretal (OR = 1,23; IC 95%: 1,10–1,38), câncer de cólon (OR = 1,25; IC 95%: 1,14–1,36) e câncer de mama (OR = 1,10; IC 95%: 1,00–1,20).

Recentemente, dois estudos randomizados investigaram os efeitos dos AUP na saúde física. O primeiro, conduzido por Hall et al. (2019), foi um ensaio clínico randomizado e cruzado com 20 adultos. Os participantes foram randomizados para consumir uma dieta de AUP e uma dieta não processada, em períodos separados de 2 semanas, sem período de *washout*. As dietas foram pareadas em termos de energia, macronutrientes, açúcar, sódio e fibras, mas os participantes podiam consumir os alimentos à vontade (*ad libitum*). Os autores observaram que a dieta de AUP resultou em um aumento no consumo energético total de 508 kcal/dia (p < 0,0001), levando a um maior ganho de peso de 0,9 kg (p = 0,009), quando comparada à dieta não processada. Além disso, a taxa de alimentação foi significativamente maior durante a dieta de AUP (17 kcal/min vs. 10 kcal/min, p < 0,0001). O segundo estudo, realizado por Hamano et al. (2024), foi um ensaio clínico randomizado, aberto e cruzado (crossover), envolvendo nove homens japoneses com sobrepeso ou obesidade. Os participantes foram randomizados para consumir dietas baseadas em AUP ou não AUP por uma semana, com um período de *washout* de duas semanas entre as intervenções. As dietas foram pareadas em termos de energia total, macronutrientes e densidade energética. Durante o consumo de AUP, os participantes ganharam 1,1 kg a mais (IC 95%: 0,2-2,0; p = 0,021) e consumiram 813,5 kcal a mais por dia (IC 95%: 342,4 a 1284,7; p = 0,0041) em comparação com o período de consumo de não AUP. Além disso, a frequência de mastigação foi significativamente menor durante o consumo de AUP (p = 0,016).

## 2.1.4. Impactos dos AUP na saúde mental

Mais recentemente, a literatura científica tem explorado a relação entre o consumo de AUP e a saúde mental. Estudos sugerem que dietas ricas em AUP estão

associadas a um maior risco de transtornos mentais, transtornos alimentares, adição por alimentos e piora na função cognitiva (Lane et al., 2024; Henney et al., 2024; Pourmotabbed et al., 2024; Figueiredo et al., 2022; Ferreira et al., 2024; Khazdouz et al., 2024; Whatnall et al., 2022; Cassemiro et al., 2024; Duquenne et al., 2024; Sinai et al., 2023). Esses achados indicam que os AUP podem prejudicar significativamente a saúde mental, atuando como um fator de risco para uma variedade de desfechos negativos.

Estudos têm demonstrado uma associação consistente entre o consumo de AUP e o aumento do risco de transtornos mentais. Lane et al. (2024), em uma revisão guarda-chuva, identificaram que o consumo elevado de AUP está associado a um maior risco de ansiedade (OR = 1,48; IC 95%: 1,37–1,59), transtornos mentais comuns (OR = 1,53; IC 95%: 1,43–1,63) e depressão (OR = 1,22; IC 95%: 1,16–1,28).

Além disso, o consumo de AUP tem sido associado a prejuízos na função cognitiva. Henney et al. (2024), em uma revisão sistemática com metanálise, encontraram que o consumo elevado de AUP está relacionado a um maior risco de demência (OR = 1,44; IC 95%: 1,09–1,90). De forma complementar, Pourmotabbed et al. (2024) também identificaram uma relação significativa entre a maior ingestão de AUP e o comprometimento cognitivo (RR = 1,17; IC 95%: 1,06–1,30).

O consumo de AUP também tem sido associado a transtornos alimentares e comportamentos compulsivos. Figueiredo et al. (2022), em um estudo transversal, observaram que um aumento de 10 pontos percentuais na ingestão de AUP foi associado a um maior risco de bulimia (OR = 1,08; IC 95%: 1,01–1,14), compulsão alimentar (OR = 1,21; IC 95%: 1,16–1,26) e outros transtornos alimentares não especificados (OR = 1,11; IC 95%: 1,02–1,20).

Além disso, estudos têm explorado a relação entre o consumo de AUP e a adição por alimentos. Whatnall et al. (2022) demonstraram que jovens adultos classificados com dependência alimentar consumiam uma porcentagem significativamente maior de calorias provenientes de AUP (β = 3,954; p = 0,002) em comparação com aqueles sem diagnóstico de dependência alimentar.

A qualidade do sono também é afetada pelo consumo de AUP. Pourmotabbed et al. (2024), em uma revisão sistemática e metanálise, encontraram uma associação significativa entre o consumo de AUP e o risco de insônia, especialmente em adolescentes (OR = 1,55; IC 95%: 1,21–1,99). Cassemiro et al. (2024) também

observaram que o consumo de AUP está associado a uma menor duração do sono e a uma pior qualidade do sono em adolescentes.

O consumo de AUP na infância tem sido associado a sintomas de hiperatividade e déficit de atenção na adolescência. Ferreira et al. (2024) observaram que o consumo de AUP aos 3-4 anos de idade foi um preditor significativo de sintomas de hiperatividade/desatenção na adolescência (RR = 1,25; IC 95%: 1,04–1,51). Sinai et al. (2023), em um estudo com crianças israelenses, também encontraram uma associação positiva entre o consumo de AUP e o transtorno de déficit de atenção e hiperatividade (TDAH). Cada aumento de 200 g/dia no consumo de AUP foi associado a um aumento de 13% na prevalência de TDAH (OR = 1,13; IC 95%: 1,02–1,26). Além disso, Khazdouz et al. (2024), em uma revisão sistemática e metanálise, investigaram a relação entre o consumo de junk food (categoria que inclui diversos alimentos ultraprocessados) e o TDAH em crianças e adolescentes. Os autores encontraram uma associação positiva entre o consumo desses alimentos e sintomas de TDAH (OR = 1,24; IC 95%: 1,15–1,34).

### 2.1.5. Mecanismos subjacentes dos AUP na saúde

Identificar um papel causal claro dos AUP no risco de doenças é um desafio, a maior parte das evidências disponíveis, provém de estudos observacionais. No entanto, há uma variedade de estudos pré-clínicos que exploram os mecanismos pelos quais componentes específicos dos AUP podem impactar diferentes sistemas do organismo, contribuindo para o desenvolvimento de doenças metabólicas, inflamatórias e neurodegenerativas. Muitos desses mecanismos estão diretamente relacionados à saúde intestinal e à microbiota.

### 2.1.5.1. Emulsificantes

Rousta et al. (2021) compararam os efeitos de dois emulsificantes alimentares comuns, carboximetilcelulose (CMC) e polissorbato 80 (P80), na inflamação intestinal e na microbiota em um modelo de colite em camundongos. O CMC aumentou a inflamação intestinal, e ambos os emulsificantes alteraram a composição da microbiota. Chassaing et al. (2015) investigaram como esses mesmos emulsificantes afetam a microbiota intestinal e contribuem para doenças inflamatórias e síndrome

metabólica em camundongos. Ambos causaram inflamação de baixo grau e obesidade/síndrome metabólica em camundongos saudáveis. Em camundongos predispostos a colite, os emulsificantes promoveram colite severa, alterando a composição da microbiota intestinal e aumentando seu potencial pró-inflamatório.

### 2.1.5.2. Adoçantes

Suez et al. (2014) investigaram o impacto do consumo de adoçantes artificiais não calóricos sobre a microbiota intestinal e a homeostase da glicose em camundongos. O consumo desses adoçantes levou a intolerância à glicose e a mudanças significativas na composição da microbiota intestinal. Rousta et al. (2021) também estudaram o impacto do adoçante artificial acessulfame potássico (ACK) em camundongos, observando que ele induziu disbiose intestinal, causou lesões no intestino delgado, aumentou a permeabilidade intestinal e a migração de linfócitos para a mucosa intestinal. Além disso, houve aumento na expressão de citocinas pró-inflamatórias e diminuição na expressão dos receptores GLP-1R e GLP-2R.

### 2.1.5.3. Corantes

He et al. (2021) investigaram o impacto dos corantes alimentares Red 40 e Yellow 6 no desenvolvimento de colite semelhante à doença inflamatória intestinal em modelos de camundongos. Esses corantes desencadearam colite em camundongos com expressão aumentada de interleucina (IL)-23. Kwon et al. (2022) avaliaram o impacto da exposição crônica ao corante sintético vermelho Allura AC em camundongos, observando que ele exacerbou modelos experimentais de colite.

### 2.1.5.4. Cloreto de sódio

Monteleone et al. (2017) investigaram o impacto de uma dieta enriquecida com cloreto de sódio (sal) em camundongos com colite experimental. A dieta rica em sal aumentou a produção de citocinas inflamatórias. Miranda et al. (2018) também estudaram o impacto de uma dieta rica em sal, focando na microbiota intestinal e na gravidade da colite experimental. Eles descobriram que a dieta reduziu a abundância

relativa de Lactobacillus sp. e a produção de butirato, afetou a imunidade mucosal e aumentou a expressão de genes pró-inflamatórios.

### 2.1.5.5. Nanopartículas e micropartículas

Bettini et al. (2017) investigaram os efeitos do dióxido de titânio de grau alimentar sobre a homeostase imunológica intestinal e sistêmica, bem como seu impacto na carcinogênese em ratos. O dióxido de titânio foi detectado nas células imunológicas das placas de Peyer e alterou a homeostase imunológica. Proquin et al. (2018) estudaram os mecanismos moleculares associados aos efeitos tumorais do dióxido de titânio em um modelo de câncer colorretal induzido em camundongos. O composto causou regulação negativa de genes envolvidos no sistema imunológico inato e adaptativo, alterações associadas ao estresse oxidativo e modulação de genes de sinalização relacionados ao câncer colorretal e a outros tipos de câncer.

### 2.1.5.6. Açúcar, sódio e gordura

Além dos efeitos na saúde intestinal e microbiota, os AUP, ricos em açúcares, sódio e gorduras, afetam o sistema de recompensa cerebral, desregulando o apetite e promovendo padrões de consumo similares ao uso de substâncias de abuso (Hanssen et al., 2022; Wilcox; Farrar, 2021; Gearhardt; Schulte, 2021). Estudos em animais mostram que dietas ricas em gordura e açúcar reduzem a expressão de genes dopaminérgicos (D1R e DAT) no núcleo accumbens, aumentam a ansiedade e fragmentam o sono REM (Kang et al., 2023). O consumo excessivo de açúcar também induz comportamentos compulsivos, abstinência e alterações neuroquímicas, como mudanças na liberação de dopamina e acetilcolina (Avena; Rada; Hoebel, 2008).

A deficiência de sódio altera a atividade dopaminérgica no núcleo accumbens, aumentando a motivação para consumir sal, mecanismo semelhante ao observado na busca por recompensas (Roitman et al., 1999; Verharen et al., 2019). Além disso, dietas ricas em gordura e açúcar estão associadas à resistência à leptina e à grelina, hormônios que regulam o apetite. Em camundongos obesos, a inflamação no hipotálamo e gânglio nodoso reduziu a sinalização dopaminérgica e a resposta à grelina (Naznin et al., 2015). A resistência à leptina, por sua vez, foi observada em

ratos com dietas ricas em gordura saturada, acompanhada de inflamação no sistema nervoso central (Hryhorczuk et al., 2017).

O consumo crônico de frutose também induziu resistência à grelina antes do ganho de peso, exacerbando a obesidade em dietas ricas em gordura (Shapiro et al., 2008). A sinalização da grelina foi comprometida em ratos alimentados com gordura, que não responderam à administração do hormônio (Briggs et al., 2010). Esses achados sugerem que a resistência hormonal e a inflamação desempenham papéis cruciais na obesidade e distúrbios metabólicos. A produção de grelina também é influenciada pelo tipo de macronutriente, sendo mais inibida por carboidratos do que por gorduras (Sánchez et al., 2004).

## 2.2. Saúde mental

A saúde mental tem sido amplamente discutida na atualidade e é reconhecida como um componente crucial do bem-estar geral, influenciando todos os aspectos da vida de um indivíduo, incluindo suas relações sociais, desempenho no trabalho e qualidade de vida (OMS, 2022). A compreensão sobre a importância da saúde mental tem crescido significativamente, destacando a necessidade de abordagens para sua promoção e manutenção (Fenwick-Smith; Dahlberg; Thompson, 2018; Deuge et al., 2020; Budd et al., 2021). No entanto, juntamente com essa conscientização, houve um aumento na prevalência dos transtornos mentais, que agora representam um dos maiores desafios de saúde pública em todo o mundo (Castaldelli-Maia; Bhugra, 2022; Arias; Saxena; Verguet, 2022).

A OMS define saúde mental não apenas como a ausência de transtornos mentais, mas como um estado de bem-estar no qual o indivíduo reconhece suas habilidades, lida com o estresse cotidiano, trabalha produtivamente e contribui para sua comunidade (OMS, 2022). Quando esse equilíbrio é comprometido, podem surgir os transtornos mentais, caracterizados por alterações clinicamente significativas na cognição, regulação emocional ou comportamento (APA, 2014).

O desempenho cognitivo, que inclui processos como atenção, memória, tomada de decisão e resolução de problemas, é fundamental para a saúde mental (Gellman, 2020). Prejuízos nessas áreas, como déficits de atenção ou dificuldades de memória, podem impactar a qualidade de vida e estão frequentemente associados a transtornos como ansiedade, depressão e TDAH. Estudos demonstram que a

depressão está associada a déficits amplos nas funções executivas e na cognição geral (Snyder, 2013; Rock et al., 2014), enquanto a ansiedade prejudica o controle atencional, afetando o desempenho cognitivo (Eysenck et al., 2007). No caso do TDAH, há evidências robustas de disfunções executivas, como dificuldades de inibição e planejamento (Willcutt et al., 2005). Esses achados reforçam que alterações no funcionamento cognitivo podem ser tanto causa quanto consequência de distúrbios emocionais e comportamentais, afetando diretamente o bem-estar psicológico (Millan et al., 2012).

Segundo o último relatório da OMS sobre saúde mental mundial, no ano de 2019, aproximadamente 970 milhões de pessoas, ou 13% da população global, viviam com algum tipo de transtorno mental. A ansiedade foi a condição mais prevalente, afetando cerca de 301 milhões de indivíduos em todo o mundo (OMS, 2022).  As maiores prevalências desse transtorno foram observadas na América Latina e Caribe, assim como nas regiões de alta renda da América do Norte e Europa Ocidental (Figura 1) (JAVAID et al., 2023). Portugal apresentou a maior taxa de prevalência mundial (8.671 casos por 100.000 habitantes), seguido pelo Brasil (7.993 casos por 100.000 habitantes), Irã (7.537 casos por 100.000 habitantes) e Nova Zelândia (7.375 casos por 100.000 habitantes) (JAVAID et al., 2023).



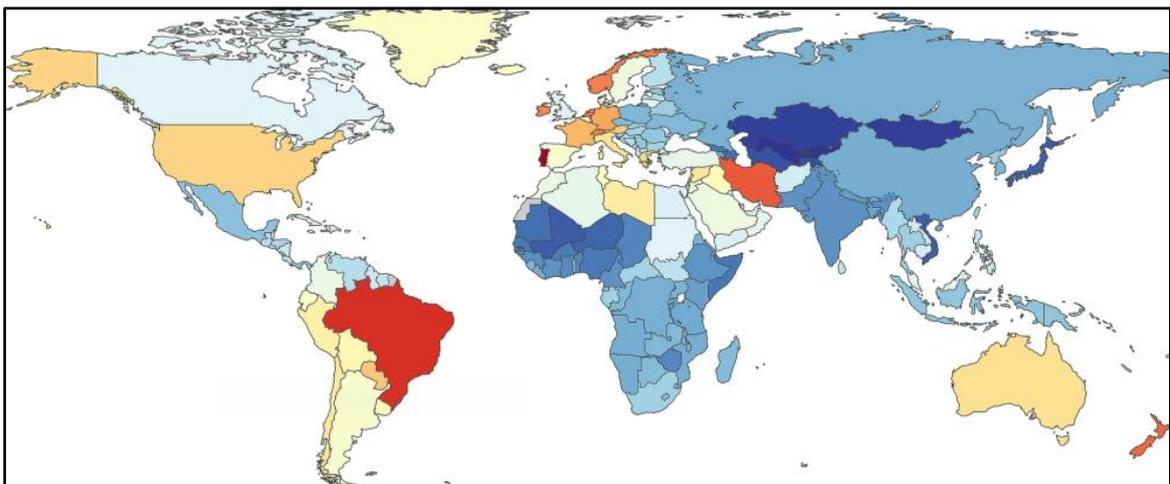**Figura 1.** Taxa de prevalência global de transtornos de ansiedade por 100.000 habitantes em 2019. As cores indicam diferentes faixas de prevalência, com vermelho escuro representando as maiores taxas (até 8.600 casos por 100.000 habitantes) e os tons de laranja, amarelo, azul claro e azul escuro representando taxas progressivamente menores, chegando a menos de 2.000 casos por 100.000 habitantes. Fonte: Javaid et al., 2023.

2.2.1. Transtorno de ansiedade generalizada (TAG)

A palavra ansiedade tem origem no latim, no substantivo"angor" e no verbo "ango", que significa "contrair". A palavra "angustus", que significa "estreito", compartilha a mesma raiz indo-europeia e reforça a ideia de que a ansiedade está associada a uma sensação de aperto (Crocq, 2015). Ao longo dos séculos, a compreensão e a classificação desse transtorno mental evoluíram significativamente. Na Filosofia e medicina greco-romana, figuras como Hipócrates (460 a.C. - 370 a.C.) e Cícero (106–43 a.C.), embora não utilizassem o termo "ansiedade" da mesma forma que é feita nos dias atuais, já diferenciavam sentimentos de ansiedade de outros afetos negativos (Crocq, 2015). Porém, foi somente no final do século XIX e início do século XX, que a ansiedade começou a ser reconhecida como um transtorno psicológico específico (Crocq, 2015). Com o avanço da psiquiatria e psicologia, no Manual de Diagnóstico e Estatístico das Perturbações Mentais 5ª edição (DSM-5), publicado em 2013 (APA, 2014), são estabelecidos critérios diagnósticos claros para os transtornos de ansiedade.

De acordo com o DSM-5, o termo TAG pode ser entendido como: a presença de ansiedade e preocupações excessivas, que é desproporcional em relação à eventualidade ou repercussão de situações futuras (APA, 2014). Essa condição é frequentemente acompanhada por sintomas físicos, que causam sofrimento significativo e impactam negativamente o cotidiano dos indivíduos (APA, 2014). O DSM-5 apresenta seis critérios diagnósticos para o Transtorno de Ansiedade Generalizada, descritos no Quadro 1.

**Quadro 1.** Critérios diagnósticos para TAG.

| Critérios primários |
|---|
| A.        Ansiedade e preocupação excessivas (expectativa apreensiva), ocorrendo na maioria dos dias por pelo menos seis meses, com diversos eventos ou atividades (tais como desempenho escolar ou profissional). |
| B.        O indivíduo considera difícil controlar a preocupação. |
| **Sintomas associados** |

| |
|---|
| C.    A ansiedade e a preocupação estão associadas com três (ou mais) dos seguintes seis sintomas (com pelo menos alguns deles presentes na maioria dos dias nos últimos seis meses).<br><br>Nota: Apenas um item é exigido para crianças.<br><br>1.    Inquietação ou sensação de estar com os nervos à flor da pele.<br>2.    Fatigabilidade.<br>3.    Dificuldade em concentrar-se ou sensações de "branco" na mente.<br>4.    Irritabilidade.<br>5.    Tensão muscular.<br>6.    Perturbação do sono (dificuldade em conciliar ou manter o sono, ou sono insatisfatório e inquieto). |
| **Critérios de impacto funciona**l |
| D.    A ansiedade, a preocupação ou os sintomas físicos causam sofrimento clinicamente significativo ou prejuízo no funcionamento social, profissional ou em outras áreas importantes da vida do indivíduo. |
| **Critérios de exclusão** |
| E.    A perturbação não se deve aos efeitos fisiológicos de uma substância (p. ex., droga de abuso, medicamento) ou a outra condição médica (p. ex., hipertireoidismo). |
| F.    A perturbação não é mais bem explicada por outro transtorno mental (p. ex., ansiedade ou preocupação quanto a ter ataques de pânico no transtorno de pânico, avaliação negativa no transtorno de ansiedade social [fobia social], contaminação ou outras obsessões no transtorno obsessivo-compulsivo, separação das figuras de apego no transtorno de ansiedade de separação, lembranças de eventos traumáticos no transtorno de estresse pós-traumático, ganho de peso na anorexia nervosa, queixas físicas no transtorno de sintomas somáticos, percepção de problemas na aparência no transtorno dismórfico corporal, ter uma doença séria no transtorno de ansiedade de doença ou o conteúdo de crenças delirantes na esquizofrenia ou transtorno delirante). |

Fonte: DSM-5 (APA, 2014).

O TAG pode impactar significativamente na qualidade de vida, no funcionamento social e no bem-estar geral dos indivíduos acometidos por esse transtorno. Bourland et al. (2000) encontraram que idosos com TAG relatam uma qualidade de vida significativamente menor do que aqueles sem transtornos psiquiátricos. Henning et al. (2007) observaram que indivíduos com TAG relatam mais comprometimento no trabalho e na função social do que em responsabilidades domésticas e familiares.

Yang et al. (2015) observaram que indivíduos com TAG apresentam função cognitiva prejudicada, especialmente em termos de atenção seletiva e memória de trabalho. Pollack et al. (2008) confirmaram que o TAG está associado a um comprometimento substancial no funcionamento e no bem-estar subjetivo dos pacientes. Além disso, Erickson e Newman (2007) verificaram que indivíduos com TAG apresentam percepções distorcidas sobre o impacto de suas interações sociais, com os participantes demonstrando mais afeto triste durante tarefas de divulgação emocional.

Ademais, Kim et al. (2019) compararam jovens com Transtorno Obsessivo-Compulsivo (TOC) e jovens com TAG, descobrindo que os jovens com TAG demonstraram maior inflexibilidade cognitiva e processamento visual mais lento. Luo et al. (2022) corroboram esses resultados ao revelar que o TAG está associado a déficits cognitivos em áreas como atenção sustentada, memória visual e aprendizado.

## 2.2.2. Desempenho cognitivo

A cognição é fundamental para todas as atividades humanas, em um sentido amplo significa processamento de informações, permitindo-nos perceber, aprender, lembrar e resolver problemas (Gellman, 2020). Esses processos mentais são mediadores essenciais em nosso dia a dia, influenciando desde a tomada de decisões até a execução de tarefas complexas (Gellman, 2020).

Compreender termos como função cognitiva e desempenho cognitivo é crucial para avaliar a saúde cognitiva. A função cognitiva refere-se aos processos mentais internos que compõem nossa capacidade de processar informações, como atenção, memória, percepção, linguagem e resolução de problemas (Gellman, 2020). Por outro lado, o desempenho cognitivo refere-se à capacidade de realizar tarefas mentais,

utilizando funções cognitivas como memória, atenção, funções executivas, linguagem e percepção (Harvey, 2019).

O desempenho cognitivo apresenta uma relação bidirecional com a saúde mental. Quando a saúde mental está comprometida, como em casos de ansiedade ou depressão, o desempenho cognitivo também pode ser afetado, levando a dificuldades de concentração, memória e tomada de decisões (Airaksinen et al., 2004; Weiser et al., 2004; Bierman et al., 2008). Por outro lado, dificuldades cognitivas podem impactar negativamente a saúde mental (Saczynski et al., 2010; Levens; Gotlib, 2012).

Estudos demonstram que déficits cognitivos são comuns em transtornos psiquiátricos, como depressão e ansiedade, e podem persistir mesmo após a remissão dos sintomas emocionais (Rock et al., 2014). Por exemplo, indivíduos com depressão apresentam comprometimento moderado em funções executivas, memória e atenção, com efeitos que variam de -0,34 a -0,65 (Cohen's d) em comparação com controles saudáveis (Rock et al., 2014). Além disso, déficits em inibição de resposta, vigilância, memória de trabalho e planejamento são particularmente evidentes em indivíduos com TDAH, com tamanhos de efeito na faixa de 0,46 a 0,69 (Willcutt et al., 2005).

A ansiedade, por sua vez, prejudica o controle atencional, especialmente nas funções de inibição e mudança, e aumenta a atenção a estímulos ameaçadores (Eysenck et al., 2007). No entanto, estratégias compensatórias, como maior esforço, podem preservar a qualidade do desempenho em alguns casos (Eysenck et al., 2007).

Desempenhos cognitivos inferiores têm sido associados a fatores como problemas de saúde mental, envelhecimento, estresse e dieta. Em um estudo transversal conduzido por Saleh et al. (2017), verificou-se que o impacto do estresse precoce no desempenho cognitivo varia entre indivíduos que desenvolveram depressão na vida adulta e aqueles que não desenvolveram. Nos indivíduos que desenvolveram depressão, maior exposição ao estresse precoce foi associada a um pior desempenho cognitivo.

Airaksinen et al. (2004), em outro estudo transversal, observaram que indivíduos com transtornos depressivos apresentam dificuldades cognitivas específicas, com variações dependendo do tipo de depressão. O grupo geral de pessoas com depressão mostrou comprometimento na memória episódica e na flexibilidade mental. Entre os subgrupos, aqueles com depressão maior e transtorno ansioso-depressivo misto apresentaram deficiências notáveis na memória.

Weiser et al. (2004) identificaram que adolescentes do sexo masculino com transtornos psiquiátricos demonstram, pelo menos, prejuízos sutis no desempenho cognitivo em comparação com adolescentes sem transtornos psiquiátricos. Complementando essas descobertas, Bierman et al. (2008) encontraram um efeito curvilíneo dos sintomas de ansiedade sobre o desempenho cognitivo: enquanto níveis leves de ansiedade estavam associados a um melhor desempenho cognitivo, níveis mais elevados de ansiedade foram relacionados a um desempenho pior.

Ramanoël et al. (2018), em seu estudo, verificaram que a redução no volume da matéria cinzenta foi associada a um pior desempenho cognitivo em um grupo de idosos. Pesquisas com animais mostram que uma dieta rica em gorduras saturadas e carboidratos refinados pode prejudicar vários sistemas cerebrais, incluindo áreas do cérebro responsáveis pelo aprendizado e memória, além de provocar um aumento na expressão de genes inflamatórios, o que resulta em pior desempenho cognitivo (Davidson et al., 2013; Gannon et al., 2022; Duffy et al., 2019; Beilharz; Maniam; Morris, 2016).

Em humanos, há diversas pesquisas sobre as associações entre padrões alimentares ou alimentos específicos, como os alimentos ultraprocessados (AUP), e o desempenho cognitivo. A menor adesão a dietas como a Mediterrânea e a MIND está associada a piores resultados cognitivos (Fu et al., 2022; Mcevoy et al., 2024; Nyaradi et al., 2014; Tapia-Serrano et al., 2021). Quanto às associações entre os AUP e o desempenho cognitivo, estudos tanto em adultos quanto em crianças indicam que o alto consumo desses alimentos foi associado a piores resultados cognitivos (Cardoso; Machado; Steele, 2022; Liu et al., 2023).

3. **COLETÂNEA DE ARTIGOS**

**1º ARTIGO**

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# Association Between Ultra-Processed Food Consumption and Cognitive Performance Among Adolescent Students From Underdeveloped Cities in Brazil: A Cross-Sectional Study

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**Objectives:** The association between ultra-processed foods (UPF) consumption and cognitive performance needs to be better characterized in adolescents, especially in low-income settings, where the cost of human capital is high. This study investigated the association between cognitive performance and UPF in adolescents from the countryside of the Brazilian Northeast.

**Methods:** Adolescents (15–18 years old) from three public high schools were included. Food intake was assessed using three 24-hour dietary recalls. The classification of foods as UPF was determined according to the Nova classification. Cognitive performance was evaluated using the Non-Verbal General Intelligence Test.

**Results:** 116 adolescents were included, of which 50 (43.1%) showed low cognitive performance. The average energy intake was 1973.5 kcal, with 24.2% coming from UPF. Participants with low cognitive performance consumed 26.5% (95% CI: [22.2; 30.7]%) of daily energy intake from UPF compared to 22.5% ([18.8; 26.2]%) of those with medium-high cognitive performance ($P$ = 0.17), without differences in energy and macronutrient intake.

**Conclusion:** Despite similar UPF consumption compared to the Brazilian average, no association was found between UPF consumption and cognitive performance in this low-income adolescent sample.

Keywords: adolescent, diet, food intake, ultra-processed foods, cognitive dysfunction

## INTRODUCTION

Global dietary habits are undergoing a significant transformation, with a concerning increase in the consumption of ultra-processed foods (UPF). In developed countries, these products account for over 50% of total energy intake [1], while in many developing countries, such as those in Latin America, this proportion approaches 30% [2, 3]. Among adolescents in different regions of the world,

such consumption varies from 25% to 65% of total daily energy intake [4–6]. According to dietary consumption analysis released in the Brazilian household budget survey of 2017–2018, in general approximately 20% of the Brazilian population's total daily calories are derived from UPF, and this share reaches 27% in Brazilian adolescents [7]. Factors such as hyper palatability, low cost, easy access, and intense marketing targeted toward the public may explain this trend [8].

The Dietary Guidelines for the Brazilian population, based on the Nova classification, recommends avoiding the consumption of UPF due to its low nutritional composition quality and the use of additives and other components in its fabrication [8, 9]. Excessive intake of UPF was found associated with the development of overweight, obesity, and chronic diseases such as diabetes, hypertension, metabolic syndrome, and dyslipidemia [10]. With the increase in UPF consumption among adolescents, these conditions, which were more prevalent among adult and elderly populations, have become increasingly present in this age group, as well [11]. Moreover, prior studies highlighted the association between UPF consumption and increased risk of cognitive impairment in older people [12, 13], but this association is not clear in adolescents.

It is noteworthy that adolescence represents an important phase of dietary habit formation as well as physical and neural development. Dietary intake during this phase is crucial to ensure the proper development of the prefrontal cortex, which is essential in the process of self-regulation [14]. Therefore, considering the nutritional characteristics of UPF, their consumption may lead to detriments in cognitive development. It is known that the adequate intake of macronutrients and micronutrients contributes to the integrity of the myelin barrier, neural cell membrane, neural proliferation, and synaptic formations [15], potentially impacting the proper cognitive development of individuals. Moreover, high sodium intake is related to cognitive impairment in adult and elderly individuals [16]. The fatty acid profile of the diet also exerts some influence, albeit marginal, with saturated fatty acid consumption being associated with cognitive impairment in adults [17]. In contrast, polyunsaturated fatty acid consumption appears to improve cognitive performance in children [18]. Furthermore, it is not known whether other factors besides the nutritional composition of these foods, such as the processing level and use of non-nutritive additives, may also play a role in the cognitive performance of the individuals [19].

To properly evaluate the impact of diet on cognition, it is essential to clarify the various terms used in this field. Cognitive performance refers to an individual's ability to perform cognitive tasks that involve mental processes such as memory, attention, executive functions, language, and perception [20, 21]. It is often assessed in clinical and research contexts to understand how different cognitive domains interact and how they can be affected by neurological or psychiatric conditions [20]. Cognitive domains refer to mental processes that involve the acquisition, processing, retention, and use of information [20, 22]. These domains reflect specific areas of mental functioning and include memory, attention, executive functions, language, and perception, among others [20]. Finally, cognitive impairment is defined as

a disruption or decline in cognitive functions, indicating that some cognitive abilities are below what is expected for an individual's age, education, and cultural context [21, 22]. This impairment can be present at any time in a person's life. It can result from a variety of conditions, such as malnutrition, exposure to heavy metals, metabolic disorders, head trauma, and side effects of drug treatments for conditions such as cancer or Parkinson's disease [21, 22]. In addition, age-related conditions such as traumatic brain injury, neurodegenerative disorders (such as Alzheimer's disease), stroke, brain tumors, and brain infections can also cause cognitive impairment [21, 22].

Current studies on the relationship between UPF consumption and cognition are scarce and more common in older adults. A systematic review with meta-analysis of observational studies found associations between higher UPF consumption and cognitive impairment in adults [23]. Others evaluated the association between the consumption of these foods and cognitive performance in adults and elderly individuals in a cross-sectional study, observing a negative relationship between the two [24]. Additional studies corroborated these findings, indicating an association between UPF consumption and cognitive impairment in adults and elderly individuals with type 2 diabetes [13, 25, 26]. Nevertheless, few studies have investigated UPF consumption and cognitive performance in younger populations. Liu et al. conducted a cohort study with 325 Chinese children aged 4–7 years, in which they assessed dietary intake using the Food Frequency Questionnaire and cognitive function using the Verbal Comprehension Index [27]. It was found that children who consumed more than two groups of UPF showed a significant decrease in test scores. However, the consumption was measured by the weekly frequency of consumption of each group of UPF, without mentioning data on daily energy intake from UPF [27].

Thus, studies conducted in populations of different age groups indicate that high consumption of UPF may be associated with inferior cognitive performance. However, this relationship in adolescents, a population in the neural development phase that deserves attention, needs to be better elucidated in the scientific literature. The literature is even scarcer regarding populations in low- and middle-income countries, where the cost of human capital due to inadequate development conditions is even higher. Therefore, this study aimed to evaluate the association between cognitive performance and UPF consumption in adolescents residing in cities in the countryside of the Brazilian Northeast.

## METHODS

### Study Design and Ethical Aspects

This study is a secondary cross-sectional analysis of baseline data from a randomized clinical trial called "Internet-Based Nutritional Education versus Conventional Nutritional Education: A Randomized Clinical Trial," registered in the Brazilian Clinical Trials Registry (ReBEC) under the number RBR-9crqgt. This clinical trial received approval from the Research Ethics Committee of the Universidade Federal de

Alagoas, with protocol number 80728017.0.0000.5013, and was conducted in accordance with the principles of the Declaration of Helsinki. All parents or legal guardians of the adolescents provided written consent, and all adolescents consented to participate voluntarily. This article follows the guidelines for Strengthening the Reporting of Observational Studies in Epidemiology-Nutritional Epidemiology [28].

## Population and Sample

Sampling was non-probabilistic, based on convenience. Participants were recruited through invitations made during presentations in the classrooms at three high schools in the state of Alagoas: Escola Estadual Monsenhor Clóvis Duarte de Barros in União dos Palmares municipality; Instituto Federal de Alagoas, in both Murici campus and Satuba Campus, in Murici municipality, and Satuba municipality, respectively. During these presentations, the researchers informed the students about the research and invited them to participate. The state of Alagoas is one of the poorest in the Brazilian Federation, with an average Human Development Index (HDI) of 0.687. It also has the highest illiteracy rate among people aged 15 and older (17.7%), an unemployment rate of 12.0% for individuals aged 14 and older, a GINI index of 0.498, and a significant percentage of households receiving income transfer program benefits: 34.9% from the Bolsa Família Program, 7.1% from the Continuous Cash Benefit program, and 7.3% from other social programs. Additionally, only 34.08% of households are connected to the sewage network, and the general water network supplies 68.14%. At the same time, the studied municipalities have even lower HDIs, with União dos Palmares at 0.593, Murici at 0.527, and Satuba at 0.660 [29, 30].

Adolescents attending these schools, aged between 15 and 18, were included according to the criteria of the World Health Organization (WHO) [31]. Adolescents who presented any condition that prevented anthropometric measurements, those who were HIV-positive, had type 1 diabetes, were pregnant, or were breastfeeding were excluded.

## Variables
### Exposure
*Dietary Intake*
Dietary intake assessment was conducted through 24-hour dietary recalls administered by trained interviewers. Three 24-hour recalls were collected over three different days, covering two weekdays and one weekend day. During the interviews, participants provided information on foods and beverages consumed from the time they woke up until bedtime. To aid in estimating the quantities consumed, interviewers used two photographic food quantification manuals [32, 33].

The collected data were processed using Avanutri® software, version 4.1 (Avanutri Equipamentos de Saúde Ltda, Rio de Janeiro, Brazil), which converted consumed foods and beverages into energy (kilocalories), carbohydrates, proteins, and fats (g). Information from the following databases was used: Brazilian Food Composition Table [34], Food Composition Table [35], and information provided by food product manufacturers, following this order of preference.

Then, foods and beverages were categorized into three subgroups according to the Nova classification: unprocessed and minimally processed foods, processed foods, and UPF [36]. According to the Nova classification, unprocessed foods are obtained directly from plants or animals and undergo no alteration after leaving nature. Minimally processed foods are natural foods subjected to minimal processes such as removal of inedible parts, drying, grinding, filtering, roasting, boiling, pasteurization, refrigeration, freezing, or vacuum packaging, among others. These processes do not add substances to the original food and do not significantly alter its nutritional value. Processed foods are those manufactured by the industry by adding salt, sugar, or other culinary substances to natural or minimally processed foods, aiming to increase durability or improve sensory qualities. UPF are industrial formulations made entirely or largely from substances derived from foods, such as sugars, oils, fats, or salt, and additives like preservatives, antioxidants, and stabilizers. Ultra-processed foods generally contain little or no natural or minimally processed food [36].

## Outcome
### Non-Verbal General Intelligence Test (NV-GIT)
The NV-GIT assesses non-verbal intelligence and identifies incorrect processes in various types of reasoning. The test consists of 30 multiple-choice questions, each with six response options, only one of which is correct [37]. The reliability and internal consistency of the NV-GIT were verified, and satisfactory results were obtained. The Cronbach's Alpha coefficient was 0.89, the Spearman-Brown correction was 0.85, and the Test-Retest method showed a coefficient of 0.93. The validity of the NV-GIT was determined through the correlation between NV-GIT scores and four tests: Ravens Progressive Matrices (0.56), R1 (0.42), D70 (0.73), and G36 (0.65) [37].

Developed with the Brazilian population, the NV-GIT is widely used in Brazil. The NV-GIT was chosen for its ease of administration and simple interpretation of results. Unlike other nonverbal intelligence tests, it allows intelligence measures to be expressed on intelligence quotient (IQ) and percentile scales. Additionally, the NV-GIT can assess the mental state of people from 10 to 79 years old, covering three levels of education: Elementary, Secondary, and higher education [37].

The research team, who was previously trained by a psychologist, administered the test to the students. Prior to the test day, the principals from each school were contacted to allow the research team to visit classes, which were paused for 50 min in order for the questionnaires to be administered. All instructions provided in the test manual were strictly followed. There was no time limit, but the test protocols could only be returned after 20 min, as instructed in the test manual, to avoid characterizing withdrawal. Scoring was done using an answer analysis grid and according to the participants' educational level. Each adolescent was classified into one of the following intelligence level categories [37]: Extremely Low (up to 3 points, IQ below 69), Low (4–7 points, IQ between 70 and 79), Below Average (8–14 points, IQ between 80 and 89), Average (15–22 points, IQ between 90 and 109), Above Average (23–25 points, IQ

between 110 and 119), High (26–27 points, IQ between 120 and 129), and Very High (28–30 points, IQ above 130).

For the present analysis, NV-GIT scores were grouped into three main categories to simplify statistical analysis. The scores were categorized as follows: Low cognitive performance, which includes the "Extremely Low," "Low," and "Below Average" score ranges; medium cognitive performance, which consists of the "Average" range; and high cognitive performance, which includes the "Above Average," "High," and "Very High" ranges.

## Assessment of Covariates
### Anthropometric Data
For anthropometric assessment, data on weight, height, and Body Mass Index (BMI) were collected. Body weight was recorded using a digital scale (Filizola®, São Paulo) with a capacity of 150 kg and a precision of 100g. Height was measured using a portable stadiometer. We used the AnthroPlus software developed by the WHO to assess child growth and calculate z-scores. This software is specifically designed to analyze growth data for children and adolescents aged 5–19 years, allowing comparison with the WHO reference curves. Z-scores were calculated for the following anthropometric indicators: Body Mass Index (BMI) by age and height by age. Participants were categorized according to the WHO reference curves [38]. Waist circumference was measured with a flexible, non-elastic tape positioned at the midpoint between the lower edge of the last rib and the iliac crest [39].

### Physical Activity Level
Physical activity level was assessed using the short version of the International Physical Activity Questionnaire (IPAQ), validated for the Brazilian population and appropriate for adolescents [40, 41]. This version consists of eight open-ended questions addressing the time spent on activities such as walking, vigorous and moderate physical efforts, as well as periods of physical inactivity (time in a sitting position) during the last week. Based on this information, participants were classified into four levels of physical activity: sedentary, irregularly active, active, and very active.

### Socioeconomic Level
The socioeconomic level was assessed using the Brazilian Economic Classification Criteria (BECC), developed by the Associação Brasileira de Empresas de Pesquisa (ABEP). Based on the BECC score, participants were classified into six economic classes, ranging from "A", the highest, to "D-E", the lowest, taking into account possession of household assets, educational level of the head of the household, and access to services such as piped water and street paving [42].

### Bias
To avoid bias, three dietary recalls from three different days, comprising two weekdays and one weekend day, were collected. This approach was adopted because the use of three recalls results in more accurate estimates of energy and nutrient intake compared to a lower number of recalls [43, 44].

## Statistical Analyses
Continuous variables were reported using the mean and the standard deviation measures, and categorical variables were exhibited as relative and absolute frequencies. Comparisons between groups for continuous variables were made using a one-way analysis of variance (ANOVA), whereas the chi-square test was utilized for categorical variables. To explore the relationship between low cognitive performance and ultra-processed food consumption, an analysis of covariance (ANCOVA) was used, adjusted for sex, age, body mass index, socioeconomic status, and physical activity level. The estimated marginal means (EMM) for energy intake according to food processing level, in percent, were calculated. An alpha value of 5% was adopted for all analyses. JAMOVI software version 4.2.0 (Sydney, Australia) was employed for all analyses.

## RESULTS

Within the age range of interest for our study, there were a total of 851 potentially eligible students from the three schools. From these, 186 were interested in participating and were able to provide their parents' consent, and hence, they were recruited. After excluding 25 participants due to eligibility criteria and 45 participants who did not complete three dietary recalls, the final sample consisted of 116 adolescents, as shown in **Figure 1**. The participants had a mean age of 16.7 (0.9) years and a mean BMI-for-age of 0.02 (1.07) Z-score. Among the included adolescents, the classification based on raw NV-GIT scores was as follows: Extremely Low (n = 4; 3.4%), Low (n = 17; 14.7%), Below Average (n = 29; 25.0%), Average (n = 45; 38.8%), Above Average (n = 15; 12.9%), High (n = 4; 3.4%), and Very High (n = 2; 1.7%). Specifically, as categorized for the present analysis, 50 (43.1%) had a low, 45 (38.8%) had a medium, and 21 (18.1%) had a high non-verbal intelligence level. The socioeconomic and anthropometric characteristics of the participants are presented in **Table 1**. No statistically significant differences were observed for variables such as age, weight, height, or waist circumference across the cognitive performance categories. However, the BMI-for-age Z-score showed a statistically significant difference ($p = 0.01$), although this difference was not clinically relevant, as the values remained within normal growth ranges for adolescents. Additionally, no significant differences were found in the level of physical activity (assessed by the IPAQ) or in socioeconomic classification (BECC) across the cognitive performance categories.

**Table 2** presents the dietary intake analysis. The mean energy intake of the sample from the three dietary recalls of each individual was 1973.5 (711.6) kcal, with a mean UPF intake of 503.6 (14.9) kcal, for a mean dietary UPF share of 24.2 (14.9) %. It is noteworthy that there were no differences in dietary energy intake and macronutrient content across levels of NV-GIT.

**Table 3** presents estimated marginal means for energy intake, in percent, according to the food processing level in the different classes of nonverbal intelligence level. No significant associations were identified between these variables. To further explore our

**FIGURE 1 |** Flowchart of participant selection (Brazil, 2018–2019).
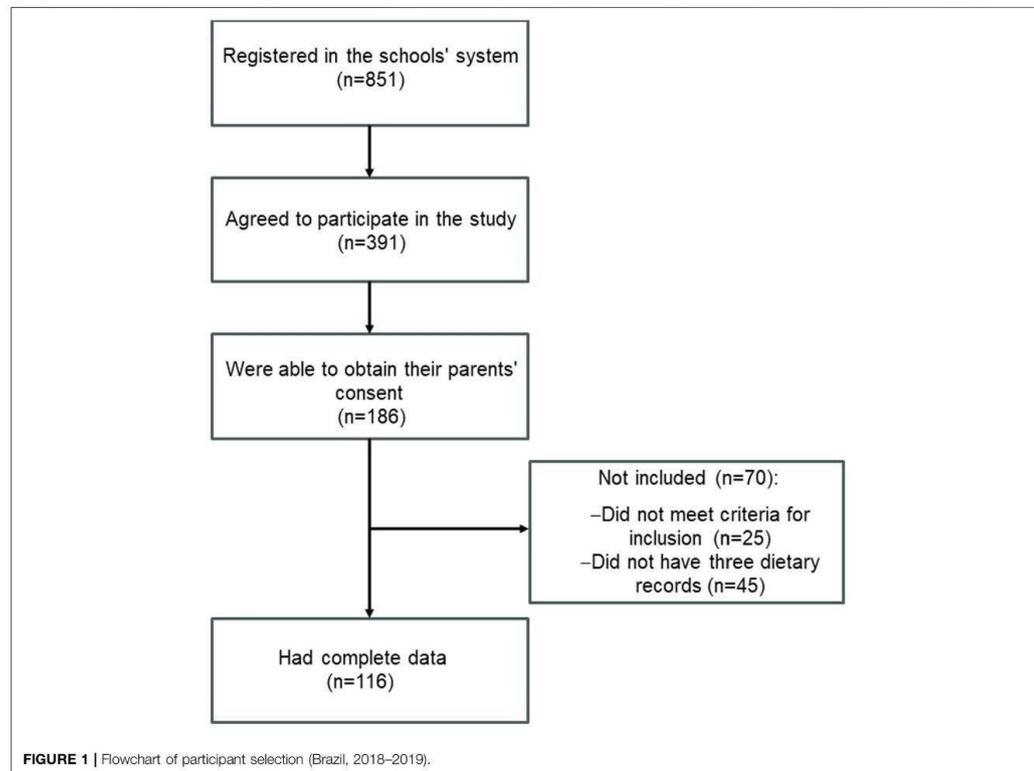
**TABLE 1 |** Sociodemographic characteristics of the sample (n = 116) (Brazil, 2018–2019).

| Variables | Total sample (n = 116) | (NV-GIT) | | | |
|---|---|---|---|---|---|
| | | Mean (SD) Low (n = 50; 43.1%) | Medium (n = 45; 38.8%) | High (n = 21; 18.1%) | p-value[a] |
| Age (years) | 16.65 (0.86) | 16.86 (0.78) | 16.47 (0.87) | 16.52 (0.98) | 0.06 |
| Weight (kg) | 60.69 (12.12) | 59.26 (10.30) | 62.56 (14.60) | 60.10 (10.14) | 0.40 |
| Height (m) | 1.66 (0.09) | 1.67 (0.10) | 1.65 (0.09) | 1.71 (0.10) | 0.09 |
| WC (cm) | 72.08 (8.22) | 70.68 (7.63) | 73.41 (9.06) | 72.60 (7.53) | 0.26 |
| BMI-for-Age (Z-score) | 0.02 (1.07) | 0.13 (1.03) | 0.37 (1.06) | −0.35 (1.05) | 0.01 |
| | n (%) | n (%) | n (%) | n (%) | p-value[b] |
| BECC | | | | | 0.07 |
| A, B1 and B2 | 23 (19.8) | 8 (16.0) | 7 (15.6) | 8 (38.1) | |
| C1, C2 and D-E | 93 (80.2) | 42 (84.0) | 38 (84.4) | 13 (61.9) | |
| IPAQ | | | | | 0.09 |
| Very active and active | 78 (67.2) | 33 (66.0) | 30 (66.7) | 15 (71.4) | |
| Irregularly active and sedentary | 38 (32.8) | 17 (34.0) | 15 (33.3) | 6 (28.6) | |

*BECC, Brazilian economic classification criteria; WC, waist circumference; W-A, Weight-for-age; BMI-A, Body mass index-for-age; IPAQ, international physical activity questionnaire; NV-GIT, Non-verbal general intelligence test.*
*[a]p-value for ANOVA one-way.*
*[b]p-value for chi-square tests.*

**TABLE 2 |** Dietary characteristics of the sample (n = 116) (Brazil, 2018–2019).

| Variables | Total sample (n = 116) | (NV-GIT) | | | |
|---|---|---|---|---|---|
| | | Low (n = 50; 43.1%) | Medium (n = 45; 38.8%) | High (n = 21; 18.1%) | p-value[a] |
| | Mean (SD) | Mean (SD) | Mean (SD) | Mean (SD) | |
| Total energy (kcal) | 1,973.56 (711.67) | 2,016.97 (804.00) | 1,881.05 (659.96) | 2,068.47 (580.48) | 0.61 |
| Carbohydrate (%) | 52.68 (7.96) | 53.00 (9.21) | 51.74 (6.83) | 53.84 (6.68) | 0.49 |
| Protein (%) | 20.12 (7.33) | 20.84 (9.52) | 20.03 (4.93) | 18.42 (4.21) | 0.74 |
| Lipids (%) | 27.69 (5.29) | 27.33 (5.01) | 28.22 (6.03) | 27.58 (4.55) | 0.74 |
| Fiber (g) | 21.77 (10.59) | 20.92 (10.44) | 22.41 (11.93) | 22.74 (8.07) | 0.52 |
| Unprocessed or Minimally Processed (kcal) | 976.95 (396.19) | 957.15 (373.28) | 986.74 (433.36) | 1,003.13 (382.29) | 0.88 |
| Unprocessed or Minimally Processed (%) | 50.90 (16.33) | 50.40 (17.34) | 52.20 (15.50) | 49.35 (16.17) | 0.23 |
| Processed (kcal) | 492.92 (302.10) | 467.23 (309.13) | 474.17 (300.22) | 594.30 (281.33) | 0.11 |
| Processed (%) | 24.82 (12.47) | 23.03 (12.41) | 25.12 (12.26) | 28.48 (12.87) | 0.77 |
| Ultra-processed (kcal) | 503.68 (407.59) | 592.59 (492.03) | 420.15 (282.25) | 471.04 (387.67) | 0.24 |
| Ultra-processed (%) | 24.26 (14.89) | 26.57 (16.12) | 22.67 (13.59) | 22.17 (14.48) | 0.34 |

[a]p-value for ANOVA one-way.

**TABLE 3 |** Estimated marginal means of multivariable analysis between Non-Verbal General Intelligence Test (NV-GIT) classifications and percentage of foods according to Nova (n = 116) (Brazil, 2018–2019).

| Food intake | (NV-GIT) | | | |
|---|---|---|---|---|
| | Low | Medium | High | p-value[a] |
| | EMM [CI 95%] | EMM [CI 95%] | EMM [CI 95%] | |
| Unprocessed or Minimally Processed (%) | 49.84 [45.17; 54.51] | 52.52 [47.60; 57.44] | 49.97 [42.67; 57.27] | 0.71 |
| Processed (%) | 23.42 [19.86; 26.98] | 25.05 [21.31; 28.80] | 27.67 [22.12; 33.23] | 0.44 |
| Ultra-processed (%) | 26.73 [22.47; 30.98] | 22.41 [17.93; 26.89] | 22.35 [15.70; 28.99] | 0.32 |

[a]Analysis of covariance adjusted for sex (female and male), age (years), body mass index-for-age (Z-score), Brazil Economic Classification Criterion (A, B1 and B2, and C1, C2, D-E), and International Physical Activity Questionnaire (Very active and active, and irregularly active and sedentary).

data, we have merged the groups with medium and high cognitive performance and tested their percent of UPF intake against those of the low cognitive performance group. Although the statistical power increased, there were no significant differences between groups (EMM of %UPF intake for low cognitive performance: 26.5 [22.2; 30.7]%; medium-high performance: 22.5 [18.8; 26.2]%; $P = 0.17$).

As an exploratory analysis, we tested which exposures were associated with the higher intake of UPF in our sample. Nevertheless, neither sex, excess weight, BBEC, nor IPAQ showed significant associations with the dietary share of UPF intake (data not shown).

## DISCUSSION

In the present study, the NV-GIT tool revealed a high prevalence of low cognitive performance (43.1%) among adolescents enrolled in three public schools in the interior of the state of Alagoas, Brazil. On average, 24.2% of their energy intake was derived from UPF, and this consumption was not associated with cognitive performance, according to the NV-GIT tool. The individuals with low cognitive performance also showed the same level of macronutrient intake, unprocessed and minimally processed foods as the individuals with medium and high cognitive performance, indicating that, in the present

sample, no measures of dietary intake were associated with the degree of cognitive performance.

The lack of a significant association between UPF consumption and performance on the NV-GIT in the present study may be explained by the specifics of the cognitive aspects assessed by this test. The NV-GIT focuses on non-verbal cognitive skills such as problem-solving, visual-spatial perception, and abstract reasoning. These aspects may be less sensitive to the potential influences of UPF consumption compared to other cognitive skills. Previous studies with adults and children have identified an association between UPF consumption and cognitive function [13, 24, 27]. In these studies, cognitive function was assessed through tests that measured both verbal and non-verbal skills, whereas the NV-GIT focuses only on non-verbal skills. Additionally, there may be a significant difference between verbal and non-verbal skills in low-income participants, with a higher overall average in the non-verbal skills test [45], like those included in this research. This disparity can influence the results of cognitive tests differently. When we decided to use a non-verbal intelligence test, we assumed that it would be possible to identify students with low cognitive performance more accurately since the overall average of these tests is high in this age range. Those with lower averages could represent individuals with more significant cognitive difficulties. This approach is particularly relevant for low-income students, who may show a big gap between their verbal and non-verbal scores [45].

The heterogeneity found in the published studies hampers our ability to compare our prevalence of low cognitive performance with the literature. Few of the published studies report such prevalence rates, and they usually use different tools to assess cognitive performance. In many of these studies, only the mean scores obtained in the various cognitive domains are reported [13, 24, 26]. Furthermore, such limitation also extends to the comparison of the findings regarding the specific association between UPF consumption and cognitive performance in adolescents, with only studies relating dietary patterns to cognitive performance in this age range [46–50]. Future studies should investigate a wider number of cognitive domains in order to assess the potential association of UPF intake with this complex outcome, especially in adolescents.

Our hypothesis that UPF intake could negatively impact cognition in adolescents was supported by the unique nutritional characteristics of UPF. These foods tend to be rich in added sugars and saturated fats, factors that have been associated with effects that may contribute to cognitive deficits [17, 19, 26, 51–53]. Increasing evidence also indicates that the consumption of UPF is associated with a higher intake of pro-inflammatory ingredients and oxidative stress, both recognized as contributing factors to cognitive impairment [54–57]. Furthermore, UPF consumption may disrupt the gut microbiota, leading to an imbalance known as gut dysbiosis, which is associated with a higher risk of cognitive impairment [58–61]. Additionally, obesity-induced adiposity, often related to excessive UPF consumption, is marked by the presence of pro-inflammatory cytokines, which have been associated as contributing factors to cognitive impairment [62–65]. In contrast, unprocessed and minimally processed foods are rich in beneficial nutrients, such as essential fatty acids, polyphenols, and vitamins, with well-established antioxidant effects [66, 67]. Studies have shown that adopting healthy dietary patterns, which include a variety of these foods, can contribute to better cognitive functioning, even promoting structural changes in the brain, such as a larger left hippocampal volume, white matter, and gray matter [68–70]. These brain structures are associated with better cognitive functioning [71–73].

It is noteworthy that the share of dietary UPF consumption among the adolescents in our research was similar to the Brazilian adolescents' mean of 27.0%, as reported by the Brazilian household budget survey of 2017–2018 [7]. Also, other studies conducted with Brazilian adolescents show similar results. Rocha et al. found that UPF contributed an average of 28% of the total energy intake among adolescents in Brazilian public and private schools [74], and Martins et al. investigating adolescents from the same Brazilian region also found a share of 26% of energy arising from UPF [75]. It is noteworthy that this share of dietary energy arising from UPF is way lower compared to studies conducted in developed countries, such as the United States and Australia, where adolescents had a share of dietary energy arising from UPF of 67.0% and 54.3%, respectively [76, 77].

This study has some limitations. First, it is a cross-sectional study, which prevents the determination of causality between the investigated variables. Another limitation of the study was the use of a questionnaire to assess participants' physical activity level, which may also be subject to memory bias, overestimation or underestimation of physical activity, and difficulty in determining the intensity of the activity. Additionally, the sample size was modest, which may affect the generalizability of the findings and the low statistical power of the study. It is worth noting that our study has some significant strengths. The analysis was conducted on an age group that is less studied, and most studies on the topic are conducted in developed countries, which helps fill knowledge gaps in this specific population. Another strength was the use of three 24-hour recalls, which provided a more accurate estimate of the participants' dietary intake [43, 44]. Additionally, the study made adjustments for relevant confounding factors, thereby improving the understanding of the analytical framework.

In conclusion, UPF consumption was not associated with cognitive performance in the NV-GIT in adolescents residing in underdeveloped cities in Brazil. Although the nature of our study does not establish direct causal relationships and the current sample was not specifically recruited to test such hypotheses, the results can be viewed as exploratory and suggest that the potential role of consuming these foods on the cognitive performance of adolescents deserves further investigation, especially for different cognitive domains.

## ETHICS STATEMENT

The studies involving humans were approved by Research Ethics Committee of the Universidade Federal de Alagoas. The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

## AUTHOR CONTRIBUTIONS

JdS: writing–original draft preparation, Writing-reviewing and editing, Formal analysis. DS: project administration, visualization, writing–reviewing and editing. CC, LdA, DF, DP, and MM: Investigation, Methodology, data curation, Writing–reviewing and editing. IdM: Resources, Writing–reviewing and editing. NB: Supervision, Conceptualization, Methodology, Writing–reviewing and editing, validation, Formal analysis. All authors contributed to the article and approved the submitted version.

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## CONFLICT OF INTEREST

The authors declare that they do not have any conflicts of interest.

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**2º ARTIGO**

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**Title:**

Association between the consumption of ultra-processed foods and generalized anxiety disorder in adults with obesity seeking weight loss

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**Abstract**

**Purpose**

The association between symptoms of generalized anxiety disorder (GAD) and the consumption of ultra-processed foods (UPF) needs to be better characterized in obese adults seeking weight loss. This study aimed to evaluate the relationship between GAD symptoms and UPF consumption in this Population.

**Methods**

A cross-sectional study was conducted with 148 adults (19-59 years old) with obesity recruited from a Brazilian university. Food consumption was assessed using three 24-hour dietary recalls, which were classified according to the NOVA classification. GAD was measured using the Generalized Anxiety Disorder Scale (GAD-7). Linear regression models adjusted for confounding factors, such as sex, age, economic status, and physical activity, were used to analyze the association between anxiety symptoms and UPF consumption.

**Results**

Higher GAD-7 scores were associated with greater UPF consumption ($\beta = 0.445\%$; 95% CI: 0.042% – 0.849%; $p = 0.031$). There was no significant association between GAD and the intake of sodium ($\beta = -18.464$mg; 95% CI: -55.618mg – 18.689mg; $p = 0.328$), sugar ($\beta = -0.127$g; 95% CI: -0.342g – 0.087g; $p = 0.243$), or saturated fat ($\beta = 0.290$g; 95% CI: -0.024g – 0.604g; $p = 0.070$). The average UPF consumption was 22.8% of total energy intake.

**Conclusion**

Obese adults seeking weight loss who had higher anxiety symptoms consumed more UPF, suggesting a relationship between anxiety and dietary patterns. Longitudinal studies are needed to explore causality and underlying mechanisms.

**Keywords:** obesity; weight loss; anxiety; diet; food intake; ultra-processed foods

**Statements and Declarations**

**Conflict of Interest:**

The authors have no conflicts of interest to disclose.

**Ethics approval and consent to participate:**

This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Research Ethics Committee of the Federal University of Alagoas (Certificate of Ethical Appreciation Presentation number 56625522.0.0000.5013). Informed consent was obtained from all individual participants included in the study.

**Consent to Publish:**

Not applicable.

**Author Contributions:**

J.V.L.S. contributed to the writing of the original draft and the review and editing of the manuscript. D.R.S. participated in the investigation and the review and editing of the manuscript. S.A.M.C., D.C.F., R.T.L.C., and N.G.S.L. were responsible for data curation, including data tabulation and organization. M.L.M. and A.E.S.J. were involved in the investigation and the review and editing of the manuscript. I.S.V.M. contributed to supervision, validation, and the review and editing of the manuscript. N.B.B. performed the formal analysis of the data, in addition to conceptualization, project administration, and the review and editing of the manuscript. All authors reviewed and approved the final version of the manuscript.

**Introduction**

Obesity is one of the major global public health challenges, with its prevalence among adults more than doubling between 1990 and 2022, affecting approximately 878 million adults worldwide [1]. This condition is associated with various physical comorbidities, especially non-communicable chronic diseases such as diabetes, cardiovascular diseases, and cancer, as well as mental disorders, among which generalized anxiety disorder (GAD) stands out [2-8]. GAD is characterized by excessive and persistent worry, accompanied by symptoms such as irritability, muscle tension, fatigue, and sleep disturbances [9], affecting over 301 million people globally [10]. Individuals with obesity, particularly those seeking to lose weight, are more vulnerable to psychological disorders compared to the general population [11]. This relationship can be explained by the psychological stress associated with the constant effort to change lifestyle habits and manage weight, which often exacerbates anxiety symptoms [12].

Diet has been widely explored as a determining factor in health, influencing both physical and mental aspects. Numerous studies are investigating the nutritional composition of diets, dietary patterns, and the level of food processing as variables of interest in determining physical and mental health outcomes [13-18]. In this context, the NOVA classification has emerged as a method to categorize foods according to the nature, extent, and purpose of industrial processing, dividing them into four groups: unprocessed or minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed foods (UPF) [19].

UPFs are industrial formulations that undergo extensive transformations and contain ingredients rarely used in traditional culinary preparations, such as chemical additives like colorants, preservatives, flavor enhancers, and hydrogenated fats, which enhance the taste, texture, and organoleptic properties of these foods [19]. Additionally, these foods are often energy-dense, high in salt, free sugars, and saturated fats, while potentially low in fiber and, in many cases, vitamins and minerals [19]. The consumption of these foods has increased significantly in recent decades, accounting for more than 50% of the calories consumed in countries such as the United States and the United Kingdom [20,21]. In Brazil, data from the Household Budget Survey (2017-2018) reveal that UPF represents approximately 20% of the daily calories consumed by the Brazilian population [22]. This finding is particularly relevant, as the Dietary Guidelines for the Brazilian Population recommend limiting the consumption of these foods and prioritizing unprocessed or minimally processed foods as the foundation of a healthy diet [23].

The relationship between anxiety and the consumption of UPF appears to be bidirectional. Evidence suggests that individuals with higher levels of anxiety are more likely to consume these foods due to their high content of rewarding nutrients, such as sugar, sodium, and fat, which activate brain reward pathways and provide

temporary relief from anxiety symptoms [24-26]. On the other hand, excessive consumption of UPF is associated with metabolic, inflammatory, and behavioral changes that may increase the risk of mental disorders, including anxiety [27-31]. However, this relationship, particularly in individuals with obesity who are interested in losing weight and may present unique metabolic and psychological vulnerabilities, still lacks sufficient clarification in the scientific literature. Therefore, this study aimed to evaluate the association between symptoms of GAD and the consumption of UPF in adults with obesity interested in weight loss. We hypothesize that individuals with higher levels of anxiety will consume more UPF.

**Methods**

**Study design and ethical aspects**

This is a cross-sectional study using baseline data from a clinical trial titled: "Effectiveness and Metabolic Impacts of Restricting Ultra-Processed Food Consumption on Metabolic Adaptation and Weight Regain in Overweight Individuals Undergoing Caloric Restriction," registered in the Brazilian Registry of Clinical Trials (ReBEC) under the number RBR-3q9vgk9. The clinical trial was approved by the Research Ethics Committee of the Federal University of Alagoas under the Certificate of Ethical Appreciation Presentation number 56625522.0.0000.5013 and conducted in accordance with the principles of the Declaration of Helsinki. All participants provided written informed consent, indicating their voluntary participation. This article follows the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology – Nutritional Epidemiology (STROBE-nut) [32].

**Location, population and sample**

The research was conducted at the Nutrition and Metabolism Laboratory of the Federal University of Alagoas (UFAL), located at the AC Simões campus in Maceió, Alagoas, with students, staff, and the surrounding community.

The sampling method was non-probabilistic and convenience-based. Participants were recruited through announcements at the AC Simões campus of UFAL and invitations posted on Instagram and the official UFAL website.

Adults (19-59 years old) of both sexes with obesity, defined by at least two of the following three criteria, were included: body mass index (BMI) between 25 and 40 kg/m², waist circumference ≥ 88 cm for women and ≥ 102 cm for men, and body fat percentage ≥ 35% for women and ≥ 25% for men, determined by bioelectrical impedance analysis. Participants were required to express a desire to lose weight but had to be weight-stable for at least one month at the time of inclusion in the clinical trial. Individuals using chronic medications such as antidiabetics, antihypertensives, antiretrovirals, immunosuppressants, and antidepressants; those with conditions preventing anthropometric measurements or assessment of energy expenditure components; postmenopausal, pregnant, or lactating women; and those who had undergone any surgical intervention for weight loss were excluded.

**Variables**

**Exposure**

Generalized anxiety disorder scale (GAD-7)

The GAD-7 is a scale developed by Spitzer et al. [33], designed to provide a quick self-report measure aimed at identifying probable cases of GAD. It was created in the United States with adult patients from 15 primary care clinics, based on the symptom criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV), for GAD and other existing anxiety scales. The scale demonstrated high reliability and satisfactory validity in terms of criterion, construct, factorial, and procedural aspects. Additionally, a cutoff point was determined to maximize its diagnostic accuracy, with a sensitivity of 89% and specificity of 82% [33].

The GAD-7 consists of seven items that assess the frequency of signs and symptoms of generalized anxiety over the past two weeks. Its items are scored on a 4-point Likert scale, ranging from 0 (not at all) to 3 (nearly every day). A general suggested cutoff point for identifying GAD is 10 [33].

**Outcome**

Dietary consumption

Dietary consumption was assessed using the 24-hour dietary recall method, employing the Multiple Pass Method [34]. Three 24-hour dietary recalls were collected on different days, including two weekdays and one

weekend day. During the collection, participants reported all foods and beverages consumed from the moment they woke up until bedtime.

To assist in estimating the quantities consumed, a photographic manual of food quantification was used [35]. The collected data were processed using the NutraBem software (Federal University of São Paulo, São Paulo - SP), which converted the foods and beverages consumed into energy (kilocalories), macronutrients (in grams), and micronutrients (in milligrams). Additionally, NutraBem, coordinated by a team of academics who constantly update the software, particularly regarding the NOVA classification of foods, already classifies the consumed foods into unprocessed foods, minimally processed foods, processed culinary ingredients, processed foods, and UPF [19].

**Covariates**

Anthropometric measurements

For the anthropometric assessment, data on body weight, height, BMI, waist circumference, and body composition were collected. Body weight was measured using a digital Filizola® scale (São Paulo), with a capacity of 150 kg and an accuracy of 100 g. Participants were weighed, and they were wearing light clothing and without shoes. Height was measured using a wall-mounted stadiometer, with participants barefoot, feet together, back straight, and looking forward, adjusting the stadiometer so that the sliding arm touched the top of the participant's head. BMI was calculated according to World Health Organization criteria, using the formula: BMI = weight (kg) / height² (m). Waist circumference was measured with a flexible and non-elastic tape, positioned at the midpoint between the lower edge of the last rib and the iliac crest. Body composition was assessed using tetrapolar bioelectrical impedance analysis (RJL Quantum IV, RJL Systems Inc., Michigan, USA). The evaluation was performed with participants in a supine position after a 12-hour overnight fast. Instructions were provided to avoid caffeine consumption during the fast, refrain from physical exercise in the 24 hours prior to the assessment, and ensure an empty bladder at the time of measurement. Resistance and reactance data, expressed in ohms ($\Omega$), along with information on age (years), sex, weight (kg), and height (cm), were processed using RJL software. The NHANES III formula was selected within the RJL software to estimate fat mass (kg), fat-free mass (kg), body water (L), and body fat percentage (%), ensuring standardized calculations based on bioelectrical impedance parameters.

Physical activity level

Physical activity level was estimated using triaxial accelerometers (ActiGraph wGT3X-BT, ActiGraph LLC, Pensacola, Florida, USA), which assess physical behavior by measuring acceleration in the anteroposterior, lateral, and vertical axes. The devices were attached to the participants' waists and worn for five consecutive days, including three weekdays and two weekend days. Participants were instructed not to remove the accelerometers during the wear period, except during water activities and bathing. Data collected by the accelerometers were processed using ActiLife software, version 6.13.3, and expressed in counts per minute (CPM), a quantitative indicator of body movement based on the data recorded by the accelerometers.

Economic status

Economic status was assessed using the Brazilian Economic Classification Criterion (CCEB) developed by the Brazilian Association of Research Companies. The CCEB classifies the Brazilian Population into different economic strata, considering the ownership of durable goods, education level, and access to services such as piped water and paved streets [36]. Based on the score obtained, individuals are categorized into six economic classes, ranging from class "A" (highest) to classes "D-E" (lowest) [36].

**Bias**

To minimize potential biases, three 24-hour dietary recalls were collected to assess food consumption, and a triaxial accelerometer was used to estimate participants' physical activity levels. These approaches were chosen based on the fact that, regarding food consumption, collecting three 24-hour dietary recalls provides a more accurate estimate of energy and nutrient intake compared to a smaller number of recalls [37,38]. As for physical activity levels, questionnaires are susceptible to memory biases, such as difficulty recalling the intensity and duration of activities [39-41]. In contrast, the use of an accelerometer allows for a more precise assessment of physical activity levels, taking into account intensity, duration, and frequency, making it a more reliable method for this measurement [39-41].

**Statistical analyses**

Continuous variables were described using measures of mean and standard deviation, while categorical variables were presented as absolute and relative frequencies. Multiple linear regression models were used to assess the association between the GAD score, estimated by the consumption of UPF, and nutritional outcomes. The independent variables were adjusted for potential confounding factors, including sex, age, body fat percentage, energy intake, socioeconomic status, and CPM (counts per minute). A directed acyclic graph (DAG) was developed to illustrate the causal pathways between generalized anxiety disorder and UPF consumption, taking into account the confounding variables included in the model (Figure 1). In addition to the variables included in the model, adjustments were also made to the participant's total energy intake [42]. Statistical analyses were performed using the Jamovi software, version 2.5.3, with an alpha value of 5%.
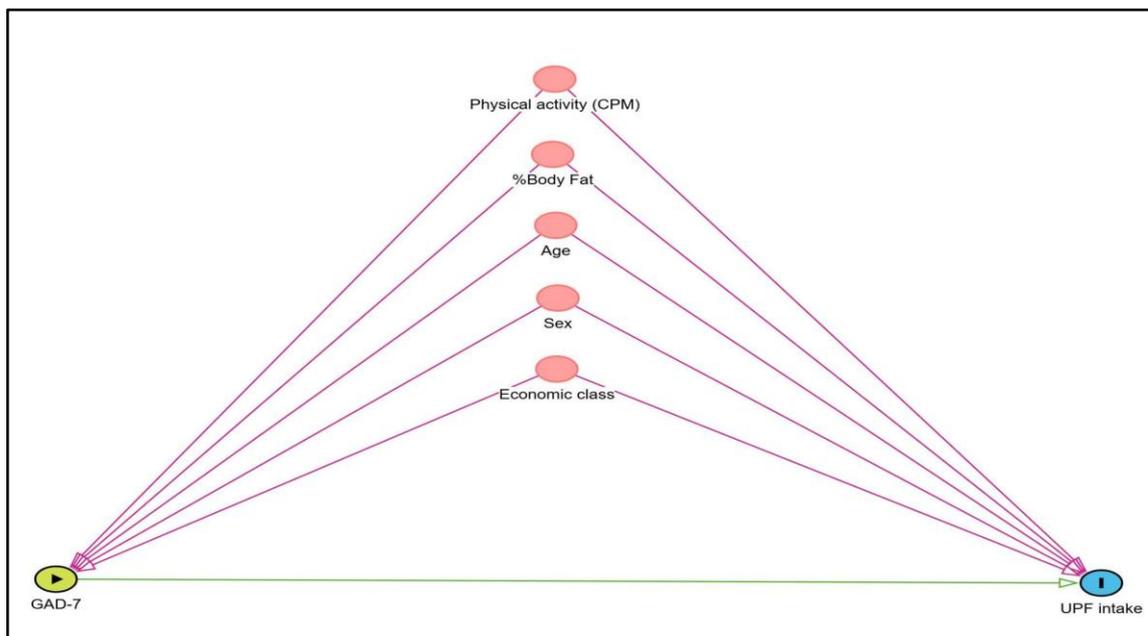


**Figure 1.** Directed acyclic graph illustrating the relationship between generalized anxiety disorder (exposure variable, yellow circle) and the consumption of ultra-processed foods (outcome variable, blue circle). The variables adjusted in the multivariable model (red ellipses) were considered potential confounding factors, with arrows indicating their relationships with the exposure and outcome.

**Results**

The selection of participants followed the process described in the flowchart (Figure 2). Initially, 365 patients were assessed for eligibility. Of these, 217 were not included due to various reasons: 180 did not meet the

inclusion criteria, 25 refused to participate, and 12 were excluded for other factors. As a result, 148 patients were included in the study.
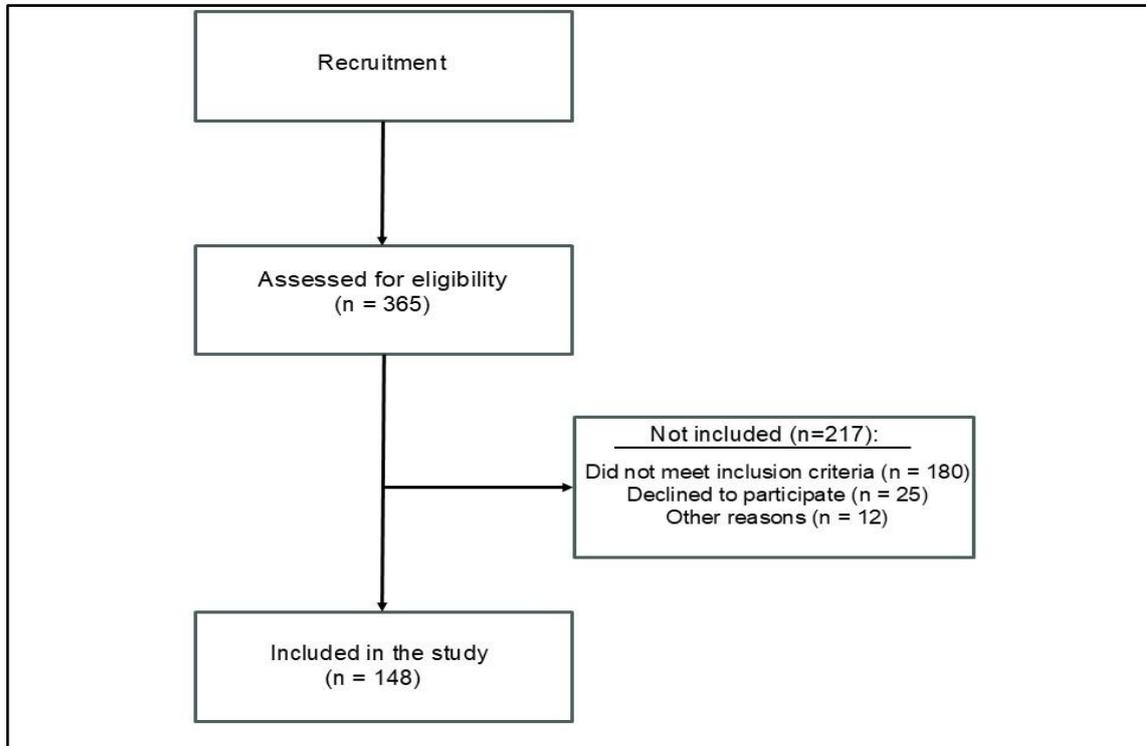


**Figure 2.** Flowchart of participant selection.

The mean age of the participants was $31.56 \pm 8.39$ years, with the majority being female (n = 115; 77.7%). Most participants belonged to economic classes B2 (n = 41; 27.7%), C1 (n = 37; 25%), and C2 (n = 42; 28.4%). Detailed characteristics of the sample are described in Table 1. The mean BMI was $31.59 \pm 3.50$ kg/m², and the mean body fat percentage was $41.89 \pm 6.09\%$. The average counts per minute (CPM) was $505.66 \pm 152.44$. The mean GAD-7 score was $9.21 \pm 5.27$ points. The average energy intake, based on three dietary recalls per participant, was $2146.13 \pm 651.19$ kcal. The average intake of AUP was $503.74 \pm 333.24$ kcal, representing an average of $22.84 \pm 12.73\%$ of the total energy intake.

**Table 1.** Descriptive characteristics and dietary consumption of the sample (n = 148).

| Variables | n | % |
|---|---|---|
| CCEB | | |
| A | 7 | 4,7 |

| | | |
|---|---|---|
| B1 | 11 | 7,4 |
| B2 | 41 | 27,7 |
| C1 | 37 | 25,0 |
| C2 | 42 | 28,4 |
| D-E | 10 | 6,8 |
| Sex | | |
| Female | 115 | 77,7 |
| Male | 33 | 22,3 |

| | **Mean** | **SD** |
|---|---|---|
| GAD-7 (Score) | 9.21 | 5.27 |
| BMI (kg/m²) | 31.59 | 3.50 |
| Body Fat (%) | 41.89 | 6.09 |
| CPM | 505.66 | 152.44 |
| Age (years) | 31.56 | 8.39 |
| Dietary Consumption | | |
| Energy (kcal) | 2146.13 | 651.19 |
| UPF (kcal) | 503.74 | 333.24 |
| UPF (%) | 22.84 | 12.73 |
| Carbohydrate (kcal) | 1030.42 | 328.07 |
| Carbohydrate (%) | 48.93 | 7.12 |
| Protein (kcal) | 393.09 | 148.47 |
| Protein (%) | 18.63 | 4.09 |
| Lipid (kcal) | 707.24 | 272.22 |
| Lipid (%) | 32.36 | 5.51 |
| Fiber (g) | 18.27 | 8.03 |
| Sodium (mg) | 3478.25 | 1608.69 |
| Sugar (g) | 84.69 | 46.62 |
| Sugar (%) | 15.65 | 6.74 |
| Saturated Fat (g) | 33.32 | 24.55 |

| Saturated Fat (%) | 13.91 | 9.78 |
|---|---|---|

CCEB, Brazilian Economic Classification Criterion; GAD-7, Generalized Anxiety Disorder-7 Scale; BMI, Body Mass Index; CPM, Counts per Minute; UPF, Ultra-Processed Foods.

The regression analysis results indicate a significant association between the GAD-7 score and the consumption of UPF ($\beta = 0.445\%$; 95% CI: 0.042% – 0.849%; p = 0.031), suggesting that higher scores of anxiety symptoms on the GAD-7 are associated with greater consumption of UPF (Table 2). The model for this variable had an adjusted $R^2$ of 0.052, indicating that although the explained variability is small, the association is statistically significant.

**Table 2.** Multiple linear regression models for the association between generalized anxiety disorder and the consumption of UPF and their rewarding components.

| Outcome | Adjusted $R^2$ | p-value[1] | $\beta$ | CI 95% | p-value[2] |
|---|---|---|---|---|---|
| UPF (%) | 0,052 | 0,042 | 0,445 | 0,042 : 0,849 | 0,031 |
| Sodium (mg) | 0,496 | <0,001 | -18,464 | -55,618 : 18,689 | 0,328 |
| Sugar (g) | 0,044 | 0,063 | -0,127 | -0,342 : 0,087 | 0,243 |
| Saturated Fat (g) | 0,027 | 0,145 | 0,290 | -0,024 : 0,604 | 0,070 |

The multiple linear regression models were adjusted for the following covariates: age (years), sex (female and male), body mass index (kg/m²), body fat (%), energy intake (kcal), Brazilian Economic Classification Criterion (A; B1 and B2; C1, C2, D-E), and physical activity level (CPM).

[1]p-value of the model; [2]p-value of the Beta coefficient.

On the other hand, no significant associations were found between the GAD-7 score and specific nutritional outcomes, such as sodium intake ($\beta = -18.464$mg; 95% CI: -55.618mg – 18.689mg; p = 0.328), sugar intake ($\beta = -0.127$g; 95% CI: -0.342g – 0.087g; p = 0.243), and saturated fat intake ($\beta = 0.290$g; 95% CI: -0.024g

– 0.604g; p = 0.070). Additionally, the models for these variables showed low adjusted R² values (0.496 for sodium, 0.044 for sugar, and 0.027 for saturated fat), reinforcing the lack of statistically significant associations.

**Discussion**

This study's results revealed that the GAD-7 score was significantly associated with the consumption of UPF, indicating that higher levels of anxiety may be related to greater intake of these foods. On the other hand, no statistically significant associations were observed between the GAD-7 score and the intake of sodium, sugar, and saturated fat. It was found that, on average, 22.84% of the participants' total caloric intake came from UPF.

Behavioral and physiological mechanisms can explain the association between GAD symptoms and UPF consumption. In behavioral terms, anxiety is linked to emotional eating, where individuals with high levels of anxiety tend to lose control over their eating, experiencing increased hunger and impulsive food consumption [43-45]. Dakanalis et al. [46], in a review, observed that patients with obesity, like the participants in this study, are more prone to emotional eating. Similarly, Cifuentes et al. [47] found that patients with obesity and anxiety exhibit less confidence in controlling their eating behaviors and a greater tendency toward emotional eating. From a physiological perspective, evidence suggests that ultra-processed foods affect the dopaminergic system, disrupting the brain's reward system. This can increase cravings for foods with rewarding components, such as UPF, creating a cycle that intensifies anxiety symptoms [48-50]. On the other hand, the literature often points to an inverse relationship compared to the findings of this study, where UPF consumption precedes the development of anxiety symptoms [51-54]. Hecht et al. [51], in a cross-sectional study using data from the National Health and Nutrition Examination Survey, observed that adults with higher UPF consumption were more likely to report more anxious days per month (RR: 1.19; 95% CI: 1.16–1.23). Complementarily, Sun et al. [52] demonstrated in a prospective cohort of 183,474 participants that higher UPF consumption was associated with an increased risk of anxiety (RR: 1.13; 95% CI: 1.06–1.21) over a follow-up period of 13.1 years.

Although the GAD-7 score is associated with UPF consumption, the statistical analysis did not reveal significant associations between the GAD-7 score and the intake of sodium, sugar, and saturated fat. This suggests that the rewarding components of UPF, such as sodium, sugar, and saturated fats, are not directly related to this effect. The impact must be more associated with the overall food matrix of these products or its energy density. UPF are rich in sodium, saturated fats, and sugars but also contain a wide variety of artificial additives, emulsifiers, and potentially inflammatory compounds, which may influence mood regulation and brain function [55-57].

It is important to highlight that the average consumption of UPF among the study participants was 22.84% of total energy intake, a value close to the 19.7% reported in the 2017-2018 Household Budget Survey: Analysis of Personal Food Consumption in Brazil for the Brazilian Population [22]. Similar values have also been found in other studies conducted in Brazil. Silva et al. [58] reported that UPF intake accounted for 22.7% of total energy intake among 8,977 adult and elderly participants, and Canhada et al. [59] indicated that 24.6% of energy intake among 11,827 adult and elderly participants came from UPF[]. It is relevant to note that the value found is considerably lower compared to studies conducted in developed countries, such as the United States and the United Kingdom, where the average consumption of UPF exceeds 50% of total energy intake [20,21].

The present study has some limitations. Firstly, the cross-sectional design prevents the determination of causal relationships between anxiety and UPF consumption. Another limitation was the sample size was not calculated for the specific objective of this study, as it is a secondary analysis, which may affect the generalizability of the results and compromise the statistical power of the study. On the other hand, the study has strengths, such as the analysis conducted in a specific population, contributing to filling knowledge gaps about this group. Additionally, the use of three 24-hour dietary recalls allowed for a more accurate estimation of participants' food intake. The use of an accelerometer to estimate physical activity levels provided an objective and precise measure, while the use of the GAD-7 as an anxiety assessment tool added validity to the results, given its widespread recognition in the literature. Adjusting for relevant confounding factors also ensured greater robustness in the statistical analysis.

**Conclusion**

In conclusion, higher GAD-7 scores were associated with greater consumption of UPF in obese adults who were interested in losing weight. Although our study's cross-sectional design does not allow for causal inferences, our findings suggest that higher levels of anxiety symptoms may be related to increased consumption of these foods. Future studies, particularly longitudinal and interventional ones, are needed to understand the mechanisms underlying this association and to evaluate the impact of modulating anxiety on dietary patterns.

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**4.  CONSIDERAÇÕES FINAIS**

Esta dissertação evidenciou que o consumo de AUP exerce impactos distintos conforme o grupo populacional analisado. Em adolescentes de cidades subdesenvolvidas, não foi observada uma associação significativa entre o desempenho cognitivo e o consumo de AUP. Por outro lado, em adultos com obesidade, interessados em perder peso, maiores sintomas de ansiedade foram relacionados a um maior consumo de AUP. Esses achados indicam que a relação entre AUP e saúde mental é influenciada por fatores contextuais e características específicas dos grupos estudados. Futuros estudos, particularmente os de natureza longitudinal, são fundamentais para investigar as causalidades e os mecanismos subjacentes a essas associações.

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